RULEMAKING ISSUE
AFFIRMATION

July 11, 2003 SECY-03-0118

FOR: The Commissioners

FROM: William D. Travers
Executive Director for Operations

SUBJECT: FINAL 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 for publication of the final rule.

BACKGROUND:

In a Staff Requirements Memorandum (SRM) dated November 19, 2001 (Attachment 1), the Commission approved the Modified Rulemaking Plan (SECY-01-0178, September 26, 2001). In the SRM, the Commission directed that the proposed rule should solicit comment on a range of probability of exceedance levels (for a seismic event) from 5E-4 through 1E-4, and that the U.S. Nuclear Regulatory Commission (NRC) staff should undertake further analysis to support a specific proposal. In an SRM dated June 18, 2002 (Attachment 2), the Commission approved publication of the proposed rule (SECY-02-0043, March 13, 2002). It was published in the Federal Register on July 22, 2002 (67 FR 47745). The comment period closed October 22, 2002, and nine comment letters were received on the proposed rule.

CONTACTS: Keith McDaniel, NMSS/IMNS
(301) 415-5252

Mahendra Shah, NMSS/SFPO
(301) 415-8537

DISCUSSION:

The geological and seismological siting and design requirements for an independent spent fuel storage installation (ISFSI) or U.S. Department of Energy (DOE) monitored retrievable storage installation (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 10 CFR 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 (SSE) for a nuclear power plant (NPP). However, Part 100 was amended in 1996 to incorporate a new section (10 CFR 100.23) in the regulations to require NPP applicants, after January 10, 1997, to account for uncertainties in the seismic hazard evaluation by using a "probabilistic" seismic hazard analysis (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. The final rule will make the 10 CFR Part 72 regulations compatible with the 1996 revision to Part 100 that addressed uncertainties in seismic hazard analysis. Specifically, the final rule changes will 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 an NPP, 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 (DE). All other new specific-license applicants for dry cask storage facilities will have the option of complying with the final rule 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 staff also believes that the potential radiological consequences of a seismic event at an ISFSI or MRS storing spent fuel in dry casks or canisters are substantially less than the potential consequences of a similar event at an NPP. Therefore, the final rule will allow an ISFSI or MRS applicant to use a design earthquake level commensurate with the risk associated with an ISFSI or MRS, and thus the rule will be risk-informed and complies with the Commission's policies on probabilistic risk assessment and performance goals. The accompanying Regulatory Guide 3.73 (draft was DG-3021) (Attachment 3) recommends an acceptable design earthquake level. The staff's analysis and the basis for the recommendation is provided in the White Paper entitled, "Selection of the Design Earthquake Ground Motion Reference Probability" (Attachment 4).

As an additional minor change, the final rule will modify 10 CFR 72.212(b)(2)(i)(B) to require general licensees to 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 will ensure that the pads support the casks during seismic events. Even though the current regulations in § 72.212(b)(2)(i)(B) do not require a dynamic loads evaluation, general licensees currently evaluate casks, pads, and areas for dynamic loads, to meet the cask design bases in the Certificate of Compliance, as required by § 72.212(b)(2)(i)(A). Therefore, the final rule changes will not require general licensees operating an ISFSI to repeat any previous written evaluations. 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.

The NRC received two requests for exemptions to § 72.102(f)(1) from the ISFSI industry to allow the application of the PSHA approach instead of the deterministic approach and the use of a design earthquake lower than the SSE for an NPP. Based on feedback from industry representatives, the staff believes that any future license applicant for an ISFSI will seek the same exemption. The final rule changes will alleviate the need for applicants to request exemptions from § 72.102(f)(1).

The Commission should be aware that on May 22, 2003, the Atomic Safety and Licensing Board issued a Partial Initial Decision, LBP-03-08, in the Private Fuel Storage adjudicatory proceeding which decided the seismic and other geotechnical issues litigated in the proceeding. Among other matters, the Board determined that the Applicant and the staff had provided adequate justification to support staff's grant of the Applicant's request for exemption from 10 CFR 72.102(f)(1), the same issue involved in this rulemaking.

Guidance Documents:

The staff has developed Regulatory Guide 3.73, "Site Evaluations and Design Earthquake Ground Motion for Dry Cask Independent Spent Fuel Storage and Monitored Retrievable Storage Installations" to accompany the final rule. This guide provides acceptable PSHA methods and recommends an appropriate mean annual probability of exceedance value for selecting the DE. This rulemaking will 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. It is anticipated that the "Notice of Availability" of Regulatory Guide 3.73 will be published in the Federal Register, coincident with the effective date of the final regulations.

Summary of Public Comments:

The NRC received nine comment letters on the proposed rule from eight commenters. The commenters were the Nuclear Energy Institute (NEI), DOE, two nuclear power utilities, three State agencies, and one license applicant for an ISFSI. Commenters were divided on the specific question posed by the Commission in the proposed rule, regarding the appropriate mean annual probability of exceedance value for the DE. Several of the more contentious comments received on this question are discussed in the "Summary of Public Comments on Specific Question Posed in Proposed Rule" (Attachment 5). All the commenters agreed with the proposal to address uncertainty by requiring the use of a PSHA or suitable sensitivity analyses for an ISFSI or MRS in the western U.S., not co-located with an NPP, and in areas of known seismic activity in the eastern U.S. All commenters supported the concept of requiring general licensees to evaluate both dynamic loads and static loads for ISFSI and MRS cask storage pads and areas. A comprehensive discussion on all public comments and the staff's responses are in the Federal Register Notice for the final rule (Attachment 6).

Performance Goals:

The staff considered the merits of the rulemaking within the context of the performance goals listed in NRC's strategic plan. It will 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. The rulemaking will increase NRC's effectiveness and efficiency by reducing the number of exemption requests that might be submitted and reviewed. This rule will 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. This rule will 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.

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 final rulemaking. The Office of the Chief Financial Officer has reviewed this Commission Paper for resource implications and has no objections.

RECOMMENDATIONS:

That the Commission:

1. Approve, for publication in the Federal Register, the attached notice of final rulemaking (Attachment 6).

2. To satisfy the requirement of the Regulatory Flexibility Act, 5 U.S.C. 605 (b), certify that this rule, if promulgated, will not have significant impact on a substantial number of small entities. This certification is included in the attached final rule.

