RULEMAKING ISSUE
NOTATION VOTE

March 13, 2002 SECY-02-0043

FOR: The Commissioners

FROM: William D. Travers
Executive Director for Operations

SUBJECT: PROPOSED RULE: GEOLOGICAL AND SEISMOLOGICAL CHARACTERISTICS FOR THE SITING AND DESIGN OF DRY CASK INDEPENDENT SPENT FUEL STORAGE INSTALLATIONS AND MONITORED RETRIEVABLE STORAGE INSTALLATIONS - 10 CFR PART 72

PURPOSE:

To request Commission approval to publish a proposed rule, in the Federal Register, that would amend 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste." The proposed amendments would make the Part 72 regulations compatible with the 1996 revision to 10 CFR Part 100 that addressed uncertainties in seismic hazard analysis, and commensurate with the risk associated with a dry cask independent spent fuel storage installation (ISFSI) or U.S. Department of Energy (DOE) monitored retrievable storage installation (MRS). The proposed amendments would also specify that general licensees evaluate dynamic loads, as well as static loads, in the design of cask storage pads and areas. These proposed amendments would make the Part 72 requirements more effective and efficient and reduce the burden on licensees and on the U.S. Nuclear Regulatory Commission (NRC), without an adverse effect on public health and safety, or on the environment.

BACKGROUND:

In 1998, in response to SECY-98-126, the Commission approved the staff's plan to amend Part 72. The amendments would have required a new specific license applicant for an ISFSI

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or MRS to use a probabilistic seismic hazard analysis (PSHA) or suitable sensitivity analyses instead of the current deterministic approach in selecting the design earthquake ground motion. The amendments would also have allowed for a graded approach of using two levels of design earthquake for ISFSI or MRS systems, structures, and components (SSCs). The design level used would have depended on the SSCs' importance to safety. Lastly, the amendments would have required that general licensees design cask storage pads and areas to adequately account for dynamic loads, in addition to static loads.

After further consideration of the use of the graded approach for the design earthquake, the staff prepared a Modified Rulemaking Plan (SECY-01-0178) that provided an additional alternative method for the seismic design of dry cask ISFSI or MRS SSCs. In the modified plan, the staff proposed maintaining the present Part 72 requirement of using a single earthquake ground motion in design, but with a lower value than that required for a nuclear power plant (NPP), that is commensurate with the level of risk associated with an ISFSI or MRS.

In a Staff Requirements Memorandum dated November 19, 2001 (Attachment 1), in response to SECY-01-0178, the Commission did not object to the staff's plan to revise the approved rulemaking plan, provided that the proposed rule solicit comment on a range of probability of exceedance values from 5.0E-04 through 1.0E-4. The Commission also directed the staff to undertake further analysis to support a specific value.

DISCUSSION:

The geological and seismological siting and design requirements for an ISFSI or MRS are contained in 10 CFR 72.102. This regulation requires that, for any ISFSI or MRS located in the western U.S. or in other areas of known potential seismic activity in the eastern U.S., seismicity be evaluated by the "deterministic" techniques of Appendix A to Part 100. For sites evaluated under Part 100, Appendix A criteria, 10 CFR 72.102(f)(1) requires that the design earthquake be equivalent to the safe shutdown earthquake for a NPP. However, Part 100 was amended in 1996 and incorporated a new 10 CFR 100.23 section in the regulations to require NPP applicants, after January 10, 1997, to account for uncertainties in the seismic hazard evaluation by using a "probabilistic" PSHA approach or suitable sensitivity analyses, instead of the "deterministic" Appendix A to Part 100 approach, as part of the geologic and seismic siting criteria for NPPs.

NRC received two requests for exemptions from the ISFSI industry, to allow the application of the PSHA approach instead of the deterministic approach. DOE requested an exemption from 10 CFR 72.102(f)(1) for an ISFSI at the Idaho National Engineering and Environmental Laboratory (INEEL), to store spent fuel from the Three Mile Island-Unit 2 NPP. The Commission approved this exemption in the Staff Requirements Memorandum dated May 20, 1998, to SECY-98-071, "Exemption to 10 CFR 72.102(f)(1) Seismic Design Requirement for Three Mile Island Unit 2 Independent Spent Fuel Storage Installation." A similar request for an exemption from Private Fuel Storage L.L.C. is currently the subject of an adjudicatory proceeding, referred to in CLI-01-12, 53 NRC 459 (2001). Based on discussions with industry representatives, the staff believes that any future license applicant for an ISFSI will seek the same exemption.

The staff is seeking a conforming change to Part 72, which would allow new dry cask ISFSI or MRS licensees to take advantage of the 1996 Part 100 amendments, specifically 10 CFR 100.23. These changes would result in alleviating the need for applicants to request exemptions from 10 CFR 72.102(f)(1). The staff also believes that a major seismic event at an ISFSI or MRS storing spent fuel in dry casks or canisters would most likely have minor radiological consequences, compared with a similar event at a NPP. Therefore, the staff proposes to lower the design earthquake to be commensurate with the level of risk associated with an ISFSI or MRS.

The proposed changes would require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the design earthquake ground motion. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation. The proposed changes are risk-informed in that they would allow an ISFSI or MRS applicant to use a design earthquake ground motion based on the lower level of risk associated with an ISFSI or MRS, relative to a nuclear power plant.

The staff has developed, as part of the proposed rule, Draft Regulatory Guide DG-3021, “Site Evaluations and Determination of Design Earthquake Ground Motion for Seismic Design of Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations.” This draft guide provides procedures acceptable to the staff for determining an appropriate design earthquake and recommends an appropriate mean annual probability of exceedance value of 5.0E-04. This rulemaking would necessitate a revision to NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," and NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities," to reflect the updated rule requirements.

In response to the Staff Requirements Memorandum dated November 19, 2001, the proposed rule includes a question to the public, in both the Federal Register notice and DG-3021, that solicits comment on an appropriate mean annual probability of exceedance value, within the range of 5.0E-04 through 1.0E-4, for the seismic design of an ISFSI or MRS. The staff is currently performing confirmatory analyses in support of a specific mean annual probability of exceedance value to be recommended in the final regulatory guide.

The staff is also proposing to modify 10 CFR 72.212(b)(2)(i)(B) to require that general licensees evaluate dynamic loads, in addition to static loads, in the design of cask storage pads and areas for ISFSIs, to ensure that casks are not placed in unanalyzed conditions. Accounting for dynamic loads in the analysis of ISFSI pads and areas would ensure that pads continue to support the casks during seismic events. General licensees currently evaluate dynamic loads for evaluating the casks, pads and areas, to meet the cask design bases in the Certificate of Compliance, as required by 10 CFR 72.212(b)(2)(i)(A). Therefore, the proposed changes would not actually require any general licensees operating an ISFSI to re-perform any written evaluations previously undertaken. Specific licensees are currently required, under 10 CFR 72.122(b)(2), to design ISFSIs to withstand the effects of dynamic loads, such as earthquakes and tornados.

The staff considered the merits of the rulemaking within the context of the performance goals listed in NRC's strategic plan. The rulemaking effort would increase NRC's effectiveness and efficiency by reducing the number of exemption requests that might be submitted and reviewed. This rule would also reduce unnecessary regulatory burden by allowing the applicant or licensee to select a design earthquake level commensurate with the risk associated with an ISFSI or MRS facility. This rule would maintain safety by selecting the design earthquake level to be commensurate with the risk associated with an ISFSI or MRS. The changes to the design earthquake level are considered risk-informed, consistent with NRC policy to develop risk-informed regulations. This rule would increase realism by enabling an ISFSI or MRS applicant to use state-of-the-art approaches, such as a PSHA or other suitable sensitivity analyses, to more accurately characterize the seismicity of a site.

RISK-INFORMING NMSS REGULATORY ACTIVITIES:

The Office of Nuclear Material Safety and Safeguards (NMSS) has developed a set of screening criteria to identify NMSS regulatory activities amenable to increased use of risk information. The staff applied the criteria to the proposed changes in the Modified Rulemaking Plan to determine if the risk-informed approach of lowering the design earthquake to a level that is commensurate with the lower risk associated with an ISFSI or MRS should be implemented. The proposed changes satisfy the screening criteria because they: (1) improve effectiveness and efficiency of the NRC regulatory process by eliminating the need for applicants to request exemptions from 10 CFR 72.102(a), 72.102(b), and 72.102(f)(1) (similar to DOE's request for the ISFSI at INEEL), and the need for NRC to review the exemption requests; (2) reduce unnecessary regulatory burden by allowing the license applicant to select a design earthquake level commensurate with the risk associated with an ISFSI or MRS facility; (3) can be supported by analytical models that evaluate the seismic behavior of a cask; (4) would not result in significant start-up or implementation costs to NRC and applicants, other than technical training in the use of the PSHA method and further development of analytical models; and (5) do not involve other factors, with the exception of potential adverse stakeholder reaction, as can be the case when using risk-informed approaches. Satisfying these criteria supports the implementation of the proposed risk-informed approach.

AGREEMENT STATE ISSUES:

This rule is classified as compatibility category "NRC" and addresses only areas of exclusive NRC regulatory authority.

COORDINATION:

The Office of the General Counsel has no legal objection to the proposed rulemaking. The Office of the Chief Financial Officer has reviewed this Commission Paper for resource implications and has no objections. The rule suggests changes in information collection requirements that must be submitted to the Office of Management and Budget (OMB) no later than the date the proposed rule is forwarded to the Federal Register for publication. Staff has coordinated with the Committee to Review Generic Requirements (CRGR) on the backfit section, and will determine if further CRGR review is needed after public comments are received on the proposed rule.

RECOMMENDATIONS:

That the Commission:

1. Approve, for publication in the Federal Register, the proposed amendments to the seismic requirements in Part 72 (Attachment 2).

2. Note:

   a. That the proposed amendments will be published in the Federal Register, allowing 75 days for public comment;

   b. That the Chief Counsel for Advocacy of the Small Business Administration will be informed of the certification and the reasons for it, as required by the Regulatory Flexibility Act, 5 U.S.C. 605(b);

   c. That a draft Regulatory Analysis has been prepared for this rulemaking (Attachment 3);

   d. That a draft Environmental Assessment has been prepared for this rulemaking (Attachment 4);

   e. That a draft Regulatory Guide has been prepared for this rulemaking and will be issued for a 75-day public comment period (Attachment 5);

   f. That appropriate Congressional committees will be informed of this action;

   g. That a press release will be issued by the Office of Public Affairs when the proposed rulemaking is filed with the Office of the Federal Register;

   h. That OMB review is required, for information collection burden, and a clearance package will be forwarded to OMB no later than the date the proposed rule is submitted to the Office of the Federal Register for publication; and

i. That resources to complete and implement this rulemaking are included in the current budget.

/RA/

William D. Travers
Executive Director
for Operations

Attachments:
1. Staff Requirements Memorandum dated November 19, 2001
2. Federal Register Notice
3. Draft Regulatory Analysis
4. Draft Environmental Assessment
5. Draft Regulatory Guide DG-3021

November 19, 2001

MEMORANDUM TO: William D. Travers
Executive Director for Operations

FROM: Annette L. Vietti-Cook, Secretary **/RA/**

SUBJECT: STAFF REQUIREMENTS - SECY-01-0178 - MODIFIED RULEMAKING PLAN: 10 CFR PART 72 -- "GEOLOGICAL AND SEISMOLOGICAL CHARACTERISTICS FOR SITING AND DESIGN OF DRY CASK INDEPENDENT SPENT FUEL STORAGE INSTALLATIONS"

This is to advise you that the Commission has not objected to the staff's plan to revise the approved rulemaking plan for the geological and seismological characteristics for the siting and design of dry cask independent spent fuel storage installations (10 CFR Part 72), subject to the comments provided below.

Central to this rulemaking is the determination of the mean annual exceedance probability of an earthquake at a proposed ISFSI. The proposed rule should solicit comment on a range of probability of exceedance levels from 5.0E-04 through 1.0E-04. Staff should undertake further analysis to support a specific proposal.

The proposed rule should be submitted to the Commission for review prior to publication.
(EDO) (SECY Suspense: 3/22/02)

cc: Chairman Meserve
Commissioner Dicus
Commissioner Diaz
Commissioner McGaffigan
Commissioner Merrifield
OGC
CFO
OCA
OIG
OPA
Office Directors, Regions, ACRS, ACNW, ASLBP (via E-Mail)
PDR

[7590-01-P]

NUCLEAR REGULATORY COMMISSION

10 CFR Part 72

RIN 3150-AG93

Geological and Seismological Characteristics for Siting and Design of Dry Cask Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations

AGENCY: Nuclear Regulatory Commission.

ACTION: Proposed rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is proposing to amend its licensing requirements for dry cask modes of storage of spent nuclear fuel, high-level radioactive waste, and power reactor-related Greater than Class C waste in an independent spent fuel storage installation (ISFSI) or in a U.S. Department of Energy (DOE) monitored retrievable storage installation (MRS). These amendments would update the seismic siting and design criteria, including geologic, seismic, and earthquake engineering considerations. The proposed rule would allow NRC and its licensees to benefit from experience gained in the licensing of existing facilities and to incorporate the rapid advancements in the earth sciences and earthquake engineering. The proposed amendments would make the Part 72 regulations compatible with the 1996 revision to Part 100 that addressed uncertainties in seismic hazard analysis, and commensurate with the risk associated with an ISFSI or MRS.

DATES: The comment period expires **(insert date 75 days after date of publication).** Comments received after this date will be considered if it is practical to do so, but the NRC is able to assure consideration only for comments received on or before this date.

ADDRESSES: Submit comments to: Secretary, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, Attention: Rulemaking and Adjudications Staff.

Deliver comments to 11555 Rockville Pike, Rockville, Maryland, between 7:30 a.m. and 4:15 p.m. on Federal workdays.

You may also provide electronic comments via the NRC's interactive rulemaking website at (http://ruleforum.llnl.gov). This site provides the capability to upload comments as files (any format), if your web browser supports that function. For information about the interactive rulemaking website, contact Ms. Carol Gallagher at (301) 415-5905, or e-mail cag@nrc.gov.

Certain documents related to this rulemaking, including comments received, may be examined at the NRC Public Document Room (PDR), Room O-1F21, 11555 Rockville Pike, Rockville, MD. These same documents may also be viewed and downloaded electronically via the rulemaking website.

The NRC maintains an Agencywide Document Access and Management System (ADAMS), which provides text and image files of NRC's public documents. These documents may be accessed through the NRC's Public Electronic Reading Room on the Internet at http://www.nrc.gov/reading-rm/adams.html. If you do not have access to ADAMS or if there are problems in accessing the documents located in ADAMS, contact the NRC's PDR reference staff at 1-800-397-4209, 301-415-4737, or by email to pdr@nrc.gov.

FOR FURTHER INFORMATION CONTACT: Keith K. McDaniel, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, telephone: (301) 415-5252, e-mail: kkm@nrc.gov.

SUPPLEMENTARY INFORMATION:

I. Background

II. Objectives

III. Applicability

IV. Discussion

V. Related Regulatory Guide

VI. Discussion of Proposed Amendments by Section

VII. Specific Question for Public Comment

VIII. Criminal Penalties

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XIV. Regulatory Analysis

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XVI. Backfit Analysis

I. Background

In 1980, the Commission added 10 CFR Part 72 to its regulations to establish licensing requirements for the independent storage of spent nuclear fuel and high-level radioactive waste (HLW) (45 FR 74693; November 12, 1980). In 1988, the Commission amended Part 72 to provide for licensing the storage of spent nuclear fuel and HLW in an MRS (53 FR 31651, August 19, 1988). Subpart E of Part 72 contains siting evaluation factors that must be investigated and assessed with respect to the siting of an ISFSI or MRS, including a requirement for evaluation of geological and seismological characteristics. ISFSI and MRS facilities are designed and constructed for the interim storage of spent nuclear fuel that has aged for at least one year, and other solidified high-level radioactive materials that are pending shipment to a high-level radioactive waste repository or other disposal.

The original regulations envisioned ISFSI and MRS facilities as spent fuel pools or single, massive dry storage structures. The regulations required seismic evaluations equivalent to those for a nuclear power plant (NPP) when the ISFSI or MRS is located west of the Rocky Mountain Front (west of approximately 104^0 west longitude), referred to hereafter as western U.S., or in areas of known seismic activity east of the Rocky Mountain Front (east of approximately 104^0 west longitude), referred to hereafter as eastern U.S. A seismic design requirement, equivalent to the requirements for a NPP (Appendix A to Part 100) seemed appropriate for these types of facilities, given the potential accident scenarios. For those sites located in eastern U.S., and not in areas of known seismic activity, the regulations allowed for less stringent alternatives.

For other types of ISFSI or MRS designs, the regulation required a site-specific investigation to establish site suitability commensurate with the specific requirements of the proposed ISFSI or MRS. The Commission explained that for ISFSIs that do not involve massive structures, such as dry storage casks and canisters, the required design earthquake ground motion (DE) will be determined on a case-by-case basis until more experience is gained with the licensing of these types of units (45 FR 74697).

For sites located in either the western U.S. or in areas of known seismic activity in the eastern U.S., the regulations in 10 CFR Part 72 currently require the use of the procedures in Appendix A to Part 100 for determining the design basis vibratory ground motion at a site. Appendix A requires the use of "deterministic" approaches in the development of a single set of earthquake sources. The applicant develops for each source a postulated earthquake to be used to determine the ground motion that can affect the site, locates the postulated earthquake according to prescribed rules, and then calculates ground motions at the site. Because the deterministic approach does not explicitly recognize uncertainties in geoscience parameters, probabilistic seismic hazard analysis (PSHA) methods were developed that allow explicit expressions for the uncertainty in ground motion estimates and provide a means for assessing sensitivity to various parameters.

Advances in the sciences of seismology and geology, along with the occurrence of some licensing issues not foreseen in the development of Appendix A to Part 100, have caused a number of difficulties in the application of this regulation to ISFSIs. Specific problematic areas include the following:

1. The limitations in data and geologic and seismic analyses and the rapid accumulation of knowledge in the geosciences have required considerable latitude in judgment. The inclusion of detailed geoscience assessments in Appendix A has caused difficulties for applicants and the NRC staff by inhibiting the use of needed judgment and flexibility in applying basic principles to new situations. Requiring the use of Appendix A has also

inhibited the use of evolving methods of analyses (for instance, probabilistic) in the licensing process; and

2. Various sections of Appendix A are subject to different interpretations. For example, there have been differences of opinion and differing interpretations among experts as to the largest earthquakes to be considered and ground motion models to be used, thus often making the licensing process less predictable.

In 1996, the Commission amended 10 CFR Parts 50 and 100 to update the criteria used in decisions regarding NPP siting, including geologic and seismic engineering considerations for future NPPs (61 FR 65157; December 11, 1996). The amendments added a new § 100.23 requiring that the uncertainties associated with the determination of the safe shutdown earthquake ground motion (SSE) be addressed through an appropriate analysis, such as a PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100. This approach takes into account the problematic areas identified above in the earlier siting requirements and is based on developments in the field over the past two decades. Further, regulatory guides have been used to address implementation issues. For example, the Commission provided guidance for NPP license applicants in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," and Standard Review Plan NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Reactors," Section 2.5.2, "Vibratory Ground Motion," Revision 3. However, the Commission left Appendix A to Part 100 in place to preserve the licensing basis for existing plants and confined the applicability of § 100.23 to new NPPs.

With over 10 years of experience licensing dry cask storage (10 specific licenses have been issued), the Commission is now proposing a conforming change to 10 CFR Part 72 to require applicants, at some locations, to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, for determining the DE. The use of a probabilistic approach or suitable sensitivity analyses to siting parallels the change made to 10 CFR Part 100.

In comparison with a NPP, an operating dry cask ISFSI or MRS facility, storing spent nuclear fuel, is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI or MRS facility does not have the variety and complexity of active systems necessary to support safe operations at a NPP. Further, the robust cask design required for non-seismic considerations (e.g., drop event, shielding), assure low probabilities of failure from seismic events. In the unlikely occurrence of a radiological release as a result of a seismic event, the radiological consequences to workers and the public are significantly lower in comparison to a NPP. This is because the conditions required for release and dispersal of significant quantities of radioactive material, such as high temperatures or pressures, are not present in an ISFSI or MRS. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI or MRS, and to the low inventory of volatile radioactive materials readily available for release to the environment. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies is designed to confine these nuclides. Hence, the Commission believes that the seismically induced risk from the operation of an ISFSI or MRS is less than at an operating NPP. Therefore, the

Commission proposes to revise the DE requirements for ISFSI and MRS facilities from the current Part 72 requirements, which are equivalent to the SSE for a NPP.

II. Objectives

An ISFSI is designed, constructed, and operated under a Part 72 specific or general license. A Part 72 specific license for an ISFSI is issued to a named person upon application filed under Part 72 regulations. A Part 72 general license for an ISFSI is issued under 10 CFR 72.210 to persons authorized to possess a NPP license under Part 50, without filing a Part 72 license application. A general licensee is required to meet the conditions specified in Subpart K of Part 72. An MRS may be designed, constructed, and operated by DOE under a Part 72 specific license.

The proposed rule reflects changes that are intended to (1) benefit from the experience gained in applying the existing regulation and from research; and (2) provide needed regulatory flexibility to incorporate into licensing under Part 72, state-of-the-art improvements in the geosciences and earthquake engineering.

The objectives of this proposed rule are to:

1. Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a NPP, to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or suitable sensitivity analyses to

address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation. (§ 72.103)

2. Allow new ISFSI or MRS applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI or MRS (§ 72.103); and

3. Require general licensees to evaluate that the designs of cask storage pads and areas adequately account for dynamic loads, in addition to static loads. (§ 72.212)

III. Applicability

This section clarifies the applicability of the proposed new § 72.103 for Part 72 specific licensees, and modified § 72.212(b)(2)(i)(B) for Part 72 general licensees.

Applicability of Proposed § 72.103

(1) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a NPP, would be required to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, for determining the DE.

(2) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and co-located with a NPP, would have the option of addressing uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, or using the existing design criteria for the NPP, for determining the DE. When the existing design criteria for the NPP are used for an ISFSI at a site with multiple NPPs, the criteria for the most recent NPP must be used.

(3) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in the eastern U.S., except in areas of known seismic activity, would have the option of addressing uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, or using the standardized DE described by an appropriate response spectrum anchored at 0.25 g (subject to the conditions in proposed § 72.103(a)(1)), or using the existing design criteria for the most recent NPP (if applicable), for determining the DE.

(4) The proposed § 72.103 is not applicable to a general licensee at an existing NPP operating an ISFSI under a Part 72 general license anywhere in the U.S.

The proposed changes apply to the design basis of both a dry cask storage type ISFSI and MRS, because these facilities are similar in design. The Commission does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because the risk associated with potential accident scenarios for wet modes of storage is greater than the risk for dry cask modes of storage. This is because wet modes of storage require active systems, such as systems to remove heat and maintain adequate water levels. These active systems have a higher probability of failure than the passive systems used in dry cask modes of storage, thus resulting in a greater seismic risk for wet modes of storage.
The Commission also does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to dry modes of storage that do not use casks because of the lack of experience gained in licensing these facilities.

Applicability of Modified § 72.212(b)(2)(i)(B)

The proposed changes in § 72.212(b)(2)(i)(B) regarding the evaluation of dynamic loads for the design of cask storage pads and areas would apply to all general licensees for an ISFSI.

The applicability of the proposed § 72.103 and modified § 72.212(b)(2)(i)(B) is summarized in the table below.

SUMMARY OF APPLICABILITY

Design Earthquake Ground Motion for ISFSI or MRS Specific License Applicants for Dry Cask Modes of Storage on or after the Effective Date of the Final Rule	
Site Condition	Specific License[1]
Western U.S., or areas of known seismic activity in the eastern U.S., **not** co-located with NPP	Must use PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2]
Western U.S., or areas of known seismic activity in the eastern U.S., **and** co-located with NPP	PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2], **or** existing NPP design criteria (multi-unit sites - use the most recent criteria)
Eastern U.S., and not in areas of known seismic activity	PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2], **or** existing NPP design criteria, if applicable (multi-unit sites - use the most recent criteria), **or** an appropriate response spectrum anchored at 0.25g (subject to the conditions in proposed § 72.103(a)(1)).

1. Proposed § 72.103 does not apply to general licensees. General licensees must satisfy the conditions given in 10 CFR 72.212.
2. Regardless of the results of the investigations, anywhere in the continental U.S., the DE must have a value for the horizontal ground motion of no less than 0.10 g with the appropriate response spectrum.

IV. Discussion

The Commission is proposing to amend certain sections of Part 72 dealing with seismic siting and design criteria for a dry cask ISFSI or MRS. The Commission intends to leave the present § 72.102 in place to preserve the ISFSI licensing bases for applications before the effective date of the rule, and continue the present ISFSI or MRS licensing bases for applications for other than dry cask modes of storage. The Commission is proposing to change the heading of § 72.102, add a new § 72.103, and modify § 72.212(b)(2)(i)(B).

A. Proposed Change to 10 CFR 72.102

The heading of § 72.102 would be changed to clarify that the present requirements are applicable to ISFSI or MRS licensees or license applicants before the effective date of the rule. The requirements of § 72.102 that applied to ISFSI or MRS licensees or license applicants for other than dry cask modes of storage would continue to apply.

B. Proposed 10 CFR 72.103

Proposed § 72.103 describes the seismic requirements for new specific license applicants for dry cask storage at an ISFSI or MRS.

1. Remove Detailed Guidance from the Regulation.

Part 72 currently requires license applicants for an ISFSI or MRS, in the western U.S. or in other areas of know seismicity, to comply with Appendix A to Part 100. Appendix A contains both requirements and guidance on how to satisfy those requirements. For example, Section IV, "Required Investigations," of Appendix A states that investigations are required for vibratory ground motion, surface faulting, and seismically induced floods and water waves.

Appendix A then provides detailed guidance on what constitutes an acceptable investigation. A similar situation exists in Section V, "Seismic and Geologic Design Bases," of Appendix A to Part 100.

Geoscience assessments require considerable latitude in judgment because of (a) limitations in data; (b) current state-of-the-art of geologic and seismic analyses; (c) rapid accumulation of knowledge; and (d) evolution in geoscience concepts. The Commission recognized the need for latitude in judgment when it amended Part 100 in 1996.

However, specifying geoscience assessments in detail in a regulation has created difficulty for applicants and the NRC staff by inhibiting needed latitude in judgment. It has inhibited the flexibility needed in applying basic principles to new situations and the use of evolving methods of analyses (for instance, probabilistic) in the licensing process.

The Commission proposes to add a new section in Part 72 that would provide specific siting requirements for an ISFSI or MRS instead of referencing another part of the regulations (Appendix A to Part 100). The proposed regulation would also reduce the level of detail by placing only basic requirements in the rule and providing the details on methods acceptable for meeting the requirements in an accompanying guidance document. Thus, the proposed regulation contains requirements to:

(i) determine the geological, seismological, and engineering characteristics of the proposed site;

(ii) establish a DE; and

(iii) identify the uncertainties associated with these requirements. Detailed guidance on the procedures acceptable to the NRC for meeting the requirements would be provided in a draft regulatory guide being issued for public comment as DG-3021, "Site Evaluations and

Determination of Design Earthquake Ground Motion for Seismic Design of Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations."

2. Address Uncertainties and Use Probabilistic Methods.

The existing approach for determining a DE for an ISFSI or MRS, embodied in Appendix A to Part 100, relies on a "deterministic" approach. Using this deterministic approach, an applicant develops a single set of earthquake sources, develops for each source a postulated earthquake to be used as the source of ground motion that can affect the site, locates the postulated earthquake according to prescribed rules, and then calculates ground motions at the site.

Although this approach has worked reasonably well for the past several decades in the sense that SSE for NPPs sited with this approach are judged to be suitably conservative, the approach has not explicitly recognized uncertainties in geosciences parameters. Because so little is known about earthquake phenomena (especially in the eastern U.S.), there have often been differences of opinion and differing interpretations among experts as to the largest earthquakes to be considered and ground-motion models to be used, often making the licensing process less predictable.

Probabilistic methods that have been developed in the past 15 to 20 years for evaluation of seismic safety of nuclear facilities allow explicit incorporation of different models for zonation, earthquake size, ground motion, and other parameters. The advantage of using these probabilistic methods is their ability to incorporate different models and data sets, thereby providing an explicit expression for the uncertainty in the ground motion estimates and a means of assessing sensitivity to various input parameters. The western and eastern U.S. have fundamentally different tectonic environments and histories of tectonic deformation.

Consequently, application of these probabilistic methodologies has revealed the need to vary the fundamental PSHA methodology depending on the tectonic environment of the site.

In 1996, when the Commission accepted the use of a PSHA methodology or suitable sensitivity analyses in § 100.23, it recognized that the uncertainties in seismological and geological information must be formally evaluated and appropriately accommodated in the determination of the SSE for seismic design of NPPs. The Commission further recognized that the nature of uncertainty and the appropriate approach to account for it depends on the tectonic environment of the site and on properly characterizing parameters input to the PSHA or suitable sensitivity analyses. Consequently, methods other than probabilistic methods, such as sensitivity analyses, may be adequate for some sites to account for uncertainties. The Commission believes that certain new applicants for ISFSI or MRS licenses, as described in Section III, "Applicability," above, must use probabilistic methods or other sensitivity analyses to account for these uncertainties instead of using the Appendix A to Part 100. The Commission does not intend to require new ISFSI or MRS applicants that are co-located with a NPP to address uncertainties because the criteria used to evaluate existing NPPs are considered to be adequate for ISFSIs, in that the criteria have been determined to be safe for NPP licensing, and the seismically induced risk of an ISFSI or MRS is significantly lower than that of a NPP, as described in Section IV.

The key elements of the Commission's proposed approach for seismic and geologic siting for ISFSI or MRS license review and approval consists of:

a. Conducting site-specific and regional geoscience investigations;

b. Setting the target exceedance probability commensurate with the level of risk associated with an ISFSI or MRS;

c. Conducting PSHA and determining ground motion level corresponding to the target exceedance probability;

d. Determining if other sources of information change the available probabilistic results or data for the site; and

e. Determining site-specific spectral shape, and scaling this shape to the ground motion level determined above.

In addition, the NRC staff will review the application using all available data including insights and information from previous licensing experience. Thus, the proposed approach requires thorough regional and site-specific geoscience investigations. Results of the regional and site-specific investigations must be considered in applying the probabilistic method. Two current probabilistic methods are the NRC- sponsored study conducted by Lawrence Livermore National Laboratory and the Electric Power Research Institute's seismic hazard study. These are essentially regional studies. The regional and site-specific investigations provide detailed information to update the database of the hazard methodology to make the probabilistic analysis site-specific.

Applicants must also incorporate local site geological factors, such as stratigraphy and topography, and account for site-specific geotechnical properties in establishing the DE. Guidelines to incorporate local site factors and advances in ground motion attenuation models, and to determine ground motion estimates, are outlined in NUREG-0800, Section 2.5.2.

Methods acceptable to the NRC for implementing the proposed regulation related to the PSHA or suitable sensitivity analyses are described in DG-3021.

3. Revise the Design Earthquake Ground Motion.

The present DE is based on the requirements contained in 10 CFR Part 100 for NPPs. In the Statement of Considerations accompanying the initial Part 72 rulemaking, the Commission recognized that the design peak horizontal acceleration for structures, systems, and components (SSCs) need not be as high as for a NPP and should be determined on a “case-by-case” basis until “more experience is gained with licensing of these types of units” (45 FR 74697; November 12, 1980). With over 10 years of experience in licensing dry cask storage and with analyses demonstrating robust behavior of dry cask storage systems (DCSSs) in accident scenarios (10 specific licenses have been issued and 9 locations use the general license provisions), the Commission now has a reasonable basis to consider lower and more appropriate DE parameters for a dry cask ISFSI or MRS. Therefore, the Commission proposes to reduce the DE for new ISFSI or MRS license applicants to be commensurate with the lower risk associated with these facilities.

I. Factors that result in the lower radiological risk at an ISFSI or MRS compared to a NPP include the following:

   a. In comparison with a NPP, an operating ISFSI or MRS is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI or MRS does not have the variety and complexity of active systems necessary to support an operating NPP. After the spent fuel is in place, an ISFSI or MRS is essentially a static operation.

   b. During normal operations, the conditions required for the release and dispersal of significant quantities of radioactive materials are not present. There are no high temperatures or pressures present during normal operations or under design basis accident conditions to cause the release and dispersal of radioactive materials. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI or MRS, and to the low inventory of volatile radioactive materials readily available for release to the environment.

c. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI or MRS is significantly less than the risk associated with a NPP. Also, the Commission has stated that the use of risk-informed regulation is appropriate.

d. The critical element for protection against radiation release is the sealed cask containing the spent fuel assemblies. The standards in Part 72 Subparts E “Siting Evaluation Factors,” and F ”General Design Criteria,” ensure that the dry cask storage designs are very rugged and robust. The casks must maintain structural integrity during a variety of postulated non-seismic events, including cask drops, tip-over, and wind driven missile impacts. These non-seismic events challenge cask integrity significantly more than seismic events. Therefore, the casks are expected to have substantial design margins to withstand forces from a seismic event greater than the design earthquake.

e. During a seismic event at an ISFSI or MRS, a cask may slide if lateral seismic forces are greater than the frictional resistance between the cask and the concrete pad. The sliding and resulting displacements are computed by the applicant to demonstrate that the casks, which are spaced to satisfy the thermal criteria in Part 72 Subpart F, are precluded from impacting other adjacent casks. Furthermore, the NRC staff guidance in reviewing cask designs is to show that public health and safety is maintained during a postulated DE. This can be demonstrated by showing that either casks are designed to prevent sliding or tip over during a seismic event, or the consequences of the calculated cask movements are acceptable. Even if the casks slide or tip over and then impact other casks or the pad during a seismic event significantly greater than the proposed DE, there are adequate design margins to ensure that the casks maintain their structural integrity.

f. The combined probability of the occurrence of a seismic event and operational failure that leads to a radiological release is much smaller than the individual probabilities of either of these events. This is because the handling building and crane are used for only a fraction of the licensed period of an ISFSI or MRS and for only a few casks at a time. Additionally, dry cask ISFSIs are expected to handle only sealed casks and not individual fuel assemblies. Therefore, the risk of a potential release of radioactivity due to failure of the cask handling building and/or crane during a seismic event is small.

II Additional rationale for reducing the DE for new ISFSI or MRS license applicants include the following:

a. Because the DE is a smooth broad-band spectrum, which envelops the controlling earthquake responses, the vibratory ground motion specified is conservative.

b. The crane used for lifting the casks in the building is designed using the same industry codes as for a NPP (ACI 349, AISC N690, ANSI N14.6, and NUREG-0612), and has a safety factor of five (5) or greater for lifted loads using the ultimate strength of the materials. Therefore, the crane would perform satisfactorily during an earthquake much larger than the design earthquake.

c. The determination of a DE for an ISFSI or MRS is consistent with the design approach used in DOE Standard DOE-STD-1020, "Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities," for similar type facilities.

The present DE (equivalent to the SSE for a NPP) has a mean annual probability of exceedance of approximately 1.0E-04 (i.e., in any one year, the probability is one in ten thousand that the DE established for the site will be exceeded). DG-3021 recommends a mean annual probability of exceedance. The Commission is soliciting public comments on the appropriate mean annual probability of exceedance, as discussed in Section VII of the SUPPLEMENTARY INFORMATION.

C. Proposed Change to 10 CFR 72.212(b)(2)(i)(B).

The Commission is proposing to modify § 72.212(b)(2)(i)(B) to require that general licensees evaluate dynamic loads, in addition to static loads, in the design of cask storage pads and areas for ISFSIs to ensure that casks are not placed in unanalyzed conditions.