3. Note:

   a. That a Regulatory Guide has been prepared for this rulemaking (Attachment 3);

   b. That a White Paper has been prepared for this rulemaking, “Selection of Design Earthquake Ground Motion Reference Probability” (Attachment 4);

   c. 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);

   d. That a final Regulatory Analysis has been prepared for this rulemaking (Attachment 7);

   e. That a final Environmental Assessment has been prepared for this rulemaking (Attachment 8);

   f. The staff has determined that this action is not a “major rule,” as defined in the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 [5 U.S.C 804(2)] and has confirmed this determination with the Office of

Management and Budget (OMB). The appropriate Congressional and General Accounting Office contacts will be informed (Attachment 9);

g. The appropriate Congressional committees will be informed;

h. A press release will be issued by the Office of Public Affairs when the final rulemaking is filed with the Office of the Federal Register; and

i. The final rule contains amended information collection requirements subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501, et seq.) that have been already approved by OMB.

/RA William F. Kane Acting For/

William D. Travers
Executive Director
for Operations

Attachments:
1. Staff Requirements Memorandum dated November 19, 2001
2. Staff Requirements Memorandum dated June 18, 2002
3. Regulatory Guide 3.73
4. White Paper
5. Summary of Public Comments on Specific Question Posed in Proposed Rule
6. Federal Register Notice
7. Regulatory Analysis
8. Environmental Assessment
9. SBREFA forms

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

June 18, 2002

MEMORANDUM TO: William D. Travers
Executive Director for Operations

FROM: Annette L. Vietti-Cook, Secretary **/RA by Andrew L. Bates Acting For/**

SUBJECT: STAFF REQUIREMENTS - SECY-02-0043 - 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

The Commission has approved publication of the proposed amendments to Part 72 subject to the following comments and the changes noted in the attachment.
(EDO) (SECY Suspense: 7/26/02)

The proposed rule should be revised to exclude wet modes of storage on the basis that new applications for this type of facility are not expected and, consequently, it is not cost-effective to allocate resources to develop the technical basis for such an expansion of the rulemaking. These changes should be applied to similar discussions in the Environmental Assessment and the draft Regulatory Guide DG-3021.

Attachment: Changes to the *Federal Register* Notice in SECY-02-0043

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

Attachment

Changes to the *Federal Register* Notice in SECY-02-0043

1. On page 5, 1st full paragraph, remove the last sentence (Because the deterministic approach ... parameters.) and place it as the new item 1. prior to the last paragraph on the page. Add the following at the end of the new item 1. "Yet Appendix A to Part 100 does not allow this application."

2. On page 5, renumber item 1. as item 2. Revise the last line to read ' ... to new situations; and ~~Requiring the use of Appendix A has also~~ ....'

3. On page 6, delete lines 1 and 2 (inhibited the use ... process; and) and renumber item 2. as item 3.

4. On page 7, 1st full paragraph, revise lines 7 and 8 to read ' ... are significantly lower ~~in comparison to~~ than those that could arise at a NPP.'

5. On page 10, 2nd full paragraph, revise line 4 to read ' ... storage because ~~the risk associated with potential accident scenarios for wet modes of storage~~ applications for this means of storage are not expected and it is not cost-effective to allocate resources to develop the technical bases for such an expansion of the rulemaking. Delete lines 5 through 8 (... is greater than the risk ... wet modes of storage.) Revise the last line to read ' ... lack of experience ~~gained~~ in licensing ....'

U.S. NUCLEAR REGULATORY COMMISSION June 2003

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

PREPUBLICATION

REGULATORY GUIDE 3.73

(Draft was DG-3021)

SITE EVALUATIONS AND DESIGN EARTHQUAKE GROUND MOTION FOR DRY CASK INDEPENDENT SPENT FUEL STORAGE AND MONITORED RETRIEVABLE STORAGE INSTALLATIONS

A. INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) has recently published amendments to 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." 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), requires 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 § 72.103, paragraph (f)(2) requires 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 non-tectonic deformations, the design bases for seismically induced floods and water waves, and other design conditions. In § 72.103, Paragraph (f)(2)(i) requires 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 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 Part 72.

This guide contains several appendices that address the objectives stated above. Appendix A contains definitions of pertinent terms. Appendix B discusses determination of the probabilistic ground motion level and controlling earthquakes and the development of a seismic hazard information base, Appendix C discusses site-specific geological, seismological, and geophysical investigations. Appendix D 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 E describes procedures for determination of the DE.

The basis for the reference probability, an annual probability of exceeding the Design Earthquake Ground Motion (DE), which is stated in Regulatory Position 3.4, is discussed in "Selection of the Design Earthquake Ground Motion Reference Probability" (Ref. 1)

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 (MRS) installations, because these facilities are similar in design. The reference probability in Regulatory Position 3.4 does not apply to wet storage because applications for this means of storage are not expected, and it is not cost-effective to allocate resources to develop the technical bases for such an expansion of the rulemaking.

This guide is consistent with Regulatory Guide 1.165 (Ref. 2), 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, the use of spectral ground motion levels at different frequencies, based on NUREG/CR-6728 (Ref. 3).

The information collections contained in this regulatory guide are covered by the requirements of 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, 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 § 72.103 as a means to determine the DE for the seismic design of an ISFSI or MRS facility. Furthermore, the rule recognizes that the nature of uncertainty and the appropriate approach to account for it depend 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° west longitude) and the Central and Eastern United States (CEUS) (Refs. 4, 5) 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. 6).

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 or suitable sensitivity analyses.

For ISFSI sites that are co-located with existing nuclear power generating stations, unless the existing geological and seismological design criteria for the nuclear power plant (NPP) are used [§ 73.103(a)(2), § 73.103(b)], 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 earthquake recurrence and ground motion attenuation models.

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° 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. 4, 5, 7) and the Electric Power Research Institute (EPRI) (Ref. 8) 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 may have little or no correlation with current tectonic forces. Therefore, it is important to account for this uncertainty by the use of multiple alternative seismotectonic 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. 4, 5, 7-9) does not exist. For this region, specific interpretations, on a site-by-site basis, should be applied (Refs. 10, 11).