During a seismic event, the cask storage pads and areas experience dynamic loads in addition to static loads. The dynamic loads depend on the interaction of the casks, cask storage pads, and areas. Consideration of the dynamic loads of the stored casks, in addition to the static loads, for the design of the cask storage pads and areas, would ensure that the cask storage pads and areas would perform satisfactorily during a seismic event.

The proposed revision would also require consideration of potential amplification of earthquakes through soil-structure interaction, and soil liquefaction potential or other soil instability due to vibratory ground motion. Depending on the properties of soil and structures, the free-field earthquake acceleration input loads may be amplified at the top of the storage pad. These amplified acceleration input values must be bound by the design bases seismic acceleration values for the cask, specified in the Certificate of Compliance. Liquefaction of the soil and instability during a vibratory motion due to an earthquake event may affect the cask stability.

The proposed changes to § 72.212 would not actually impose new burden on the general licensees because they currently need to consider dynamic loads to meet the requirements in § 72.212(b)(2)(i)(A). Section 72.212(b)(2)(i)(A) requires that general licensees perform written evaluations to meet conditions set forth in the cask Certificate of Compliance (CoC). These CoCs require that dynamic loads, such as seismic and tornado loads, be evaluated to meet the cask design bases. Specific licensees are currently required, under § 72.122(b)(2), to design ISFSIs to withstand the effects of dynamic loads, such as earthquakes and tornados.

V. Related Regulatory Guide

The NRC is developing a new regulatory guide, a draft of which has been issued as developed DG-3021, "Site Evaluations and Determination of Design Earthquake Ground Motion for Seismic Design of Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations." This guide is being developed to provide license applicants with the necessary guidance for implementing the proposed regulation. DG-3021 is being developed to provide general guidance and recommendations, describes acceptable procedures and provides a list of references that present acceptable methodologies to identify and characterize capable tectonic sources and seismogenic sources. Section IV.B of this SUPPLEMENTARY INFORMATION describes the key elements.

Requests for single copies of draft or active regulatory guides (which may be reproduced) or for placement on an automatic distribution list for single copies of future draft guides in specific divisions should be made in writing to the U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Reproduction and Distribution Services Section, or by fax to (301)415-2289; email <DISTRIBUTION@NRC.GOV>. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike (first floor), Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or 1-(800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>.

In the future editorial changes to NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," and NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities," would be made. For example, the standard review plans would need to reference the proposed § 72.103 and the effective version of the draft guide, DG-3021.

VI. Discussion of Proposed Amendments by Section

This proposed rule would make the following changes to 10 CFR Part 72:

Section 72.9 Information collection requirements: OMB approval.

In Section 72.9, the list of sections where approved information collection requirements appear is amended to add Section 72.103.

Section 72.102 Geological and seismological characteristics. (current heading)

Section 72.102 Geological and seismological characteristics for applications before [insert Effective Date of the Rule] and applications for other than dry cask modes of storage. (proposed new heading)

The heading of § 72.102 is proposed to be revised because § 72.103 is added for ISFSI or MRS applications after the effective date of the rule. Section 72.103 would only apply to dry cask modes of storage. Therefore, the heading of § 72.102 is being modified to show the revised applicability of this section. The requirements of § 72.102 would continue to apply for an ISFSI or MRS using wet modes of storage or dry modes of storage that do not use casks.

The Commission does not intend for existing Part 72 licensees to re-evaluate the geological and seismological characteristics for siting and design using the revised criteria in the proposed changes to the regulations. These existing facilities are considered safe because the criteria used in their evaluation have been determined to be safe for NPP licensing, and the seismically induced risk of an ISFSI or MRS is significantly lower than that of a NPP. The proposed change leaves the current § 72.102 in place to preserve the licensing bases of present ISFSIs.

Section 72.103 Geological and seismological characteristics for applications for dry cask modes of storage on or after **[insert Effective Date of the Rule]**.

The trend towards dry cask storage has resulted in the need for applicants for new licenses to request exemptions from § 72.102(f)(1), which requires that for sites evaluated under the criteria of Appendix A to Part 100, the DE must be equivalent to the SSE for a NPP. By making § 72.102 applicable only to existing ISFSIs and by providing a new § 72.103, the proposed rule is intended to preclude the need for exemption requests from new license applicants.

The proposed requirements in § 72.103 parallel the requirements in § 72.102. However, new applicants for sites located in either the western U.S. or in the eastern U.S. in areas of known seismic activity, and not co-located with a NPP, for dry cask storage applications, on or after the effective date of this rule, would be required to address the uncertainties in seismic hazard analysis by using a PSHA or sensitivity analyses instead of using the deterministic methods of Appendix A to Part 100 without sensitivity analyses. Applicants located in either the western U.S. or in areas of known seismic activity in eastern U.S., and co-located with a NPP, have the option of using the proposed PSHA methodology or suitable sensitivity analyses for determining the DE, or using the existing design criteria for the NPP. This proposed change to require an understanding of the uncertainties in the determination of the DE would make the regulations compatible with 10 CFR 100.23 for NPPs and would allow the geological and seismological criteria for an ISFSI or MRS dry cask storage facilities to be risk-informed.

Proposed § 72.103(a)(1) would provide that sites located in eastern U.S. and not in areas of known seismic activity, would be acceptable if the results from onsite foundation and geological investigation, literature review, and regional geological reconnaissance show no unstable geological characteristics, soil stability problems, or potential for vibratory ground motion at the site in excess of an appropriate response spectrum anchored at 0.2 g. Section 72.103(a)(1) would parallel the requirements currently included in § 72.102(a)(1).

Proposed § 72.103(a)(2) would provide that applicants conducting evaluations in accordance with § 72.103(a)(1) may use a standardized DE described by an appropriate response spectrum anchored at 0.25 g. These requirements parallel the requirements currently included in § 72.102(a)(2). Section 72.102(a)(2) provides an alternative to determine a site-specific DE using the criteria and level of investigations required by Appendix A to Part 100. Proposed § 72.103(a)(2) would also provide, as an alternative, that a site-specific DE may be determined by using the criteria and level of investigations in proposed § 72.103(f). Section 72.103(f) is a new provision that would require certain new ISFSI or MRS license applicants to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, in determining the DE instead of the current deterministic approach in Appendix A to Part 100.

Proposed § 72.103(a)(2) would also provide that if an ISFSI or MRS is located at a NPP site, the existing geological and seismological design criteria for the NPP may be used instead of PSHA techniques or suitable sensitivity analysis because the risk due to a seismic event at an ISFSI or MRS is less than that of a NPP. If the existing design criteria for the NPP is used and the site has multiple NPPs, then the criteria for the most recent NPP must be used to ensure that the seismic design criteria used is based on the latest seismic hazard information at the site.

Proposed § 72.103(b) would provide that applicants for licenses for sites located in either the western U.S. or in the eastern U.S. in areas of known seismic activity, must investigate the geological, seismological, and engineering characteristics of the site using the

PSHA techniques or suitable sensitivity analysis of proposed § 72.103(f). If an ISFSI or MRS is located at a NPP site, the existing geological and seismological design criteria for the NPP may be used instead of PSHA techniques or suitable sensitivity analysis because the risk due to a seismic event at an ISFSI or MRS is less than that of a NPP. If the existing design criteria for the NPP is used and the site has multiple NPPs, then the criteria for the most recent NPP must be used to ensure that the seismic design criteria used is based on the latest seismic hazard information at the site.

Proposed § 72.103(c) is identical to § 72.102(c). Proposed § 72.103(c) would require that sites, other than bedrock sites, must be evaluated for the liquefaction potential or other soil instability due to vibratory ground motion. This is to ensure that ISFSI or MRS would be adequately supported on a stable foundation during a seismic event.

Proposed § 72.103(d) is identical to § 72.102(d). Proposed § 72.103(d) would require that site specific investigation and laboratory analysis must show that soil conditions are adequate for the proposed foundation loading. This is to ensure that ISFSI or MRS would be adequately supported on a stable foundation during a seismic event.

Proposed § 72.103(e) is identical to § 72.102(e). Proposed § 72.103(e) would require that in an evaluation of alternative sites, those which require a minimum of engineered provisions to correct site deficiencies are preferred, and that sites with unstable geologic characteristics should be avoided. This is to ensure that sites with minimum deficiencies are selected and that ISFSI or MRS would be adequately supported on a stable foundation during a seismic event.

Proposed § 72.103(f) would describe the steps required for seismic hazard analysis to determine the DE for use in the design of structures, systems, and components of an ISFSI or MRS. The proposed scope of site investigations to determine the geological, seismological, and engineering characteristics of a site and its environs is similar to § 100.23 requirements. Unlike § 72.102(f), which requires that for sites that have been evaluated under the criteria of Appendix A to Part 100 the DE must be equivalent to the SSE for a NPP, proposed § 72.103(f) requires evaluating uncertainty in seismic hazard analysis by using a PSHA or suitable sensitivity analyses, similar to 10 CFR 100.23 requirements for a NPP.

Proposed § 72.103(f)(1) would require that the geological, seismological, and engineering characteristics of a site and its environs must be investigated in sufficient scope and detail to permit an adequate evaluation of the proposed site and to determine the DE. These requirements track existing requirements in § 100.23(c).

Proposed §§ 72.103(f)(2)(i) through (iv) would specify criteria for determining the DE for the site, the potential for surface tectonic and nontectonic deformations, the design basis for seismically induced floods and water waves, and other design conditions. In particular, § 72.103(f)(2)(i) would provide that a license applicant must address uncertainties in seismic hazard analysis by using appropriate analyses, such as, a PSHA or suitable sensitivity analyses, for determining the DE. Sections 72.103(f)(2)(ii) through (iv) track the corresponding requirements in § 100.23(d).

Finally, the proposed § 72.103(f)(3) would provide that regardless of the results of the investigations anywhere in the continental U.S., the DE must have a value for the horizontal ground motion of no less than 0.10 g with the appropriate response spectrum. This provision would be identical to the requirement currently included in § 72.102(f)(2).

<u>Section 72.212 Conditions of general license issued under § 72.210.</u>

Section 72.212(b)(2)(i)(B) would be revised to require general licensees to address the dynamic loads of the stored casks in addition to the static loads. The requirements would be

changed because during a seismic event the cask experiences dynamic inertia loads in addition to the static loads, which are supported by the concrete pad. The dynamic loads depend on the interaction of the casks, the pad, and the foundation. Consideration of the dynamic loads, in addition to the static loads, of the stored casks would ensure that the pad would perform satisfactorily during a seismic event.

The proposed new paragraph would also require consideration of potential amplification of earthquakes through soil-structure interaction, and soil liquefaction potential or other soil instability due to vibratory ground motion. Depending on the properties of soil and structures, the free-field earthquake acceleration input loads may be amplified at the top of the storage pad. These amplified acceleration input values must be bound by the design bases seismic acceleration values for the cask, specified in the Certificate of Compliance. Liquefaction of the soil and instability during a vibratory motion due to an earthquake event may affect the cask stability, and thus must be addressed.

The proposed changes to § 72.212 are intended to require that general licensees perform appropriate load evaluations of cask storage pads and areas to ensure that casks are not placed in an unanalyzed condition. Similar requirements currently exist in § 72.102(c) for an ISFSI specific license and are proposed in § 72.103(c).

VII. Specific Question for Public Comment

The Commission welcomes comments on all aspects of this proposed rule and is especially interested in receiving comments on the following question:

Discussion:

The present mean annual probability of exceedance value for determining the DE for an ISFSI or MRS is approximately 1.0E-04 (i.e., in any one year, the probability is one in ten thousand, which is the reciprocal of 1.0E-04, that the DE established for the site will be exceeded). This value is based on nuclear plant requirements. The Commission is considering allowing for the use of a mean annual probability of exceedance value in the range of 5.0E-04 (i.e., in any one year, the probability is one in two thousand that the DE established for the site will be exceeded) to 1.0E-04 for ISFSI or MRS applications. Draft Regulatory Guide DG-3021, "Site Evaluations and Determination of Design Earthquake Ground Motion for Seismic Design of Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations," listed in Section V, has been developed to provide guidelines that are acceptable to the NRC staff for determining the DE for an ISFSI or MRS. Currently, DG-3021 recommends a mean annual probability of exceedance value of 5.0E-04 as an appropriate risk-informed value for the design of a dry cask storage ISFSI or MRS. However, the NRC staff is undertaking further analysis to support a specific value. An ISFSI or MRS license applicant would need to demonstrate that the use of a higher probability of exceedance value would not impose any undue radiological risk to public health and safety.

Question:

In view of this discussion and the discussion in Section IV.C., what is the appropriate mean annual probability of exceedance value to be used for the seismic design of an ISFSI or MRS and what is the justification for this probability?

VIII. Criminal Penalties

For the purpose of Section 223 of the Atomic Energy Act (AEA), the Commission is proposing to amend 10 CFR Part 72 under one or more of sections 161b, 161i, or 161o of the AEA. Willful violations of the rule would be subject to criminal enforcement.

IX. Agreement State Compatibility

Under the "Policy Statement on Adequacy and Compatibility of Agreement State Programs" approved by the Commission on June 30, 1997, and published in the Federal Register on September 3, 1997 (62 FR 46517), this rule is classified as Compatibility Category "NRC." Compatibility is not required for Category "NRC" regulations. The NRC program elements in this category are those that relate directly to areas of regulation reserved to the NRC by the AEA of 1954, as amended, or the provisions of Title 10 of the Code of Federal Regulations. Although an Agreement State may not adopt program elements reserved to NRC, it may wish to inform its licensees of certain requirements via a mechanism that is consistent with the particular State's administrative procedure laws, but does not confer regulatory authority on the State.

X. Plain Language

The Presidential Memorandum dated June 1, 1998, entitled "Plain Language in Government Writing" directed that the Government's writing be in plain language. The NRC requests comments on the proposed rule specifically with respect to the clarity and effectiveness of the language used. Comments should be sent to the address listed under the heading “ADDRESSES” above.

XI. Voluntary Consensus Standards

The National Technology Transfer Act of 1995 (Pub. L. 104-113) requires that Federal agencies use technical standards that are developed or adopted by voluntary consensus standards bodies unless the use of such a standard is inconsistent with applicable law or otherwise impractical. In this proposed rule, the NRC is presenting amendments to its regulations in 10 CFR Part 72 for the geological and seismological criteria of a dry cask independent spent fuel storage facility, to make them commensurate with the risk of the facility. This action does not constitute the establishment of a standard that establishes generally-applicable requirements.

XII. Finding of No Significant Environmental Impact: Availability

The Commission has determined under the National Environmental Policy Act of 1969, as amended, and the Commission’s regulations in Subpart A of 10 CFR Part 51, not to prepare an environmental impact statement for this proposed rule because the Commission has concluded, based on an Environmental Assessment, that this proposed rule, if adopted, would not be a major Federal action significantly affecting the quality of the human environment.

The Commission concluded that no significant environmental impact would result from this rulemaking. In comparison with a NPP, an operating ISFSI or MRS is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI or MRS does not have the variety and complexity of active systems necessary to support an operating NPP. Once the spent fuel is in place, an ISFSI or MRS is essentially a static operation and, during normal operations, the conditions required for the release and dispersal of significant quantities of radioactive materials are not present. There are no high temperatures or pressures present during normal operations or under design basis accident conditions to cause the release and dispersal of radioactive materials. This is primarily due to the low heat generation rate of spent fuel after it has decayed for more than one year before storage in an ISFSI or MRS and the low inventory of volatile radioactive materials readily available for release to the environs. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. The short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel stored at an ISFSI or MRS. Furthermore, even if the short-lived nuclides were present during an event of a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the seismically induced radiological risk associated with an ISFSI or MRS is less than the risk associated with a NPP.

The determination of this environmental assessment is that there will be no significant environmental impact due to the proposed changes because the same level of safety would be maintained by the new requirements, taking into account the lesser risk from an ISFSI or MRS. However, the general public should note that the NRC welcomes public participation. Comments on any aspect of the Environmental Assessment may be submitted to the NRC as indicated under the ADDRESSES heading.

The NRC has sent a copy of the Environmental Assessment and this proposed rule to every State Liaison Officer and requested their comments on the Environmental Assessment.

The Environmental Assessment may be examined at the NRC Public Document Room, O-1F21,11555 Rockville Pike, Rockville, MD. Single copies of the Environmental Assessment are available from Keith K. McDaniel, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001, telephone: (301) 415-5252, e-mail: kkm@nrc.gov.

XIII. Paperwork Reduction Act Statement

This proposed rule amends information collection requirements that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq). This proposed rule has been submitted to the Office of Management and Budget (OMB) for review and approval of the information collection requirements.

The burden to the public for these information collections is estimated to average 2,563 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the information collection. The U.S. Nuclear Regulatory Commission is seeking public comment on the potential impact of the information collections contained in the proposed rule and on the following issues:

1. Is the proposed information collection necessary for the proper performance of the functions of the NRC, including whether the information will have practical utility?
2. Is the estimate of burden accurate?
3. Is there a way to enhance the quality, utility, and clarity of the information to be collected?

4. How can the burden of the information collection be minimized, including the use of automated collection techniques?

Send comments on any aspect of these proposed information collections, including suggestions for reducing the burden, to the Records Management Branch (T-6 E6), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by Internet electronic mail at INFOCOLLECTS@NRC.GOV; and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0132), Office of Management and Budget, Washington, DC 20503. Comments to OMB on the information collections or on the above issues should be submitted by **(insert date 30 days after publication in the <u>Federal Register</u>).** Comments received after this date will be considered if it is practical to do so, but assurance of consideration cannot be given to comments received after this date.

Public Protection Notification

The NRC may not conduct or sponsor, and a person is not required to respond to a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

XIV. Regulatory Analysis

The Commission has prepared a draft Regulatory Analysis (RA) entitled: “Regulatory Analysis of Geological and Seismological Characteristics for Design of Dry Cask Independent

Spent Fuel Storage Installations." The RA examines the costs and benefits of the alternatives considered by the Commission.

The Commission requests public comment on the RA. Comments may be submitted to the NRC as indicated under the ADDRESSES heading. The RA is available on the NRC rulemaking website at http://ruleforum.llnl.gov, and is also available for inspection at the NRC Public Document Room located at One White Flint North, Room O-1F21, 11555 Rockville Pike, Rockville, MD. Single copies of the RA are available from Keith K. McDaniel, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001, telephone: (301) 415-5252, e-mail: kkm@nrc.gov.

XV. Regulatory Flexibility Certification

In accordance with the Regulatory Flexibility Act of 1980 (5 U.S.C. 605(b)), the Commission certifies that this proposed rule will not, if promulgated, have a significant economic impact on a substantial number of small entities. This proposed rule affects applicants for a Part 72 specific license, and general licensees on or after the effective date of the rule for an ISFSI or MRS. These companies do not generally fall within the scope of the definition of "small entities" set forth in the Regulatory Flexibility Act or the Small Business Size Standards set out in regulations issued by the Small Business Administration at 13 CFR Part 121.

XVI. Backfit Analysis

The Commission has determined that the backfit rule, § 72.62, does not apply to the changes in § 72.9, § 72.102, and § 72.103 because they do not involve any provisions that would impose backfits as defined in § 72.62(a).

Section 72.212(b)(2)(i)(B) currently requires evaluations of static loads of the stored casks for design of the cask storage pads and areas (foundation). The proposed revisions to this section would require general licensees also to address the dynamic loads of the stored casks. During a seismic event, the cask storage pads and areas experience dynamic loads in addition to static loads. The dynamic loads depend on the interaction of the casks, cask storage pads, and areas. Consideration of the dynamic loads of the stored casks, in addition to the static loads, for the design of the cask storage pads and areas, would ensure that the cask storage pads and areas would perform satisfactorily during a seismic event.

The proposed revision would also require consideration of potential amplification of earthquakes through soil-structure interaction, and soil liquefaction potential or other soil instability due to vibratory ground motion. Depending on the properties of soil and structures, the free-field earthquake acceleration input loads may be amplified at the top of the storage pad. These amplified acceleration input values must be bound by the design bases seismic acceleration values for the cask, specified in the Certificate of Compliance (CoC). The soil liquefaction and instability during a vibratory motion due to an earthquake event may affect the cask stability.

The proposed changes to § 72.212(b)(2)(i)(B) will impact procedures required to operate an ISFSI and; therefore, implicate the backfit rule. The proposed changes would require that general licensees perform appropriate analyses to assure that the cask seismic design bases bound the specific site seismic conditions, and that casks are not placed in an unanalyzed condition. Therefore, these proposed changes are necessary to assure adequate protection to occupational or public health and safety. Although the Commission is imposing this backfit because it is necessary to assure adequate protection to occupational or public health and safety, the proposed changes to § 72.212 would not actually impose new burden on the general licensees because they currently need to consider dynamic loads to meet the requirements in § 72.212(b)(2)(i)(A). Section 72.212(b)(2)(i)(A) requires that general licensees perform written evaluations to meet conditions set forth in the cask CoC. These CoCs require that dynamic loads, such as seismic and tornado loads, be evaluated to meet the cask design bases. Since the general licensees currently evaluate dynamic loads for evaluating the casks, pads and areas, the proposed changes to § 72.212(b)(2)(i)(B) would not actually require any general licensees presently operating an ISFSI to re-perform any written evaluations previously undertaken.

List of Subjects In 10 CFR Part 72

Administrative practice and procedure, Criminal penalties, Manpower training programs, Nuclear materials, Occupational safety and health, Penalties, Radiation protection, Reporting and recordkeeping requirements, Security measures, Spent fuel, Whistleblowing.

For the reasons set out in the preamble and under the authority of the Atomic Energy Act of 1954, as amended; the Energy Reorganization Act of 1974, as amended; and 5 U.S.C. 553; the NRC is proposing to adopt the following amendments to 10 CFR Part 72.

PART 72–LICENSING REQUIREMENTS FOR THE INDEPENDENT STORAGE OF SPENT NUCLEAR FUEL, HIGH-LEVEL RADIOACTIVE WASTE, AND REACTOR-RELATED GREATER THAN CLASS C WASTE

1. The authority citation for Part 72 continues to read as follows:

Authority: Secs. 51, 53, 57, 62, 63, 65, 69, 81, 161, 182, 183, 184, 186, 187, 189, 68 Stat. 929, 930, 932, 933, 934, 935, 948, 953, 954, 955, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2071, 2073, 2077, 2092, 2093, 2095, 2099, 2111, 2201, 2232, 2233, 2234, 2236, 2237, 2238, 2282); sec. 274, Pub. L. 86-373, 73 Stat. 688, as amended (42 U.S.C. 2021); sec. 201, as amended, 202, 206, 88 Stat. 1242, as amended, 1244, 1246 (42 U.S.C. 5841, 5842, 5846); Pub. L. 95-601, sec. 10, 92 Stat. 2951 as amended by Pub. L. 102-486, sec. 7902, 106 Stat. 3123 (42 U.S.C. 5851); sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332); secs. 131, 132, 133, 135, 137, 141, Pub. L. 97-425, 96 Stat. 2229, 2230, 2232, 2241, sec. 148, Pub. L. 100-203, 101 Stat. 1330-235 (42 U.S.C. 10151, 10152, 10153, 10155, 10157, 10161, 10168).

Section 72.44(g) also issued under secs. 142(b) and 148(c), (d), Pub. L. 100-203, 101 Stat. 1330-232, 1330-236 (42 U.S.C. 10162(b), 10168(c),(d)). Section 72.46 also issued under sec. 189, 68 Stat. 955 (42 U.S.C. 2239); sec. 134, Pub. L. 97-425, 96 Stat. 2230 (42 U.S.C. 10154). Section 72.96(d) also issued under sec. 145(g), Pub. L. 100-203, 101 Stat. 1330-235 (42 U.S.C. 10165(g)). Subpart J also issued under secs. 2(2), 2(15), 2(19), 117(a), 141(h), Pub. L. 97-425, 96 Stat. 2202, 2203, 2204, 2222, 2224, (42 U.S.C. 10101, 10137(a), 10161(h)). Subparts K and L are also issued under sec. 133, 98 Stat. 2230 (42 U.S.C. 10153) and sec. 218(a), 96 Stat. 2252 (42 U.S.C. 10198).

2. In § 72.9, paragraph (b) is revised to read as follows:

§ 72.9 Information collection requirements: OMB approval.

(b) The approved information collection requirements contained in this part appear in §§ 72.7, 72.11, 72.16, 72.22 through 72.34, 72.42, 72.44, 72.48 through 72.56, 72.62, 72.70, through 72.82, 72.90, 72.92, 72.94, 72.98, 72.100, 72.102, 72.103, 72.104, 72.108, 72.120, 72.126, 72.140 through 72.176, 72.180 through 72.186, 72.192, 72.206, 72.212, 72.216, 72.218, 72.230, 72.232, 72.234, 72.236, 72.240, 72.242, 72.244, 72.248.

3. The heading of § 72.102 is revised to read as follows:

§ 72.102 Geological and seismological characteristics for applications before **[insert Effective Date of the Rule]** and applications for other than dry cask modes of storage.

* * * * *

4. A new § 72.103 is added to read as follows:

§ 72.103 Geological and seismological characteristics for applications for dry cask modes of storage on or after **[insert Effective Date of the Rule]**.

(a)(1) East of the Rocky Mountain Front (east of approximately 104^{o} west longitude), except in areas of known seismic activity including but not limited to the regions around New Madrid, MO, Charleston, SC, Attica, NY will be acceptable if the results from onsite foundation and geological investigation, literature review, and regional geological reconnaissance show no unstable geological characteristics, soil stability problems, or potential for vibratory ground motion at the site in excess of an appropriate response spectrum anchored at 0.2 g.

(2) For those sites that have been evaluated under paragraph (a)(1) of this section that are east of the Rocky Mountain Front, and that are not in areas of known seismic activity, a standardized design earthquake ground motion (DE) described by an appropriate response spectrum anchored at 0.25 g may be used. Alternatively, a site-specific DE may be

determined by using the criteria and level of investigations required by paragraph (f) of this section. For a site with a co-located nuclear power plant (NPP), the existing geological and seismological design criteria for the NPP may be used. If the existing design criteria for the NPP is used and the site has multiple NPPs, then the criteria for the most recent NPP must be used.

(b) West of the Rocky Mountain Front (west of approximately 104^{o} west longitude), and in other areas of known potential seismic activity east of the Rocky Mountain Front, seismicity must be evaluated by the techniques presented in paragraph (f) of this section. Sites that lie within the range of strong near-field ground motion from historical earthquakes on large capable faults should be avoided. If an ISFSI or MRS is located on a NPP site, the existing geological and seismological design criteria for the NPP may be used. If the existing design criteria for the NPP is used and the site has multiple NPPs, then the criteria for the most recent NPP must be used.

(c) Sites other than bedrock sites must be evaluated for their liquefaction potential or other soil instability due to vibratory ground motion.

(d) Site-specific investigations and laboratory analyses must show that soil conditions are adequate for the proposed foundation loading.

(e) In an evaluation of alternative sites, those which require a minimum of engineered provisions to correct site deficiencies are preferred. Sites with unstable geologic characteristics should be avoided.

(f) The DE for use in the design of structures, systems, and components must be determined as follows:

(1) *Geological, seismological, and engineering characteristics.* The geological, seismological, and engineering characteristics of a site and its environs must be investigated

in sufficient scope and detail to permit an adequate evaluation of the proposed site, to provide sufficient information to support evaluations performed to arrive at estimates of the DE, and to permit adequate engineering solutions to actual or potential geologic and seismic effects at the proposed site. The size of the region to be investigated and the type of data pertinent to the investigations must be determined based on the nature of the region surrounding the proposed site. Data on the vibratory ground motion, tectonic surface deformation, nontectonic deformation, earthquake recurrence rates, fault geometry and slip rates, site foundation material, and seismically induced floods and water waves must be obtained by reviewing pertinent literature and carrying out field investigations. However, each applicant shall investigate all geologic and seismic factors (for example, volcanic activity) that may affect the design and operation of the proposed ISFSI or MRS facility irrespective of whether these factors are explicitly included in this section.

(2) *Geologic and seismic siting factors.* The geologic and seismic siting factors considered for design must include a determination of the DE for the site, the potential for surface tectonic and nontectonic deformations, the design bases for seismically induced floods and water waves, and other design conditions as stated in paragraph (f)(2)(iv) of this section.

(i) *Determination of the Design Earthquake Ground Motion (DE).* The DE for the site is characterized by both horizontal and vertical free-field ground motion response spectra at the free ground surface. In view of the limited data available on vibratory ground motions for strong earthquakes, it usually will be appropriate that the design response spectra be smoothed spectra. The DE for the site is determined considering the results of the investigations required by paragraph (f)(1) of this section. Uncertainties are inherent in these estimates and must be addressed through an appropriate analysis, such as a probabilistic seismic hazard analysis (PSHA) or suitable sensitivity analyses.

(ii) *Determination of the potential for surface tectonic and nontectonic deformations.* Sufficient geological, seismological, and geophysical data must be provided to clearly establish if there is a potential for surface deformation.

(iii) *Determination of design bases for seismically induced floods and water waves.* The size of seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined.

(iv) *Determination of siting factors for other design conditions.* Siting factors for other design conditions that must be evaluated include soil and rock stability, liquefaction potential, and natural and artificial slope stability. Each applicant shall evaluate all siting factors and potential causes of failure, such as, the physical properties of the materials underlying the site, ground disruption, and the effects of vibratory ground motion that may affect the design and operation of the proposed ISFSI or MRS.

(3) Regardless of the results of the investigations anywhere in the continental U.S., the DE must have a value for the horizontal ground motion of no less than 0.10 g with the appropriate response spectrum.

5. In § 72.212, paragraph (b)(2)(i)(B) is revised to read as follows:

§ 72.212 Conditions of general license issued under § 72.210.

* * * * *

(b) * * *

(2) * * *

(i) * * *

(B) cask storage pads and areas have been designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes through soil-structure interaction, and soil liquefaction potential or other soil instability due to vibratory ground motion; and

*   *   *   *   *

Dated at Rockville, Maryland, this _________day of _____________, 2002.

For the Nuclear Regulatory Commission.

____
Annette L. Vietti-Cook,
Secretary for the Commission.

Regulatory Analysis of Geological and Seismological Characteristics for Siting and Design of Dry Cask Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations

Draft Report

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards

February 2002

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Executive Summary

The Nuclear Regulatory Commission (NRC) is proposing to amend its siting and design requirements in 10 CFR Part 72 for dry cask modes of storage of (1) spent nuclear fuel in an independent spent fuel storage installation (ISFSI) and (2) spent nuclear fuel and solid high-level radioactive waste in a monitored retrievable storage installation (MRS). For this document, the term "ISFSI" is used to include both dry cask ISFSI and MRS facilities, as appropriate. The Commission does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because the risk associated with potential accident scenarios for wet modes of storage is greater than the risk for dry cask modes of storage. This is because wet modes of storage require active systems, such as systems to remove heat and maintain adequate water levels. These active systems have a higher probability of failure than the passive systems used in dry cask modes of storage, thus resulting in a greater seismic risk for wet modes of storage. The Commission also does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to dry modes of storage that do not use casks because of the lack of experience gained in licensing these facilities.

The Commission considered a number of options to change the siting and design requirements in Part 72. This draft Regulatory Analysis (RA) is part of the Commission's analysis of the options being considered and is a supporting document for the *Federal Register* Notice containing the proposed rule.

The rulemaking proposes the following changes:

1. Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a probabilistic seismic hazard analysis (PSHA) or other suitable sensitivity analyses, for determining the design earthquake ground motion (DE). All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

2. Allow new ISFSI applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI (§ 72.103). A draft regulatory guide accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

3. Require general licensees to evaluate that the designs of cask storage pads and areas adequately account for dynamic loads, in addition to static loads (§ 72.212).

The proposed changes are consistent with the Commission's strategic goals in that

- The rulemaking effort would increase NRC's effectiveness and efficiency by reducing the number of exemption requests that would need to be submitted by the applicants and reviewed by NRC.

- This rule would maintain safety by selecting the DE level to be commensurate with the risk associated with an ISFSI.

- The changes to the DE level are considered risk-informed, consistent with NRC policy to develop risk-informed regulations.

- This rule would increase realism by enabling ISFSI applicants to use the state-of-the-art approach (PSHA or suitable sensitivity analyses) to more accurately characterize the seismicity of a site as opposed to the current deterministic approach which does not account for uncertainties in seismic data and interpretations.

The Commission considered four options for this rulemaking:

Option 1.

No Action. The siting requirements for new dry cask ISFSIs would continue to conform to the existing requirements of §§ 72.102.

Option 1 would maintain the current siting requirements for new dry cask ISFSI specific license applicants. Thus, relative to existing requirements, no values or impacts would result from Option 1, but the benefits (values) to be derived from the other options would remain unrealized.

Option 2.

Require new Part 72 specific license applicants to conform to the geologic and seismic siting criteria in § 100.23 (PSHA or suitable sensitivity analyses) in lieu of the criteria in Appendix A to Part 100 (deterministic approach).

Under this option, the cost for complying with Part 72 requirements would increase by approximately $100,000 per applicant to conduct a PSHA or suitable sensitivity analyses instead of using the current deterministic approach. Assuming one applicant per year the annual cost is $100,000. NRC would incur costs associated with development of guidance and revisions to existing documents, such as the Standard Review Plan and related materials, estimated at approximately $24,640 as a one time cost. NRC would also incur costs associated with the review of the PSHA, estimated to be $12,320 annually. However, value would be provided by adoption of this option because Part 72 requirements would be more compatible with similar requirements for NPPs, thus improving regulatory efficiency. Further, this option may provide improvements in knowledge, which could result in improvements in regulatory and policy requirements.

Option 3.

Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100, and also give them the option to use a graded approach (design of structures, systems, and components to different levels based on their importance to safety) to seismic design of the ISFSI.

Option 3 would require new specific license applicants to comply with § 100.23 (use a PSHA or suitable sensitivity analyses), as well as provide the option for using a graded approach to seismic design for SSCs. The requirement to comply with § 100.23 is the same as described in section 3.3.2 of this analysis for Option 2. Therefore, the estimate of values and impacts to specific licensees and NRC is the same as described under Option 2, which would result in additional costs to specific license applicants of $100,000 per year. In some cases, ISFSI specific license applicants have sought exemptions from the design requirements contained in § 72.102, considering site characteristics and other factors. This option would reduce or eliminate the need for these exemption requests by reducing the DE level for certain SSCs. Assuming that one new specific license applicant would have submitted an exemption request each year, the estimated savings would be $150,000 per year under Option 3. Further, under Option 3, reducing the DE for certain SSCs would result in savings by reducing analytical costs and certain capital costs. NRC would realize cost savings associated with reviewing the exemption request, estimated to be the total cost for NRC staff to review a single exemption request is estimated to be approximately $18,480 per year under Option 3.

The overall effect of Option 3 would be a cost savings to new specific license applicants. The amount of these savings, however, is highly site-specific, depending on site characteristics, and the specified DE level.

Option 4.

(1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but allow for the use of a lower DE that is commensurate with the lower level of risk associated with the potential accident scenarios for ISFSIs. The draft regulatory guide, DG-3021 "Site Evaluations and Determination of Design Earthquake Ground Motion for Seismic Design of Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations," accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04 for ISFSI applications. This recommended level is lower than the present level of approximately 1.0E-04 (equivalent to the safe shutdown earthquake (SSE) for a NPP).

The values and impacts associated with Option 4 are similar to those for Option 3. The advantage of Option 4 over Option 3 is simply that under Option 4, no SSCs would be required to be designed to withstand a DE with a mean annual probability of exceedance of 1.0E-04 (equivalent to the SSE of a NPP), resulting in lower analytical and certain capital costs.

The overall effect of Option 4 would be a cost savings to new specific license applicants. The amount of these savings, however, is highly site-specific, depending on site characteristics, and the specified DE level.

Options Summary

Under Options 2 through 4, public and occupational health would be improved because the seismic hazard would be better characterized by using state-of-the-art methods to address uncertainties in seismic data and interpretations.

Option 4 was determined to be the most preferable based on professional judgment and limited quantitative analysis because it (1) improves effectiveness and efficiency of the NRC regulatory process by eliminating the need for applicants to request exemptions from §§ 72.102(a), 72.102(b), and 72.102(f)(1), and the need for NRC to review the exemption requests; (2) reduces unnecessary regulatory burden for the applicant or specific licensee by potentially reducing the required DE level to account for the lower risk associated with ISFSI facilities; (3) would not result in significant overall additional implementation or operation costs to NRC and applicants, and (4) supports the implementation of the NRC's risk-informed approach to regulation.

Additional Change

The Commission is also proposing a change to § 72.212(b)(2)(i)(B) to require that general licensees evaluate dynamic loads (in addition to static loads) in the design of cask storage pads and areas. This proposed change is an additional modification, separate from the changes proposed in the options above.

NRC would change § 72.212(b)(2)(i)(B) to require written evaluations, prior to use, establishing that cask storage pads and areas have been evaluated for the static and dynamic loads of the stored casks. There are no additional costs associated with evaluating cask pads and areas for dynamic loads because general licensees are already required to consider dynamic loads to meet the cask design basis of the Certificate of Compliance (CoC) under § 72.212(b)(i)(A).

1.0 Introduction

The NRC is proposing to amend its siting and design requirements in 10 CFR Part 72 for dry cask modes of storage of (1) spent nuclear fuel in an ISFSI and (2) spent nuclear fuel in solid high-level radioactive waste in a MRS. For this document, the term "ISFSI" is used to include both ISFSI and MRS facilities, as appropriate. The Commission does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because the risk associated with potential accident scenarios for wet modes of storage is greater than the risk for dry cask modes of storage. This is because wet modes of storage require active systems, such as systems to remove heat and maintain adequate water levels. These active systems have a higher probability of failure than the passive systems used in dry cask modes of storage, thus resulting in a greater seismic risk for wet modes of storage. The Commission also does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to dry modes of storage that do not use casks because of the lack of experience gained in licensing these facilities.

The Commission considered four options to change the siting and design requirements in Part 72. This draft RA is part of the Commission's analysis of the options considered and is a supporting document for the *Federal Register* Notice containing the proposed rule. The purpose of this draft RA is to evaluate the costs and benefits associated with the regulatory changes being considered by the Commission. The NRC considers the regulatory analysis process an integral part of its statutory mission to ensure reasonable assurance for the protection of public health and safety, property, environmental quality, and national defense and security from civilian uses of nuclear materials. This document presents background material, describes the objectives of the proposed rule, outlines the alternatives being considered, and evaluates the values and impacts of the proposed action and alternatives.

1.1 Background

In 1980, the Commission added 10 CFR Part 72 to its regulations to establish licensing requirements for the storage of spent fuel in an ISFSI (45 FR 74693, November 12, 1980). Subpart E of Part 72 contains siting evaluation factors that must be investigated and assessed with respect to the siting of an ISFSI, including a requirement for evaluation of geological and seismological characteristics. The original regulations envisioned these facilities as spent fuel pools or single, massive dry storage structures. The regulations required seismic evaluations equivalent to those for a NPP when the ISFSI is located in the western U.S. (approximately 104^0 west longitude) or in areas of known seismic activity in the central and eastern U.S. A seismic design requirement, equivalent to the requirements for a NPP (Appendix A to 10 CFR Part 100) seemed appropriate for these types of facilities, given the potential accident scenarios. For those sites located in the central and eastern U.S., and not in areas of known seismic activity, the regulations allowed for less stringent alternatives.

For other types of ISFSI designs, the regulation required a site-specific investigation to establish site suitability commensurate with the specific requirements of the proposed ISFSI. The Commission explained that for ISFSIs which do not involve massive structures, such as dry storage casks and canisters, the required DE will be determined on a case-by-case basis until more experience is gained with the licensing of these types of units. (45 FR 74697)

For sites located in either the western U.S. or in the eastern U.S. in areas of known seismic activity, the regulations in Part 72 require the use of the procedures in Appendix A to Part 100 for determining the design basis vibratory ground motion at a site. Appendix A requires the use of "deterministic" approaches in the development of a single set of earthquake sources. The applicant develops for each source a postulated earthquake to be used to determine the ground motion that can affect the site, locates the postulated earthquake according to prescribed rules, and then calculates ground motions at the site. Because the deterministic approach does not explicitly recognize uncertainties in geoscience parameters, PSHA methods were developed that allow explicit expressions for the uncertainty in ground motion estimates and provide a means for assessing sensitivity to various parameters.

Advances in the sciences of seismology and geology, along with the occurrence of some licensing issues not foreseen in the development of Appendix A to Part 100, have caused a number of difficulties in the application of this regulation to dry cask ISFSIs. Specific problematic areas include the following:

- The limitations in data and geologic and seismic analyses and the rapid accumulation of knowledge in the geosciences have required considerable latitude in judgment. The inclusion of detailed geoscience assessments in Appendix A has caused difficulties for applicants and the Commission by inhibiting the use of needed judgment and flexibility in applying basic principles to new situations. Requiring the use of Appendix A has also inhibited the use of evolving methods of analyses (for instance, probabilistic) in the licensing process.

- Various sections of Appendix A are subject to different interpretations. For ISFSI applications, some sections in the Appendix do not provide sufficient information for implementation. As a result, the Appendix has been the source of licensing delays and debate.

In 1996, the Commission amended 10 CFR Parts 50 and 100 to update the criteria used in decisions regarding NPP siting, including geologic and seismic engineering considerations for future NPPs (61 FR 65157, December 11, 1996). The amendments placed a new § 100.23 in the regulations requiring that the uncertainties in seismic hazard analysis in determining the SSE be addressed through appropriate analyses, such as a PSHA or suitable sensitivity analyses in lieu of Appendix A. This approach takes into account the shortcomings in the earlier siting requirements and is based on developments in the field over the past two decades. Further, regulatory guides have been used to address implementation issues. For example, the Commission provided guidance for nuclear power plant license applicants in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," and Standard Review Plan-NUREG 0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Reactors." However, the Commission left Appendix A to Part 100 in place to preserve the licensing basis for existing plants and confined the applicability of § 100.23 to new NPPs.

With over 10 years of experience licensing dry cask storage the Commission is now proposing a conforming change to 10 CFR Part 72 to require some sites to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. This approach parallels the change made to 10 CFR Part 100.

In comparison with a NPP, an operating ISFSI facility is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI facility does not have the variety and complexity of active systems necessary to support an operating NPP. Further, the robust cask design required for non-seismic considerations (e.g., drop event, shielding), assure low probabilities of failure from seismic events.

In the unlikely occurrence of a radiological release as a result of a seismic event, the radiological consequences to workers and the public are significantly lower in comparison to a NPP. This is because the conditions required for release and dispersal of significant quantities of radioactive material, such as high temperatures or pressures, are not present in an ISFSI. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI, and to the low inventory of volatile radioactive materials readily available for release to the environment. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI is less than the risk associated with a NPP and the use of a lower DE is appropriate.

1.2 Objectives of the Proposed Rulemaking

Part 72 currently requires siting and design of ISFSI facilities in accordance with requirements that were established for the licensing of NPPs. The proposed changes to Part 72 are intended to (1) provide benefit from the experience gained in applying the existing regulation and from research, and (2) provide needed regulatory flexibility to incorporate state-of-the-art improvements in the geosciences and earthquake engineering.

The objectives of this proposed rule are to:

1. Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation (§ 72.103).

2. Allow ISFSI applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI (§ 72.103).

3. Require general licensees to ensure that the designs of cask storage pads and areas adequately account for dynamic loads, in addition to static loads (§ 72.212).

2.0 Identification and Preliminary Analysis of Alternative Approaches

NRC is considering three changes to its seismological and geological siting and design regulations for ISFSI applications.

(1) The first change considers the plausibility of requiring new applicants for sites located in either the western U.S. or in the eastern U.S. in areas of known seismic activity, and not co-located with a NPP, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation (§ 72.103).

The existing approach for determining a DE for an ISFSI, embodied in Appendix A to Part 100, relies on a "deterministic" approach. Using this deterministic approach, an applicant develops a single set of earthquake sources, develops for each source a postulated earthquake to be used as the source of ground motion that can affect the site, locates the postulated earthquake according to prescribed rules, and then calculates ground motions at the site.

Although this approach has worked reasonably well for the past several decades, in the sense that safe shutdown earthquake ground motions for NPPs sited with this approach are judged to be suitably conservative, the approach has not explicitly recognized uncertainties in geosciences parameters. Because so little is known about earthquake phenomena (especially in the eastern U.S.), there have often been differences of opinion and differing interpretations among experts as to the largest earthquakes to be considered and ground-motion models to be used.

Probabilistic methods that have been developed in the past 15 to 20 years for evaluation of seismic safety of nuclear facilities allow explicit incorporation of different models for zonation, earthquake size, ground motion, and other parameters. The advantage of using these probabilistic methods is their ability to incorporate different models and data sets, thereby providing an explicit expression for the uncertainty in the ground motion estimates and a means of assessing sensitivity to various input parameters. The western and eastern U.S. have fundamentally different tectonic environments and histories of tectonic deformation. Consequently, application of these probabilistic methodologies has revealed the need to vary the fundamental PSHA methodology depending on the tectonic environment of the site.

In 1996, when the Commission accepted the use of a PSHA methodology or suitable sensitivity analyses in §100.23, it recognized that the uncertainties in seismological and geological information must be formally evaluated and appropriately accommodated in the determination of the SSE for seismic design of NPPs. The Commission further recognized that the nature of uncertainty and the appropriate approach to account for it depends on the tectonic environment of the site and on properly characterizing parameters input to the PSHA or suitable sensitivity analyses. Consequently, methods other than probabilistic methods such as sensitivity analyses may be adequate for some sites to account for uncertainties. The Commission believes that certain new applicants for ISFSI specific licenses, as described in section 3.2, must also account for these uncertainties instead of using the Appendix A to Part 100.
NRC staff will review the application using all available data including insights and information from previous licensing experience. Thus, the proposed approach requires thorough regional

and site-specific geoscience investigations. Results of the regional and site-specific investigations must be considered in application of the probabilistic method. Two current probabilistic methods are the NRC- sponsored study conducted by Lawrence Livermore National Laboratory and the Electric Power Research Institute's seismic hazard study. These are regional studies without detailed information on any specific location. The regional and site-specific investigations provide detailed information to update the database of the hazard methodology to make the probabilistic analysis site-specific.

Applicants also must incorporate local site geological factors such as stratigraphy and topography and account for site-specific geotechnical properties in establishing the DE. In order to incorporate local site factors and advances in ground motion attenuation models, ground motion estimates are determined using the procedures outlined in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Reactors", Section 2.5.2, "Vibratory Ground Motion."

(2) The second change would allow applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI.

The present DE for ISFSIs is based on the requirements contained in 10 CFR Part 100 for NPPs. In the Statement of Consideration accompanying the initial Part 72 rulemaking, the Commission recognized that the design peak horizontal acceleration for SSCs need not be as high as for a nuclear power reactor, and should be determined on a "case-by-case" basis until more experience is gained with licensing of these types of units (45 FR 74697). With over 10 years of experience licensing dry cask storage, and analyses demonstrating robust behavior of dry cask storage systems (DCSSs) in accident scenarios, the Commission now has a reasonable basis to consider lower and more appropriate DE parameters for dry cask ISFSIs.

The present ISFSI DE (equivalent to the SSE for a NPP) has a mean annual probability of exceedance of approximately 1.0E-04 (i.e., in any one year, the probability is one in ten thousand that the DE established for the site will be exceeded). In comparison with a NPP, an operating ISFSI facility is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI facility does not have the variety and complexity of active systems necessary to support an operating NPP. Further, the robust cask design required for non-seismic considerations (e.g., drop event, shielding), assure low probabilities of failure from seismic events.

In the unlikely occurrence of a radiological release as a result of a seismic event, the radiological consequences to workers and the public are significantly lower in comparison to a NPP. This is because the conditions required for release and dispersal of significant quantities of radioactive material, such as high temperatures or pressures, are not present in an ISFSI. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI, and to the low inventory of volatile radioactive materials readily available for release to the environment. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI is less than the risk associated with a NPP and the use of a lower DE is appropriate.

Additional rationale supporting the Commission's proposal to reduce the DE is provided below.

- The critical element for protection against radiation release is the sealed cask containing the spent fuel assemblies. The standards in Part 72 Subparts E - Siting Evaluation Factors and F - General Design Criteria, ensure that the dry storage cask designs are very rugged and robust. The casks must maintain structural integrity during a variety of postulated non-seismic events, including cask drops, tip-over, and wind driven missile impacts. These non-seismic events challenge the cask integrity significantly more than seismic events. Therefore, the casks are expected to have substantial design margins to withstand forces from a seismic event greater than the DE.

- During a seismic event at an ISFSI or MRS, a cask may slide if lateral seismic forces are greater than the frictional resistance between the cask and the concrete pad. The sliding and resulting displacements are computed by the applicant to demonstrate that the casks, which are spaced to satisfy the thermal criteria in Part 72 Subpart F, are precluded from impacting other adjacent casks. Furthermore, the NRC staff guidance in reviewing cask designs is to show that public health and safety is maintained during a postulated DE. This can be demonstrated by showing that either casks are designed to prevent sliding or tip over during a seismic event, or the consequences of the calculated cask movements are acceptable. Even if the casks slide or tip over and then impact other casks or the pad during a seismic event significantly greater than the proposed DE, there are adequate design margins to ensure that the casks maintain their structural integrity.

- Because the DE is a smooth broad-band spectrum, which envelops the controlling earthquake responses, the vibratory ground motion specified is conservative.

- The combined probability of the occurrence of a seismic event and operational failure that leads to a radiological release is much smaller than the individual probabilities of either of these events. This is because the handling building and crane are used for only a fraction of the licensed period of an ISFSI or MRS and for only a few casks at a time. Additionally, away from reactor ISFSIs are expected to handle only sealed casks and not individual fuel assemblies. Therefore, the risk of a potential release of radioactivity due to failure of the cask handling building and/or crane during a seismic event is small.

- The crane used for lifting the casks in the building is designed using the same industry codes as for a nuclear power plant (ACI 349, AISC N690, ANSI N14.6, and NUREG-0612), and has a safety factor of five (5) or greater for lifted loads using the ultimate strength of the materials. Therefore, the crane would perform satisfactorily for an earthquake much larger than the DE.

- The determination of a DE for an ISFSI or MRS is consistent with the design approach used in DOE Standard DOE-STD-1020, “Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities,” for similar type facilities.

(3) The third change would require that the design of cask storage pads and areas at ISFSIs adequately account for dynamic loads in addition to static loads.

The Commission is proposing a change to § 72.212(b)(2)(i)(B) to require general licensees to evaluate both static and dynamic loads for new ISFSIs after the effective date of the rule to ensure that casks are not placed in an unanalyzed condition. The change would state that the design of cask storage pads and areas must adequately account for dynamic loads (in addition to static loads). For example, dynamic effects can cause soil-structure interactions that could amplify ground motion to the point that the acceleration on the casks is greater than the DE acceleration, or soil liquefaction could cause unacceptable pad and foundation settlement. Evaluating dynamic loads of cask pads and areas would ensure that the pad continues to support the casks during seismic events.

The specific options under consideration are:

Option 1. No Action. The siting requirements for new dry casks ISFSIs would continue to conform to the existing requirements of § 72.102.

Option 2. Require new Part 72 specific license applicants, for sites located in either the western U.S., or in the eastern U.S. in areas of known seismic activity, to comply with the requirements of § 100.23 in lieu of § 72.102(f) which requires the use of Appendix A to Part 100. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use § 100.23 to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation Appendix A to Part 100.

Option 3. Require new Part 72 specific license applicants, for sites located in either the western U.S., or in the eastern U.S. in areas of known seismic activity, to comply with the requirements of § 100.23 in lieu of § 72.102(f) which requires the use of Appendix A to Part 100. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use § 100.23 to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation Appendix A to Part 100. This option further requires the use of a graded approach to seismic design of the ISFSI SSCs.

Option 4. (1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation (§ 72.103).

(2) Maintain the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the lower level of risk associated with the potential accident scenarios for ISFSIs. Draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

Additional Proposed Change. The Commission is also proposing a change to § 72.212(b)(2)(i)(B) that would require general licensees to evaluate both static and dynamic loads for new ISFSIs. This proposed change is an additional modification, separate from the changes proposed in the options above.

2.1 Comparison of Proposed Options

This section compares the requirements of the proposed options. These options differ with regard to seismological and geological siting criteria and estimation of the DE for ISFSIs, and whether single-level DEs will be used in evaluating the design of ISFSI SSCs. As noted above, requirements for consideration of dynamic loads in the design of cask storage pads and areas may be promulgated along with any option. A summary of the requirements of the proposed options is provided in Table 2-1.

Table 2-1. Comparison of Requirements Under Proposed Options

Option	Seismic Siting Criteria, DE Definition	DE for Systems, Structures, and Components (SSCs)
1. (No Action)	Current § 72.102. Sites in the western U.S. do seismic analysis as required by Appendix A to Part 100. In the eastern U.S., use Appendix A analysis or DE with response spectrum anchored at 0.25g ground motion. If Appendix A is used at any site, DE is defined as the SSE for a NPP.	Current § 72.102.
2	Applicant must conform to § 100.23, requiring PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100, or other options compatible with the existing regulation.	Current § 72.102.
3	Applicant must conform to § 100.23, requiring PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100, or other options compatible with the existing regulation.	Require applicants to use graded approach to seismic design of SSCs. Similar to Parts 60 and 63; Category 1 event annual probability = 1.0E-03, Category 2 event annual probability = 1.0E-04.
4	Applicant must comply with new § 72.103 requiring use of PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100, or other options compatible with the existing regulation.	Single level DE for SSCs or other options compatible with the existing regulation.

2.2 Option 1: No-Action Alternative

Under Option 1, new specific license applicants for dry cask ISFSIs would continue to meet the existing requirements of § 72.102. As noted in section 1, currently, ISFSI applicants at sites in the western U.S. or in areas of known seismic activity in the eastern U.S. must currently perform deterministic site seismic evaluations as prescribed in Appendix A to Part 100. ISFSIs located in the eastern U.S. and not in areas of known seismic activity may use a standardized DE (peak ground acceleration of 0.25g) if justified by sufficient geological investigations and literature review. For any application in which the methods in Appendix A are used, the DE for the ISFSI must be no less than the SSE for a NPP. Under the No-Action alternative the current requirement for static analysis of cask storage pads would also be retained. This approach does not consider uncertainties in the seismic hazard assessment, is not risk-informed, and may not be cost effective.

2.3 Option 2: Require New Part 72 Specific License Applicants to Conform to § 100.23 in Lieu of Appendix A to Part 100

This option would require specific license applicants located in either the western U.S., or in the eastern U.S. in areas of known seismic activity, to comply with the requirements of § 100.23 in lieu of § 72.102(f) which requires the use of Appendix A to Part 100. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use § 100.23 to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation. This would bring the seismic site evaluation requirements for ISFSIs into conformance with the updated requirements for NPPs. By accepting the use of a PSHA methodology or suitable sensitivity analyses in § 100.23, the Commission has recognized that the uncertainties in seismological and geological information must be formally evaluated and appropriately accommodated in the determination of the SSE for seismic design of NPPs. The Commission, in promulgating § 100.23 further recognized that the nature of uncertainty and the appropriate approach to account for it depends on the tectonic environment of the site and on properly characterizing parameters input to the PSHA or suitable sensitivity analyses such as seismic sources, the recurrence of earthquakes within a seismic source, the maximum magnitude of earthquakes within a seismic source, and engineering estimation of earthquake ground motion.

The Commission notes that while strict adherence to the requirements in Appendix A for determining the DE for the ISFSI (equivalent to a NPP SSE) will be removed, those applicants for ISFSIs, co-located with existing nuclear power plant sites, would be allowed to use all of the geophysical investigation information obtained from the original licensing process (which used the Appendix A requirements), in verifying that all applicable seismic data are considered in determining the design basis. The benefit of this option is that it would be a conforming change to Part 100 for evaluating geological and seismological criteria. It should be noted that under this option, the extent of site investigations and characterization remains the same as required in Part 100. Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," was developed to provide general guidance on procedures acceptable to the staff for satisfying the requirements of § 100.23 for NPPs. This guidance would be considered acceptable for ISFSIs.

This option retains the § 72.102(f)(1) requirement that the DE for ISFSIs be equivalent to the SSE for a NPP. Thus, while improving the technical requirements for site seismic analysis, this option is still not risk-informed, in that the same DEs are defined for the much less hazardous ISFSIs as for NPPs. Finally, this option requires evaluation of dynamic, as well as static, loads of cask storage pads and areas.

2.4 Option 3:

(1) Require New Part 72 Specific License Applicants to Conform to § 100.23 in lieu of Appendix A to Part 100

(2) Provide new Part 72 applicants the option to use a graded approach to seismic design for ISFSI SSCs.

This option is the same as Option 2, except that it would also require applicants to use a graded approach to developing seismic design criteria for SSCs. The specific approach proposed for dry cask ISFSIs would be comparable to the Parts 60 and 63 graded approach to design ground motion for SSCs of pre-closure facilities (§ 60.2). In general, a graded approach to design requires those SSCs whose failure would result in greater accident consequences to use higher design requirements for phenomena such as earthquakes and tornadoes (Category

2 event). Similarly, those SSCs whose failure would result in lesser consequences due to normal operations would be designed to less stringent requirements (Category 1 event). For seismic design considerations of the Yucca Mountain site, the Commission has accepted the approach described in DOE Topical Report YMP/TR-003-NP, Rev. 2, Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain, pertaining to Part 63. In this approach Category 1 design basis ground motion refers to a mean annual probability of exceedance of 1.0E-03. Category 2 design basis ground motion refers to a mean annual probability of exceedance of 1.0E-04.

Individual SSCs that are required to maintain the annual dose within the regulatory limits of 10 CFR Part 20 would be designed to a Category 1 design earthquake. Other SSCs needed to be functional to prevent the dose limit of 5 rem from being exceeded at the controlled area boundary due to a seismic event, would be designed to a Category 2 design earthquake. Thus, the seismic design of the SSCs would be commensurate with their importance to safety.
By requiring uncertainties in seismic hazard analysis to be addressed using a PSHA or suitable sensitivity analyses in determining the DE for ISFSIs, and the use of a graded approach to defining seismic criteria for SSCs, Option 3 sets siting and design criteria that are much more risk-informed than Options 1 and 2, and are more flexible than the proposed requirements in Option 2. Although considered suitable for a high-level waste repository at the Yucca Mountain site, this option, would be more complex to implement than Option 2 and, as discussed in Section 4, would not achieve a meaningful risk reduction for ISFSIs compared to the approach defined in Option 4. Finally, like Option 2, this option also requires evaluation of dynamic, as well as static, loads of cask storage pads and areas.

2.5 Option 4:

(1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the level of risk associated with an ISFSI. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

Option 4 would require that:

(1) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a NPP, would be required to address uncertainties in the seismic hazard analysis by using

appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE.;

(2) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in either the western U.S. or in areas of known seismic activity in eastern U.S., and co-located with a NPP, would have the option of using a PSHA methodology or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis in determining the DE, or using the existing design criteria for the NPP. When the existing design criteria for the NPP are used for an ISFSI at a site with multiple NPPs, the criteria for the most recent NPP must be used;

(3) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in eastern U.S., except in areas of known seismic activity, would have the option of using a PSHA methodology or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis in determining the DE, or using the standardized DE described by an appropriate response spectrum anchored at 0.25 g (subject to the conditions in proposed § 72.103(a)(1)), or using the existing design criteria for the most recent NPP (if applicable); and

(4) The proposed changes regarding the use of a PSHA methodology or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis for determining the DE are not applicable to a general licensee at an existing NPP operating an ISFSI under a Part 72 general license anywhere in the U.S.

Option 4 would also maintain the present Part 72 requirement of using a single DE for defining ISFSI SSC seismic design criteria, but with a lower ground motion that is commensurate with the level of risk associated with ISFSIs. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications. Seismic design criteria for Part 72, when originally issued in 1980, were based on the nuclear plant requirements, and require a DE with a mean annual probability of exceedance of approximately 1.0E-04. Part 72 regulations classify ISFSI facility systems, structures, and components (SSCs) based on their importance to safety. SSCs, whose function is to protect the public health and safety from undue risk, and prevent damage to the spent fuel during handling and storage, are classified as important to safety. These SSCs are evaluated for a single level of DE as an accident condition event only (§ 72.106). For normal operations and anticipated occurrences (§ 72.104), earthquake events are not included.

In the Statements of Consideration accompanying the initial Part 72 Rulemaking, the Commission recognized that the design peak horizontal acceleration for SSCs need not be as high as for a nuclear power reactor, and should be determined on a “case-by-case” basis until “more experience is gained with licensing of these types of units.” With over 10 years of experience licensing dry cask storage, and analyses demonstrating robust behavior of DCSSs in accident scenarios, NRC staff now have a reasonable basis to consider a different design value that is adequate for licensing dry cask storage ISFSIs.

The DCSSs for ISFSI applications are typically self-contained massive concrete or steel structures, weighing approximately 40 to 100 tons when fully loaded. There are very few, if any, moving parts. They are set on a concrete support pad. Several limitations have been set on the maximum height to which the casks can be lifted, based on the drop accident analysis.

There is a minimum center-to-center spacing requirement for casks stored in an array on a common support pad. The most conservative estimates of structural thresholds of seismic inertia deceleration due to a drop accident event, before the confinement is breached so as to exceed the permissible radiation levels, is in the range of 30 g to 40 g.

2.6 Dynamic Loads and Soil Stability

Changes to § 72.212(b)(2)(i)(B) are also needed to communicate that general licensees must evaluate both static and dynamic loads for designing new ISFSIs after the effective date of the rule to ensure that casks are not placed in an unanalyzed condition. This proposed change would be included with any of the options requiring rulemaking (Options 2-4). The change would state that the design of cask storage pads and areas must adequately account for dynamic loads (in addition to static loads). For example, dynamic effects can cause soil-structure interactions that could amplify ground motion to the point that the acceleration on the casks is greater than the DE acceleration, or that soil liquefaction could cause unacceptable pad and foundation settlement. Evaluation of dynamic loads of cask pads and areas would ensure that the pad, which may be considered as failed in a seismic event, could continue to support the casks without placing them in an unanalyzed condition.

2.7 Consideration of Performance-Based Approaches

The proposed rule was reviewed to determine the extent to which the rule satisfies the regulatory framework (NUREG-1614, Vol. 2, Part 1, page 45) for implementing the performance-based approaches based on high-level guidelines staff provided to the Commission in SECY-00-191, “High-Level Guidelines for Performance-Based Activities,” September 1, 2000.

The guidelines in SECY-00-191 can be applied to regulatory activities, to identify and assess the use of performance-based regulatory approaches, instead of prescriptive criteria to assure safety performance. Four high-level viability guidelines of SECY-00-191 were evaluated for ISFSI or MRS facility performance during a seismic event as follows: (1) measurable parameters to monitor acceptable performance exist or can be developed by specifying the failure modes of SSCs important to safety; (2) objective criteria to assess performance exist or can be developed, such as the cask stability and ability of the handling facility to continue to function; (3) licensee flexibility in meeting the established performance criteria exists or can be developed; and (4) a framework exists or can be developed such that even if the performance criteria are not met, the probability of an immediate safety concern would be low.

Examples of the measurable performance parameters for SSCs important to safety in an ISFSI are stability against (1) soil liquefaction during vibratory motion ; and (2) cask sliding and resulting displacements, during an earthquake event. These SSCs have significant margins of safety during a seismic event, as discussed earlier in this Chapter. Because of the significant safety margins, the proposed rule thus allows the applicants flexibility to choose the most suitable design to meet the performance attributes.

The viability guidelines also incorporate the concept that the licensee can and will take corrective action if a significant decrease occurs in the level of confidence that adequate margins are being maintained. The proposed rule in combination with other provisions of 10 CFR Part 72 allows verification of design margins by post-earthquake inspections, and corrective actions, as necessary. Therefore, it is concluded that the proposed rule can be issued with assurance that licensees will have flexibility in implementing the requirements and the proposed rule meets the regulatory framework outlined in SECY-00-191 and accomplishes the safety objectives in a cost effective manner.

3.0 Analysis of Values and Impacts

This chapter examines the values and impacts expected to result from NRC's proposed rulemaking. It is divided into three main sections. Section 3.1 identifies attributes that are and are not expected to be affected by the rulemaking. Section 3.2 describes how values and impacts were analyzed. Section 3.3 examines the projected values and impacts associated with the potential actions to revise the siting and design requirements for ISFSIs.

The NRC proposed rulemaking would modify 10 CFR Part 72 to require certain specific license applicants for a dry cask storage facility to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. The proposed rule would also allow the ISFSI or MRS applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI or MRS, and require that the designs of cask storage pads and areas adequately account for dynamic loads. Each of the potential actions would result in certain values and/or impacts. Thus, the values and impacts of the Commission's proposed rulemaking as a whole consist of the sum of all values and impacts associated with each of the potential actions. For many of the affected attributes, the values and impacts are expected to be negligible. Some of these values and impacts are difficult to estimate due to high levels of variability and the site-specific nature of the activity, and therefore have not been quantified in this analysis.

3.1 Identification of Affected Attributes

This section identifies and describes the factors within the public and private sectors that the regulatory alternatives (discussed in Section 2) are expected to affect. These factors were classified as "attributes," using the list of potential attributes provided in Chapter 5 of *Regulatory Analysis Technical Evaluation Handbook*.[1] Each attribute listed in Chapter 5 was evaluated, and the basis for selecting those attributes expected to be affected by the potential action is presented in the balance of this section.

Affected Attributes

- Industry Implementation -- The potential regulatory options would result in implementation costs and savings to industry. Use of a PSHA or suitable sensitivity analyses, while new to the regulation of ISFSIs, is expected to result in increased analytical costs to specific licensees compared to the current costs for using a deterministic approach. Use of a risk-informed approach to site design, whether the graded approach described in Option 3, or the single DE approach described in Option 4, would result in some minimal reduction in capital costs, because SSCs could be designed to a lower level DE than currently required. The advantage of Option 4 over Option 3 is that under Option 4, specific licensees would not be required to design any SSCs to withstand a DE as high as the SSE of a NPP. The proposed regulatory change to require written evaluations of analysis of dynamic loads would not result in additional costs to general licensees.

[1] *Regulatory Analysis Technical Evaluation Handbook, Final Report*, NUREG/BR-0184, Office of Nuclear Regulatory Research, January 1997.

- Industry Operation – Use of the PSHA or suitable sensitivity analyses, and design of the facility to the new DE are not expected to affect industry operations. In fact, cost reductions may occur because the use of a PSHA or suitable sensitivity analyses will reduce uncertainties in the DE definition, thus reducing potential costs in the case of an earthquake event.

- NRC Implementation -- The regulatory options would result in NRC implementation costs. Specifically, NRC would incur implementation costs to revise guidance documents, and where applicable, develop new guidance.

- NRC Operation -- The regulatory options would result in NRC operation savings resulting from a reduction in the number of exemption requests to the requirements in § 72.102(f)(1) submitted by specific license applicants.

- Public Health (Accident) -- Reductions in radiation exposures to the public may occur because site seismicity at some sites will be more accurately characterized, thus reducing accident consequences.

- Occupational Health (Accident) -- Reductions in radiation exposures to workers may occur because site seismicity at some sites will be more accurately characterized, thus reducing accident consequences.

- Regulatory Efficiency -- The regulatory options would be expected to result in enhanced regulatory efficiency by increasing the level of consistency among different regulations.

- Improvements in Knowledge -- The regulatory options could result in improved data collection and safety evaluations (i.e., less uncertainty) and, consequently, in improvements in regulatory and policy requirements.

Attributes *Not* Affected

- Public Health (Routine) -- No significant changes are expected with respect to routine radiation exposures to the public.

- Occupational Health (Routine) -- Changes to radiation exposures to workers during normal operations are not expected to increase as a result of any of the proposed changes.

- Off-site Property -- Effects on off-site property are not expected to be impacted by any of the proposed changes.
- On-site Property -- Effects on on-site property (direct and indirect) are not expected to be impacted by any of the proposed changes.

- Industry Operation -- The regulatory options would not result in any changes to current industry operational practices.

- Other Government -- The regulatory options are not expected to affect implementation and operation costs of other government agencies, because siting and licensing of

ISFSIs is carried out solely by NRC staff. U.S. Department of Energy sites may incur costs and costs savings similar to those expected for industry.

- Environmental Considerations -- Effects on the environment, due to changes in accident frequencies and accident consequences are not expected to result from any of the proposed changes.

- Safeguards and Security Considerations -- The regulatory options are not expected to impact security considerations.

- General Public -- The regulatory options are not expected to have any effects on the general public.

- Antitrust Considerations -- The regulatory options are not expected to have any antitrust effects.

3.2 Analytical Methodology

This section describes the process used to evaluate values and impacts associated with the regulatory options. The *values* (benefits) of the rule include any desirable changes in affected attributes (e.g., reduction in cost burden for design of ISFSI SSCs) while the *impacts* (costs) include any undesirable changes in affected attributes (e.g., increased costs for using PSHA or suitable sensitivity analyses instead of Appendix A to Part 100). As described in Section 3.1, the attributes expected to be affected include the following:

- Industry Implementation
- Industry Operation
- NRC Implementation
- NRC Operation
- Public Health (Accident)
- Occupational Health (Accident)
- Regulatory Efficiency
- Improvements in Knowledge

For many of these attributes, the nature or cause of a value or impact is straightforward. For example, values and impacts associated with the attribute "NRC operations" should result from, respectively, either a decrease or increase in the number of NRC staff hours (or other NRC resources) required to oversee the Part 72 requirements on a day-to-day basis. Similarly, values and impacts associated with the attribute "regulatory efficiency" should result from changes to the overall clarity, consistency, or level of consolidation of applicable regulations. The overall value or impact for some attributes, however, results from the interaction of several influencing factors. For example, a regulatory option that requires the use of a new approach to conducting siting evaluations may result in increased costs for performing the analysis, while at the same time providing better data, resulting in decreased costs for facility design. In this case, it would be the *net effect* of the influencing factors (i.e., analytical costs and capital costs) that would govern whether an overall value or impact would result for several affected attributes, including industry implementation and NRC implementation and operations.

Ideally, a value-impact analysis quantifies these net effects and calculates the overall values and impacts of each regulatory option. This requires a baseline characterization of the universe of potential licensees, including factors such as:

- Number of planned ISFSIs and location;
- Industry costs to prepare § 72.102(f)(1) exemption requests;
- NRC costs to review exemption requests;
- Industry costs of using the present deterministic method;
- Industry costs of using a PSHA or other sensitivity analyses;
- Industry costs of designing SSCs important to safety with a mean annual probability of exceedance of 5.0E-04;
- Industry costs of designing SSCs important to safety with a mean annual probability of exceedance of 1.0E-04;
- Industry costs for conducting analyses on storage pads accounting for static loads only; and
- Industry costs for conducting analyses on storage pads accounting for dynamic loads.

NRC reviewed regulatory analyses conducted to support similar rulemakings for 10 CFR Part 100 in an attempt to obtain these data. The documents reviewed include the regulatory analysis prepared to support the proposed rule for Reactor Siting Criteria (57 FR 47802) and for Seismic and Geologic Siting Criteria for Nuclear Power Plants (61 FR 65157). In addition, NRC contacted five experts in the field of ISFSI siting and characterization and design, to solicit input on the values and impacts of the proposed options. NRC also sought data on the costs associated with siting and design of ISFSI facilities from a nuclear energy trade association, and industry representatives from operating nuclear power plants.

Assumptions

NRC is making certain assumptions with respect to the values and impacts associated with the proposed rule.