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 faults that have experienced repeated movements at or near the ground surface during the Quaternary, tectonic 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 subducting plates 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. The non-Poissonian models to account for temporal clustering have not been developed sufficiently to be able to provide a specific guidance. Therefore, judgement would have to be exercised in considering the temporal clustering in the PSHA.

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 NPPs, 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 C to this guide. Geotechnical investigations are described in Regulatory Guide 1.132, “Site Investigations for Foundations of Nuclear Power Plants” (Ref. 12), and NUREG/CR-5738 (Ref. 13). 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 D describes a method for assessing the impact of new information, obtained during the site-specific investigations on the data bases used for 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 C 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 kilometers (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 12, updated with NUREG/CR-5738 (Ref. 13).

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 should be measured. These include 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).

2. SEISMIC SOURCES SIGNIFICANT TO THE SITE SEISMIC HAZARD

2.1 For sites in the CEUS, the EPRI or LLNL PSHA methodologies and data bases may be used to determine the DE, provided the site seismic sources, not included in these data bases, are appropriately characterized, and sensitivity analyses are performed 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 D, 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 C 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 PSHA 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 C. The bases for the identification of seismic sources should be described. A general list of characteristics to be evaluated for seismic sources is presented in Appendix C.

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 of a seismic source, 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; and 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 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 caused by 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 historic earthquakes. Because these catalogs are incomplete and cover a relatively short period of time, the earthquake recurrence rate cannot be estimated reliably. 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.

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 (Refs. 6, 8).

2.3.2 For sites located within the WUS, earthquakes can often be associated with known tectonic structures, with a high degree of certainty. 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. 14-18);
- Subsurface rupture length versus magnitude (Ref. 19);
- Rupture area versus magnitude (Ref. 20);
- Maximum and average displacement versus magnitude (Ref. 19); and
- Slip rate versus magnitude (Ref. 21).

When such correlations as in References 15-21 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. All the sources of uncertainty must be appropriately modeled.

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, since 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 C.

3.2 For CEUS sites, perform an evaluation of LLNL or EPRI seismic sources, in accordance with Appendix D, 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 overestimates the hazard and there is a strong technical basis that supports such a revision. 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. 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. 6). 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 B.

3.4 Using the mean reference probability of 5E-4/yr (Ref. 1), determine the 5 percent of critically damped mean spectral ground motion levels for 1 Hz ($S_{a,1}$) and 10 Hz ($S_{a,10}$).

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

3.6 Instead of the controlling earthquake approach described in Regulatory Positions 3.4 and 3.5, an alternate approach can be as follows:

a. Using the mean reference probability of 5E-4/yr (Ref. 1), determine the 5 percent of critically damped mean spectral ground motion levels for a sufficient number of frequencies significant to an ISFSI or an MRS facility; and

b. Envelope the ground motions to determine the DE.

4. PROCEDURES FOR DETERMINING THE DE

After completing the PSHA (see Regulatory Position 3) and determining the controlling earthquakes, the following procedures should be used to determine the DE. Appendix E 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 22 (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 which 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 C of this guide, and Reference 22 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 guidance to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, this guide will be used in the evaluation of applications for new dry cask ISFSI or MRS licenses submitted after [insert effective date of Final Rule]. This guide will not be used in the evaluation of an application for dry cask ISFSI or MRS licenses submitted before [insert effective date of Final Rule].

REFERENCES

1. U.S. Nuclear Regulatory Commission, “Selection of the Design Earthquake Ground Motion Reference Probability,” June, 2003.(Accession Number MLxxxxxxxx in Public Document Room)

2. U.S. Nuclear Regulatory Commission, “Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion,” Regulatory Guide 1.165, March 1997.[1]

3. R.K. McGuire, W.J. Silva, and C.J. Constantino, “Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines,” NUREG/CR-6728, October 2001.

4. D.L. Bernreuter, et al., "Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains," NUREG/CR-5250, Volumes 1-8, 1989.[2]

5. P. Sobel, "Revised Livermore Seismic Hazard Estimates for Sixty-Nine Nuclear Power Plant Sites East of the Rocky Mountains," NUREG-1488, U.S. Nuclear Regulatory Commission, April 1994.[2]

6. R.J. Budnitz, et al., "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," NUREG/CR- 6372, Volumes 1 and 2, USNRC, April 1997.[3]

7. J.B. Savy, et al., "Eastern Seismic Hazard Characterization Update," UCRL-ID-115111, Lawrence Livermore National Laboratory, June 1993.[3] (Accession number 9310190318 in NRC's Public Document Room)

8. 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.

9. Electric Power Research Institute (EPRI), “The Earthquakes of Stable Continental Regions,” Volume 1: *Assessment of Large Earthquake Potential,* EPRI TR-102261-V1, 1994.

10. Pacific Gas and Electric Company, "Final Report of the Diablo Canyon Long Term Seismic Program; Diablo Canyon Power Plant," Docket Nos. 50-275 and 50-323, 1988.[3]

[1]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; e-mail <distribution@nrc.gov>. Copies are available for inspection or copying for a fee from the NRC Public Document Room (PDR) 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>.

[2]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 (NTIS) 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 PDR 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; e-mail is pdr@nrc.gov.

[3]Copies are available for inspection or copying for a fee from the NRC PDR 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>.

11. H. Rood, et al., "Safety Evaluation Report Related to the Operation of Diablo Canyon Nuclear Power Plant, Units 1 and 2," NUREG-0675, Supplement No. 34, USNRC, June 1991.[2]

12. U.S. Nuclear Regulatory Commission, "Site Investigations for Foundations of Nuclear Power Plants," Regulatory Guide 1.132, March 1979. (See also DG-1101, the proposed Revision 2 of Regulatory Guide 1.132, February 2001.)[1]

13. N. Torres, et al., “Field Investigations for Foundations of Nuclear Power Facilities,” NUREG/CR-5738, USNRC, 1999.[2]

14. K.L. Hanson, et al., “Techniques for Identifying Faults and Determining Their Origins,” NUREG/CR-5503, USNRC, July 1999.[2]

15. D.B. Slemmons, “Faults and Earthquake Magnitude,” U.S. Army Corps of Engineers, Waterways Experiment Station, Misc. Papers S-7-1, Report 6, 1997.