Option 4 is the only option that considers whether a site is located with a NPP in determining applicability of the proposed requirements (see Table 3-1 below). Options 2 and 3 do not make this distinction.

NRC has estimated the potential universe of facilities that may be affected by the different provisions of the proposed rule. Currently, NRC has issued 10 site specific licenses in the U.S. for storage of spent nuclear fuel. Based on past experience and intelligence gathering, NRC estimates that one new specific license application will be received for approval each year for the foreseeable future. Indications from industry are that in the near future, the Diablo Canyon (CA), Humboldt Bay (WA), and Owl Creek Energy Project (WY) facilities will apply for a specific license to operate an ISFSI. The estimate of one application per year is expected to be conservative, accounting for the potential that some sites currently planning to operate their

ISFSI under a general license may decide to apply for a site specific license after promulgation of the proposed changes.

Nine facilities are presently operating ISFSIs under a general license. NRC is estimating that an additional three facilities per year will choose to operate their ISFSIs under a general license.

Table 3-1: Summary of Applicability for Option 4

DE for ISFSI or MRS Specific License Applicants for Dry Cask Modes of Storage on or after the Effective Date of the Final Rule	
Site Condition	**Specific License[1]**
Western U.S., or areas of known seismic activity in the eastern U.S., **not** co-located with NPP	Must use PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2]
Western U.S., or areas of known seismic activity in the eastern U.S., **and** co-located with NPP	PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2], **or** existing NPP design criteria (multi-unit sites - use the most recent criteria)
Eastern U.S., and not in areas of known seismic activity	PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2], **or** existing NPP design criteria, if applicable (multi-unit sites - use the most recent criteria), **or** an appropriate response spectrum anchored at 0.25g (subject to the conditions in proposed § 72.103(a)(1)).

1. Proposed § 72.103 does not apply to general licensees. General licensees must satisfy the conditions given in 10 CFR 72.212.
2. Regardless of the results of the investigations, anywhere in the continental U.S., the DE must have a value for the horizontal ground motion of no less than 0.10 g with the appropriate response spectrum.

3.3 Values and Impacts of Proposed Regulatory Alternatives

3.3.1 Option 1: No-Action Alternative

Under the no-action alternative (Option 1), NRC would maintain the current siting requirements for new dry cask ISFSI specific license applicants at current § 72.102. Thus, relative to existing requirements, no values or impacts would result from Option 1, but the benefits (values) to be derived from the other options would remain unrealized.

3.3.2 Option 2: Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100

Under this option, new Part 72 specific license applicants, for sites located in either the western U.S., or in the eastern U.S. in areas of known seismic activity, would be required to comply with the requirements of § 100.23 in lieu of § 72.102(f) which requires the use of Appendix A to Part 100. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use § 100.23 to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

Estimate for New ISFSI Specific License Applicants

Conducting a PSHA analysis to determine the DE will result in new ISFSI specific license applicants incurring costs, regardless of the site location. As part of the development of the DE, geological and seismological data must be reviewed and updated for any new findings on seismic source activity and ground motion modeling that may impact the DE. Two scenarios were contemplated in estimating the costs of this activity:

Scenario 1: A review of new data suggests that new seismic sources should be postulated and the existing analysis be redone. This would require a determination of the controlling earthquakes and evaluation of the ground motion spectra specific to the site ($150,000 to $250,000).

Scenario 2: The review of new data indicates that new seismic sources need not be postulated and the existing data/analysis could be used. If the existing data and models are considered acceptable (although they may be more than 10 years old), then the determination of controlling earthquakes and the resulting ground motion spectra are relatively straightforward ($50,000 to $100,000).

Under current Part 72 requirements, the DE is developed using the deterministic approach contained in Appendix A to Part 100. The estimated costs associated with developing the DE using this methodology for a new specific license applicant located in either the western U.S. or in the eastern U.S. in areas of known seismic activity, are approximately $50,000 to $100,000.

Assuming that one new ISFSI specific license application is submitted each year, the increase in cost between the use of a PSHA or suitable sensitivity analyses and Appendix A is estimated to range from $0 to $200,000, or an average of $100,000.

Estimate for NRC

NRC would incur costs associated with development of guidance and revisions to existing documents such as the Standard Review Plan and related materials. It is estimated that these revisions would take approximately two staff-months to complete. Assuming a cost of $77 per hour for staff, and 40 days at 8 hours each, this results in a one time cost of approximately $24,640.

NRC would also incur costs associated with review of the PSHA analysis or suitable sensitivity analyses. NRC estimates that an additional one staff-month would be required to complete a PSHA review or suitable sensitivity analyses versus a deterministic review. Assuming a cost of $77 per hour for staff, and 20 days at 8 hours each, this results in a cost of approximately $12,320 per application. Assuming one new specific license application per year, the estimated additional annual cost for review of a PSHA or suitable sensitivity analyses is $12,320.

Value would be provided by adoption of this option because Part 72 requirements would be more compatible with similar requirements for NPPs, thus improving regulatory efficiency. Further, this option may provide improvements in knowledge, which could result in improvements in regulatory and policy requirements. These values, however, are difficult to evaluate, and therefore have not been quantified in this analysis.

3.3.3 Option 3:

(1) **Require new Part 72 applicants to conform to § 100.23 in lieu of Appendix A to Part 100 (Option 2).**

(2) **Provide new Part 72 applicants the option to use a graded approach to seismic design for ISFSI SSCs.**

This option is similar to Option 2 and would also require using a graded approach to seismic design for SSCs. The requirement to comply with § Part 100.23 is the same as described in section 3.3.2 for Option 2 above. Therefore, the estimate of values and impacts to specific licensees and NRC is the same as described under Option 2.

Under this option, new ISFSI specific license applicants would be required to use a graded approach to seismic design for ISFSI SSCs. In general, a graded approach to design requires those SSCs whose failure would result in greater accident consequences to use higher design requirements for phenomena such as earthquakes and tornadoes. Similarly, those SSCs whose failure would result in lesser accident consequences would be designed to less stringent requirements. This graded approach would be in lieu of § 72.102(f)(1), which requires sites that have been evaluated under the criteria of Appendix A to Part 100 to design structures to a DE that is equivalent to the SSE for a NPP.

Estimate for New ISFSI Specific License Applicants

Option 3 would require new applicants to comply with § 100.23 as well as provide the option for using a graded approach to seismic design for SSCs. The requirement to comply with § 100.23 (use of PSHA or suitable sensitivity analyses) is the same as described in section 3.3.2 of this analysis for Option 2, which is approximately $100,000 per year. Therefore, the estimate of values and impacts to specific licensees and NRC is the same as described under Option 2, which would result in additional costs to specific license applicants. The SSCs important to safety in an ISFSI are associated with the storage cask, and include the canister, the canister handling systems, concrete pad supporting the cask, the transfer building supporting the handling systems, and the transfer cask. Other SSCs important to safety may include the pressure monitoring system, protective cover, security lock and wire, etc. and can be designed for a lower level DE. In some cases, ISFSI specific license applicants have sought exemptions from the design requirements contained in § 72.102, considering site characteristics and other factors. This option would reduce or eliminate the need for these exemption requests by reducing the DE level for certain SSCs. The analytical costs to ISFSI specific license applicants associated with designing these SSCs can be significant and are highly dependent on the site and the component being qualified. Differences in capital costs of designing electrical and mechanical equipment result primarily from an increase in the anchorage and load path loads and the resulting hardware designs. These cost differences are minimal. Therefore, reducing the DE level of certain SSCs would result in savings by reducing analytical costs and certain capital costs.

NRC estimates that the costs to a specific license applicant for preparing an exemption request would be approximately $300,000 as a one-time cost. Adoption of Option 3 would negate the need for exemption requests, thereby, resulting in cost savings to specific license applicants of approximately $150,000 per applicant. Assuming that one new specific license applicant would have submitted an exemption request each year, the estimated cost savings would be $150,000 per year.

The overall affect of Option 3 would be a cost savings to new specific license applicants. The amount of these savings, however, is highly site-specific, depending on site characteristics, and the specified DE level.

Estimate for NRC

NRC is expected to realize minimal costs associated with this option. NRC would incur costs associated with development of guidance and revisions to existing documents. The estimate of values and impacts to NRC are expected to be similar to those described under Option 2, approximately $24,640 as a one time cost for development of guidance and document revision.

NRC would also incur costs associated with review of the PSHA analysis or suitable sensitivity analyses. NRC estimates that an additional one staff-month would be required to complete a PSHA or suitable sensitivity analyses review versus a deterministic review. Assuming a cost of $77 per hour for staff, and 20 days at 8 hours each, this results in a cost of approximately $12,320 per application. Assuming one new specific license application per year, the estimated additional annual cost for review of a PSHA or suitable sensitivity analyses is $12,320.

NRC staff review of exemption requests is estimated to require 240 hours. At a cost of $77 per hour, the total cost for NRC staff to review a single exemption request is estimated to be approximately $18,480. Assuming that one new specific license applicant would have submitted an exemption request each year, the estimated cost savings is $18,480 per year under Option 3.
Value would be provided by adoption of this option because Part 72 requirements would be more compatible with similar requirements for pre-closure facilities, thus improving regulatory efficiency. These values however are difficult to evaluate, and therefore have not been quantified in this analysis.

3.3.4 Option 4:

(1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the level of risk associated with an ISFSI. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

This option would require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

This option also maintains the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the level of risk associated with an ISFSI. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications. For purposes of this analysis therefore, the values and impacts of the proposed change to the DE are estimated using this value.

Estimate for New ISFSI Specific License Applicants

The values and impacts associated with Option 4 are similar to those for Option 3. Therefore, the estimate of values and impacts to specific licensees and NRC is the same as described under Option 2 and 3, which would result in additional costs to specific license applicants of $100,000 per year for addressing uncertainties in seismic hazard analysis. The SSCs important to safety in an ISFSI are associated with the storage cask, and include the canister, the canister handling systems, concrete pad supporting the cask, the transfer building supporting the handling systems, and the transfer cask. Other SSCs important to safety may include the pressure monitoring system, protective cover, security lock and wire, etc. and can be designed for a lower level DE. In some cases, ISFSI specific license applicants have sought exemptions from the design requirements contained in § 72.102, considering site characteristics and other factors. Option 4 would reduce or eliminate the need for these exemption requests by reducing the DE for SSCs. Under Option 4, it is assumed, for purposes of this regulatory analysis, that all SSCs important to safety would be designed for a DE with a mean annual probability of exceedance of 5.0E-04. The analytical costs to ISFSI specific license applicants associated with designing these SSCs can be significant and are highly dependent on the site and the component being qualified. Differences in capital costs of designing electrical and mechanical equipment result primarily from an increase in the anchorage and load path loads and the resulting hardware designs. These cost differences are minimal. Therefore, reducing the DE of certain SSCs would result in savings by reducing analytical costs and certain capital costs.

The advantage of Option 4 over Option 3 is simply that under Option 4, no SSCs would be designed to withstand a DE with a mean annual probability of exceedance of 1.0E-04 (equivalent to the SSE of a NPP), resulting in lower analytical and certain capital costs.

NRC estimates that the costs to a specific license applicant for preparing an exemption request would be approximately $300,000 as a one-time cost. Adoption of Option 4 would negate the need for exemption requests, thereby, resulting in cost savings to specific license applicants of approximately $150,000 per applicant. Assuming that one new specific license applicant would have submitted an exemption request each year, the estimated cost savings would be $150,000 per year.

The overall affect of Option 4 would be a cost savings to new specific license applicants. The amount of these savings, however, is highly site-specific, depending on site characteristics, and the specified DE.

Estimate for NRC

Similar to Option 3, NRC is expected to realize minimal costs associated with this option. NRC would incur costs associated with development of guidance and revisions to existing documents. The estimate of values and impacts to specific licensees and NRC is expected to be similar to those described under Option 3, approximately $24,640 as a one time cost for development of guidance and document revision.

NRC would also incur costs associated with review of the PSHA analysis or suitable sensitivity analyses. NRC estimates that an additional one staff-month would be required to complete a PSHA or suitable sensitivity analyses review versus a deterministic review. Assuming a cost of $77 per hour for staff, and 20 days per month at 8 hours each, this results in a cost of approximately $12,320 per application. Assuming one new specific license application per year, the estimated additional annual cost for review of a PSHA or suitable sensitivity analyses is $12,320.

NRC staff review of exemption requests is estimated to require 240 hours. At a cost of $77 per hour, the total cost for NRC staff to review a single exemption request is estimated to be approximately $18,480 per request. Assuming that one new specific license applicant submits an exemption request each year, the estimated cost savings is $18,480 per year.

Value would be provided by adoption of this option because Part 72 requirements would be more compatible with similar requirements for pre-closure facilities, thus improving regulatory efficiency. These values however are difficult to evaluate, and therefore have not been quantified in this analysis.

3.3.5 Considering Dynamic Loads

The Commission is also proposing a change to § 72.212(b)(2)(i)(B) to require general licensees to evaluate both static and dynamic loads for new ISFSIs. This proposed change is an additional modification, separate from the changes proposed in the options above.

Estimate for General Licensees

NRC would change § 72.212(b)(2)(i)(B) to require written evaluations, prior to use, establishing that cask storage pads and areas have been evaluated for the static and dynamic loads of the stored casks. There are no additional costs associated with evaluating cask pads and areas for dynamic loads because general licensees are already required to consider dynamic loads to meet the cask design basis of the Certificate of Compliance (CoC) under § 72.212(b)(i)(A).

Estimate for NRC

NRC is not expected to incur any additional costs associated with this change.

3.3.6 Summary of Values and Impacts

Overall, there are costs and costs savings associated with these options. Option 2 would result in a cost increase for conducting the PSHA or suitable sensitivity analyses. Options 3 and 4 would result in net cost savings by reducing analytical and certain capital costs associated with developing the DE. There are no additional costs with evaluating cask pads and areas for dynamic loads because general licensees are already required to consider dynamic loads to meet the cask design basis of the Certificate of Compliance (CoC) under § 72.212(b)(i)(A).

Table 3-2 provides a summary of the values and impacts associated with each of the options discussed above.

Table 3-2: Summary of Values and Impacts of Options 1 - 4

Option	Use of PSHA or suitable sensitivity analyses		Use of Lower DE		§ 72.212 - Dynamic Loads	
	Industry	NRC	Industry	NRC	Industry	NRC
1- No Action	$0	$0	$0	$0	$0	$0
2	$100,000/yr cost[1] Safety benefit[3]	$24,640 as a one time cost $12,320 cost to review PSHA or suitable sensitivity analyses	$0	$0	$0 Safety benefit[3]	$0
3	$100,000/yr cost Safety benefit[3]	$24,640 as a one time cost $12,320 cost to review PSHA or suitable sensitivity analyses	Capital savings - minimal Analytical savings - substantial Exemption request submittal savings - $150,000/yr[2]	Review of exemption request submittal - $18,480/yr savings	$0 Safety benefit[3]	$0
4	$100,000/yr cost Safety benefit[3]	$24,640 as a one time cost $12,320 cost to review PSHA or suitable sensitivity analyses	Capital savings - minimal Analytical savings - substantial Exemption request submittal savings - $150,000/yr	Review of exemption request submittal - $18,480/yr savings	$0 Safety benefit[3]	$0

[1] Assumes one specific license applicant each year at an average cost of $100,000 per applicant.
[2] Assumes one exemption request submittal each year.
[3] Public health and safety is being maintained at the current level, or slightly improved.

4.0 Backfit Analysis

The Commission has determined that the backfit rule, § 72.62, does not apply to the changes in § 72.9, § 72.102, and § 72.103 because they do not involve any provisions that would impose backfits as defined in § 72.62(a).

Section 72.212(b)(2)(i)(B) currently requires evaluations of static loads of the stored casks for design of the cask storage pads and areas (foundation). The proposed revisions to this section would require general licensees to also address the dynamic loads of the stored casks. During a seismic event, the cask storage pads and areas experience dynamic loads in addition to static loads. The dynamic loads depend on the interaction of the casks, cask storage pads, and areas. Consideration of the dynamic loads of the stored casks, in addition to the static loads, for the design of the cask storage pads and areas, would ensure that the cask storage pads and areas would perform satisfactorily during a seismic event.

The proposed revision would also require consideration of potential amplification of earthquakes through soil-structure interaction, and soil liquefaction potential or other soil instability due to vibratory ground motion. Depending on the properties of soil and structures, the free-field earthquake acceleration input loads may be amplified at the top of the storage pad. These amplified acceleration input values must be bound by the design bases seismic acceleration values for the cask, specified in the Certificate of Compliance (CoC). The soil liquefaction and instability during a vibratory motion due to an earthquake event may affect the cask stability.

The proposed changes to § 72.212(b)(2)(i)(B) will impact procedures required to operate an ISFSI and; therefore, implicate the backfit rule. The proposed changes would require that general licensees perform appropriate analyses to assure that the cask seismic design bases bound the specific site seismic conditions, and that casks are not placed in an unanalyzed condition. Therefore, these proposed changes are necessary to assure adequate protection to occupational or public health and safety. Although the Commission is imposing this backfit because it is necessary to assure adequate protection to occupational or public health and safety, the proposed changes to § 72.212 would not actually impose new burden on the general licensees because they currently need to consider dynamic loads to meet the requirements in § 72.212(b)(2)(i)(A). Section 72.212(b)(2)(i)(A) requires that general licensees perform written evaluations to meet conditions set forth in the cask CoC. These CoCs require that dynamic loads, such as seismic and tornado loads, be evaluated to meet the cask design bases. Since the general licensees currently evaluate dynamic loads for evaluating the casks, pads and areas, the proposed changes to § 72.212(b)(2)(i)(B) would not actually require any general licensees presently operating an ISFSI to re-perform any written evaluations previously undertaken.

5.0 Decision Rationale

For each of the options identified, the values and impacts associated with modifying the seismological and geological siting and design criteria in Part 72 have been considered. Option 4 was determined to be the most preferable based on professional judgment and limited quantitative analysis because it (1) improves effectiveness and efficiency of the NRC regulatory process by eliminating the need for applicants to request exemptions from §§ 72.102(a), 72.102(b), and 72.102(f)(1), and the need for NRC to review the exemption requests; (2) reduces unnecessary costs for the applicant or specific licensee by reducing the DE to account for the lower risk associated with ISFSI facilities; (3) would not result in significant overall additional implementation or operation costs to NRC and applicants, and (5) supports the implementation of the NRC's risk-informed approach to regulation. The main advantage of Option 4 over Option 3 is that under Option 4, no SSCs would be designed to withstand a DE with a mean annual probability of exceedance of 1.0E-04 (equivalent to the SSE of a NPP), resulting in lower analytical and certain capital costs than associated with Option 3. Under Option 4, public health and safety will be maintained at the current level, or be slightly improved.

6.0 Implementation

This action would be enacted through a Proposed Rule Notice, public comments, and a Final Rule, with promulgation of the Final Rule by approximately one year after publication of the Proposed Rule. No impediments to implementation of the recommended alternatives have been identified. NRC has determined, as described in section 4.0, that one change would impose a backfit, as defined in § 72.62(a). The proposed changes to § 72.212(b)(2)(i)(B) will impact procedures required to operate an ISFSI and; therefore, implicate the backfit rule. The proposed changes would require that general licensees perform appropriate analyses to assure that the cask seismic design bases bound the specific site seismic conditions, and that casks are not placed in an unanalyzed condition. Therefore, these proposed changes are necessary to assure adequate protection to occupational or public health and safety. Although the Commission is imposing this backfit because it is necessary to assure adequate protection to occupational or public health and safety, the proposed changes to § 72.212 would not actually impose new burden on the general licensees because they currently need to consider dynamic loads to meet the requirements in § 72.212(b)(2)(i)(A).

A Regulatory Guide for licensees would be required to provide an explanation of the regulatory requirements and methods for complying with the revised requirements for ISFSI site characterization and design.

The estimated resources entailed in this rulemaking would be on the order of 2.1 FTEs. These resources will come principally from NMSS, NRR, RES, and OGC. These resources are within FY 2001 budget allocations and the proposed FY 2002 budget.

NMSS . . . 1.8 FTE
Other . . . 0.3 FTE

Environmental Assessment of Geological and Seismological Characteristics for Siting and Design of Dry Cask Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations

Draft Report

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards

February 2002

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Executive Summary

This document presents the Environmental Assessment of the U.S. Nuclear Regulatory Commission's (NRC or the Commission) proposal to amend its licensing requirements in 10 CFR Part 72 pertaining to the seismic siting and design criteria for dry cask modes of storage of (1) spent nuclear fuel in an independent spent fuel storage installation (ISFSI) and (2) spent nuclear fuel and solid high-level radioactive waste in a monitored retrievable storage installation (MRS). For purposes of this document, the term "ISFSI" is used to include both dry ISFSI and MRS facilities, as appropriate. The Commission does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because the risk associated with potential accident scenarios for wet modes of storage is greater than the risk for dry cask modes of storage. This is because wet modes of storage require active systems, such as systems to remove heat and maintain adequate water levels. These active systems have a higher probability of failure than the passive systems used in dry cask modes of storage, thus resulting in a greater seismic risk for wet modes of storage. The Commission also does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to dry modes of storage that do not use casks because of the lack of experience gained in licensing these facilities. The Commission considered a number of options to change the siting and design requirements in Part 72.

The rulemaking proposes the following changes:

1. Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a probabilistic seismic hazard analysis (PSHA) or other suitable sensitivity analyses, for determining the design earthquake ground motion (DE). All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

2. Allow new ISFSI applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI (§ 72.103). A draft regulatory guide accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the safe shutdown earthquake (SSE) of a NPP, for ISFSI applications.

3. Require general licensees to evaluate that the designs of cask storage pads and areas adequately account for dynamic loads, in addition to static loads (§ 72.212).

The Commission intends to leave present § 72.102 in place to preserve the licensing basis of present ISFSIs. The proposed provisions would be added as a new § 72.103, which would provide the requirements that would be utilized for new specific license applicants.

The proposed changes are consistent with the Commission's strategic goals in that

- The rulemaking effort would increase NRC's effectiveness and efficiency by reducing the number of exemption requests that would need to be submitted and reviewed.

- This rule would maintain safety by selecting the DE to be commensurate with the risk associated with an ISFSI.

- The changes to the DE are considered risk-informed, consistent with NRC policy to develop risk-informed regulations.

- This rule would increase realism by enabling ISFSI applicants to use the state-of-the-art approach (PSHA or suitable sensitivity analyses) to more accurately characterize the seismicity of a site.

The Commission considered four options for this rulemaking:

Option 1.

No Action. The siting requirements for new dry cask ISFSIs would continue to conform to the existing requirements of §§ 72.102.

Option 1, the no-action alternative, would not result in any change to current seismic design criteria, nor would it affect the DE for ISFSI SSCs.

Option 2.

Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100.

No adverse environmental impacts are expected under Option 2. Under this option, certain applicants would be required to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, for developing the DE for ISFSIs. The use of PSHA or suitable sensitivity analyses for derivation of the DE would be more risk-informed than the deterministic approach. Under this option, all ISFSIs would still meet the radiological protection standards in §§ 72.104(a) and 72.106(b), and thus the degree of protection of the public health would not be compromised.

Option 3.

Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100, and also give them the option to use a graded approach to seismic design of the ISFSI SSCs.

No adverse environmental impacts are expected under Option 3. As under Option 2, derivation of DEs for ISFSIs using a risk-informed PSHA or suitable sensitivity analyses would be required for certain specific license applicants, and would be protective. Under the graded approach to developing design criteria for ISFSIs, the DE for SSCs important to safety designed for Category 2 events would still be the SSE for a NPP. For these SSCs, there is therefore no change in risk of radiological exposure. SSCs could be designed to withstand less stringent criteria (Category 1 events) only if the applicant's analysis provides reasonable assurance that the failure of the SSC would not cause the facility to exceed the radiological protection requirements of § 72.104(a) under normal operations. If the specific license applicant's analysis cannot support this conclusion, the SSC would have to be designed such that the facility can withstand more stringent criteria without impairing the ISFSI's capability to perform safety functions and not exceed the radiological protection requirements of §§ 72.104(a) and 72.106(b). Thus, no additional risk to the public would be incurred.

Option 4.

(1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but allow for the use of a lower DE that is commensurate with the level of risk associated with an ISFSI. The draft regulatory guide, DG-3021 "Site Evaluations and Determination of Design Earthquake Ground Motion for Seismic Design of Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations," accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04 for ISFSI applications. This recommended level is lower than the present level of approximately 1.0E-04 (equivalent to the SSE for a NPP).

Option 4 is similar to Options 2 and 3 in that it requires certain specific license applicants to address uncertainties in seismic hazard analysis to use a risk-informed PSHA or suitable sensitivity analyses for deriving the DE for ISFSIs. Thus, there would be no adverse effect associated with that aspect of this option. Option 4 is different from and 3 in that specific licensees would not be required to design any SSCs to withstand a DE as high as the SSE of a NPP. With more than 10 years of experience licensing dry cask storage systems, together with analyses demonstrating their robust behavior in accident scenarios involving earthquakes, the NRC staff concludes that designing ISFSI SSCs using a single-level DE with a ground motion that is commensurate with the level of risk associated with an ISFSI, is sufficient to provide reasonable assurance in demonstrating public health and safety.

Options Summary.

Overall, no adverse environmental impacts will result from any of the options identified.   Dry storage casks used at an ISFSI are passive systems with natural cooling sufficient to maintain safe temperatures and a robustness or structural integrity to withstand external forces. The cask walls provide adequate shielding and no radioactive products are released under any credible accident conditions. Other systems, structures, and components (SSCs) will also be designed to standards affording a high degree of environmental protection under normal operations and credible accident conditions. In addition, none of the proposed changes will significantly affect the construction or operation of an ISFSI facility.

Additional Change

The Commission is also proposing a change to § 72.212(b)(2)(i)(B) to require that general licensees evaluate dynamic loads (in addition to static loads) in the design of cask storage pads and areas. This proposed change is an additional modification, separate from the changes proposed in the options above.

NRC would change § 72.212(b)(2)(i)(B) to require written evaluations, prior to use, establishing that cask storage pads and areas have been evaluated for the static and dynamic loads of the stored casks. No adverse environmental impacts are expected to result from the proposed change to evaluate dynamic as well as static loads in the design of ISFSI storage pads and areas. The proposed changes are intended to require that general licensees perform appropriate analyses to ensure that the seismic design bases for the casks are met and that casks are not placed in an unanalyzed condition. Therefore, these proposed changes are necessary to assure adequate protection to occupational and public health and safety. The proposed changes to § 72.212 would not actually impose new burden on the general licensees because they currently need to consider dynamic loads to meet the requirements in § 72.212(b)(2)(i)(A). Since the general licensees currently evaluate dynamic loads for evaluating the cask pads and areas, the proposed changes to § 72.212(b)(2)(i)(B) would not actually require any present general licensees operating an ISFSI to re-perform any written evaluations previously undertaken.

1.0 Introduction

The Nuclear Regulatory Commission (NRC) is proposing to amend its siting and design requirements in 10 CFR Part 72 pertaining to the seismic siting and design criteria for dry cask modes of storage of (1) spent nuclear fuel in an ISFSI and (2) spent nuclear fuel in solid high-level radioactive waste in a U.S. Department of Energy (DOE) MRS. For this document, the term "ISFSI" is used to include both ISFSI and MRS facilities, as appropriate. The Commission does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because the risk associated with potential accident scenarios for wet modes of storage is greater than the risk for dry cask modes of storage. This is because wet modes of storage require active systems, such as systems to remove heat and maintain adequate water levels. These active systems have a higher probability of failure than the passive systems used in dry cask modes of storage, thus resulting in a greater seismic risk for wet modes of storage. The Commission also does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to dry modes of storage that do not use casks because of the lack of experience gained in licensing these facilities.

The Commission considered four seismic evaluation options. This draft Environmental Assessment (EA) is a part of the Commission's analysis of the options being considered and is a supporting document for the *Federal Register* Notice containing the proposed rule. The purpose of this draft EA is to evaluate the potential environmental impacts associated with the regulatory changes as required by the National Environmental Policy Act (NEPA). This document presents background material, describes the purpose and need for the proposed action, outlines the proposed action and alternatives being considered, and evaluates the environmental consequences of the proposed action and alternatives.

1.1 Background

In 1980, the Commission added 10 CFR Part 72 to its regulations to establish licensing requirements for the storage of spent fuel in an ISFSI (45 FR 74693, November 12, 1980). Subpart E of Part 72 contains siting evaluation factors that must be investigated and assessed with respect to the siting of an ISFSI, including a requirement for evaluation of geological and seismological characteristics. The original regulations envisioned these facilities as spent fuel pools or single, massive dry storage structures. The regulations required seismic evaluations equivalent to those for a NPP when the ISFSI is located in the western U.S. (west of approximately 104^0 west longitude), or in areas of known seismic activity in the central and eastern U.S. A seismic design requirement, equivalent to the requirements for a NPP (Appendix A to 10 CFR Part 100) seemed appropriate for these types of facilities, given the potential accident scenarios. For those sites located in the central and eastern U.S., and not in areas of known seismic activity, the regulations allowed for less stringent alternatives.

For other types of ISFSI designs, the regulation required a site-specific investigation to establish site suitability commensurate with the specific requirements of the proposed ISFSI. The Commission explained that for ISFSIs which do not involve massive structures, such as dry storage casks and canisters, the required DE will be determined on a case-by-case basis until more experience is gained with the licensing of these types of units (45 FR 74697).

For sites located in the western U.S., or in the eastern U.S. in areas of known seismic activity, the regulations in § 72.102 require the use of the procedures in Appendix A to Part 100 for determining the design basis vibratory ground motion at a site. Appendix A to Part 100 requires the use of “deterministic” approaches in the development of a single set of earthquake sources. The applicant develops for each source a postulated earthquake to be used to determine the ground motion that can affect the site, locates the postulated earthquake according to prescribed rules, and then calculates ground motions at the site. Because the deterministic approach does not explicitly recognize uncertainties in geoscience parameters, PSHA methods and suitable sensitivity analyses were developed that allow explicit expressions for the uncertainty in ground motion estimates and provide a means for assessing sensitivity to various parameters.

Advances in the sciences of seismology and geology, along with the occurrence of some licensing issues not foreseen in the development of Appendix A to Part 100, have caused a number of difficulties in the application of this regulation to dry cask ISFSIs. Specific problematic areas include the following:

S The limitations in data and geologic and seismic analyses and the rapid accumulation of knowledge in the geosciences have required considerable latitude in judgment. The inclusion of detailed geoscience assessments in Appendix A has caused difficulties for applicants and the Commission by inhibiting the use of needed judgment and flexibility in applying basic principles to new situations. Requiring the use of Appendix A has also inhibited the use of evolving methods of analyses (for instance, probabilistic) in the licensing process.

S Various sections of Appendix A are subject to different interpretations. For ISFSI applications, some sections in the Appendix do not provide sufficient information for implementation. As a result, the Appendix has been the source of licensing delays and debate.

In 1996, the Commission amended 10 CFR Parts 50 and 100 to update the criteria used in decisions regarding NPP siting, including geologic and seismic engineering considerations for future NPPs (61 FR 65157, December 11, 1996). The amendments placed a new § 100.23 in the regulations requiring that the uncertainties in seismic hazard analysis associated with the determination of the SSE be addressed through an appropriate analysis, such as a PSHA or suitable sensitivity analyses in lieu of Appendix A. This approach takes into account the shortcomings in the earlier siting requirements and is based on developments in the field over the past two decades. Further, regulatory guides have been used to address implementation issues. For example, the Commission provided guidance for nuclear power plant license applicants in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," and Standard Review Plan-NUREG 0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Reactors." However, the Commission left Appendix A to Part 100 in place to preserve the licensing basis for existing plants and confined the applicability of § 100.23 to new NPPs.

With over 10 years of experience licensing dry cask storage the Commission is now proposing a conforming change to 10 CFR Part 72 to require some sites to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. This approach parallels the change made to 10 CFR Part 100.

In comparison with a NPP, an operating ISFSI facility is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI facility does not have the variety and complexity of active systems necessary to support an operating NPP. Further, the robust cask design required for non-seismic considerations (e.g., drop event, shielding), assure low probabilities of failure from seismic events.

In the unlikely occurrence of a radiological release as a result of a seismic event, the radiological consequences to workers and the public are significantly lower in comparison to a NPP. This is because the conditions required for release and dispersal of significant quantities of radioactive material, such as high temperatures or pressures, are not present in an ISFSI. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI, and to the low inventory of volatile radioactive materials readily available for release to the environment. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI is less than the risk associated with a NPP and the use of a lower DE is appropriate.

2.0 Purpose and Need for Proposed Action

Part 72 currently requires siting and design of ISFSI facilities in accordance with requirements that were established for the licensing of nuclear power plants (Appendix A to Part 100). The purpose of the proposed changes to Part 72 is to (1) provide benefit from the experience gained in applying the existing regulation and from research, (2) incorporate state-of-the-art improvements in the geosciences and earthquake engineering, and (3) make the siting and design criteria risk-informed. These changes are needed because the current requirements are unnecessarily conservative for ISFSI applications, resulting in more costly facility designs, while not providing any measurable additional safety benefit.

The rulemaking proposes to:

1. Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

2. Allow new ISFSI applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI (§ 72.103). A draft regulatory guide accompanying this proposed rule recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

3. Require general licensees to evaluate that the designs of cask storage pads and areas adequately account for dynamic loads, in addition to static loads (§ 72.212).

NRC is considering three changes to its seismological and geological siting and design regulations for ISFSI applications.

(1) The first change considers the plausibility of requiring new applicants for sites located in either the western U.S. or in the eastern U.S. in areas of known seismic activity, and not co-located with a NPP, to address uncertainties in determining the DE ground motion seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation (§ 72.103).

The existing approach for determining a DE for an ISFSI, embodied in Appendix A to Part 100, relies on a "deterministic" approach. Using this deterministic approach, an applicant develops a single set of earthquake sources, develops for each source a postulated earthquake to be used as the source of ground motion that can affect the site, locates the postulated earthquake according to prescribed rules, and then calculates ground motions at the site.

Although this approach has worked reasonably well for the past several decades, in the sense that safe shutdown earthquake ground motions for NPPs sited with this approach are judged to be suitably conservative, the approach has not explicitly recognized uncertainties in geosciences parameters. Because so little is known about earthquake phenomena (especially in the eastern U.S.), there have often been differences of opinion and differing interpretations among experts as to the largest earthquakes to be considered and ground-motion models to be used.

Probabilistic methods that have been developed in the past 15 to 20 years for evaluation of seismic safety of nuclear facilities allow explicit incorporation of different models for zonation, earthquake size, ground motion, and other parameters. The advantage of using these probabilistic methods is their ability to incorporate different models and data sets, thereby providing an explicit expression for the uncertainty in the ground motion estimates and a means of assessing sensitivity to various input parameters. The western and eastern U.S. have fundamentally different tectonic environments and histories of tectonic deformation. Consequently, application of these probabilistic methodologies has revealed the need to vary the fundamental PSHA methodology depending on the tectonic environment of the site.

In 1996, when the Commission accepted the use of a PSHA methodology or suitable sensitivity analyses in §100.23, it recognized that the uncertainties in seismological and geological information must be formally evaluated and appropriately accommodated in the determination of the SSE for seismic design of NPPs. The Commission further recognized that the nature of uncertainty and the appropriate approach to account for it depends on the tectonic environment of the site and on properly characterizing parameters input to the PSHA or suitable sensitivity analyses. Consequently, methods other than probabilistic methods such as sensitivity analyses may be adequate for some sites to account for uncertainties. The Commission believes that certain new applicants for ISFSI specific licenses, as described in section 3.0, must also account for these uncertainties instead of using the Appendix A to Part 100.

NRC staff will review the application using all available data including insights and information from previous licensing experience. Thus, the proposed approach requires thorough regional and site-specific geoscience investigations. Results of the regional and site-specific investigations must be considered in application of the probabilistic method. Two current probabilistic methods are the NRC- sponsored study conducted by Lawrence Livermore National Laboratory and the Electric Power Research Institute’s seismic hazard study. These are regional studies without detailed information on any specific location. The regional and site-specific investigations provide detailed information to update the database of the hazard methodology to make the probabilistic analysis site-specific.

Applicants also must incorporate local site geological factors such as stratigraphy and topography and account for site-specific geotechnical properties in establishing the DE. In order to incorporate local site factors and advances in ground motion attenuation models, ground motion estimates are determined using the procedures outlined in NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Reactors”, Section 2.5.2, “Vibratory Ground Motion.”

(2) The second change would allow applicants to use a DE appropriate for and commensurate with the risk associated with an ISFSI.

The present DE for ISFSIs is based on the requirements contained in 10 CFR Part 100 for NPPs. In the Statement of Consideration accompanying the initial Part 72 rulemaking, the Commission recognized that the design peak horizontal acceleration for SSCs need not be as high as for a nuclear power reactor, and should be determined on a “case-by-case” basis until more experience is gained with licensing of these types of units (45 FR 74697). With over 10 years of experience licensing dry cask storage, and analyses demonstrating robust behavior of dry cask storage systems (DCSSs) in accident scenarios, the Commission now has a reasonable basis to consider lower and more appropriate DE parameters for dry cask ISFSIs.

The present ISFSI DE (equivalent to the SSE for a NPP) has a mean annual probability of exceedance of approximately 1.0E-04 (i.e., in any one year, the probability is one in ten thousand that the DE established for the site will be exceeded). In comparison with a nuclear power plant, an operating ISFSI is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI does not have the variety and complexity of active systems necessary to support an operating NPP. Further, the robust cask design required for non-seismic considerations (e.g., drop event, shielding), assure low probabilities of failure from seismic events.

In the unlikely occurrence of a radiological release as a result of a seismic event, the radiological consequences to workers and the public are significantly lower in comparison to a NPP. This is because the conditions required for release and dispersal of significant quantities of radioactive material, such as high temperatures or pressures, are not present in an ISFSI. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI, and to the low inventory of volatile radioactive materials readily available for release to the environment. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI is less than the risk associated with a NPP and the use of a lower DE is appropriate.

Additional rationale supporting the Commission's proposal to reduce the DE is provided below.

- The critical element for protection against radiation release is the steel cask containing the spent fuel assemblies. The standards in Part 72 Subparts E - Siting Evaluation Factors and F - General Design Criteria, ensure that the dry storage cask designs are very rugged and robust, and are expected to have substantial design margins to withstand forces from a seismic event greater than the DE.

- During a seismic event at an ISFSI, a cask may slide if lateral seismic forces are greater than the frictional resistance between the cask and the concrete pad. The sliding and resulting displacements are computed by the applicant to demonstrate that the casks, which are spaced to satisfy the thermal criteria in Part 72 Subpart F, are precluded from impacting other adjacent casks. Furthermore, the NRC staff guidance in reviewing cask designs is to show that casks are designed to prevent sliding or tip over during a seismic event. However, even if the casks slide or tip over and then impact other casks or the pad during a seismic event significantly greater than the proposed DE, there are adequate design margins to ensure that the casks maintain their structural integrity.

- Because the DE is a smooth broad-band spectrum, which envelops the controlling earthquake responses, the vibratory ground motion specified is conservative.

- The combined probability of the occurrence of a seismic event and operational failure that leads to a radiological release is much smaller than the individual probabilities of either of these events. This is because the handling building and crane are used for only a fraction of the licensed period of an ISFSI and for only a few casks at a time. Therefore, the risk of a potential release of radioactivity due to failure of the cask handling building and/or crane during a seismic event is small.

- The crane used for lifting the casks in the building is designed using the same industry codes as for a nuclear power plant (ACI 349, AISC N690, ANSI N14.6, and NUREG-0612), and has a safety factor of five (5) or greater for lifted loads using the ultimate strength of the materials. Therefore, the crane would perform satisfactorily for an earthquake ground motion much larger than the DE.

- The determination of a DE for ISFSIs is consistent with the design approach used in DOE Standard DOE-STD-1020, “Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities,” for similar type facilities.

(3) The third change would require that the design of cask storage pads and areas at ISFSIs adequately account for dynamic loads in addition to static loads.

The Commission is proposing a change to clarify that 10 CFR Part 72 general licensees must perform both static and dynamic loads for new ISFSIs after the effective date of the rule to ensure that casks are not placed in an unanalyzed condition. The change would state that the design of cask storage pads and areas must adequately account for dynamic loads (in addition to static loads). For example, dynamic effects can cause soil-structure interactions that could amplify ground motion to the point that the acceleration on the casks is greater than the DE acceleration, or soil liquefaction could cause unacceptable pad and foundation settlement. Accounting for dynamic loads in the analysis of ISFSI pads and areas would ensure that the pad continues to support the casks during seismic events.

3.0 Proposed Action and Alternatives

The options (alternatives) under consideration are:

Option 1. No Action. The siting requirements for new dry casks ISFSIs would continue to conform to the existing requirements of § 72.102.

Option 2. Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100.

Option 3. Require new Part 72 specific license applicants to conform to § 100.23 in lieu of Appendix A to Part 100, and also give them the option to use a graded approach to seismic design of the ISFSI SSCs.

Option 4. (1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the level of risk associated with an ISFSI. Draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

Option 4 is the only option that considers whether a site is located with a NPP in determining applicability of the proposed requirements (see Table 3-1 below). Options 2 and 3 do not make this distinction.

Table 3-1. Summary of Applicability

DE for ISFSI or MRS Specific License Applicants for Dry Cask Modes of Storage on or after the Effective Date of the Final Rule	
Site Condition	Specific License[1]
Western U.S., or areas of known seismic activity in the eastern U.S., **not** co-located with NPP	Must use PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2]
Western U.S., or areas of known seismic activity in the eastern U.S., **and** co-located with NPP	PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2], **or** existing NPP design criteria (multi-unit sites - use the most recent criteria)
Eastern U.S., and not in areas of known seismic activity	PSHA or suitable sensitivity analyses to account for uncertainties in seismic hazards evaluations[2], **or** existing NPP design criteria, if applicable (multi-unit sites - use the most recent criteria), **or** an appropriate response spectrum anchored at 0.25g (subject to the conditions in proposed § 72.103(a)(1)).

1. Proposed § 72.103 does not apply to general licensees. General licensees must satisfy the conditions given in 10 CFR 72.212.
2. Regardless of the results of the investigations, anywhere in the continental U.S., the DE must have a value for the horizontal ground motion of no less than 0.10 g with the appropriate response spectrum.

Additional Change

The Commission is also proposing a change to § 72.212(b)(2)(i)(B) to require that general licensees evaluate dynamic loads (in addition to static loads) in the design of cask storage pads and areas. This proposed change is an additional modification, separate from the changes proposed in the options above.

NRC would change § 72.212(b)(2)(i)(B) to require written evaluations, prior to use, establishing that cask storage pads and areas have been evaluated for the static and dynamic loads of the stored casks.

3.1 Comparison of Proposed Options

This section compares the requirements of the proposed options. These options differ with regard to seismological and geological siting criteria and estimation of the DE for ISFSIs, and whether single-level DEs will be used in evaluating the design of ISFSI SSCs. As noted above, requirements for consideration of dynamic loads in the design of cask storage pads and areas may be promulgated along with any option. A summary of the requirements of the proposed options is provided in Table 3-2.

Table 3-2. Comparison of Requirements Under Proposed Options

Option	Seismic Siting Criteria, DE Definition	DE for Systems, Structures, and Components (SSCs)
1. (No Action)	Current § 72.102. Sites in the western U.S. do seismic analysis as required by Appendix A to Part 100. In the eastern U.S., use Appendix A analysis or DE with response spectrum anchored at 0.25g ground motion. If Appendix A is used at any site, DE is defined as the SSE for a NPP.	Current § 72.102.
2	Applicant must conform to § 100.23, requiring PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100, or other options compatible with the existing regulation.	Current § 72.102.
3	Applicant must conform to § 100.23, requiring PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100, or other options compatible with the existing regulation.	Require applicants to use graded approach to seismic design of SSCs. Similar to Parts 60 and 63; Category 1 event annual probability = 1.0E-03, Category 2 event annual probability = 1.0E-04.
4	Applicant must comply with new § 72.103 requiring use of PSHA or suitable sensitivity analyses in lieu of Appendix A to Part 100, or other options compatible with the existing regulation.	Single level DE for SSCs or other options compatible with the existing regulation.

3.1.1 Option 1: No-Action Alternative

Under Option 1, new specific license applicants for dry cask ISFSIs would continue to meet the existing requirements of 10 CFR 72.102. As noted in section 1, currently, ISFSI applicants at sites located in either the western U.S. or in the eastern U.S. in areas of known seismic activity must currently perform deterministic site seismic evaluations as prescribed in Appendix A to Part 100. ISFSIs located in the eastern U.S. and not in areas of known seismic activity may use a standardized design earthquake (peak ground acceleration of 0.25g) if justified by sufficient geological investigations and literature review. For any application in which the methods in Appendix A are used, the DE for the ISFSI must be no less than the SSE for a NPP.

As noted in the previous sections, the current requirements may result in more costly designs, are deterministic, and employ outdated criteria developed for power reactors, to define siting criteria for the much less complex and hazardous ISFSIs. Therefore, this approach does not consider uncertainties in the seismic hazard assessment, is not risk-informed, and may not be cost effective.

3.1.2 Option 2: Require New Part 72 Specific License Applicants to Conform to § 100.23 in lieu of Appendix A to Part 100

This option would require certain specific license applicants to address uncertainties in seismic hazard analysis by using a PSHA or suitable sensitivity analyses for determining the DE, as described in §§ 72.103 and 100.23. This would bring the seismic site evaluation requirements for ISFSIs into conformance with the updated requirements for NPPs. By accepting the use of a PSHA methodology or suitable sensitivity analyses in § 100.23, the Commission has recognized that the uncertainties in seismological and geological information must be formally evaluated and appropriately accommodated in the determination of the SSE for seismic design of NPPs. The Commission, in promulgating § 100.23 further recognized that the nature of uncertainty and the appropriate approach to account for it depends on the tectonic environment of the site and on properly characterizing parameters input to the PSHA or suitable sensitivity analyses such as seismic sources, the recurrence of earthquakes within a seismic source, the maximum magnitude of earthquakes within a seismic source, and engineering estimation of earthquake ground motion.

The Commission notes that while strict adherence to the requirements in Appendix A for determining the DE for the ISFSI (equivalent to a NPP SSE) will be removed, those applicants for ISFSIs, co-located with existing nuclear power plant sites, would be allowed to use all of the geophysical investigation information obtained from the original licensing process (which used the Appendix A requirements), in verifying that all applicable seismic data are considered in determining the design basis. The benefit of this option is that it would be a conforming change to Part 100 for evaluating geological and seismological criteria. It should be noted that under this option, the extent of site investigations and characterization remains the same as required in Part 100. Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," was developed to provide general guidance on procedures acceptable to the staff for satisfying the requirements of § 100.23 for NPPs. This guidance would be considered acceptable for ISFSIs.

This option retains the § 72.102(f)(1) requirement that the DE for ISFSIs be equivalent to the SSE for a NPP. Thus, while improving the technical requirements for site seismic analysis, this option is still not risk-informed, in that the same DEs are defined for the much less hazardous ISFSIs as for NPPs.

3.1.3. Option 3:

(1) Require New Part 72 Specific License Applicants to Conform to § 100.23 in lieu of Appendix A to Part 100

(2) Provide new Part 72 applicants the option to use a graded approach to seismic design for ISFSI SSCs.

This option is the same as Option 2, except that it would require applicants to use a graded approach to developing seismic design criteria for SSCs. The specific approach proposed for dry cask ISFSIs would be comparable to the Parts 60 and 63 graded approach to design ground motion for SSCs of pre-closure facilities (§ 60.2). In general, a graded approach to design requires those SSCs whose failure would result in greater accident consequences to use higher design requirements for phenomena such as earthquakes and tornadoes (Category 2 event). Similarly, those SSCs whose failure would result in lesser accident consequences would be designed to less stringent requirements (Category 1 event). For seismic events, the Commission has accepted the approach described in DOE Topical Report YMP/TR-003-NP, Rev. 2, Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain, pertaining to Part 63. In this approach Category 1 design basis ground motion refers to a mean annual probability of exceedance of 1.0E-03. Category 2 design basis ground motion refers to a mean annual probability of exceedance of 1.0E-04.

Individual SSCs that are required to maintain the annual dose within the regulatory limits of 10 CFR Part 20 would be designed to a Category 1 design earthquake. Other SSCs needed to be functional to prevent the dose limit of 5 rem from being exceeded at the controlled area boundary due to a seismic event, would be designed to a Category 2 design earthquake. Thus, the seismic design of the SSCs would be commensurate with their importance to safety.
By requiring uncertainties in seismic hazard analysis to be addressed using a PSHA or suitable sensitivity analyses to define the DE for ISFSIs, and the use of a graded approach to defining seismic criteria for SSCs, Option 3 sets siting and design criteria that are much more risk-informed than Options 1 and 2, and are more flexible than the proposed requirements in Option 2. It would, however, be more complex to implement than Option 2 and, as discussed in Section 4, would not achieve a meaningful risk reduction compared to the approach defined in Option 4.

3.1.4 Option 4:

(1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the level of risk associated with an ISFSI. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level of an SSE for a NPP, for ISFSI applications.

Option 4 would require that:

(1) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a NPP, would be required to address uncertainties in seismic hazard analysis by using a PSHA or suitable sensitivity analyses, for determining the DE;

(2) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in either the western U.S. or in areas of known seismic activity in eastern U.S., and co-located with a NPP, would have the option of using a PSHA methodology or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis in determining the DE, or using the

existing design criteria for the NPP. When the existing design criteria for the NPP are used for an ISFSI at a site with multiple NPPs, the criteria for the most recent NPP must be used;

(3) Applicants who apply on or after the effective date of the final rule, for a Part 72 specific license for a dry cask storage ISFSI or MRS, located in eastern U.S., except in areas of known seismic activity, would have the option of using a PSHA methodology or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis in determining the DE, or using the standardized DE described by an appropriate response spectrum anchored at 0.25 g (subject to the conditions in proposed § 72.103(a)(1)), or using the existing design criteria for the most recent NPP (if applicable); and

(4) The proposed changes regarding the use of a PSHA methodology or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis in determining the DE are not applicable to a general licensee at an existing NPP operating an ISFSI under a Part 72 general license anywhere in the U.S.

Option 4 would also maintain the present Part 72 requirement of using a single DE for defining ISFSI SSC seismic design criteria, but with a lower ground motion that is commensurate with the level of risk associated with ISFSIs. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications. Seismic design criteria for Part 72, when originally issued in 1980, were based on the nuclear plant requirements, and require a DE with a mean annual probability of exceedance of approximately 1.0E-04. Part 72 regulations classify ISFSI facility systems, structures, and components (SSCs) based on their importance to safety. SSCs, whose function is to protect the public health and safety from undue risk, and prevent damage to the spent fuel during handling and storage, are classified as important to safety. These SSCs are evaluated for a single level of DE as an accident condition event only (§ 72.106). For normal operations and anticipated occurrences (§ 72.104), earthquake events are not included.

In the Statements of Consideration accompanying the initial Part 72 Rulemaking, the Commission recognized that the design peak horizontal acceleration for SSCs need not be as high as for a nuclear power reactor, and should be determined on a "case-by-case" basis until "more experience is gained with licensing of these types of units." With over 10 years of experience licensing dry cask storage, and analyses demonstrating robust behavior of DCSSs in accident scenarios, NRC staff now have a reasonable basis to consider a different design value that is adequate for licensing dry cask storage ISFSIs.

The DCSSs for ISFSI applications are typically self-contained massive concrete or steel structures, weighing approximately 40 to 100 tons when fully loaded. There are very few, if any, moving parts. They are set on a concrete support pad. Several limitations have been set on the maximum height to which the casks can be lifted, based on the drop accident analysis. There is a minimum center-to-center spacing requirement for casks stored in an array on a common support pad. The most conservative estimates of structural thresholds of seismic inertia deceleration due to a drop accident event, before the confinement is breached so as to exceed the permissible radiation levels, is in the range of 30 g to 40 g.

3.2 Dynamic Loads and Soil Stability

Changes to § 72.212(b)(2)(i)(B) are also needed to communicate that general licensees must evaluate both static and dynamic loads for designing new ISFSIs after the effective date of the rule to ensure that casks are not placed in an unanalyzed condition. The change would state that the design of cask storage pads and areas must adequately account for dynamic loads (in addition to static loads). For example, dynamic effects can cause soil-structure interactions that could amplify ground motion to the point that the acceleration on the casks is greater than the design earthquake acceleration, or that soil liquefaction could cause unacceptable pad and foundation settlement. Evaluation of dynamic loads for cask pads and areas would ensure that the pad, which may be considered as failed in a seismic event, could continue to support the casks without placing them in an unanalyzed condition.

4.0 Environmental Consequences

Overall, no adverse environmental impacts will result from any of the options identified. Dry storage casks used at ISFSI's are passive systems with natural cooling sufficient to maintain safe temperatures and a robustness or structural integrity to withstand external forces. The cask walls provide adequate shielding and no radioactive products are released under normal and credible conditions. Other systems, structures, and components would also be designed to standards affording a high degree of environmental protection under normal and credible conditions.

4.1 Environmental Consequences of Option 1: No-Action

The no-action alternative would not result in any change to current seismic design criteria, nor would it affect the DE definition for ISFSI SSCs. No environmental impacts are expected under the current regulation. This conclusion is based on the finding of no significant impact prepared for the previous Part 72 rulemaking (45 FR 74693, November 12, 1980) and NRC's years of experience with licensing ISFSIs.

4.2 Environmental Consequences of Option 2: Require New Part 72 Specific License Applicants to Conform to § 100.23 in lieu of Appendix A to Part 100

No adverse environmental impacts are expected under Option 2. Under this option, certain specific license applicants would be required to address uncertainties in seismic hazard analysis by using a PSHA or suitable sensitivity analyses in determining the DE for ISFSIs. This option would require the same site investigation and characterization as under current rules, and would retain the requirement that the DE for the ISFSI be at least as stringent as the SSE for a NPP. The use of a PSHA or suitable sensitivity analyses for addressing uncertainties in seismic hazard analysis for determining the DE for ISFSIs would be more risk-informed than the deterministic approach. Under this option, all ISFSIs would still meet the radiological protections standards in 10 CFR 72.104(a) and 72.106(b), and thus the degree of protection of the environment and public health is maintained.

4.3 Environmental Consequences of Option 3:

(1) Require New Part 72 Specific License Applicants to Conform to § 100.23 in lieu of Appendix A to Part 100

(2) Provide new Part 72 applicants the option to use a graded approach to seismic design for ISFSI SSCs.

No adverse environmental impacts are expected under Option 3. As under Option 2, use of a PSHA or suitable sensitivity analyses to address uncertainties in seismic hazard analysis for determining the DE for an ISFSI would be protective. Under the graded approach to developing design criteria for ISFSIs, the DE for SSCs important to safety would still be the SSE for a NPP. For these SSCs, there is therefore no change in risk of radiological exposure. SSCs could be designed to withstand Frequency Category 1 events (the less stringent criteria) only if the applicant's analysis provides reasonable assurance that the failure of the SSC would not cause the facility to exceed the radiological protection requirements of § 72.104(a) under normal operations. If the specific license applicant's analysis cannot support this conclusion, the SSC would have to be designed such that the facility can withstand Frequency Category 2 events without impairing the ISFSI's capability to perform safety functions and not exceed the radiological protection requirements of § 72.106(b). Thus, no additional risk to the environment and public would be incurred.

4.4 Environmental Consequences of Option 4:

(1) Require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with a nuclear power plant, to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. All other new specific license applicants for dry cask storage facilities would have the option of complying with the proposed requirement to use a PSHA or other suitable sensitivity analyses to address uncertainties in seismic hazard analysis, or other options compatible with the existing regulation.

(2) Maintain the present Part 72 requirement of using a single-level DE, but with a lower DE that is commensurate with the level of risk associated with an ISFSI. The draft regulatory guide, DG-3021, accompanying this proposed rule, recommends a DE with a mean annual probability of exceedance of 5.0E-04, which is lower than the current level for the SSE of a NPP, for ISFSI applications.

This option is similar to Options 2 and 3 in that it requires certain specific license applicants to address uncertainties in the seismic hazard analysis by using appropriate analyses, such as a PSHA or other suitable sensitivity analyses, for determining the DE. Thus, there would be no adverse effect associated with that aspect of this option. Option 4 also maintains the current single design event for ISFSI SSCs, however, specific licensees would not be required to design any SSCs to withstand a DE as high as the SSE of a NPP. The draft regulatory guide accompanying this proposed rule recommends a DE with a mean annual probability of exceedance of 5.0E-04, for ISFSI applications. NRC staff believe that the use of the less severe design event for all SSCs provides an adequate level of protection from adverse environmental consequences. The general rationale for this finding includes the following considerations:

The present DE (equivalent to the SSE for a NPP) has a mean annual probability of exceedance of approximately 1.0E-04. In comparison with a nuclear power plant, an operating ISFSI is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI does not have the variety and complexity of active systems necessary to support an operating NPP. Further, the robust cask design required for non-seismic considerations (e.g., drop event, shielding), assure low probabilities of failure from seismic events.

In the unlikely occurrence of a radiological release as a result of a seismic event, the radiological consequences to workers and the public are significantly lower in comparison to a NPP. This is because the conditions required for release and dispersal of significant quantities of radioactive material, such as high temperatures or pressures, are not present in an ISFSI. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than one year of decay before storage in an ISFSI, and to the low inventory of volatile radioactive materials readily available for release to the environment. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI is less than the risk associated with a NPP and the use of a lower DE is appropriate.

The Commission indicated in the Statement of Considerations accompanying the initial Part 72 rulemaking that “[f]or ISFSI’s which do not involve massive structures, such as dry storage casks and canisters, the required DE will be determined on a case-by-case basis until more experience is gained with the licensing of these types of units.” [45 FR 74697 (1980)]. With more than 10 years of experience licensing dry cask storage systems, together with analyses demonstrating their robust behavior in accident scenarios involving earthquakes, the NRC staff concludes that designing ISFSI SSCs using a single-level DE that is commensurate with the level of risk associated with an ISFSI, is sufficient to provide reasonable assurance in demonstrating public health and safety.

The NRC staff’s findings with regard to protectiveness include:

- The critical element for protection against radiation release is the sealed cask containing the spent fuel assemblies. The standards in Part 72 Subparts E - Siting Evaluation Factors and F - General Design Criteria, ensure that the dry storage cask designs are very rugged and robust, and are expected to have substantial design margins to withstand forces from a seismic event greater than the DE.

- During a seismic event at an ISFSI, a cask may slide if lateral seismic forces are greater than the frictional resistance between the cask and the concrete pad. The sliding and resulting displacements are computed by the applicant to demonstrate that the casks, which are spaced to satisfy the thermal criteria in Part 72 Subpart F, are precluded from impacting other adjacent casks. Furthermore, the NRC staff guidance in reviewing cask designs is to show that casks are designed to prevent sliding or tip over during a seismic event. However, even if the casks slide or tip over and then impact other casks or the pad during a seismic event significantly greater than the proposed DE, analyses have shown that there are adequate design margins to ensure that the casks maintain their structural integrity.

- Because the DE is a smooth broad-band spectrum, which envelops the controlling earthquake responses, the vibratory ground motion specified is conservative.

- The combined probability of the occurrence of a seismic event and operational failure that leads to a radiological release is much smaller than the individual probabilities of either of these events. This is because the handling building and crane are used for only a fraction of the licensed period of an ISFSI and for only a few casks at a time. Therefore, the risk of a potential release of radioactivity due to failure of the cask handling building and/or crane during a seismic event is small.

- The crane used for lifting the casks in the building is designed using the same industry codes as for a nuclear power plant (ACI 349, AISC N690, ANSI N14.6, and NUREG-0612), and has a safety factor of five (5) or greater for lifted loads using the ultimate strength of the materials. Therefore, the crane would perform satisfactorily for an earthquake much larger than the DE.

- The determination of a DE for ISFSIs is consistent with the design approach used in DOE Standard DOE-STD-1020, “Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities,” for similar type facilities.

In addition, none of the proposed changes will significantly affect the construction or operation of an ISFSI facility and therefore, there is no increased risk to the environment associated with this option.

4.5 Environmental Consequences of Considering Dynamic Loads

NRC would change § 72.212(b)(2)(i)(B) to require written evaluations, prior to use, establishing that cask storage pads and areas have been evaluated for the static and dynamic loads of the stored casks. No adverse environmental impacts are expected to result from the proposed change to evaluate dynamic as well as static loads in the design of ISFSI storage pads and areas. The proposed changes are intended to require that general licensees perform appropriate analyses to ensure that the seismic design bases for the casks are met and that casks are not placed in an unanalyzed condition. Therefore, these proposed changes are necessary to assure adequate protection to occupational and public health and safety. The proposed changes to § 72.212 would not actually impose new burden on the general licensees because they currently need to consider dynamic loads to meet the requirements in § 72.212(b)(2)(i)(A). Since the general licensees currently evaluate dynamic loads for evaluating the cask pads and areas, the proposed changes to § 72.212(b)(2)(i)(B) would not actually require any present general licensees operating an ISFSI to re-perform any written evaluations previously undertaken.

4.6 Summary

The purpose of the options under consideration is to enable ISFSI applicants to incorporate state-of-the-art improvements in the geosciences and engineering and require a risk-informed regulation, while maintaining protection against radiological risks. As discussed in sections 3 and 4, NRC staff has concluded that neither the options to use a PSHA or suitable sensitivity analyses to address uncertainties in seismic hazard analysis for determining the DE for ISFSIs, nor the recommendation to reduce the mean annual probability of exceedance for the DE will adversely affect the safety of ISFSI designs. Dry storage casks used at an ISFSI are passive systems with natural cooling sufficient to maintain safe temperatures and a robustness or structural integrity to withstand external forces. The cask walls provide adequate shielding and no radioactive products are released under any credible accident conditions. Other SSCs will also be designed to standards affording a high degree of environmental protection under normal operations and credible accident conditions. In addition, none of the proposed changes will significantly affect the construction or operation of an ISFSI facility.

Under all the options under consideration, ISFSIs will still be able to meet the radiological protection standards of §§72.104(a) and 106(b). Thus, there will be no adverse environmental impacts from the proposed rule changes, no matter which option is chosen.

5.0 Finding of No Significant Impact

Based on the foregoing draft environmental assessment, the Commission has determined under the National Environmental Policy Act of 1969, as amended, and the Commission's regulations in Subpart A of 10 CFR Part 51, not to prepare an environmental impact statement for this proposed rule because the Commission has concluded, based on an Environmental Assessment, that this proposed rule, if adopted, would not be a major Federal action significantly affecting the quality of the human environment.

The Commission concluded that no significant environmental impact would result from this rulemaking. In comparison with a NPP, an operating ISFSI or MRS is a passive facility in which the primary activities are waste receipt, handling, and storage. An ISFSI or MRS does not have the variety and complexity of active systems necessary to support an operating NPP. Once the spent fuel is in place, an ISFSI or MRS is essentially a static operation and, during normal operations, the conditions required for the release and dispersal of significant quantities of radioactive materials are not present. There are no high temperatures or pressures present during normal operations or under design basis accident conditions to cause the release and dispersal of radioactive materials. This is primarily due to the low heat generation rate of spent fuel after it has decayed for more than one year before storage in an ISFSI or MRS and the low inventory of volatile radioactive materials readily available for release to the environs. The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. The short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel stored at an ISFSI or MRS. Furthermore, even if the short-lived nuclides were present during an event of a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the seismically induced radiological risk associated with an ISFSI or MRS is less than the risk associated with a NPP.

The determination of this environmental assessment is that there will be no significant environmental impact due to the proposed changes because the same level of safety would be maintained by the new requirements, taking into account the lesser risk from an ISFSI or MRS. However, the general public should note that the NRC welcomes public participation. Comments on any aspect of the Environmental Assessment may be submitted to: Secretary, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, Attention: Rulemaking and Adjudications Staff.

Deliver comments to 11555 Rockville Pike, Rockville, Maryland, between 7:30 a.m. and 4:15 p.m. on Federal workdays.

You may also provide electronic comments via the NRC's interactive rulemaking website at (http://ruleforum.llnl.gov). This site provides the capability to upload comments as files (any format), if your web browser supports that function. For information about the interactive rulemaking website, contact Ms. Carol Gallagher at (301) 415-5905, or e-mail cag@nrc.gov.

The NRC has sent a copy of the Environmental Assessment and this proposed rule to every State Liaison Officer and requested their comments on the Environmental Assessment. The Environmental Assessment may be examined at the NRC Public Document Room, O-1F21,11555 Rockville Pike, Rockville, MD. Single copies of the Environmental Assessment are available from Keith K. McDaniel, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001, telephone: (301) 415-5252, e-mail: kkm@nrc.gov.

6.0 Agencies and Persons Consulted

No other agencies or persons were consulted in the preparation of this draft environmental assessment.

Note: State regulatory agencies and members of the public will have an opportunity to comment on the draft EA when it is published in the *Federal Register*.

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH

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Division 3
DG-3021

DRAFT REGULATORY GUIDE

Contact: M. Shah (301)415-8537

PREPUBLICATION

DRAFT REGULATORY GUIDE DG-3021

SITE EVALUATIONS AND DETERMINATION OF DESIGN EARTHQUAKE GROUND MOTION FOR SEISMIC DESIGN OF INDEPENDENT SPENT FUEL STORAGE INSTALLATIONS AND MONITORED RETRIEVABLE STORAGE INSTALLATIONS

A. INTRODUCTION

The NRC has recently published proposed amendments to 10 CFR Part 72, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste.” The Proposed Section 72.103, “Geological and Seismological Characteristics for Applications for Dry Modes of Storage on or after [insert effective date of Final Rule],” in paragraph (f)(1), would require that the geological, seismological, and engineering characteristics of a site and its environs be investigated in sufficient scope and detail to permit an adequate evaluation of the proposed site. The investigation must provide sufficient information to support evaluations performed to arrive at estimates of the design earthquake ground motion (DE) and to permit adequate engineering solutions to actual or potential geologic and seismic effects at the proposed site. In the Proposed Section 72.103, paragraph (f)(2) would require that the geologic and seismic siting factors considered for design include a determination of the DE for the site, the potential for surface tectonic and nontectonic deformations, the design bases for seismically induced floods and water waves, and other design conditions. In the Proposed Section 72.103, Paragraph (f)(2)(i) would require that uncertainties inherent in estimates of the DE be addressed through an appropriate analysis, such as a probabilistic seismic hazard analysis (PSHA) or suitable sensitivity analyses.

This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received complete staff review or approval and does not represent an official NRC staff position.

Public comments are being solicited on this draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. Comments may be submitted electronically or downloaded through the NRC’s interactive web site at <WWW.NRC.GOV> through Rulemaking. Copies of comments received may be examined at the NRC Public Document Room, 11555 Rockville Pike, Rockville, MD. Comments will be most helpful if received by

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This guide is being developed to provide general guidance on procedures acceptable to the NRC staff for (1) conducting a detailed evaluation of site area geology and foundation stability, (2) conducting investigations to identify and characterize uncertainty in seismic sources in the site region important for the PSHA, (3) evaluating and characterizing uncertainty in the parameters of seismic sources, (4) conducting PSHA for the site, and (5) determining the DE to satisfy the requirements of 10 CFR Part 72.

This guide contains several appendices that address the objectives stated above. Appendix A contains definitions of pertinent terms. Appendix B describes the rationale used to determine the reference probability for the DE exceedance level that is acceptable to the staff. Appendix C discusses determination of the probabilistic ground motion level and controlling earthquakes and the development of a seismic hazard information base, Appendix D discusses site-specific geological, seismological, and geophysical investigations. Appendix E describes a method to confirm the adequacy of existing seismic sources and source parameters as the basis for determining the DE for a site. Appendix F describes procedures for determination of the DE.

This guide applies to the design basis of both dry cask storage Independent Spent Fuel Storage Installations (ISFSIs) and U.S. Department of Energy monitored retrievable storage installations (MRS), because these facilities are similar in design. The reference probability in Regulatory Position 3.4 and Appendix B does not apply to wet storage because of the greater consequences associated with the potential accident scenarios for these facilities. This is because wet storage requires active systems, such as systems to remove heat and maintain adequate water levels. These active systems have a higher probability of failure than the passive systems used in dry modes of storage, thus resulting in a greater seismic risk for wet modes of storage.

This guide is consistent with Regulatory Guide 1.165 (Ref. 1), but it has been modified to reflect ISFSI and MRS applications, experience in the use of the dry cask storage methodology, and advancements in the state of knowledge in ground motion modeling (for example, see NUREG/CR-6728 (Ref. 2)).

Regulatory guides are issued to describe and make available to the public such information as methods acceptable to the NRC staff for implementing specific parts of the NRC's regulations, techniques used by the staff in evaluating specific problems or postulated accidents, and guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required. Regulatory guides are issued in draft form for public comment to involve the public in the early stages of developing the regulatory positions. Draft regulatory guides have not received complete staff review and do not represent official NRC staff positions.

The information collections contained in this draft regulatory guide are covered by the requirements of 10 CFR Part 72, which were approved by the Office of Management and Budget (OMB), approval number 3150-0132. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

B. DISCUSSION

BACKGROUND

A PSHA has been identified in the proposed Section 72.103 as a means to determine the DE for seismic design of an ISFSI or MRS facility. The proposed rule further recognizes that the nature of uncertainty and the appropriate approach to account for it depends on the tectonic environment of the site and on properly characterizing parameters input to the PSHA, such as seismic sources, the recurrence of earthquakes within a seismic source, the maximum magnitude of earthquakes within a seismic source, engineering estimation of earthquake ground motion, and the level of understanding of the tectonics. Therefore, methods other than probabilistic methods such as sensitivity analyses may be adequate to account for uncertainties.

Every site and storage facility is unique, and therefore requirements for analysis and investigations vary. It is not possible to provide procedures for addressing all situations. In cases that are not specifically addressed in this guide, prudent and sound engineering judgment should be exercised.

PSHA methodology and procedures were developed during the past 20 to 25 years specifically for evaluation of seismic safety of nuclear facilities. Significant experience has been gained by applying this methodology at nuclear facility sites, both reactor and non-reactor sites, throughout the United States. The Western United States (WUS) (west of approximately 104^{o} west longitude) and the Central and Eastern United States (CEUS) (Refs. 3, 4) have fundamentally different tectonic environments and histories of tectonic deformation. Results of the PSHA methodology applications identified the need to vary the fundamental PSHA methodology application depending on the tectonic environment of a site. The experience with these applications also served as the basis for the Senior Seismic Hazard Analysis Committee guidelines for conducting a PSHA for nuclear facilities (Ref. 5).

APPROACH

The general process to determine the DE at a new ISFSI or MRS site includes:

1. Site- and region-specific geological, seismological, geophysical, and geotechnical investigations, and

2. A PSHA.

For ISFSI sites that are co-located with existing nuclear power generating stations, the level of effort will depend on the availability and quality of existing evaluations. In performing this evaluation, the applicant should evaluate whether new data require re-evaluation of previously accepted seismic sources and potential adverse impact on the existing seismic design bases of the nuclear power plant.

CENTRAL AND EASTERN UNITED STATES

The CEUS is considered to be that part of the United States east of the Rocky Mountain front, or east of longitude 104^{o} west (Refs. 6, 7). To determine the DE in the CEUS, an accepted PSHA methodology with a range of credible alternative input interpretations should be used. For sites in the CEUS, the seismic hazard methods, the data developed, and seismic sources identified by Lawrence Livermore National Laboratory (LLNL) (Refs. 3, 4, 6) and the Electric Power Research Institute (EPRI) (Ref. 7) have been reviewed and are acceptable to the staff. The LLNL and EPRI studies developed data bases and scientific interpretations of available information and determined seismic sources and source characterizations for the CEUS (e.g., earthquake occurrence rates, estimates of maximum magnitude).