16. D.B. Slemmons, “Determination of Design Earthquake Magnitudes for Microzonation,” *Proceedings of the Third International Microzonation Conference*, University of Washington, Seattle, Volume 1, pp. 119-130, 1982.

17. M.G. Bonilla, H.A. Villalobos, and R.E. Wallace, “Exploratory Trench Across the Pleasant Valley Fault, Nevada,” Professional Paper 1274-B, U.S. Geological Survey, pp. B1-B14, 1984.[3]

18. S.G. Wesnousky, “Relationship Between Total Affect, Degree of Fault Trace Complexibility, and Earthquake Size on Major Strike-Slip Faults in California” (Abs), *Seismological Research Letters*, Volume 59, No. 1, p.3, 1988.

19. D.L. Wells and K.J. Coppersmith, “New Empirical Relationships Among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement,” *Bulletin of the Seisomological Society of America*, Volume 84, 1994.

20. M. Wyss, “Estimating Maximum Expectable Magnitude of Earthquakes from Fault Dimensions,” *Geology*, Volume 7 (7), pp. 336-340, 1979.

21. D.P. Schwartz and K.J. Coppersmith, “Seismic Hazards: New Trends in Analysis Using Geologic Data,” *Active Tectonics*, National Academy Press, Washington, DC, pp. 215-230, 1986.

22. U.S. Nuclear Regulatory Commission, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” NUREG-0800, Section 2.5.2, Revision 3, 1997.[1]

APPENDIX A
DEFINITIONS

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 10 CFR 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 as a function of magnitude. 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 earthquake that was not felt except by a very few, whereas 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. The Moment Magnitude of an earthquake (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.

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

Mean Annual Probability of Exceedance — Mean annual probability of exceedance of an earthquake of a given magnitude or an acceleration level is the mean probability that the given magnitude or acceleration level will be exceeded in a year. The reciprocal of the mean annual probability of exceedance for a particular magnitude earthquake is commonly referred to as the return period of earthquakes exceeding that magnitude.

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 is the mean annual probability of exceeding the design earthquake ground motion.

Safe Shutdown Earthquake Ground Motion (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 that of surrounding sources. A seismogenic source will generate vibratory ground motion but is assumed not to cause surface displacement. Seismogenic sources cover a wide range of seismotectonic conditions, from a well-defined tectonic structure to simply a large region of diffuse seismicity (seismotectonic province).

Stable Continental Region (SCR) — An SCR 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
DETERMINATION OF CONTROLLING EARTHQUAKES AND DEVELOPMENT OF SEISMIC HAZARD INFORMATION BASE

B.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 Hertz (Hz). The controlling earthquakes are developed for the ground motion level corresponding to the reference probability of 5E-4/yr.

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 E to this regulatory guide describe a procedure to determine the DE using the controlling earthquakes and results from the PSHA.

B.2 PROCEDURE TO DETERMINE CONTROLLING EARTHQUAKES

The following approach is acceptable to the Nuclear Regulatory Commission 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 E 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. B.1-B.3) for Central and Eastern United States (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 (Ref. B.4). 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), 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 B.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 B.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 kilometer (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 earthquake 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:

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

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:

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

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:

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

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:

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

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

In cases where more than one earthquake magnitude-distance pair contributes significantly to the spectral accelerations at a given frequency, it may be necessary to use more than one controlling earthquake for determining the spectral response at the frequency.

Step 2-8

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

B.3 EXAMPLE FOR A CEUS SITE

To illustrate the procedure in Section B.2, calculations are shown here for a CEUS site using the 1993 LLNL hazard results (Refs. B.1, B.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 earthquakes 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. B.1, B.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 B.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. The corresponding ground motion level values are given in Table B.2. See Figure B.1.

Table B.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 B.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 B.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 B.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 B.2. The vertical line corresponds to the value 88 centimeter/second/second (cm/s/s) listed in Table B.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-6/yr. Tables B.3 and B.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 5E-4/yr.

Table B.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-6	4.61E-5	0.0	0.0	0.0
15 - 25	0.0	1.26E-5	0.0	0.0	0.0
25 - 50	0.0	1.49E-5	1.05E-5	0.0	0.0
50 - 100	0.0	7.48E-6	3.65E-5	1.24E-5	0.0
100 - 200	0.0	1.15E-6	4.17E-5	2.98E-4	0.0
200 - 300	0.0	0.0	0.0	8.99E-6	0.0
> 300	0.0	0.0	0.0	0.0	0.0

Table B.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-4	1.44E-4	2.39E-5	0.0	0.0
15 - 25	2.68E-5	4.87E-5	4.02E-6	0.0	0.0
25 - 50	5.30E-6	3.04E-5	2.65E-5	0.0	0.0
50 - 100	0.0	2.96E-6	8.84E-6	3.50E-6	0.0
100 - 200	0.0	0.0	0.0	7.08E-6	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-7 are shown as 0.0 in Tables B.3 and B.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 B.5 and B.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 B.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 B.7 shows $P>100(m,d)_1$ for the 1 Hz frequency.

Table B.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 B.3 to B.5 show the above information in terms of the relative percentage contribution.

Table B.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 B.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 ≤1.0E-7 are shown as 0.0 in Tables B.5, B.6, and B.7.