In the CEUS, characterization of seismic sources is more problematic than in the active plate-margin region because there is generally no clear association between seismicity and known tectonic structures or near-surface geology. In general, the observed geologic structures were generated in response to tectonic forces that no longer exist and have little or no correlation with current tectonic forces. Therefore, it is important to account for this uncertainty by the use of multiple alternative models.

The identification of seismic sources and reasonable alternatives in the CEUS considers hypotheses presently advocated for the occurrence of earthquakes in the CEUS (e.g., the reactivation of favorably oriented zones of weakness or the local amplification and release of stresses concentrated around a geologic structure). In tectonically active areas of the CEUS, such as the New Madrid Seismic Zone, where geological, seismological, and geophysical evidence suggest the nature of the sources that generate the earthquakes, it may be more appropriate to evaluate those seismic sources by using procedures similar to those normally applied in the WUS.

WESTERN UNITED STATES

The WUS is considered to be that part of the United States that lies west of the Rocky Mountain front, or west of approximately 104^{o} west longitude. For the WUS, an information base of earth science data and scientific interpretations of seismic sources and source characterizations (e.g., geometry, seismicity parameters) comparable to the CEUS as documented in the LLNL and EPRI studies (Refs. 3, 4, 6-8) does not exist. For this region, specific interpretations on a site-by-site basis should be applied (Ref. 9, 10).

The active plate-margin regions include, for example, coastal California, Oregon, Washington, and Alaska. For the active plate-margin regions, where earthquakes can often be correlated with known tectonic structures, structures should be assessed for their earthquake and surface deformation potential. In these regions, at least three types of sources may exist: (1) faults that are known to be at or near the surface, (2) buried (blind) sources that may often be manifested as folds at the earth's surface, and (3) subduction zone sources, such as those in the Pacific Northwest. The nature of surface faults can be evaluated by conventional surface and near-surface investigation techniques to assess orientation, geometry, sense of displacements, length of rupture, quaternary history, etc.

Buried (blind) faults are often associated with surficial deformation such as folding, uplift, or subsidence. The surface expression of blind faulting can be detected by mapping the uplifted or down-dropped geomorphological features or stratigraphy, survey leveling, and geodetic methods. The nature of the structure at depth can often be evaluated by deep core borings and geophysical techniques.

Continental U.S. subduction zones are located in the Pacific Northwest and Alaska. Seismic sources associated with subduction zones are sources within the overriding plate, on the interface between the subducting and overriding lithospheric plates, and in the interior of the downgoing oceanic slab. The characterization of subduction zone seismic sources includes consideration of the three-dimensional geometry of the subducting plate, rupture segmentation of subduction zones, geometry of historical ruptures, constraints on the up-dip and down-dip extent of rupture, and comparisons with other subduction zones worldwide.

The Basin and Range region of the WUS, and to a lesser extent the Pacific Northwest and the Central United States, exhibit temporal clustering of earthquakes. Temporal clustering is best exemplified by the rupture histories within the Wasatch fault zone in Utah and the Meers fault in central Oklahoma, where several large late Holocene coseismic faulting events occurred at relatively close intervals (hundreds to thousands of years) that were preceded by long periods of quiescence that lasted thousands to tens of thousands of years. Temporal clustering should be considered in these regions or wherever paleoseismic evidence indicates that it has occurred.

C. REGULATORY POSITION

1. GEOLOGICAL, GEOPHYSICAL, SEISMOLOGICAL, AND GEOTECHNICAL INVESTIGATIONS

1.1 Comprehensive geological, seismological, geophysical, and geotechnical investigations of the site area and region should be performed. For ISFSIs co-located with existing nuclear power plants, the existing technical information should be used along with all other available information to plan and determine the scope of additional investigations. The investigations described in this regulatory guide are performed primarily to gather data pertinent to the safe design and construction of the ISFSI or MRS. Appropriate geological, seismological, and geophysical investigations are described in Appendix D to this guide. Geotechnical investigations are described in Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" (Ref. 11), and NUREG/CR-5738 (Ref. 12). Another important purpose for the site-specific investigations is to determine whether there are any new data or interpretations that are not adequately incorporated into the existing PSHA data bases. Appendix E describes a method for evaluating new information derived from the site-specific investigations in the context of the PSHA.

Investigations should be performed at four levels, with the degree of detail based on distance from the site, the nature of the Quaternary tectonic regime, the geological complexity of the site and region, the existence of potential seismic sources, the potential for surface deformation, etc. A more detailed discussion of the areas and levels of investigations and the bases for them are presented in Appendix D to this regulatory guide. General guidelines for the levels of investigation are as follows.

1.1.1 Regional geological and seismological investigations are not expected to be extensive nor in great detail, but should include literature reviews, the study of maps and remote sensing data, and, if necessary, ground truth reconnaissances conducted within a radius of 320 km (200 miles) of the site to identify seismic sources (seismogenic and capable tectonic sources).

1.1.2 Geological, seismological, and geophysical investigations should be carried out within a radius of 40 km (25 miles) in greater detail than the regional investigations to identify and characterize the seismic and surface deformation potential of any capable tectonic sources and the seismic potential of seismogenic sources, or to demonstrate that such structures are not present. Sites with capable tectonic or seismogenic sources within a radius of 40 km (25 miles) may require more extensive geological and seismological investigations and analyses (similar in detail to investigations and analysis usually preferred within an 8-km (5-mile) radius).

1.1.3 Detailed geologic, seismological, geophysical, and geotechnical investigations should be conducted within a radius of 8 km (5 miles) of the site, as appropriate, to evaluate the potential for tectonic deformation at or near the ground surface and to assess the transmission characteristics of soils and rocks in the site vicinity. Sites in the CEUS where geologically young or recent tectonic activity is not present may be investigated in less detail. Methods for evaluating the seismogenic potential of tectonic structures and geological features developed in Reference 13 should be followed.

1.1.4 Very detailed geological, geophysical, and geotechnical engineering investigations should be conducted within the site [radius of approximately 1 km (0.5 miles)] to assess specific soil and rock characteristics as described in Reference 11, updated with NUREG/CR-5738 (Ref. 12).

1.2 The areas of investigation may be expanded beyond those specified above in regions that include capable tectonic sources, relatively high seismicity, or complex geology, or in regions that have experienced a large, geologically recent earthquake.

1.3 Data sufficient to clearly justify all assumptions and conclusions should be presented. Because engineering solutions cannot always be satisfactorily demonstrated for the effects of permanent ground displacement, it is prudent to avoid a site that has a potential for surface or near-surface deformation. Such sites normally will require extensive additional investigations.

1.4 For the site and for the area surrounding the site, lithologic, stratigraphic, hydrologic, and structural geologic conditions should be characterized. The investigations should include the measurement of the static and dynamic engineering properties of the materials underlying the site and an evaluation of the physical evidence concerning the behavior during prior earthquakes of the surficial materials and the substrata underlying the site. The properties needed to assess the behavior of the underlying material during earthquakes, including the potential for liquefaction, and the characteristics of the underlying material in transmitting earthquake ground motions to the foundations of the facility (such as seismic wave velocities, density, water content, porosity, elastic moduli, and strength) should be measured.

2. SEISMIC SOURCES SIGNIFICANT TO THE SITE SEISMIC HAZARD

2.1 For sites in the CEUS, when the EPRI or LLNL probabilistic seismic hazard analysis methodologies and data bases are used to determine the design earthquake, it still may be necessary to investigate and characterize potential seismic sources that were unknown or uncharacterized and to perform sensitivity analyses to assess their significance to the seismic hazard estimate. The results of the investigation discussed in Regulatory Position 1 should be used, in accordance with Appendix E, to determine whether the LLNL or EPRI seismic sources and their characterization should be updated. The guidance in Regulatory Positions 2.2 and 2.3 below and in Appendix D of this guide may be used if additional seismic sources are to be developed as a result of investigations.

2.2 When the LLNL or EPRI methods are not used or are not applicable, the guidance in Regulatory Position 2.3 should be used for identification and characterization of seismic sources. The uncertainties in the characterization of seismic sources should be addressed as appropriate. Seismic sources is a general term referring to both seismogenic sources and capable tectonic sources. The main distinction between these two types of seismic sources is that a seismogenic source would not cause surface displacement, but a capable tectonic source causes surface or near-surface displacement.

Identification and characterization of seismic sources should be based on regional and site geological and geophysical data, historical and instrumental seismicity data, the regional stress field, and geological evidence of prehistoric earthquakes. Investigations to identify seismic sources are described in Appendix D. The bases for the identification of seismic sources should be identified. A general list of characteristics to be evaluated for seismic sources is presented in Appendix D.

2.3 As part of the seismic source characterization, the seismic potential for each source should be evaluated. Typically, characterization of the seismic potential consists of four equally important elements:

1. Selection of a model for the spatial distribution of earthquakes in a source.

2. Selection of a model for the temporal distribution of earthquakes in a source.

3. Selection of a model for the relative frequency of earthquakes of various magnitudes, including an estimate for the largest earthquake that could occur in the source under the current tectonic regime.

4. A complete description of the uncertainty.

For example, in the LLNL study a truncated exponential model was used for the distribution of magnitudes given that an earthquake has occurred in a source. A stationary Poisson process is used to model the spatial and temporal occurrences of earthquakes in a source.

For a general discussion of evaluating the earthquake potential and characterizing the uncertainty, refer to Reference 5.

2.3.1 For sites in the CEUS, when the LLNL or EPRI method is not used or not applicable (such as in the New Madrid, MO; Charleston, SC; Attica, NY, Seismic Zones), it is necessary to evaluate the seismic potential for each source. The seismic sources and data that have been accepted by the NRC in past licensing decisions may be used, along with the data gathered from the investigations carried out as described in Regulatory Position 1.

Generally, the seismic sources for the CEUS are area sources because there is uncertainty about the underlying causes of earthquakes. This uncertainty is due to a lack of active surface faulting, a low rate of seismic activity, or a short historical record. The assessment of earthquake recurrence for CEUS area sources commonly relies heavily on catalogs of observed seismicity. Because these catalogs are incomplete and cover a relatively short period of time, it is difficult to obtain reliable estimates of the rate of activity. Considerable care must be taken to correct for incompleteness and to model the uncertainty in the rate of earthquake recurrence. To completely characterize the seismic potential for a source, it is also necessary to estimate the largest earthquake magnitude that a seismic source is capable of generating under the current tectonic regime. This estimated magnitude defines the upper bound of the earthquake recurrence relationship.

The assessment of earthquake potential for area sources is particularly difficult because one of the physical constraints most important to the assessment, the dimensions of the fault rupture, is not known. As a result, the primary methods for assessing maximum earthquakes for area sources usually include a consideration of the historical seismicity record, the pattern and rate of seismic activity, the Quaternary (2 million years and younger) characteristics of the source, the current stress regime (and how it aligns with known tectonic structures), paleoseismic data, and analogs to sources in other regions considered tectonically similar to the CEUS. Because of the shortness of the historical catalog and low rate of seismic activity, considerable judgment is needed. It is important to characterize the large uncertainties in the assessment of the earthquake potential.

2.3.2 For sites located within the WUS, earthquakes can often be associated with known tectonic structures. For faults, the earthquake potential is related to the characteristics of the estimated future rupture, such as the total rupture area, the length, or the amount of fault displacement. The following empirical relations can be used to estimate the earthquake potential from fault behavior data and also to estimate the amount of displacement that might be expected for a given magnitude. It is prudent to use several of the following different relations to obtain an estimate of the earthquake magnitude.

- Surface rupture length versus magnitude (Refs. 14-17),
- Subsurface rupture length versus magnitude (Ref. 18),
- Rupture area versus magnitude (Ref. 19),
- Maximum and average displacement versus magnitude (Ref. 18), and
- Slip rate versus magnitude (Ref. 20).

When such correlations as in References 14-20 are used, the earthquake potential is often evaluated as the mean of the distribution. The difficult issue is the evaluation of the appropriate rupture dimension to be used. This is a judgmental process based on geological data for the fault in question and the behavior of other regional fault systems of the same type.

In addition to maximum magnitude, the other elements of the recurrence model are generally obtained using catalogs of seismicity, fault slip rate, and other data. In some cases, it may be appropriate to use recurrence models with memory. All the sources of uncertainty must be appropriately modeled. Additionally, the phenomenon of temporal clustering should be considered when there is geological evidence of its past occurrence.

2.3.3 For sites near subduction zones, such as in the Pacific Northwest and Alaska, the maximum magnitude must be assessed for subduction zone seismic sources. Worldwide observations indicate that the largest known earthquakes are associated with the plate interface, although intraslab earthquakes may also have large magnitudes. The assessment of plate interface earthquakes can be based on estimates of the expected dimensions of rupture or analogies to other subduction zones worldwide.

3. PROBABILISTIC SEISMIC HAZARD ANALYSIS PROCEDURES

A PSHA should be performed for the site as it allows the use of multiple models to estimate the likelihood of earthquake ground motions occurring at a site and systematically takes into account uncertainties that exist in various parameters (such as seismic sources, maximum earthquakes, and ground motion attenuation). Alternative hypotheses are considered in a quantitative fashion in a PSHA. Alternative hypotheses can also be used to evaluate the sensitivity of the hazard to the uncertainties in the significant parameters and to identify the relative contribution of each seismic source to the hazard.

The following steps describe a procedure that is acceptable to the NRC staff for performing a PSHA.

3.1 Perform regional and site geological, seismological, and geophysical investigations in accordance with Regulatory Position 1 and Appendix D.

3.2 For CEUS sites, perform an evaluation of LLNL or EPRI seismic sources in accordance with Appendix E to determine whether they are consistent with the site-specific data gathered in Regulatory Position 1 or require updating. The PSHA should only be updated if the new information indicates that the current version significantly underestimates the hazard and there is a strong technical basis that supports such a revision. It may be possible to justify a lower hazard estimate with an exceptionally strong technical basis. However, it is expected that large uncertainties in estimating seismic hazard in the CEUS will continue to exist in the future, and substantial delays in the licensing process will result in trying to justify a lower value with respect to a specific site. For these reasons the NRC staff discourages efforts to justify a lower hazard estimate. In most cases, limited-scope sensitivity studies should be sufficient to demonstrate that the existing data base in the PSHA envelops the findings from site-specific investigations. In general, significant revisions to the LLNL and EPRI data base are to be undertaken only periodically (every 10 years), or when there is an important new finding or occurrence. An overall revision of the data base would also require a reexamination of the acceptability of the reference probability discussed in Appendix B and used in Regulatory Position 4 below. Any significant update should follow the guidance of Reference 5.

3.3 For CEUS sites only, perform the LLNL or EPRI PSHA using original or updated sources as determined in Regulatory Position 2. For sites in WUS, perform a site-specific PSHA (Ref. 5). The ground motion estimates should be made for rock conditions in the free-field or by assuming hypothetical rock conditions for a non-rock site to develop the seismic hazard information base discussed in Appendix C.

3.4 Using the mean reference probability (5E-4/yr) described in Appendix B, determine the 5 percent of critically damped mean spectral ground motion levels for 1 Hz ($S_{a,1}$) and 10 Hz ($S_{a,10}$) (Ref. 2). The use of an alternative reference probability will be reviewed and accepted on a case-by-case basis.

3.5 Deaggregate the mean probabilistic hazard characterization in accordance with Appendix C to determine the controlling earthquakes (i.e., magnitudes and distances), and document the hazard information base, as described in Appendix C.

3.6 As an alternative method, instead of the controlling earthquakes approach described in Appendix C and Regulatory Position 4 below, determine the ground motions at a sufficient number of frequencies significant to the ISFSI or MRS design, and then envelope the ground motions to determine the DE.

4. PROCEDURES FOR DETERMINING THE DESIGN EARTHQUAKE GROUND MOTION

After completing the PSHA (see Regulatory Position 3) and determining the controlling earthquakes, the following procedures should be used to determine the DE. Appendix F contains an additional discussion of some of the characteristics of the DE.

4.1 With the controlling earthquakes determined as described in Regulatory Position 3 and by using the procedures in Revision 3 of Reference 21 (which may include the use of ground motion models not included in the PSHA but that are more appropriate for the source, region, and site under consideration or that represent the latest scientific development), develop 5 percent of critical damping response spectral shapes for the actual or assumed rock conditions. The same controlling earthquakes are also used to derive vertical response spectral shapes.

4.2 Use $S_{a,10}$ to scale the response spectrum shape corresponding to the controlling earthquake. If there is a controlling earthquake for $S_{a,1}$, determine that the $S_{a,10}$ scaled response spectrum also envelopes the ground motion spectrum for the controlling earthquake for $S_{a,1}$. Otherwise, modify the shape to envelope the low-frequency spectrum or use two spectra in the following steps. For a rock site, go to Regulatory Position 4.4.

4.3 For non-rock sites, perform a site-specific soil amplification analysis considering uncertainties in site-specific geotechnical properties and parameters to determine response spectra at the free ground surface in the free-field for the actual site conditions. Procedures described in Appendix D of this guide and Reference 21 can be used to perform soil-amplification analyses.

4.4 Compare the smooth DE spectrum or spectra used in design at the free-field with the spectrum or spectra determined in Regulatory Position 2 for rock sites or determined in Regulatory Position 3 for the non-rock sites to assess the adequacy of the DE spectrum or spectra.

4.5 To obtain an adequate DE based on the site-specific response spectrum or spectra, develop a smooth spectrum or spectra or use a standard broad band shape that envelopes the spectra of Regulatory Position 2 or 3.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff’s plans for using this draft regulatory guide.

This draft guide has been released to encourage public participation in its development. Except in those cases in which an applicant or licensee proposes an acceptable alternative method for complying with the specified portions of the NRC’s regulations, the methods to be described in the active guide reflecting public comments will be used in the evaluation of applications for new dry cask ISFSI and MRS facilities.

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[1] Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161; (telephone (703)487-4650; <http://www.ntis.gov/ordernow>. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email is PDR@NRC.GOV.

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APPENDIX A
DEFINITIONS

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[3] Requests for single copies of draft or active regulatory guides (which may be reproduced) or for placement on an automatic distribution list for single copies of future draft guides in specific divisions should be made in writing to the U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Reproduction and Distribution Services Section, or by fax to (301)415-2289; email <DISTRIBUTION@NRC.GOV>. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike (first floor), Rockville, MD; the PDR’s mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or 1-(800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>.

Capable Tectonic Source — A capable tectonic source is a tectonic structure that can generate both vibratory ground motion and tectonic surface deformation such as faulting or folding at or near the earth's surface in the present seismotectonic regime. It is described by at least one of the following characteristics:

a. Presence of surface or near-surface deformation of landforms or geologic deposits of a recurring nature within the last approximately 500,000 years or at least once in the last approximately 50,000 years.

b. A reasonable association with one or more moderate to large earthquakes or sustained earthquake activity, usually accompanied by significant surface deformation.

c. A structural association with a capable tectonic source that has characteristics of either a or b above such that movement on one could be reasonably expected to be accompanied by movement on the other.

In some cases, the geological evidence of past activity at or near the ground surface along a potential capable tectonic source may be obscured at a particular site. This might occur, for example, at a site having a deep overburden. For these cases, evidence may exist elsewhere along the structure from which an evaluation of its characteristics in the vicinity of the site can be reasonably based. Such evidence is to be used in determining whether the structure is a capable tectonic source within this definition.

Notwithstanding the foregoing paragraphs, the association of a structure with geological structures that are at least pre-Quaternary, such as many of those found in the Central and Eastern regions of the United States, in the absence of conflicting evidence, will demonstrate that the structure is not a capable tectonic source within this definition.

Controlling Earthquakes — Controlling earthquakes are the earthquakes used to determine spectral shapes or to estimate ground motions at the site. There may be several controlling earthquakes for a site. As a result of the probabilistic seismic hazard analysis (PSHA), controlling earthquakes are characterized as mean magnitudes and distances derived from a deaggregation analysis of the mean estimate of the PSHA.

Design Earthquake Ground Motion (DE) — The DE is the vibratory ground motion for which certain structures, systems, and components, classified as important to safety, are designed, pursuant to Part 72. The DE for the site is characterized by both horizontal and vertical free-field ground motion response spectra at the free ground surface.

Earthquake Recurrence — Earthquake recurrence is the frequency of occurrence of earthquakes having various magnitudes. Recurrence relationships or curves are developed for each seismic source, and they reflect the frequency of occurrence (usually expressed on an annual basis) of magnitudes up to the maximum, including measures of uncertainty.

Intensity — The intensity of an earthquake is a qualitative description of the effects of the earthquake at a particular location, as evidenced by observed effects on humans, on human-built structures, and on the earth's surface at a particular location. Commonly used scales to specify intensity are the Rossi-Forel, Mercalli, and Modified Mercalli. The Modified Mercalli Intensity (MMI) scale describes intensities with values ranging from I to XII in the order of severity. MMI of I indicates an event that was not felt except by a very few, while MMI of XII indicates total damage of all works of construction, either partially or completely.

Magnitude — An earthquake's magnitude is a measure of the strength of an earthquake as determined from seismographic observations and is an objective, quantitative measure of the size of an earthquake. The magnitude is expressed in various ways based on the seismograph record, e.g., Richter Local Magnitude, Surface Wave Magnitude, Body Wave Magnitude, and Moment Magnitude. The most commonly used magnitude measurement is the Moment Magnitude, M_w , which is based on the seismic moment computed as the rupture force along the fault multiplied by the average amount of slip, and thus is a direct measure of the energy released during an earthquake event. The Moment Magnitude of an earthquake event (M_w or M) varies from 2.0 and higher values, and since magnitude scales are logarithmic, a unit change in magnitude corresponds to a 32-fold change in the energy released during an earthquake event.

Maximum Magnitude — The maximum magnitude is the upper bound to recurrence curves.

Mean Annual Probability of Exceedance — Mean annual probability of exceedance of an earthquake event of a given magnitude or an acceleration level is the probability that the given magnitude or acceleration level may exceed in a year. The mean annual probability of exceedance of an earthquake event is a reciprocal of the return period of the event.

Nontectonic Deformation — Nontectonic deformation is distortion of surface or near-surface soils or rocks that is not directly attributable to tectonic activity. Such deformation includes features associated with subsidence, karst terrain, glaciation or deglaciation, and growth faulting.

Reference Probability – The reference probability of occurrence of an earthquake event is the mean annual probability of exceeding the design earthquake.

Response Spectrum — A plot of the maximum values of responses (acceleration, velocity, or displacement) of a family of idealized single-degree-of-freedom damped oscillators as a function of its natural frequencies (or periods) to a specified vibratory motion input at their supports.

Return Period — The return period of an earthquake event is an inverse of the mean annual probability of exceedance of the earthquake event.

Safe Shutdown Earthquake (SSE) — The SSE is the vibratory ground motion for which certain structures, systems, and components in a nuclear power plant are designed, pursuant to Appendix S to 10 CFR Part 50, to remain functional. The SSE for the site is characterized by both horizontal and vertical free-field ground motion response spectra at the free ground surface.

Seismic Potential — A model giving a complete description of the future earthquake activity in a seismic source zone. The model includes a relation giving the frequency (rate) of earthquakes of any magnitude, an estimate of the largest earthquake that could occur under the current tectonic regime, and a complete description of the uncertainty. A typical model used for PSHA is the use of a truncated exponential model for the magnitude distribution and a stationary Poisson process for the temporal and spatial occurrence of earthquakes.

Seismic Source — Seismic source is a general term referring to both seismogenic sources and capable tectonic sources.

Seismogenic Source — A seismogenic source is a portion of the earth that is assumed to have a uniform earthquake potential (same expected maximum earthquake and recurrence frequency), distinct from the seismicity of the surrounding regions. A seismogenic source will generate vibratory ground motion but is assumed not to cause surface displacement.

Seismogenic sources cover a wide range of possibilities, from a well-defined tectonic structure to simply a large region of diffuse seismicity (seismotectonic province) thought to be characterized by the same earthquake recurrence model. A seismogenic source is also characterized by its involvement in the current tectonic regime (the Quaternary, or approximately the last 2 million years).

Stable Continental Region (SCR) — A stable continental region is composed of continental crust, including continental shelves, slopes, and attenuated continental crust, and excludes active plate boundaries and zones of currently active tectonics directly influenced by plate margin processes. It exhibits no significant deformation associated with the major Mesozoic-to-Cenozoic (last 240 million years) orogenic belts. It excludes major zones of Neogene (last 25 million years) rifting, volcanism, or suturing.

Stationary Poisson Process — A probabilistic model of the occurrence of an event over time (or space) that has the following characteristics: (1) the occurrence of the event in small intervals is constant over time (or space), (2) the occurrence of two (or more) events in a small interval is negligible, and (3) the occurrence of the event in non-overlapping intervals is independent.

Tectonic Structure — A tectonic structure is a large-scale dislocation or distortion, usually within the earth's crust. Its extent may be on the order of tens of meters (yards) to hundreds of kilometers (miles).

APPENDIX B
REFERENCE PROBABILITY FOR THE EXCEEDANCE LEVEL OF THE DESIGN EARTHQUAKE GROUND MOTION

B.1 INTRODUCTION

This appendix provides a rationale for a reference probability that is acceptable to the NRC staff. The reference probability is used in conjunction with the probabilistic seismic hazard analysis (PSHA) for determining the Design Earthquake Ground Motion (DE) for ISFSI or MRS designs.

B.2 QUESTION ON REFERENCE PROBABILITY FOR DESIGN EARTHQUAKE

The reference probability is the mean annual probability of exceeding the DE. It is the reciprocal of the return period for the design earthquake.

The NRC staff welcomes comments on all aspects of this draft regulatory guide, but is especially interested in receiving comments on the appropriate mean annual probability of exceedance value to be used for the seismic design of an ISFSI or MRS. Please note the following considerations and include a justification for the appropriate mean annual probability of exceedance value.

The present mean annual probability of exceedance value for determining the DE for an ISFSI or MRS is approximately 1.0E-04 (i.e., in any one year, the probability is 1 in 10,000, which is the reciprocal of 1.0E-04, that the DE established for the site will be exceeded). This value is based on requirements for nuclear plants. The NRC is considering allowing for the use of a mean annual probability of exceedance value in the range of 5.0E-04 (i.e., in any one year, the probability is 1 in 2,000 that the DE established for the site will be exceeded) to 1.0E-04 for ISFSI or MRS applications. This Draft Regulatory Guide DG-3021, “Site Evaluations and Determination of Design Earthquake Ground Motion for Seismic Design of Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations,” is being developed to provide guidelines that are acceptable to the NRC staff for determining the DE for an ISFSI or MRS. DG-3021 proposes to recommend a mean annual probability of exceedance value of 5.0E-04 as an appropriate risk-informed value for the design of a dry storage ISFSI or MRS. However, the NRC staff is undertaking further analysis to support a specific value. An ISFSI or MRS license applicant would have to demonstrate that the use of a higher probability of exceedance value would not impose any undue radiological risk to public health and safety. In view of this discussion, the NRC staff is requesting comments on the appropriate mean annual probability of exceedance value to be used for the seismic design of an ISFSI or MRS and a justification for this probability.

B.3 RATIONALE FOR THE REFERENCE PROBABILITY

The following describes the rationale for determining the reference probability for use in the PSHA for a dry cask storage system (DCSS) during a seismic event. The mean reference probability of exceedance of 5.0E-4/yr for a seismic event is considered appropriate for the design of a DCSS. The use of a higher reference probability will be reviewed and accepted on a case-by-case basis.

B.3.1 Part 72 Approach

Part 72 regulations classify the structures, systems, and components (SSC) in an ISFSI or MRS facility based on their importance to safety. SSCs are classified as important to safety if they have the function of protecting public health and safety from undue risk and preventing damage to the spent fuel during handling and storage. These SSCs are evaluated for a single level of DE as an accident condition event only (section 72.106). For normal operations and anticipated occurrences (section 72.104), earthquake events are not included.

The DCSSs for ISFSIs or MRSs are typically self-contained massive concrete or steel structures, weighing approximately 40 to 100 tons when fully loaded. There are very few, if any, moving parts. They are set on a concrete support pad. Several limitations have been set on the maximum height to which the casks can be lifted, based on the drop accident analysis. There is a minimum center-to-center spacing requirement for casks stored in an array on a common support pad. The most conservative estimates of structural thresholds of seismic inertia deceleration from a drop accident event, before the confinement is breached so as to exceed the permissible radiation levels, is in the range of 30 g to 40 g.

B.3.2 Reference Probability

The present DE is based on the requirements contained in 10 CFR Part 100 for nuclear power plants. In the Statement of Considerations accompanying the initial Part 72 rulemaking, the NRC recognized that the design peak horizontal acceleration for structures, systems, and components (SSCs) need not be as high as for a nuclear power reactor and should be determined on a “case-by-case” basis until “more experience is gained with licensing of these types of units” (45 FR 74697; November 12, 1980). With over 10 years of experience in licensing dry cask storage and with analyses that demonstrate robust behavior of dry cask storage systems (DCSSs) in accident scenarios (10 specific licenses have been issued and 9 locations use the general license provisions), the NRC now has a reasonable basis to consider lower and more appropriate DE parameters for a dry cask ISFSI or MRS. Therefore, the NRC proposes to reduce the DE for new ISFSI or MRS license applicants to be commensurate with the lower risk associated with these facilities. Factors that result in lower radiological risk at an ISFSI or MRS compared to a nuclear power plant include the following:

- In comparison with a nuclear power plant, an operating ISFSI or MRS is a relatively simple facility in which the primary activities are waste receipt, handling, and storage. An ISFSI or MRS does not have the variety and complexity of active systems necessary to support an operating nuclear power plant. After the spent fuel is in place, an ISFSI or MRS is essentially a static operation.

- During normal operations, the conditions required for the release and dispersal of significant quantities of radioactive materials are not present. There are no high temperatures or pressures present during normal operations or under design basis accident conditions to cause the release and dispersal of radioactive materials. This is primarily due to the low heat-generation rate of spent fuel that has undergone more than 1 year of decay before storage in an ISFSI or MRS, and to the low inventory of volatile radioactive materials readily available for release to the environment.

- The long-lived nuclides present in spent fuel are tightly bound in the fuel materials and are not readily dispersible. Short-lived volatile nuclides, such as I-131, are no longer present in aged spent fuel. Furthermore, even if the short-lived nuclides were present during a fuel assembly rupture, the canister surrounding the fuel assemblies would confine these nuclides. Therefore, the Commission believes that the seismically induced radiological risk associated with an ISFSI or MRS is significantly less than the risk associated with a nuclear power plant. Also, it is NRC policy to use risk-informed regulation as appropriate.

! The critical element for protection against radiation release is the sealed cask containing the spent fuel assemblies. The standards in Part 72 in Subparts E, “Siting Evaluation Factors,” and F, ”General Design Criteria,” ensure that the dry cask storage designs are very rugged and robust. The casks must maintain structural integrity during a variety of postulated non-seismic events, including cask drops, tip-overs, and wind-driven missile impacts. These non-seismic events challenge cask integrity significantly more than seismic events. Therefore, the casks are expected to have substantial design margins to withstand forces from a seismic event greater than the design earthquake.

! During a seismic event at an ISFSI or MRS, a cask may slide if lateral seismic forces are greater than the frictional resistance between the cask and the concrete pad. The sliding and resulting displacements are computed by the applicant to demonstrate that the casks, which are spaced to satisfy the thermal criteria in Subpart F of Part 72, are precluded from impacting other adjacent casks. Furthermore, the NRC staff guidance in reviewing cask designs is to show that public health and safety is maintained during a postulated DE. This can be demonstrated by showing that either casks are designed to prevent sliding or tip over during a seismic event, or the consequences of the calculated cask movements are acceptable. Even if the casks slide or tip over and then impact other casks or the pad during a seismic event significantly greater than the proposed DE, there are adequate design margins to ensure that the casks maintain their structural integrity.

! The combined probability of the occurrence of a seismic event and operational failure that leads to a radiological release is much smaller than the individual probabilities of either of these events. This is because the handling building and crane are used for only a fraction of the licensed period of an ISFSI or MRS and for only a few casks at a time. Additionally, dry cask ISFSIs are expected to handle only sealed casks and not individual fuel assemblies. Therefore, the potential risk of a release of radioactivity caused by failure of the cask handling or crane during a seismic event is small.

Additional factors for reducing the DE for new ISFSI or MRS license applicants include:

! Because the DE is a smooth broad-band spectrum that envelops the controlling earthquake responses, the vibratory ground motion specified is conservative.

1. The crane used for lifting the casks in the building is designed using the same industry codes as for a nuclear power plant, and has a safety factor of 5 or greater for lifted loads using the ultimate strength of the materials. Therefore, the crane would perform satisfactorily during an earthquake much larger than the design earthquake.

2. The determination of a DE for an ISFSI or MRS is consistent with the design approach used in DOE Standard DOE-STD-1020, “Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities,”[1] for similar type facilities.

Based on the preceding analysis, the NRC staff concludes that there is a reasonable basis to design ISFSI or MRS SSCs for a single design earthquake, using a mean annual probability of exceedance 5.0E-04, and adequately protect public health and safety.

[1] U.S. Department of Energy, “Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities, DOE-STD-1020-2002, January 2002. Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161; (telephone (703)487-4650; <http://www.ntis.gov/ordernow>. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR’s mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email is PDR@NRC.GOV.

APPENDIX C
DETERMINATION OF CONTROLLING EARTHQUAKES AND DEVELOPMENT OF SEISMIC HAZARD INFORMATION BASE

C.1 INTRODUCTION

This appendix elaborates on the steps described in Regulatory Position 3 of this regulatory guide to determine the controlling earthquakes used to define the Design Earthquake Ground Motion (DE) at the site and to develop a seismic hazard information base. The information base summarizes the contribution of individual magnitude and distance ranges to the seismic hazard and the magnitude and distance values of the controlling earthquakes at 1 and 10 Hz. The controlling earthquakes are developed for the ground motion level corresponding to the reference probability as defined in Appendix B to this regulatory guide.

The spectral ground motion levels, as determined from a probabilistic seismic hazard analysis (PSHA), are used to scale a response spectrum shape. A site-specific response spectrum shape is determined for the controlling earthquakes and local site conditions. Regulatory Position 4 and Appendix F to this regulatory guide describe a procedure to determine the DE using the controlling earthquakes and results from the PSHA.

C.2 PROCEDURE TO DETERMINE CONTROLLING EARTHQUAKES

The following approach is acceptable to the NRC staff for determining the controlling earthquakes and developing a seismic hazard information base. This procedure is based on a de-aggregation of the probabilistic seismic hazard in terms of earthquake magnitudes and distances. When the controlling earthquakes have been obtained, the DE response spectrum can be determined according to the procedure described in Appendix F to this regulatory guide.

Step 2-1

Perform a site-specific PSHA using the Lawrence Livermore National Laboratory (LLNL) or Electric Power Research Institute (EPRI) methodologies (Refs. 1-3) for CEUS sites or perform a site-specific PSHA for sites not in the CEUS or for sites for which LLNL or EPRI methods and data are not applicable, for actual or assumed rock conditions. The hazard assessment (mean, median, 85th percentile, and 15th percentile) should be performed for spectral accelerations at 1, Hz, 10 Hz, and the peak ground acceleration. A lower-bound earthquake moment magnitude, M, of 5.0 is recommended.

Step 2-2

Using the reference probability (5E-4/yr) as defined in Appendix B to this regulatory guide, determine the ground motion levels for the spectral accelerations at 1 and 10 Hz from the total mean hazard obtained in Step 2-1.

Step 2-3

Perform a complete PSHA for each of the magnitude-distance bins illustrated in Table C.1. (These magnitude-distance bins are to be used in conjunction with the LLNL or EPRI methods. For other situations, other binning schemes may be necessary.)

Table C.1 Recommended Magnitude and Distance Bins

	Moment Magnitude Range of Bins				
Distance Range of Bin (km)	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	>7
0 - 15					
15 - 25					
25 - 50					
50 - 100					
100 - 200					
200 - 300					
>300					

Step 2-4

From the de-aggregated results of Step 2-3, the mean annual probability of exceeding the ground motion levels of Step 2-2 (spectral accelerations at 1 and 10 Hz) are determined for each magnitude-distance bin. These values are denoted by H_{mdf1} for 1 Hz, and H_{mdf10} for 10 Hz.

Using H_{mdf} values, the fractional contribution of each magnitude and distance bin to the total hazard for the 1 Hz, $P(m,d)_1$, is computed according to:

$$P(m,d)_1 = H_{mdf1}/(\sum_m \sum_d H_{mdf1}) \qquad \text{(Equation 1)}$$

The fractional contribution of each magnitude and distance bin to the total hazard for the 10 Hz, $P(m,d)_{10}$, is computed according to:

$$P(m,d)_{10} = H_{mdf10}/(\sum_m \sum_d H_{mdf10}) \qquad \text{(Equation 2)}$$

Step 2-5

Review the magnitude-distance distribution for the 1 Hz frequency to determine whether the contribution to the hazard for distances of 100 km (63 mi) or greater is substantial (on the order of 5 percent or greater).

If the contribution to the hazard for distances of 100 km (63 mi) or greater exceeds 5 percent, additional calculations are needed to determine the controlling earthquakes using the magnitude-distance distribution for distances greater than 100 km (63 mi). This distribution, $P{>}100(m,d)_1$, is defined by:

$$P{>}100(m,d)_1 = P(m,d)_1 / \sum_m \sum_{d>100} P(m,d)_1 \qquad \text{(Equation 3)}$$

The purpose of this calculation is to identify a distant, larger event that may control low-frequency content of a response spectrum.

The distance of 100 km (63 mi) is chosen for CEUS sites. However, for all sites the results of full magnitude-distance distribution should be carefully examined to ensure that proper controlling earthquakes are clearly identified.

Step 2-6

Calculate the mean magnitude and distance of the controlling earthquake associated with the ground motions determined in Step 2 for the 10 Hz frequency. The following relation is used to calculate the mean magnitude using results of the entire magnitude-distance bins matrix:

$$M_c = \sum_d m \sum_m P(m, d)_{10} \qquad \text{(Equation 4)}$$

where m is the central magnitude value for each magnitude bin.

The mean distance of the controlling earthquake is determined using results of the entire magnitude-distance bins matrix:

$$\text{Ln}\ \{ Dc\ (10\ \text{Hz})\} = \sum_d \text{Ln}\ (d) \sum_m P(m, d)_{10} \qquad \text{(Equation 5)}$$

where d is the centroid distance value for each distance bin.

Step 2-7

If the contribution to the hazard calculated in Step 2-5 for distances of 100 km (63 mi) or greater exceeds 5 percent for the 1 Hz frequency, calculate the mean magnitude and distance of the controlling earthquakes associated with the ground motions determined in Step 2-2 for the average of 1 Hz. The following relation is used to calculate the mean magnitude using calculations based on magnitude-distance bins greater than distances of 100 km (63 mi) as discussed in Step 2-5:

$$Mc\ (1\text{Hz}) = \sum_m m \sum_{d>100} P > 100\ (m, d)_1 \qquad \text{(Equation 6)}$$

where m is the central magnitude value for each magnitude bin.

The mean distance of the controlling earthquake is based on magnitude-distance bins greater than distances of 100 km as discussed in Step 2-5 and determined according to:

$$\text{Ln}\ \{ Dc\ (1\ \text{Hz})\} = \sum_{d>100} \text{Ln}\ (d) \sum_m P(m, d)_{10} \qquad \text{(Equation 7)}$$

where d is the centroid distance value for each distance bin.

Step 2-8

Determine the DE response spectrum using the procedure described in Appendix F of this regulatory guide.

C.3 EXAMPLE FOR A CEUS SITE

To illustrate the procedure in Section C.2, calculations are shown here for a CEUS site using the 1993 LLNL hazard results (Refs. C.1, C.2). It must be emphasized that the recommended magnitude and distance bins and procedure used to establish controlling earthquakes were developed for application in the CEUS where the nearby earthquakes generally control the response in the 10 Hz frequency range, and larger but distant events can control the lower frequency range. For other situations, alternative binning schemes as well as a study of contributions from various bins will be necessary to identify controlling earthquakes consistent with the distribution of the seismicity.

Step 3-1

The 1993 LLNL seismic hazard methodology (Refs. C.1, C.2) was used to determine the hazard at the site. A lower bound earthquake moment magnitude, M, of 5.0 was used in this analysis. The analysis was performed for spectral acceleration at 1 and 10 Hz. The resultant hazard curves are plotted in Figure C.1.

Step 3-2

The hazard curves at 1 and 10 Hz obtained in Step 1 are assessed at the reference probability value of 5E-4/yr, as defined in Appendix B to this regulatory guide. The corresponding ground motion level values are given in Table C.2. See Figure C.1.

Table C.2 Ground Motion Levels

Frequency (Hz)	1	10
Spectral Acc. (cm/s/s)	88	551

Step 3-3

The mean seismic hazard is de-aggregated for the matrix of magnitude and distance bins as given in Table C.1.

A complete probabilistic hazard analysis was performed for each bin to determine the contribution to the hazard from all earthquakes within the bin, i.e., all earthquakes with earthquake moment magnitudes greater than 5.0 and distance from 0 km to greater than 300 km. See Figure C.2 where the mean 1 Hz hazard curve is plotted for distance bin 25 - 50 km and magnitude bin 6 - 6.5.

The hazard values corresponding to the ground motion levels, found in Step 2-2, and listed in Table C.2, are then determined from the hazard curve for each bin for spectral accelerations at 1 Hz and 10 Hz. This process is illustrated in Figure C.2. The vertical line corresponds to the value 88 cm/s/s listed in Table C.2 for the 1 Hz hazard curve and intersects the hazard curve for the 25 - 50 km distance bin, 6 - 6.5 magnitude bin, at a hazard value (probability of exceedance) of 1.07E-06 per year. Tables C.3 and C.4 list the appropriate hazard value for each bin for 1 Hz and 10 Hz frequencies respectively. It should be noted that if the mean hazard in each of the 35 bins is added up it equals the reference probability of 5.0E-04.

Table C.3 Mean Exceeding Probability Values for Spectral Accelerations at 1 Hz (88 cm/s/s)

	Moment Magnitude Range of Bins				
Distance Range of Bin (km)	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	>7
0 - 15	9.68E-06	4.61E-05	0.0	0.0	0.0
15 - 25	0.0	1.26E-05	0.0	0.0	0.0
25 - 50	0.0	1.49E-05	1.05E-05	0.0	0.0
50 - 100	0.0	7.48E-06	3.65E-05	1.24E-05	0.0
100 - 200	0.0	1.15E-06	4.17E-05	2.98E-04	0.0
200 - 300	0.0	0.0	0.0	8.99E-06	0.0
> 300	0.0	0.0	0.0	0.0	0.0

Table C.4 Mean Exceeding Probability Values for Spectral Accelerations at 10 Hz (551 cm/s/s)

	Moment Magnitude Range of Bins				
Distance Range of Bin (km)	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	>7
0 - 15	1.68E-04	1.44E-04	2.39E-05	0.0	0.0
15 - 25	2.68E-05	4.87E-05	4.02E-06	0.0	0.0
25 - 50	5.30E-06	3.04E-05	2.65E-05	0.0	0.0
50 - 100	0.0	2.96E-06	8.84E-06	3.50E-06	0.0
100 - 200	0.0	0.0	0.0	7.08E-06	0.0
200 - 300	0.0	0.0	0.0	0.0	0.0
> 300	0.0	0.0	0.0	0.0	0.0

Note: The values of probabilities ≤1.0E-07 are shown as 0.0 in Tables C.3 and C.4.

Step 3-4

Using de-aggregated mean hazard results, the fractional contribution of each magnitude-distance pair to the total hazard is determined. Tables C.5 and C.6 show $P(m,d)_1$ and $P(m,d)_{10}$ for the 1 Hz and 10 Hz, respectively.

Step 3-5

Because the contribution of the distance bins greater than 100 km in Table C.5 contains more than 5 percent of the total hazard for 1 Hz, the controlling earthquake for the 1 Hz frequency will be calculated using magnitude-distance bins for distance greater than 100 km. Table C.7 shows $P{>}100\ (m,d)_1$ for the 1 Hz frequency.

Table C.5 P(m,d)$_1$ for Spectral Accelerations at 1 Hz Corresponding to the Reference Probability

	Moment Magnitude Range of Bins				
Distance Range of Bin (km)	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	>7
0 - 15	0.019	0.092	0.0	0.0	0.0
15 - 25	0.0	0.025	0.0	0.0	0.0
25 - 50	0.0	0.030	0.021	0.0	0.0
50 - 100	0.0	0.015	0.073	0.025	0.0
100 - 200	0.0	0.002	0.083	0.596	0.0
200 - 300	0.0	0.0	0.0	0.018	0.0
> 300	0.0	0.0	0.0	0.0	0.0

Figures C.3 to C.5 show the above information in terms of the relative percentage contribution.

Table C.6 P(m,d)$_{10}$ for Spectral Accelerations at 10 Hz Corresponding to the Reference Probability

	Moment Magnitude Range of Bins				
Distance Range of Bin (km)	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	>7
0 - 15	0.336	0.288	0.048	0.0	0.0
15 - 25	0.054	0.097	0.008	0.0	0.0
25 - 50	0.011	0.061	0.053	0.0	0.0
50 - 100	0.0	0.059	0.018	0.007	0.0
100 - 200	0.0	0.0	0.0	0.014	0.0
200 - 300	0.0	0.0	0.0	0.0	0.0
> 300	0.0	0.0	0.0	0.0	0.0

Table C.7 P>100 (m,d)$_1$ for Spectral Acceleration at 1 Hz Corresponding to the Reference Probability

	Moment Magnitude Range of Bins				
Distance Range of Bin (km)	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	>7
100 - 200	0.0	0.003	0.119	0.852	0.0
200 - 300	0.0	0.0	0.0	0.026	0.0
>300	0.0	0.0	0.0	0.0	0.0

Note: The values of probabilities $\leq$1.0E-07 are shown as 0.0 in Tables C.5, C.6, and C.7.

Steps 3-6 and 3-7

To compute the controlling magnitudes and distances at 1 Hz and 10 Hz for the example site, the values of P>100 (m,d)$_1$ and P(m,d)$_{10}$ are used with m and d values corresponding to the mid-point of the magnitude of the bin (5.25, 5.75, 6.25, 6.75, 7.3) and centroid of the ring area (10, 20.4, 38.9, 77.8, 155.6, 253.3, and somewhat arbitrarily 350 km). Note that the mid-point of the last magnitude bin may change because this value is dependent on the maximum magnitudes used in the hazard analysis. For this example site, the controlling earthquake characteristics (magnitudes and distances) are given in Table C.8.

Step 3-8

The DE response spectrum is determined by the procedures described in Appendix F.

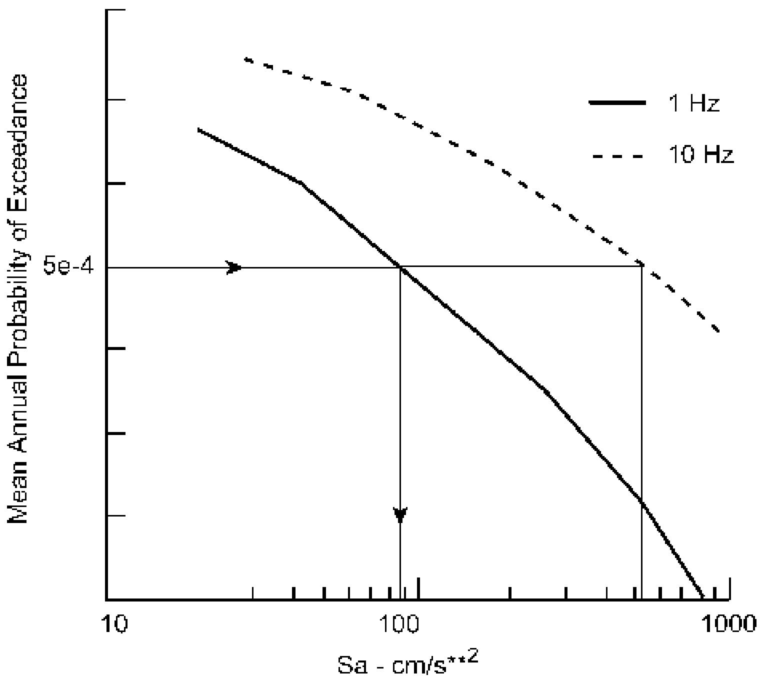

Figure C.1 Total Median Hazard Curves

C.4 SITES NOT IN THE CEUS

The determination of the controlling earthquakes and the seismic hazard information base for sites not in the CEUS is also carried out using the procedure described in Section C.2 of this appendix. However, because of differences in seismicity rates and ground motion attenuation at these sites, alternative magnitude-distance bins may have to be used. An alternative reference probability may also have to be developed, particularly for sites in the active plate margin region and for sites at which a known tectonic structure dominates the hazard.

Table C.8 Magnitudes and Distances of Controlling Earthquakes from the LLNL Probabilistic Analysis

1 Hz	10 Hz
Mc and Dc > 100 km	Mc and Dc
6.7 and 157 km	5.9 and 18 km

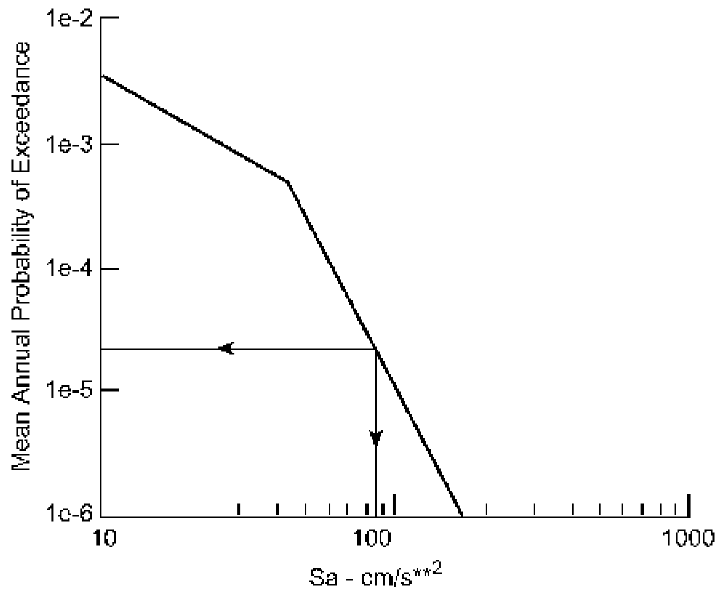

Figure C.2 1 Hz Mean Hazard Curve for Distance Bin 25-50 km and Magnitude Bin 6-6.5

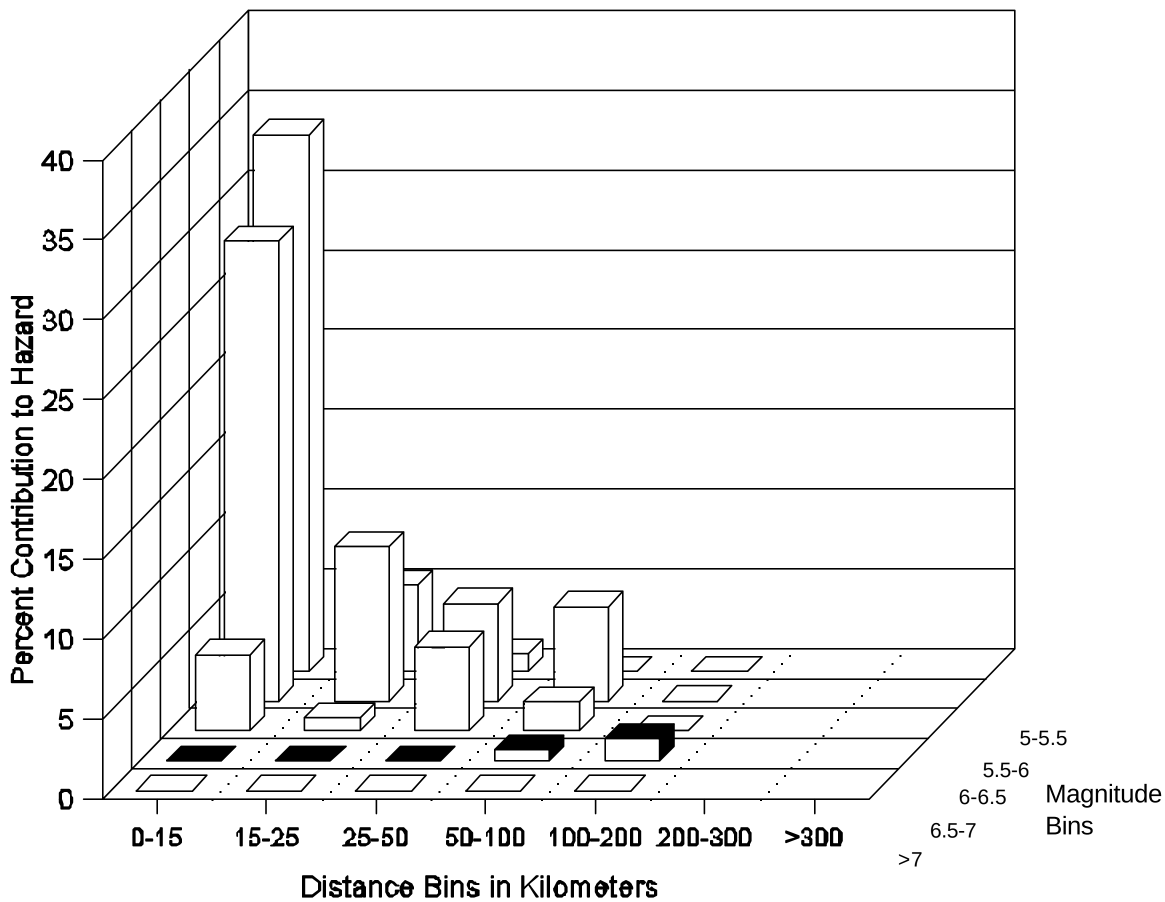

Figure C.3 Full Distribution of Hazard for 10 Hz

Figure C.4 Full Distribution of Hazard for 1 Hz

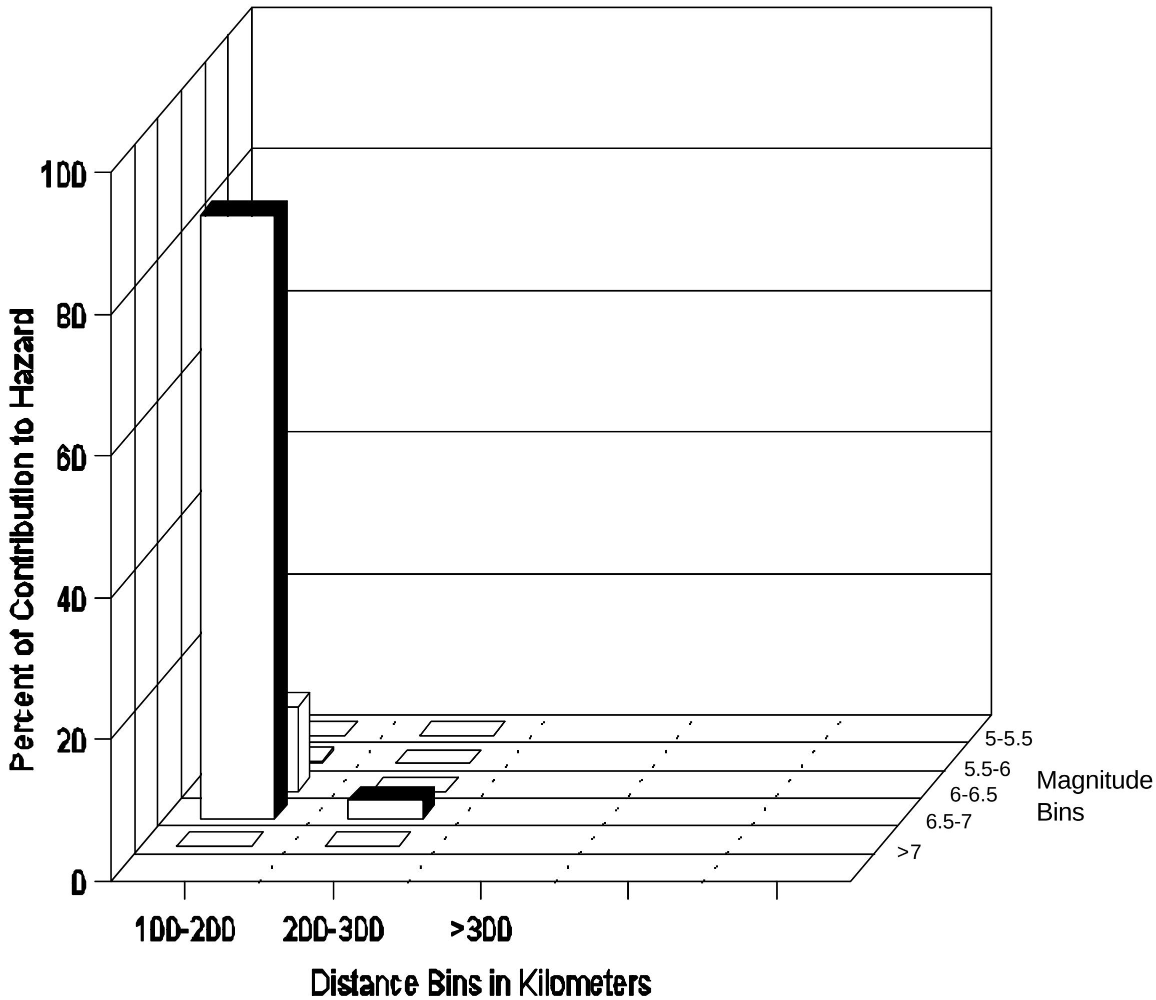

Figure C.5 Renormalized Hazard Distribution for Distances Greater than 100 km for 1 Hz

REFERENCES

C.1 P. Sobel, "Revised Livermore Seismic Hazard Estimates for Sixty-Nine Nuclear Power Plant Sites East of the Rocky Mountains," NUREG-1488, USNRC, April 1994.[1]

C.2 J.B. Savy et al., "Eastern Seismic Hazard Characterization Update," UCRL-ID-115111, Lawrence Livermore National Laboratory, June 1993. (Accession number 9310190318 in NRC's Public Document Room)[2]

C.3 Electric Power Research Institute (EPRI), "Probabilistic Seismic Hazard Evaluations at Nuclear Power Plant Sites in the Central and Eastern United States," NP-4726, All Volumes, 1989-1991.

[1] Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161; <http://www.ntis.gov/ordernow>; telephone (703)487-4650. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email is PDR@NRC.GOV.

[2] Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike (first floor), Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or 1-(800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>.

APPENDIX D
GEOLOGICAL, SEISMOLOGICAL, AND GEOPHYSICAL INVESTIGATIONS TO CHARACTERIZE SEISMIC SOURCES

D.1 INTRODUCTION

As characterized for use in probabilistic seismic hazard analyses (PSHA), seismic sources are zones within which future earthquakes are likely to occur at the same recurrence rates. Geological, seismological, and geophysical investigations provide the information needed to identify and characterize source parameters, such as size and geometry, and to estimate earthquake recurrence rates and maximum magnitudes. The amount of data available about earthquakes and their causative sources varies substantially between the WUS (west of the Rocky Mountain front) and the Central and Eastern United States (CEUS), or stable continental region (SCR) (east of the Rocky Mountain front). Furthermore, there are variations in the amount and quality of data within these regions.

In active tectonic regions there are both capable tectonic sources and seismogenic sources, and because of their relatively high activity rate they may be more readily identified. In the CEUS, identifying seismic sources is less certain because of the difficulty in correlating earthquake activity with known tectonic structures, the lack of adequate knowledge about earthquake causes, and the relatively lower activity rate. However, several significant tectonic structures exist and some of these have been interpreted as potential seismogenic sources (e.g., the New Madrid fault zone, Nemaha Ridge, and Meers fault).

In the CEUS, there is no single recommended procedure to follow to characterize maximum magnitudes associated with such candidate seismogenic sources; therefore, it is most likely that the determination of the properties of the seismogenic source, whether it is a tectonic structure or a seismotectonic province, will be inferred rather than demonstrated by strong correlations with seismicity or geologic data. Moreover, it is not generally known what relationships exist between observed tectonic structures in a seismic source within the CEUS and the current earthquake activity that may be associated with that source. Generally, the observed tectonic structure resulted from ancient tectonic forces that are no longer present. The historical seismicity record, the results of regional and site studies, and judgment play key roles. If, on the other hand, strong correlations and data exist suggesting a relationship between seismicity and seismic sources, approaches used for more active tectonic regions can be applied.

The primary objective of geological, seismological, and geophysical investigations is to develop an up-to-date, site-specific earth science data base that supplements existing information (Ref. D.1). In the CEUS, the results of these investigations will also be used to assess whether new data and their interpretation are consistent with the information used as the basis for accepted probabilistic seismic hazard studies. If the new data are consistent with the existing earth science data base, modification of the hazard analysis is not required. For sites in the CEUS where there is significant new information (see Appendix E) provided by the site investigation, and for sites in the WUS, site-specific seismic sources are to be determined. It is anticipated that for most sites in the CEUS, new information will have been adequately bounded by existing seismic source interpretations.

The following are to be evaluated for a seismic source for site-specific source interpretations:

- Seismic source location and geometry (location and extent, both surface and subsurface). This evaluation will normally require interpretations of available geological, geophysical, and seismological data in the source region by multiple experts or a team of experts. The evaluation should include interpretations of the seismic potential of each source and relationships among seismic sources in the region in order to express uncertainty in the evaluations. Seismic source evaluations generally develop four types of sources: (1) fault-specific sources, (2) area sources representing concentrated historic seismicity not associated with known tectonic structure, (3) area sources representing geographic regions with similar tectonic histories, type of crust, and structural features, and (4) background sources. Background sources are generally used to express uncertainty in the overall seismic source configuration interpreted for the site region. Acceptable approaches for evaluating and characterizing uncertainties for input to a seismic hazard calculation are contained in NUREG/CR-6372 (Ref. D.2).

- Evaluations of earthquake recurrence for each seismic source, including recurrence rate and recurrence model. These evaluations normally draw most heavily on historical and instrumental seismicity associated with each source and paleoearthquake information. Preferred methods and approaches for evaluating and characterizing uncertainty in earthquake recurrence generally will depend on the type of source. Acceptable methods are described in NUREG/CR-6372 (Ref. D.2).

- Evaluations of the maximum earthquake magnitude for each seismic source. These evaluations will draw on a broad range of source-specific tectonic characteristics, including tectonic history and available seismicity data. Uncertainty in this evaluation should normally be expressed as a maximum magnitude distribution. Preferred methods and information for evaluating and characterizing maximum earthquakes for seismic sources vary with the type of source. Acceptable methods are contained in NUREG/CR-6372 (Ref. D.2).

- Other evaluations, depending on the geologic setting of a site, such as local faults that have a history of Quaternary (last 2 million years) displacements, sense of slip on faults, fault length and width, area of faults, age of displacements, estimated displacement per event, estimated earthquake magnitude per offset event, orientations of regional tectonic stresses with respect to faults, and the possibility of seismogenic folds. Capable tectonic sources are not always exposed at the ground surface in the WUS as demonstrated by the buried reverse causative faults of the 1983 Coalinga, 1988 Whittier Narrows, l989 Loma Prieta, and 1994 Northridge earthquakes. These examples emphasize the need to conduct thorough investigations not only at the ground surface but also in the subsurface to identify structures at seismogenic depths. Whenever faults or other structures are encountered at a site (including sites in the CEUS) in either outcrop or excavations, it is necessary to perform adequately detailed specific investigations to determine whether or not they are seismogenic or may cause surface deformation at the site. Acceptable methods for performing these investigations are contained in NUREG/CR-5503 (Ref. D.3).

- Effects of human activities such as withdrawal of fluid from or addition of fluid to the subsurface associated with mining or the construction of dams and reservoirs.

- Volcanic hazard is not addressed in this regulatory guide and will be considered on a case-by-case basis in regions where a potential for this hazard exists. For sites where volcanic hazard is evaluated, earthquake sources associated with volcanism should be evaluated and included in the seismic source interpretations input to the hazard calculation.

D.2. INVESTIGATIONS TO EVALUATE SEISMIC SOURCES

D.2.1 General

Investigations of the site and region around the site are necessary to identify both seismogenic sources and capable tectonic sources and to determine their potential for generating earthquakes and causing surface deformation. If it is determined that surface deformation need not be taken into account at the site, sufficient data to clearly justify the determination should be presented in the application for an early site permit, construction permit, operating license, or combined license. Generally, any tectonic deformation at the earth's surface within 40 km (25 miles) of the site will require detailed examination to determine its significance. Potentially active tectonic deformation within the seismogenic zone beneath a site will have to be assessed using geophysical and seismological methods to determine its significance.

Engineering solutions are generally available to mitigate the potential vibratory effects of earthquakes through design. However, engineering solutions cannot always be demonstrated to be adequate for mitigation of the effects of permanent ground displacement phenomena such as surface faulting or folding, subsidence, or ground collapse. For this reason, it is prudent to select an alternative site when the potential for permanent ground displacement exists at the proposed site (Ref. D.4).

In most of the CEUS, instrumentally located earthquakes seldom bear any relationship to geologic structures exposed at the ground surface. Possible geologically young fault displacements either do not extend to the ground surface or there is insufficient geologic material of the appropriate age available to date the faults. Capable tectonic sources are not always exposed at the ground surface in the WUS, as demonstrated by the buried (blind) reverse causative faults of the 1983 Coalinga, 1988 Whittier Narrows, 1989 Loma Prieta, and 1994 Northridge earthquakes. These factors emphasize the need to conduct thorough investigations not only at the ground surface but also in the subsurface to identify structures at seismogenic depths.

The level of detail for investigations should be governed by knowledge of the current and late Quaternary tectonic regime and the geological complexity of the site and region. The investigations should be based on increasing the amount of detailed information as they proceed from the regional level down to the site area [e.g., 320 km (200 mi) to 8 km (5 mi) distance from the site]. Whenever faults or other structures are encountered at a site (including sites in the CEUS) in either outcrop or excavations, it is necessary to perform many of the investigations described below to determine whether or not they are capable tectonic sources.

The investigations for determining seismic sources should be carried out at three levels, with areas described by radii of 320 km (200 mi), 40 km (25 mi), and 8 km (5 mi) from the site. The level of detail increases closer to the site. The specific site, to a distance of at least 1 km (0.6 mi), should be investigated in more detail than the other levels.

The regional investigations [within a radius of 320 km (200 mi) of the site] should be planned to identify seismic sources and describe the Quaternary tectonic regime. The data should be presented at a scale of 1:500,000 or smaller. The investigations are not expected to be extensive or in detail, but should include a comprehensive literature review supplemented by focused geological reconnaissances based on the results of the literature study (including topographic, geologic, aeromagnetic, and gravity maps and airphotos). Some detailed investigations at specific locations within the region may be necessary if potential capable tectonic sources or seismogenic sources that may be significant for determining the safe shutdown earthquake ground motion are identified.

The large size of the area for the regional investigations is recommended because of the possibility that all significant seismic sources, or alternative configurations, may not have been enveloped by the LLNL/EPRI data base. Thus, it will increase the chances of (1) identifying evidence for unknown seismic sources that might extend close enough for earthquake ground motions generated by that source to affect the site and (2) confirming the PSHA's data base. Furthermore, because of the relatively aseismic nature of the CEUS, the area should be large enough to include as many historical and instrumentally recorded earthquakes for analysis as reasonably possible. The specified area of study is expected to be large enough to incorporate any previously identified sources that could be analogous to sources that may underlie or be relatively close to the site. In past licensing activities for sites in the CEUS, it has often been necessary, because of the absence of datable horizons overlying bedrock, to extend investigations out many tens or hundreds of kilometers from the site along a structure or to an outlying analogous structure in order to locate overlying datable strata or unconformities so that geochronological methods could be applied. This procedure has also been used to estimate the age of an undatable seismic source in the site vicinity by relating its time of last activity to that of a similar, previously evaluated structure, or a known tectonic episode, the evidence of which may be many tens or hundreds of miles away.

In the WUS it is often necessary to extend the investigations to great distances (up to hundreds of kilometers) to characterize a major tectonic structure, such as the San Gregorio-Hosgri Fault Zone and the Juan de Fuca Subduction Zone. On the other hand, in the WUS it is not usually necessary to extend the regional investigations that far in all directions. For example, for a site such as Diablo Canyon, which is near the San Gregorio-Hosgri Fault, it would not be necessary to extend the regional investigations farther east than the dominant San Andreas Fault, which is about 75 km (45 mi) from the site; nor west beyond the Santa Lucia Banks Fault, which is about 45 km (27 mi). Justification for using lesser distances should be provided.

Reconnaissance-level investigations, which may need to be supplemented at specific locations by more detailed explorations such as geologic mapping, geophysical surveying, borings, and trenching, should be conducted to a distance of 40 km (25 mi) from the site; the data should be presented at a scale of 1:50,000 or smaller.

Detailed investigations should be carried out within a radius of 8 km (5 mi) from the site, and the resulting data should be presented at a scale of 1:5,000 or smaller. The level of investigations should be in sufficient detail to delineate the geology and the potential for tectonic deformation at or near the ground surface. The investigations should use the methods described in subsections D.2.2 and D.2.3 that are appropriate for the tectonic regime to characterize seismic sources.

The areas of investigations may be asymmetrical and may cover larger areas than those described above in regions of late Quaternary activity, regions with high rates of historical seismic activity (felt or instrumentally recorded data), or sites that are located near a capable tectonic source such as a fault zone.

Data from investigations at the site (approximately 1 km^2) should be presented at a scale of 1:500 or smaller. Important aspects of the site investigations are the excavation and logging of exploratory trenches and the mapping of the excavations for the plant structures, particularly plant structures that are characterized as Seismic Category I. In addition to geological, geophysical, and seismological investigations, detailed geotechnical engineering investigations, as described in Regulatory Guide 1.132 (Ref. D.5) and NUREG/CR-5738 (Ref. D.6), should be conducted at the site.

The investigations needed to assess the suitability of the site with respect to effects of potential ground motions and surface deformation should include determination of (1) the lithologic, stratigraphic, geomorphic, hydrologic, geotechnical, and structural geologic characteristics of the site and the area surrounding the site, including its seismicity and geological history, (2) geological evidence of fault offset or other distortion such as folding at or near ground surface within the site area (8 km radius), and (3) whether or not any faults or other tectonic structures, any part of which are within a radius of 8 km (5 mi) from the site, are capable tectonic sources. This information will be used to evaluate tectonic structures underlying the site area, whether buried or expressed at the surface, with regard to their potential for generating earthquakes and for causing surface deformation at or near the site. This part of the evaluation should also consider the possible effects caused by human activities such as withdrawal of fluid from or addition of fluid to the subsurface, extraction of minerals, or the loading effects of dams and reservoirs.

D.2.2 Reconnaissance Investigations, Literature Review, and Other Sources of Preliminary Information

Regional literature and reconnaissance-level investigations should be planned based on reviews of available documents and the results of previous investigations. Possible sources of information, in addition to refereed papers published in technical journals, include universities, consulting firms, and government agencies. The following guidance is provided but it is not considered all-inclusive. Some investigations and evaluations will not be applicable to every site, and situations may occur that require investigations that are not included in the following discussion. In addition, it is anticipated that new technologies will be available in the future that will be applicable to these investigations.