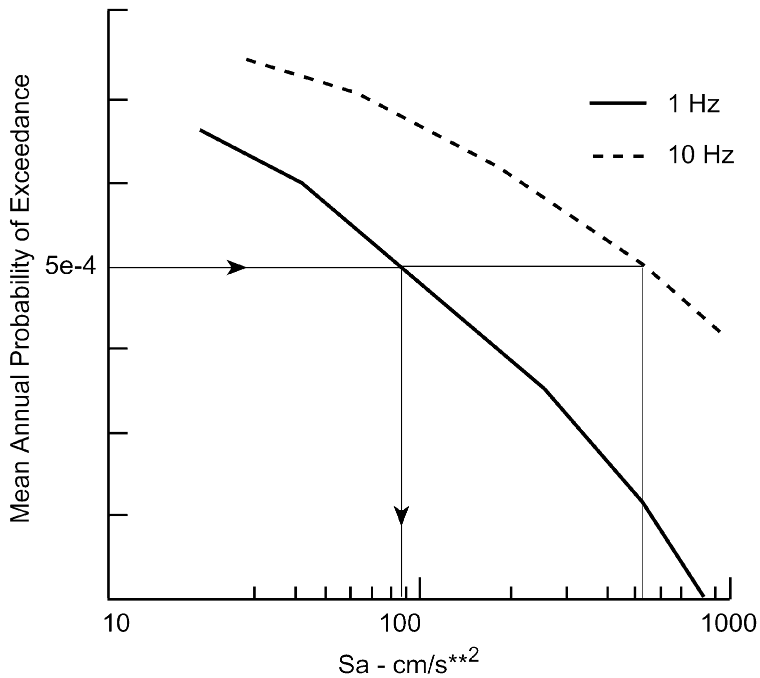

Figure B.1 Total Mean Hazard Curves

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 B.8.

Step 3-8

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

B.4 SITES NOT IN THE CEUS

The determination of the controlling earthquakes and of the seismic hazard information base for sites not in the CEUS is also carried out using the procedure described in Section B.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.

Table B.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

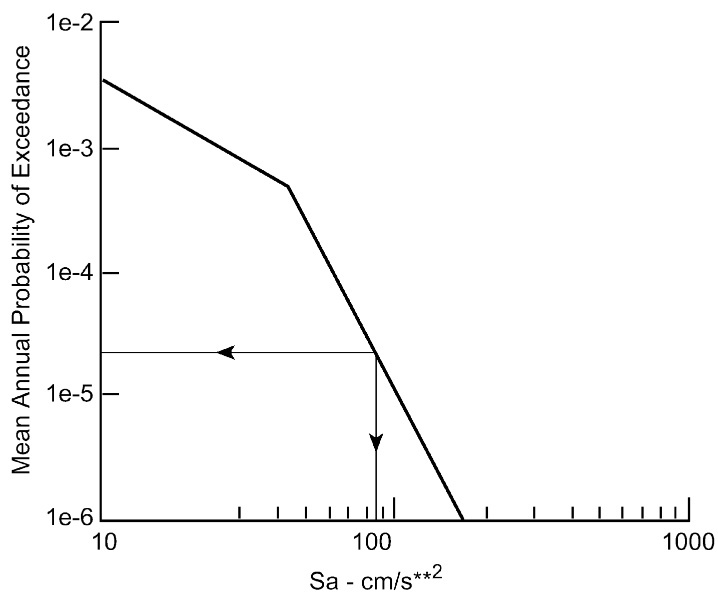

Figure B.2 1 Hz Mean Hazard Curve for Distance Bin 25-50 km and Magnitude Bin 6-6.5

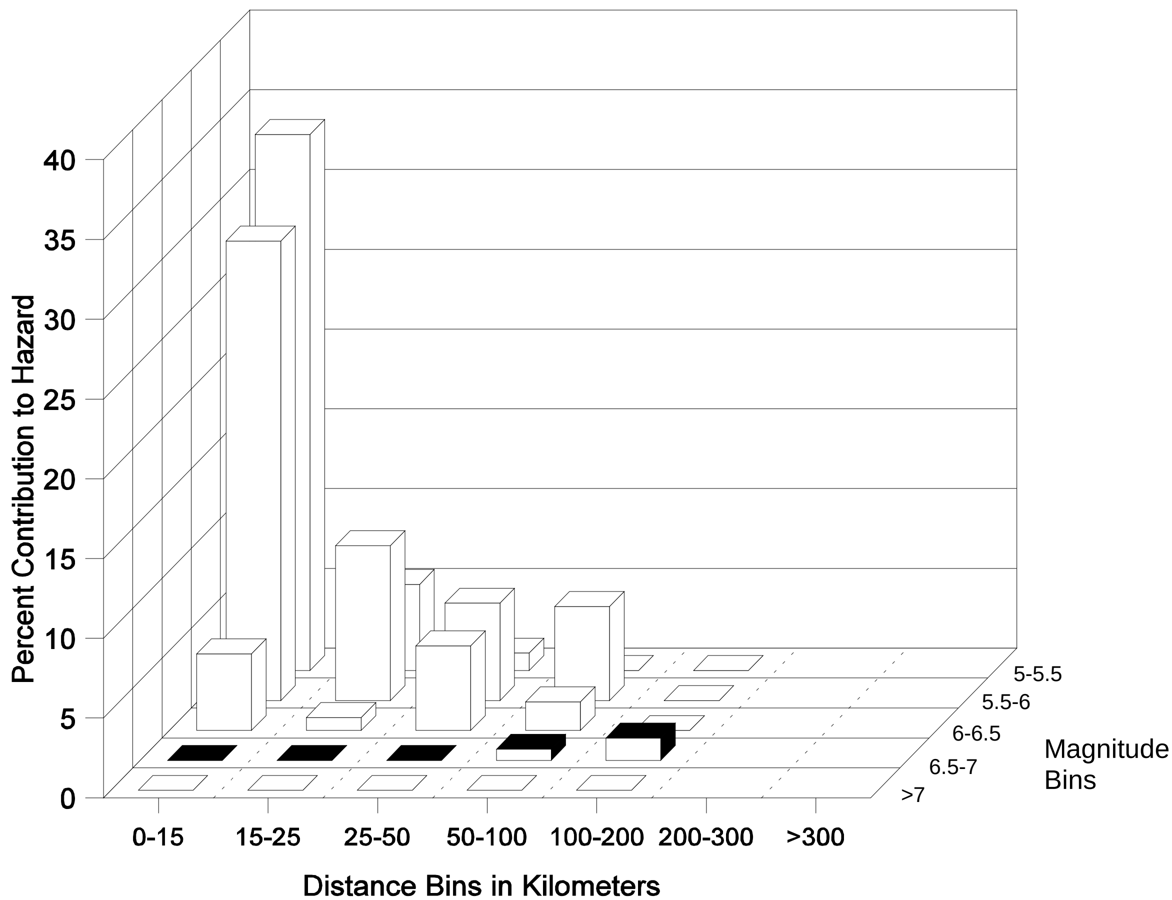

Figure B.3 Full Distribution of Hazard for 10 Hz

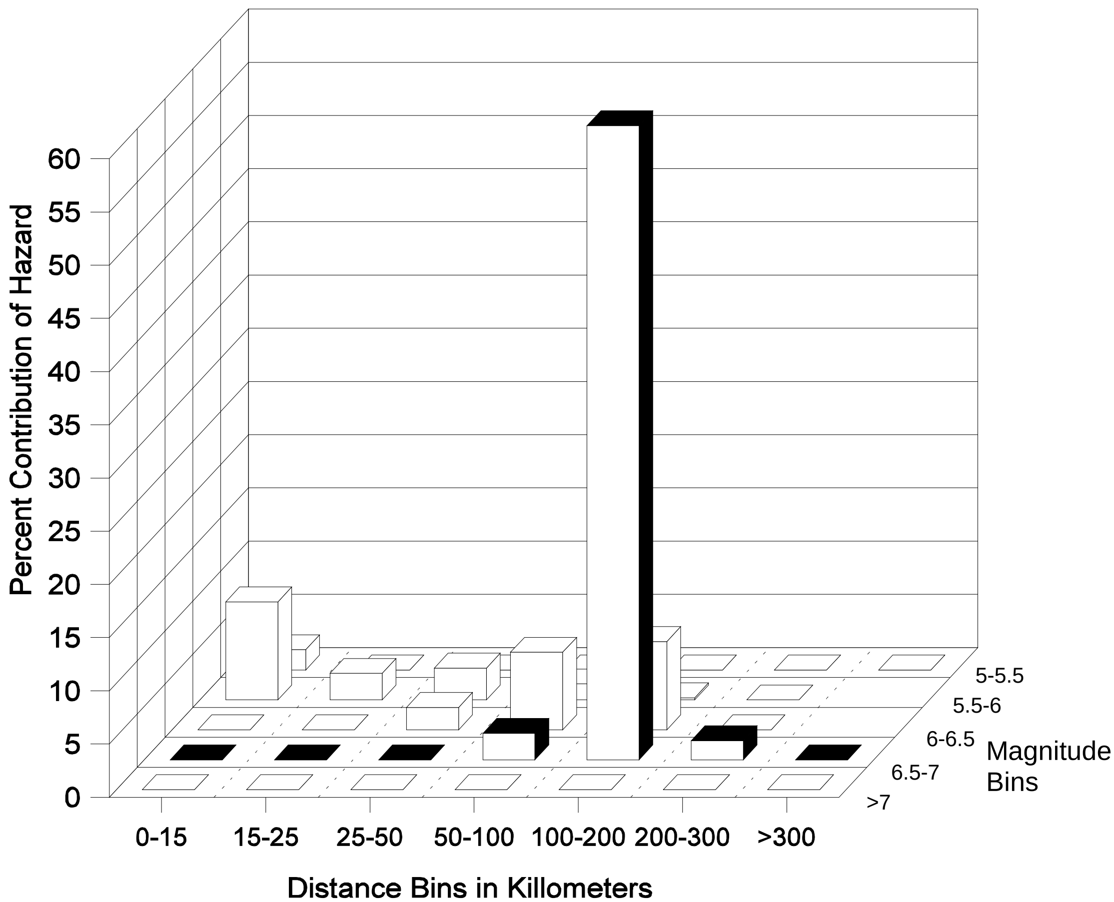

Figure B.4 Full Distribution of Hazard for 1 Hz

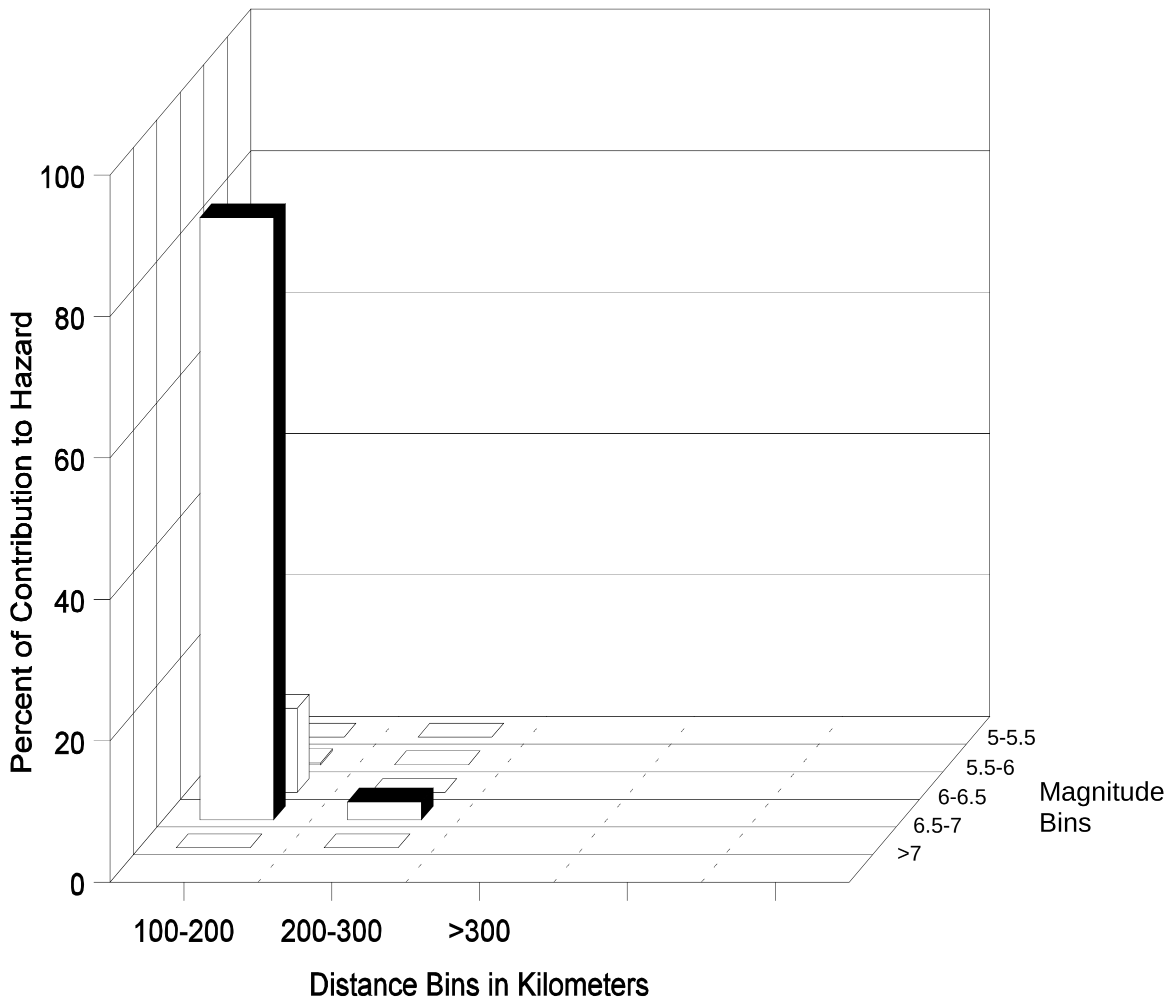

Figure B.5 Renormalized Hazard Distribution for Distances Greater than 100 km for 1 Hz

REFERENCES

B.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]

B.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]

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

B.4 Senior Seismic Hazard Analysis Committee, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," NUREG/CR- 6372, USNRC, April 1997.[1]

[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 (NTIS) 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 Public Document Room's (PDR's) mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; e-mail is <pdr@nrb.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 C
GEOLOGICAL, SEISMOLOGICAL, AND GEOPHYSICAL INVESTIGATIONS TO CHARACTERIZE SEISMIC SOURCES

C.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 Western United States (WUS) (west of the Rocky Mountain front) and the Central and Eastern United States (CEUS), or stable continental region (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. Reference C.1 may be used to assess large earthquake potential in the CEUS.

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. C.2). 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 D) 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. C.3).

- 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. C.3).

- 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. C.3).

- 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. C.4).

- 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.

C.2. INVESTIGATIONS TO EVALUATE SEISMIC SOURCES

C.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 a 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. C.5).

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 Lawrence Livermore National Laboratory (LLNL)/Electric Power Research Institute (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 C.2.2 and C.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. C.6) and NUREG/CR-5738 (Ref. C.7), 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.

C.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.

C.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.

C.2.3.1 Surface Investigations of the Site Area [within 8 km (5 mi.)]

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.

C.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.

C.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.

C.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).

C.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 knickpoints; abrupt changes in fluvial deposits or terraces; changes in paleo-channels across a fault; or uplifted, down-dropped, or laterally displaced marine terraces.

C.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.

C.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; and cracks or fissures.

C.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. C.8), approximate magnitude of the associated earthquake, recurrence intervals, slip rate, and the nature of the causative fault at depth.

C.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. C.6) and updated in NUREG/CR-5738 (Ref. C.7). The investigations include, but may not be confined to, the following:

C.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.

C.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;

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

C.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 U.S. Nuclear Regulatory Commission (NRC) staff will accept evaluations using the methods described in NUREG/CR-5503 (Ref. C.4). 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.

C.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 caused by 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. C.4); acceptable geochronology dating methods are described in NUREG/CR-5562 (Ref. C.8).