D.2.3 Detailed Site Vicinity and Site Area Investigations

The following methods are suggested but they are not all-inclusive and investigations should not be limited to them. Some procedures will not be applicable to every site, and situations will occur that require investigations that are not included in the following discussion. It is anticipated that new technologies will be available in the future that will be applicable to these investigations.

D.2.3.1 Surface Investigations

Surface exploration to assess the geology and geologic structure of the site area is dependent on the site location and may be carried out with the use of any appropriate combination of the geological, geophysical, and seismological techniques summarized in the following paragraphs. However, not all of these methods must be carried out at a given site.

D.2.3.1.1. Geological interpretations should be performed of aerial photographs and other remote-sensing as appropriate for the particular site conditions, to assist in identifying rock outcrops, faults and other tectonic features, fracture traces, geologic contacts, lineaments, soil conditions, and evidence of landslides or soil liquefaction.

D.2.3.1.2. Mapping topographic, geomorphic, and hydrologic features should be performed at scales and with contour intervals suitable for analysis and descriptions of stratigraphy (particularly Quaternary), surface tectonic structures such as fault zones, and Quaternary geomorphic features. For coastal sites or sites located near lakes or rivers, this includes topography, geomorphology (particularly mapping marine and fluvial terraces), bathymetry, geophysics (such as seismic reflection), and hydrographic surveys to the extent needed to describe the site area features.

D.2.3.1.3. Vertical crustal movements should be evaluated using: (1) geodetic land surveying and (2) geological analyses (such as analysis of regional dissection and degradation patterns), marine and lacustrine terraces and shorelines, fluvial adjustments (such as changes in stream longitudinal profiles or terraces), and other long-term changes (such as elevation changes across lava flows).

D.2.3.1.4. Analysis should be performed to determine the tectonic significance of offset, displaced, or anomalous landforms such as displaced stream channels or changes in stream profiles or the upstream migration of knick-points; abrupt changes in fluvial deposits or terraces; changes in paleo-channels across a fault; or uplifted, down-dropped, or laterally displaced marine terraces.

D.2.3.1.5. Analysis should be performed to determine the tectonic significance of Quaternary sedimentary deposits within or near tectonic zones such as fault zones, including (1) fault-related or fault-controlled deposits such as sag ponds, graben fill deposits, and colluvial wedges formed by the erosion of a fault paleo-scarp, and (2) non-fault-related, but offset, deposits such as alluvial fans, debris cones, fluvial terrace, and lake shoreline deposits.

D.2.3.1.6. Identification and analysis should be performed of deformation features caused by vibratory ground motions, including seismically induced liquefaction features (sand boils, explosion craters, lateral spreads, settlement, soil flows), mud volcanoes, landslides, rockfalls, deformed lake deposits or soil horizons, shear zones, cracks or fissures.

D.2.3.1.7. Analysis should be performed of fault displacements, including the interpretation of the morphology of topographic fault scarps associated with or produced by surface rupture. Fault scarp morphology is useful for estimating the age of last displacement (in conjunction with the appropriate geochronological methods described NUREG/CR-5562 (Ref. D.6), approximate magnitude of the associated earthquake, recurrence intervals, slip rate, and the nature of the causative fault at depth.

D.2.3.2 Subsurface Investigations at the Site [within 1 km (0.5 mi)]

Subsurface investigations at the site to identify and describe potential seismogenic sources or capable tectonic sources and to obtain required geotechnical information are described in Regulatory Guide 1.132 (Ref. D.5) and updated in NUREG/CR-5738 (Ref. D.7). The investigations include, but may not be confined to, the following:

D.2.3.2.1. Geophysical investigations that have been useful in the past include magnetic and gravity surveys, seismic reflection and seismic refraction surveys, bore-hole geophysics, electrical surveys, and ground-penetrating radar surveys.

D.2.3.2.2. Core borings to map subsurface geology and obtain samples for testing such as determining the properties of the subsurface soils and rocks and geochronological analysis;

D.2.3.2.3. Excavation and logging of trenches across geological features to obtain samples for the geochronological analysis of those features.

D.2.3.2.4. At some sites, deep unconsolidated material/soil, bodies of water, or other material may obscure geologic evidence of past activity along a tectonic structure. In such cases, the analysis of evidence elsewhere along the structure can be used to evaluate its characteristics in the vicinity of the site.

In the CEUS it may not be possible to reasonably demonstrate the age of youngest activity on a tectonic structure with adequate deterministic certainty. In such cases the uncertainty should be quantified; the NRC staff will accept evaluations using the methods described in NUREG/CR-5503 (Ref. D.3). A demonstrated tectonic association of such structures with geologic structural features or tectonic processes that are geologically old (at least pre-Quaternary) should be acceptable as an age indicator in the absence of conflicting evidence.

D.2.3.3 Surface-Fault Rupture and Associated Deformation at the Site

A site that has a potential for fault rupture at or near the ground surface and associated deformation should be avoided. Where it is determined that surface deformation need not be taken into account, sufficient data or detailed studies to reasonably support the determination should be presented. Requirements for setback distance from active faults for hazardous waste treatment, storage and disposal facilities can be found in U.S. Environmental Protection Agency regulations (40 CFR Part 264).

The presence or absence of Quaternary faulting at the site needs to be evaluated to determine whether there is a potential hazard that is due to surface faulting. The potential for surface fault rupture should be characterized by evaluating (1) the location and geometry of faults relative to the site, (2) nature and amount of displacement (sense of slip, cumulative slip, slip per event, and nature and extent of related folding and/or secondary faulting), and (3) the likelihood of displacement during some future period of concern (recurrence interval, slip rate, and elapsed time since the most recent displacement). Acceptable methods and approaches for conducting these evaluations are described in NUREG/CR-5503 (Ref. D.3); acceptable geochronology dating methods are described in NUREG/CR-5562 (Ref. D.7).

For assessing the potential for fault displacement, the details of the spatial pattern of the fault zone (e.g., the complexity of fault traces, branches, and en echelon patterns) may be important as they may define the particular locations where fault displacement may be expected in the future. The amount of slip that might be expected to occur can be evaluated directly based on paleoseismic investigations or it can be estimated indirectly based on the magnitude of the earthquake that the fault can generate.

Both non-tectonic and tectonic deformation can pose a substantial hazard to an ISFSI or MRS, but there are likely to be differences in the approaches used to resolve the issues raised by the two types of phenomena. Therefore, non-tectonic deformation should be distinguished from tectonic deformation at a site. In past nuclear power plant licensing activities, surface displacements caused by phenomena other than tectonic phenomena have been confused with tectonically induced faulting. Such structures, such as found in karst terrain; and growth faulting, occurring in the Gulf Coastal Plain or in other deep soil regions, cause extensive subsurface fluid withdrawal.

Glacially induced faults generally do not represent a deep-seated seismic or fault displacement hazard because the conditions that created them are no longer present. However, residual stresses from Pleistocene glaciation may still be present in glaciated regions, although they are of less concern than active tectonically induced stresses. These features should be investigated with respect to their relationship to current in situ stresses.

The nature of faults related to collapse features can usually be defined through geotechnical investigations and can either be avoided or, if feasible, adequate engineering fixes can be provided.

Large, naturally occurring growth faults as found in the coastal plain of Texas and Louisiana can pose a surface displacement hazard, even though offset most likely occurs at a much less rapid rate than that of tectonic faults. They are not regarded as having the capacity to generate damaging vibratory ground motion, can often be identified and avoided in siting, and their displacements can be monitored. Some growth faults and antithetic faults related to growth faults and fault zones should be applied in regions where growth faults are known to be present. Local human-induced growth faulting can be monitored and controlled or avoided.

If questionable features cannot be demonstrated to be of non-tectonic origin, they should be treated as tectonic deformation.

D.2.4 Site Geotechnical Investigations and Evaluations

D.2.4.1 Geotechnical Investigations

The geotechnical investigations should include, but not necessarily be limited to, (1) defining site soil and near-surface geologic strata properties as may be required for hazard evaluations, engineering analyses, and seismic design, (2) evaluating the effects of local soil and site geologic strata on ground motion at the ground surface, (3) evaluating dynamic properties of the near-surface soils and geologic strata, (4) conducting soil-structure interaction analyses, and (5) assessing the potential for soil failure or deformation induced by ground shaking (liquefaction, differential compaction, land sliding).

The extent of investigation to determine the geotechnical characteristics of a site depends on the site geology and subsurface conditions. By working with experienced geotechnical engineers and geologists, an appropriate scope of investigations can be developed for a particular facility following the guidance contained in Regulatory Guide 1.132 (Ref. D.5) updated with NUREG/CR-5738 (Ref. D.6). The extent of subsurface investigations is dictated by the foundation requirements and by the complexity of the anticipated subsurface conditions. The locations and spacing of borings, soundings, and exploratory excavations should be chosen to adequately define subsurface conditions. Subsurface explorations should be chosen to adequately define subsurface conditions; exploration sampling points should be located to permit the construction of geological cross sections and soil profiles through foundations of safety-related structures and other important locations at the site.

Sufficient geophysical and geotechnical data should be obtained to allow for reasonable assessments of representative soil profile and soil parameters and to reasonably quantify variability. The guidance found in Regulatory Guide 1.132 (Ref. D.5) and NUREG/CR-5738 (Ref. D.6) is acceptable. In general, this guidance should be adapted to the requirements of the site to establish the scope of geotechnical investigations for the site as well as the appropriate methods that will be used.

For ISFSIs co-located with existing nuclear plants, site investigations should be conducted if the existing site information is not available or insufficient. Soil/rock profiles (cross-sections) at the locations of the facilities should be provided based on the results of site investigations. The properties required are intimately linked to the designs and evaluations to be conducted. For example, for analyses of soil response effects, assessment of strain dependent-soil-dynamic modulus and damping characteristics are required. An appropriate site investigation program should be developed in consultation with the geotechnical engineering representative of the project team.

Subsurface conditions should be investigated by means of borings, soundings, well logs, exploratory excavations, sampling, geophysical methods (e.g., cross-hole, down-hole, and geophysical logging) that adequately assess soil and ground water conditions and other methods described in NUREG/CR-5738 (Ref. D.6). Appropriate investigations should be made to determine the contribution of the subsurface soils and rocks to the loads imposed on the structures.

A laboratory testing program should be carried out to identify and classify the subsurface soils and rocks and to determine their physical and engineering properties. Laboratory tests for both static and dynamic properties (e.g., shear modulus, damping, liquefaction resistance, etc.) are generally required. The dynamic property tests should include, as appropriate, cyclic triaxial tests, cyclic simple shear tests, cyclic torsional shear tests, and resonant column tests. Both static and dynamic tests should be conducted as recommended in American Society for Testing and Materials (ASTM) standards or test procedures acceptable to the staff. The ASTM specification numbers for static and dynamic laboratory tests can be found in the annual books of ASTM Standards, Volume 04.08. Examples of soil dynamic property and strength tests are shown in Table D.1. Sufficient laboratory test data should be obtained to allow for reasonable assessments of mean values of soil properties and their potential variability.

For coarse geological materials such as coarse gravels and sand-gravel mixtures, special testing equipment and testing facility should be used. Larger sample size is required for laboratory tests on this type of materials (e.g., samples with 12-inch diameter were used in the Rockfalls Testing Facility). It is generally difficult to obtain in situ undisturbed samples of unconsolidated gravelly soils for laboratory tests. If it is not feasible to collect test samples and, thus, no laboratory test results are available, the dynamic properties should be estimated from the published data of similar gravelly soils.

Table D.1 Examples of Soil Dynamic Property and Strength Tests

D 3999-91 (Ref. D.8)	Standard Test Method for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus
D 4015-92 (Ref. D.9)	Standard Test Methods for Modulus and Damping of Soils by the Resonant-Column Method
D 5311-92 (Ref. D10)	Standard Test Method for Load-Controlled Cyclic Triaxial Strength of Soil

D.2.4.2 Seismic Wave Transmission Characteristics of the Site

To be acceptable, the seismic wave transmission characteristics (spectral amplification or deamplification) of the materials overlying bedrock at the site are described as a function of the significant structural frequencies. The following material properties should be determined for each stratum under the site: (1) thickness, seismic compressional and shear wave velocities, (2) bulk densities, (3) soil index properties and classification, (4) shear modulus and damping variations with strain level, and (5) the water table elevation and its variation throughout the site.

Where vertically propagating shear waves may produce the maximum ground motion, a one-dimensional equivalent-linear analysis or nonlinear analysis may be appropriate. Where horizontally propagating shear waves, compressional waves, or surface waves may produce the maximum ground motion, other methods of analysis may be more appropriate. However, since some of the variables are not well defined and investigative techniques are still in the developmental stage, no specific generally agreed-upon procedures can be recommended at this time. Hence, the staff must use discretion in reviewing any method of analysis. To ensure appropriateness, site response characteristics determined from analytical procedures should be compared with historical and instrumental earthquake data, when such data are available.

D.2.4.3 Site Response Analysis for Soil Sites

As part of quantification of earthquake ground motions at an ISFSI or MRS site, an analysis of soil response effects on ground motions should be performed. A specific analysis is not required at a hard rock site. Site response analyses (often referred to as site amplification analyses) are relatively more important when the site surficial soil layer is a soft clay and/or when there is a high stiffness contrast (wave velocity contrast) between a shallow soil layer and underlying bedrock. Such conditions have shown strong local soil effects on ground motion. Site response analyses are always important for sites that have predominant frequencies within the range of interest for the DE ground motions. Thus, the stiffness of the soil and bedrock as well as the depth of soil deposit should be carefully evaluated.

In performing a site response analysis, the ground motions (usually acceleration time histories) defined at bedrock or outcrop are propagated through an analytical model of the site soils to determine the influence of the soils on the ground motions. The required soil parameters for the site response analysis include the depth, soil type, density, shear modulus and damping, and their variations with strain levels for each of the soil layers. Internal friction angle, cohesive strength, and over-consolidation ratio for clay are also needed for non-linear analyses. The strain dependent shear modulus and damping curves should be developed based on site-specific testing results and supplemented as appropriate by published data for similar soils. The effects of confining pressures (that reflect the depths of the soil) on these strain-dependent soil dynamic characteristics should be assessed and considered in site response analysis. The variability in these properties should be accounted in the site response analysis. The results of the site response analysis should show the input motion (rock response spectra), output motion (surface response spectra), and spectra amplification function (site ground motion transfer function).

D.2.4.4 Ground Motion Evaluations

D.2.4.4.1. Liquefaction is a soil behavior phenomenon in which cohesionless soils (sand, silt, or gravel) under saturated conditions lose a substantial part or all of their strength because of high pore water pressures generated in the soils by strong ground motions induced by earthquakes. Potential effects of liquefaction include reduction in foundation bearing capacity, settlements, land sliding and lateral movements, flotation of lightweight structures (such as tanks) embedded in the liquefied soil, and increased lateral pressures on walls retaining liquefied soil. Guidance in Draft Regulatory Guide DG-1105, “Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites” (Ref. D.11), is being developed to be used for evaluating the site for liquefaction potential.

Investigations of liquefaction potential typically involve both geological and geotechnical engineering assessments. The parameters controlling liquefaction phenomena are (1) the lithology of the soil at the site, (2) the ground water conditions, (3) the behavior of the soil under dynamic loadings, and (4) the potential severity of the vibratory ground motion. The following site-specific data should be acquired and used along with state-of-the-art evaluation procedures (e.g., Ref. D.12, Ref. D.13).

- Soil grain size distribution, density, static and dynamic strength, stress history, and geologic age of the sediments;
- Ground water conditions;
- Penetration resistance of the soil, e.g., Standard Penetration Test (SPT), Cone Penetration Test (CPT);
- Shear wave velocity of the soil velocity of the soil;
- Evidence of past liquefaction; and
- Ground motion characteristics.

A soil behavior phenomenon similar to liquefaction is strength reduction in sensitive clays. Although this behavior phenomenon is relatively rare in comparison to liquefaction, it should not be overlooked as a potential cause for land sliding and lateral movements. Therefore, the existence of sensitive clays at the site should be identified.

D.2.4.4.2. Ground settlement during and after an earthquake that is due to dynamic loads, change of ground water conditions, soil expansion, soil collapse, erosion, and other causes must be considered. Ground settlement that is due to the ground shaking induced by an earthquake can be caused by two factors: (1) compaction of dry sands by ground shaking and (2) settlement caused by dissipation of dynamically induced pore water in saturated sands. Differential settlement would cause more damage to facilities than would uniform settlement. Differential compaction of cohesionless soils and resulting differential ground settlement can accompany liquefaction or may occur in the absence of liquefaction. The same types of geologic information and soil data used in liquefaction potential assessments, such as the SPT value, can also be used in assessing the potential for differential compaction. Ground subsidence has been observed at the surface above relatively shallow cavities formed by mining activities (particularly coal mines) and where large quantities of salt, oil, gas, or ground water have been extracted (Ref. D.14). Where these conditions exist near a site, consideration and investigation must be given to the possibility that surface subsidence will occur.

D.2.4.4.3. The stability of natural and man-made slopes must be evaluated when their failures would affect the safety and operation of an ISFSI or MRS. In addition to land sliding facilitated by liquefaction-induced strength reduction, instability and deformation of hillside and embankment slopes can occur from the ground shaking inertia forces causing a temporary exceedance of the strength of soil or rock. The slip surfaces of previous landslides, weak planes or seams of subsurface materials, mapping and dating paleo-slope failure events, loss of shear strength of the materials caused by the natural phenomena hazards such as liquefaction or reduction of strength due to wetting, hydrological conditions including pore pressure and seepage, and loading conditions imposed by the natural phenomena events must all be considered in determining the potential for instability and deformations. Various possible modes of failure should be considered. Both static and dynamic analyses must be performed for the stability of the slopes.

The following information, at a minimum, is to be collected for the evaluation of slope instability:

- Slope cross sections covering areas that would be affected the slope stability;
- Soil and rock profiles within the slope cross sections;
- Static and dynamic soil and rock properties, including densities, strengths, and deformability;
- Hydrological conditions and their variations; and
- Rock fall events.

D.2.5 Geochronology

An important part of the geologic investigations to identify and define potential seismic sources is the geochronology of geologic materials. An acceptable classification of dating methods is based on the rationale described in Reference D.15. The following techniques, which are presented according to that classification, are useful in dating Quaternary deposits.

D.2.5.1 Sidereal Dating Methods

- Dendrochronology
- Varve chronology
- Schlerochronology

D.2.5.2 Isotopic Dating Methods

- Radiocarbon
- Cosmogenic nuclides - ^{36}Cl, ^{10}Be, ^{21}Pb, and ^{26}Al
- Potassium argon and argon-39-argon-40
- Uranium series - ^{234}U-^{230}Th and ^{235}U- ^{231}Pa
- ^{210}Lead
- Uranium-lead, thorium-lead

D.2.5.3 Radiogenic Dating Methods

- Fission track
- Luminescence

- Electron spin resonance

D.2.5.4 Chemical and Biological Dating Methods

- Amino acid racemization
- Obsidian and tephra hydration
- Lichenometry

D.2.5.6 Geomorphic Dating Methods

- Soil profile development
- Rock and mineral weathering
- Scarp morphology

D.2.5.7 Correlation Dating Methods

- Paleomagnetism (secular variation and reversal stratigraphy)
- Tephrochronology
- Paleontology (marine and terrestrial)
- Global climatic correlations - Quaternary deposits and landforms, marine stable isotope records, etc.

In the CEUS, it may not be possible to reasonably demonstrate the age of last activity of a tectonic structure. In such cases the NRC staff will accept association of such structures with geologic structural features or tectonic processes that are geologically old (at least pre-Quaternary) as an age indicator in the absence of conflicting evidence.

These investigative procedures should also be applied, where possible, to characterize offshore structures (faults or fault zones, and folds, uplift, or subsidence related to faulting at depth) for coastal sites or those sites located adjacent to landlocked bodies of water. Investigations of offshore structures will rely heavily on seismicity, geophysics, and bathymetry rather than conventional geologic mapping methods that normally can be used effectively onshore. However, it is often useful to investigate similar features onshore to learn more about the significant offshore features.

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D.7 J.M. Sowers et al., "Dating and Earthquakes: Review of Quaternary Geochronology and Its Application to Paleoseismology," NUREG/CR-5562, USNRC, 1998..[1]

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D.11 USNRC, "Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites," Draft Regulatory Guide DG-1105, issued for public comment March 2001.

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[1] Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161; (telephone (703)487-4650; <http://www.ntis.gov/ordernow>. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; email is PDR@NRC.GOV.1.

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APPENDIX E
PROCEDURE FOR THE EVALUATION OF NEW GEOSCIENCES INFORMATION OBTAINED FROM THE SITE-SPECIFIC INVESTIGATIONS

E.1 INTRODUCTION

This appendix provides methods acceptable to the NRC staff for assessing the impact of new information obtained during site-specific investigations on the data base used for the probabilistic seismic hazard analyses (PSHA).

Regulatory Position 4 in this guide describes acceptable PSHAs that were developed by the Lawrence Livermore National Laboratory (LLNL) and the Electric Power Research Institute (EPRI) to characterize the seismic hazard for nuclear power plants and to develop the Safe Shutdown Earthquake (SSE). The procedure to determine the design earthquake ground motion (DE) outlined in this guide relies primarily on either the LLNL or EPRI PSHA results for the Central and Eastern United States (CEUS).

It is necessary to evaluate the geological, seismological, and geophysical data obtained from the site-specific investigations to demonstrate that these data are consistent with the PSHA data bases of these two methodologies. If new information identified by the site-specific investigations would result in a significant increase in the hazard estimate for a site, and this new information is validated by a strong technical basis, the PSHA may have to be modified to incorporate the new technical information. Using sensitivity studies, it may also be possible to justify a lower hazard estimate with an exceptionally strong technical basis. However, it is expected that large uncertainties in estimating seismic hazard in the CEUS will continue to exist in the future, and substantial delays in the licensing process will result from trying to justify a lower value with respect to a specific site.

In general, major recomputations of the LLNL and EPRI data base are planned periodically (approximately every 10 years), or when there is an important new finding or occurrence. The overall revision of the data base will also require a reexamination of the reference probability discussed in Appendix B.

E.2 POSSIBLE SOURCES OF NEW INFORMATION THAT COULD AFFECT THE SSE

Types of new data that could affect the PSHA results can be put in three general categories: seismic sources, earthquake recurrence models or rates of deformation, and ground motion models.

E.2.1 Seismic Sources

There are several possible sources of new information from the site-specific investigations that could affect the seismic hazard. Continued recording of small earthquakes, including microearthquakes, may indicate the presence of a localized seismic source. Paleoseismic evidence, such as paleoliquefaction features or displaced Quaternary strata, may indicate the presence of a previously unknown tectonic structure or a larger amount of activity on a known structure than was previously considered. Geophysical studies (aeromagnetic, gravity, and seismic reflection/refraction) may identify crustal structures that suggest the presence of previously unknown seismic sources. In situ stress measurements and the mapping of tectonic structures in the future may indicate potential seismic sources.

Detailed local site investigations often reveal faults or other tectonic structures that were unknown, or reveal additional characteristics of known tectonic structures. Generally, based on past licensing experience in the CEUS, the discovery of such features will not require a modification of the seismic sources provided in the LLNL and EPRI studies. However, initial evidence regarding a newly discovered tectonic structure in the CEUS is often equivocal with respect to activity, and additional detailed investigations are required. By means of these detailed investigations, and based on past licensing activities, previously unidentified tectonic structures can usually be shown to be inactive or otherwise insignificant to the seismic design basis of the facility, and a modification of the seismic sources provided by the LLNL and EPRI studies will not be required. On the other hand, if the newly discovered features are relatively young, possibly associated with earthquakes that were large and could impact the hazard for the proposed facility, a modification may be required.

Of particular concern is the possible existence of previously unknown, potentially active tectonic structures that could have moderately sized, but potentially damaging, near-field earthquakes or could cause surface displacement. Also of concern is the presence of structures that could generate larger earthquakes within the region than previously estimated.

Investigations to determine whether there is a possibility for permanent ground displacement are especially important in view of the provision to allow for a combined licensing procedure under 10 CFR Part 52 as an alternative to the two-step procedure of the past (Construction Permit and Operating License). In the past at numerous nuclear power plant sites, potentially significant faults were identified when excavations were made during the construction phase prior to the issuance of an operating license, and extensive additional investigations of those faults had to be carried out to properly characterize them.

E.2.2 Earthquake Recurrence Models

There are three elements of the source zone's recurrence models that could be affected by new site-specific data: (1) the rate of occurrence of earthquakes, (2) their maximum magnitude, and (3) the form of the recurrence model (e.g.,a change from truncated exponential to a characteristic earthquake model). Among the new site-specific information that is most likely to have a significant impact on the hazard is the discovery of paleoseismic evidence such as extensive soil liquefaction features, which would indicate with reasonable confidence that much larger estimates of the maximum earthquake than those predicted by the previous studies would ensue. The paleoseismic data could also be significant even if the maximum magnitudes of the previous studies are consistent with the paleo-earthquakes if there are sufficient data to develop return period estimates significantly shorter than those previously used in the probabilistic analysis. The paleoseismic data could also indicate that a characteristic earthquake model would be more applicable than a truncated exponential model.

In the future, expanded earthquake catalogs will become available that will differ from the catalogs used by the previous studies. Generally, these new catalogues have been shown to have only minor impacts on estimates of the parameters of the recurrence models. Cases that might be significant include the discovery of records that indicate earthquakes in a region that had no seismic activity in the previous catalogs, the occurrence of an earthquake larger than the largest historic earthquakes, re-evaluating the largest historic earthquake to a significantly larger magnitude, or the occurrence of one or more moderate to large earthquakes (magnitude 5.0 or greater) in the CEUS.

Geodetic measurements, particularly satellite-based networks, may provide data and interpretations of rates and styles of deformation in the CEUS that can have implications for earthquake recurrence. New hypotheses regarding present-day tectonics based on new data or reinterpretation of old data may be developed that were not considered or given high weight in the EPRI or LLNL PSHA. Any of these cases could have an impact on the estimated maximum earthquake if the result is larger than the values provided by LLNL and EPRI.

E.2.3 Ground Motion Attenuation Models

Alternative ground motion attenuation models may be used to determine the site-specific spectral shape as discussed in Regulatory Position 4 and Appendix F of this regulatory guide. If the ground motion models used are a major departure from the original models used in the hazard analysis and are likely to have impacts on the hazard results of many sites, a re-evaluation of the reference probability may be needed. Otherwise, a periodic (e.g., every 10 years) reexamination of the PSHA and the associated data base is considered appropriate to incorporate new understanding regarding ground motion attenuation models.

E.3 PROCEDURE AND EVALUATION

The EPRI and LLNL studies provide a wide range of interpretations of the possible seismic sources for most regions of the CEUS, as well as a wide range of interpretations for all the key parameters of the seismic hazard model. The first step in comparing the new information with those interpretations is determining whether the new information is consistent with the following LLNL and EPRI parameters: (1) the range of seismogenic sources as interpreted by the seismicity experts or teams involved in the study, (2) the range of seismicity rates for the region around the site as interpreted by the seismicity experts or teams involved in the studies, and (3) the range of maximum magnitudes determined by the seismicity experts or teams. The new information is considered not significant and no further evaluation is needed if it is consistent with the assumptions used in the PSHA, no additional alternative seismic sources or seismic parameters are needed, or it supports maintaining or decreasing the site mean seismic hazard.

An example is a new ISFSI co-located near an existing nuclear power plant site that was recently investigated by state-of-the-art geosciences techniques and evaluated by current hazard methodologies. Detailed geological, seismological, and geophysical site-specific investigations would be required to update existing information regarding the new site, but it is very unlikely that significant new information would be found that would invalidate the previous PSHA.

On the other hand, after evaluating the results of the site-specific investigations, if there is still uncertainty about whether the new information will affect the estimated hazard, it will be necessary to evaluate the potential impact of the new data and interpretations on the mean of the range of the input parameters. Such new information may indicate the addition of a new seismic source, a change in the rate of activity, a change in the spatial patterns of seismicity, an increase in the rate of deformation, or the observation of a relationship between tectonic structures and current seismicity. The new findings should be assessed by comparing them with the specific input of each expert or team that participated in the PSHA. Regarding a new source, for example, the specific seismic source characterizations for each expert or team (such as tectonic feature being modeled, source geometry, probability of being active, maximum earthquake magnitude, or occurrence rates) should be assessed in the context of the significant new data and interpretations.

It is expected that the new information will be within the range of interpretations in the existing data base, and the data will not result in an increase in overall seismicity rate or increase in the range of maximum earthquakes to be used in the probabilistic analysis. It can then be concluded that the current LLNL or EPRI results apply. It is possible that the new data may necessitate a change in some parameter. In this case, appropriate sensitivity analyses should be performed to determine whether the new site-specific data could affect the ground motion estimates at the reference probability level.

An example is a consideration of the seismic hazard near the Wabash River Valley (Ref. E.1). Geological evidence found recently within the Wabash River Valley and several of its tributaries indicated that an earthquake much larger than any historic event had occurred several thousand years ago in the vicinity of Vincennes, Indiana. A review of the inputs by the experts and teams involved in the LLNL and EPRI PSHAs revealed that many of them had made allowance for this possibility in their tectonic models by assuming the extension of the New Madrid Seismic Zone northward into the Wabash Valley. Several experts had given strong weight to the relatively high seismicity of the area, including the number of magnitude five historic earthquakes that have occurred, and thus had assumed the larger event. This analysis of the source characterizations of the experts and teams resulted in the conclusion by the analysts that a new PSHA would not be necessary for this region because an event similar to the prehistoric earthquake had been considered in the existing PSHAs.

A third step would be required if the site-specific geosciences investigations revealed significant new information that would substantially affect the estimated hazard. Modification of the seismic sources would more than likely be required if the results of the detailed local and regional site investigations indicate that a previously unknown seismic source is identified in the vicinity of the site. A hypothetical example would be the recognition of geological evidence of recent activity on a fault near a site in the SCR similar to the evidence found on the Meers Fault in Oklahoma (Ref. E.2). If such a source is identified, the same approach used in the active tectonic regions of the WUS should be used to assess the largest earthquake expected and the rate of activity. If the resulting maximum earthquake and the rate of activity are higher than those provided by the LLNL or EPRI experts or teams regarding seismic sources within the region in which this newly discovered tectonic source is located, it may be necessary to modify the existing interpretations by introducing the new seismic source and developing modified seismic hazard estimates for the site. The same would be true if the current ground motion models are a major departure from the original models. These occurrences would likely require performing a new PSHA using the updated data base, and may require determining the appropriate reference probability.

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APPENDIX F
PROCEDURE TO DETERMINE THE DESIGN EARTHQUAKE GROUND MOTION

F.1 INTRODUCTION

This appendix elaborates on Step 4 of Regulatory Position 4 of this guide, which describes an acceptable procedure to determine the design earthquake ground motion (DE). The DE is defined in terms of the horizontal and vertical free-field ground motion response spectra at the free ground surface. It is developed with consideration of local site effects and site seismic wave transmission effects. The DE response spectrum can be determined by scaling a site-specific spectral shape determined for the controlling earthquakes or by scaling a standard broad-band spectral shape to envelope the ground motion levels for 1 Hz ($S_{a,1}$) and 10 Hz ($S_{a,10}$), as determined in Step C.2-2 of Appendix C to this guide. The standard response spectrum is generally specified at 5 percent critical damping.

It is anticipated that a regulatory guide will be developed that provides guidance on assessing site-specific effects and determining smooth design response spectra, taking into account recent developments in ground motion modeling and site amplification studies (for example, Ref. F.1).

F.2 DISCUSSION

For engineering purposes, it is essential that the design ground motion response spectrum be a broad-band smooth response spectrum with adequate energy in the frequencies of interest. In the past, it was general practice to select a standard broad-band spectrum, such as the spectrum in Regulatory Guide 1.60 (Ref. F.2), and scale it by a peak ground motion parameter [usually peak ground acceleration (PGA)], which is derived based on the size of the controlling earthquake. Past practices to define the DE are still valid and, based on this consideration, the following three possible situations are depicted in Figures F.1 to F.3.

Figure F.1 depicts a situation in which a site is to be used for a certified ISFSI or MRS design (if available) with an established DE. In this example, the certified design DE spectrum compares favorably with the site-specific response spectra determined in Step 2 or 3 of Regulatory Position 4.

Figure F.2 depicts a situation in which a standard broad-band shape is selected and its amplitude is scaled so that the design DE envelopes the site-specific spectra.

Figure F.3 depicts a situation in which a specific smooth shape for the design DE spectrum is developed to envelope the site-specific spectra. In this case, it is particularly important to be sure that the DE contains adequate energy in the frequency range of engineering interest and is sufficiently broad-band.

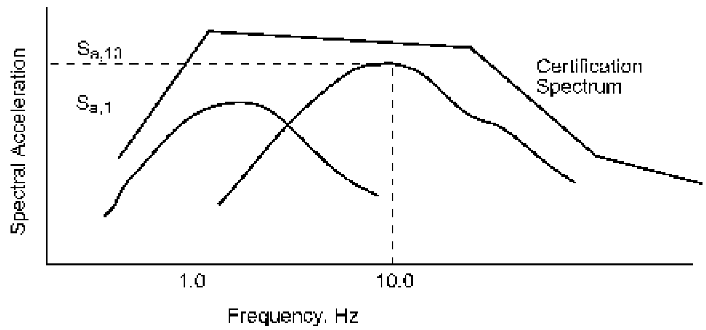

Figure F.1 Use of DE Spectrum of a Certified Design

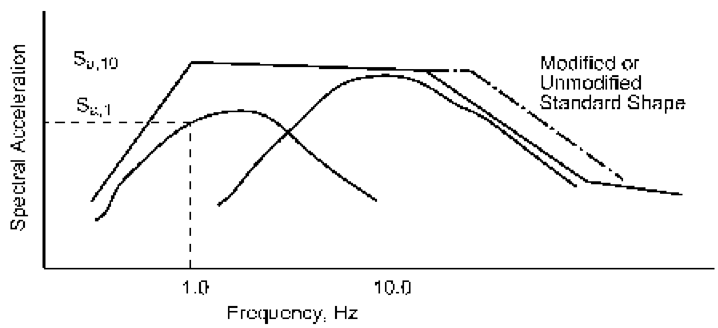

Figure F.2 Use of a Standard Shape for DE

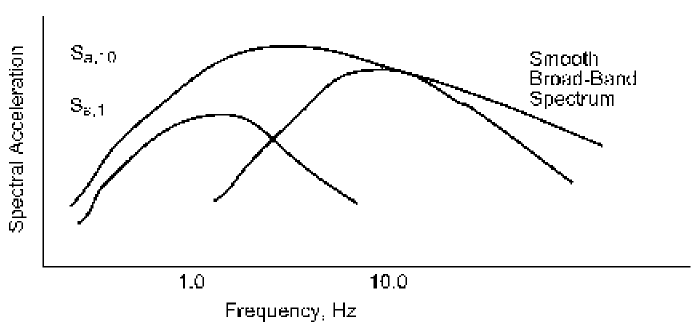

Figure F.3 Development of a Site-Specific DE Spectrum

(Note: The above figures illustrate situations for a rock site. For other site conditions, the DE spectra are compared at free-field after performing site amplification studies as discussed in Step 3 of Regulatory Position 4.)

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REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this draft regulatory guide. The regulatory analysis “Regulatory Analysis of Geological and Seismological Characteristics for and Design of Dry Cask Independent Spent Fuel Storage Installations (10 CFR Part 72),” was prepared for the amendments, and it provides the regulatory basis for this guide and examines the costs and benefits of the rule as implemented by the guide. A copy of the regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, as Attachment __ to SECY-______. The PDR’s mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or 1-(800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>.