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.

C.2.4 Site Geotechnical Investigations and Evaluations

C.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, and 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. C.6) updated with NUREG/CR-5738 (Ref. C.7). 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. C.6) and NUREG/CR-5738 (Ref. C.7) 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. C.7). 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 C.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 C.1 Examples of Soil Dynamic Property and Strength Tests

D 3999-91 (Ref. C.9)	"Standard Test Method for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus"
D 4015-92 (Ref. C.10)	"Standard Test Methods for Modulus and Damping of Soils by the Resonant-Column Method"
D 5311-92 (Ref. C.11)	"Standard Test Method for Load-Controlled Cyclic Triaxial Strength of Soil"

C.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.

C.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 design earthquake 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 for 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).

C.2.4.4 Ground Failure Evaluations

C.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. C.12), 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. C.13, Ref. C.14).

- 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);

- 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.

C.2.4.4.2. Ground settlement during and after an earthquake that is caused by 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. C.15). Where these conditions exist near a site, consideration and investigation must be given to the possibility that surface subsidence will occur.

C.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 from 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.

C.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 C.16. The following techniques, which are presented according to that classification, are useful in dating Quaternary deposits.

C.2.5.1 Sidereal Dating Methods

- Dendrochronology
- Varve chronology
- Schlerochronology

C.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

C.2.5.3 Radiogenic Dating Methods

- Fission track
- Luminescence
- Electron spin resonance

C.2.5.4 Chemical and Biological Dating Methods

- Amino acid racemization
- Obsidian and tephra hydration
- Lichenometry

C.2.5.6 Geomorphic Dating Methods

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

C.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.

REFERENCES

C.1 Electric Power Research Institute, "The Earthquakes of Stable Continental Regions," Volume 1: *Assessment of Large Earthquake Potential*, EPRI TR-102261-V1, 1994.

C.2 Electric Power Research Institute, "Seismic Hazard Methodology for the Central and Eastern United States," EPRI NP-4726, All Volumes, 1988 through 1991.

C.3 Senior Seismic Hazard Analysis Committee (SSHAC), "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," NUREG/CR-6372, USNRC, 1997.[1]

C.4 K.L. Hanson, et al., Techniques for Identifying Faults and Determining Their Origins," NUREG/CR-5503, USNRC,[1]1999.

C.5 International Atomic Energy Agency, "Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting," Safety Series No. 50-SG-S1, Revision 1, 1991.

C.6 U.S. Nuclear Regulatory Commission, "Site Investigations for Foundation of Nuclear Power Plants," Regulatory Guide 1.132, March 1979.[2] (Proposed Revision 2, DG-1101, was issued for public comment in February 2001.)

C.7 N. Torres, et al.,"Field Investigations for Foundations of Nuclear Power Facilities," NUREG/CR-5738, USNRC, 1999.[1]

C.8 J.M. Sowers, et al., "Dating and Earthquakes: Review of Quaternary Geochronology and Its Application to Paleoseismology," NUREG/CR-5562, USNRC, 1998.[1]

C.9 American Society of Testing and Materials, "Standard Test Method for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus," D 3999, 1991.

C.10 American Society of Testing and Materials, "Standard Test Methods for Modulus and Damping of Soils by the Resonant-Column Method," D 4015, 2000.

[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 (NTIS) 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 (PDR) 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; e-mail is <pdr@nrc.gov.>.

[2] 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; e-mail <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>.

C.11 American Society of Testing and Materials, “Standard Test Method for Load-Controlled Cyclic Triaxial Strength of Soil,” D 5311, 1996.

C.12 U.S. Nuclear Regulatory Commission, “Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites,” Draft Regulatory Guide DG-1105, issued for public comment March 2001.

C.13 H.B. Seed and I.M. Idriss, “Ground Motions and Soil Liquefaction during Earthquakes,” Earthquake Engineering Research Institute, Oakland, California, Monograph Series, 1982.

C.14 H.B. Seed et al., “Influence of SPT Procedures in Soil Liquefaction Resistance Evaluation,” *Journal of the Geotechnical Engineering Division,* ASCE, 111, GT12, 1225-1273, 1985.

C.15 A.W. Hatheway and C.R. McClure, “Geology in the Siting of Nuclear Power Plants,” *Reviews in Engineering Geology,* Geological Society of America, Volume IV, 1979.

C.16 S. M. Colman, K. L. Pierce, and P.W. Birkland, “Suggested Terminology for Quaternary Dating Methods,” *Quaternary Research*, Volume 288, pp. 314-319, 1987.

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

D.1 INTRODUCTION

This appendix provides methods acceptable to the U. S. Nuclear Regulatory Commission 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. 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 were to result in a significant increase in the hazard estimate for a site, and if this new information were validated by a strong technical basis, the PSHA might 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.

D.2 POSSIBLE SOURCES OF NEW INFORMATION THAT COULD AFFECT THE DE

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.

D.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, before the issuance of an operating license, and extensive additional investigations of those faults had to be carried out to properly characterize them.

D.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 were larger than the values provided by LLNL and EPRI.

D.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 E 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.

D.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 Independent Spent Fuel Storage Installation 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 EPRI/LLNL study results, including the uncertainties.

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. D.1). Geological evidence found recently within the Wabash River Valley and several of its tributaries indicated that an earthquake much larger than any historic earthquake 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 earthquake. This analysis of the source characterizations of the experts and teams resulted in the analysts' conclusion that a new PSHA would not be necessary for this region because an earthquake 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 Stable Continental Region similar to the evidence found on the Meers Fault in Oklahoma (Ref. D.2). If such a source were identified, the same approach used in the active tectonic regions of the Western United States 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 might require determining the appropriate reference probability.

REFERENCES

D.1 Memorandum from A. Murphy, U.S. Nuclear Regulatory Commission, to L. Shao, U.S. Nuclear Regulatory Commission, Subject: “Summary of a Public Meeting on the Revision of Appendix A to 10 CFR Part 100, "Seismic and Geologic Siting Criteria for Nuclear Power Plants,"; Enclosure (Viewgraphs): NUMARC, "Development and Demonstration of Industry's Integrated Seismic Siting Decision Process," February 23, 1993.[1]

D.2 A.R. Ramelli, D.B. Slemmons, and S.J. Brocoum, "The Meers Fault: Tectonic Activity in Southwestern Oklahoma," NUREG/CR-4852, U.S. Nuclear Regulatory Commission, March 1987.[2]

[1] Copies are available for inspection or copying, for a fee, from the U.S. Nuclear Regulatory Commission Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the PDR’s mailing address is USNRC PDR, Washington, DC 20555; [telephones: (301)415-4737 or (800)397-4205]; fax (301)415-3548; e-mail <pdr@nrc.gov>.

[2] 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 (NTIS) 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 PDR at 11555 Rockville Pike, 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 is <pdr@nrc.gov>.

APPENDIX E
PROCEDURE TO DETERMINE THE DESIGN EARTHQUAKE GROUND MOTION

E.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 Section B.2, Step 2-2, of Appendix B to this guide. The standard response spectrum is generally specified at 5 percent critical damping.

E.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. E.1), and scale it by a peak ground motion parameter (usually peak ground acceleration), 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 E.1 to E.3.

Figure E.1 depicts a situation in which a site is to be used for a certified Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation 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 E.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 E.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.

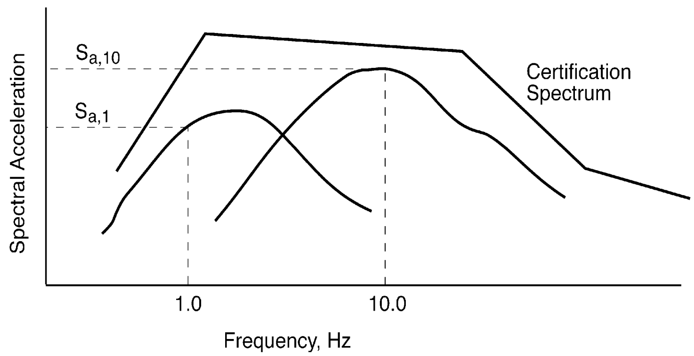

Figure E.1 Use of DE Spectrum of a Certified Design

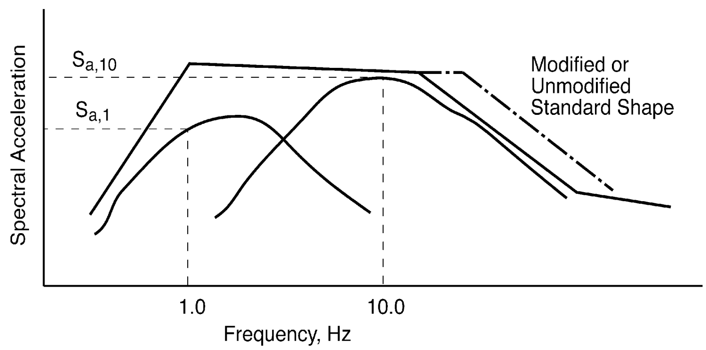

Figure E.2 Use of a Standard Shape for DE

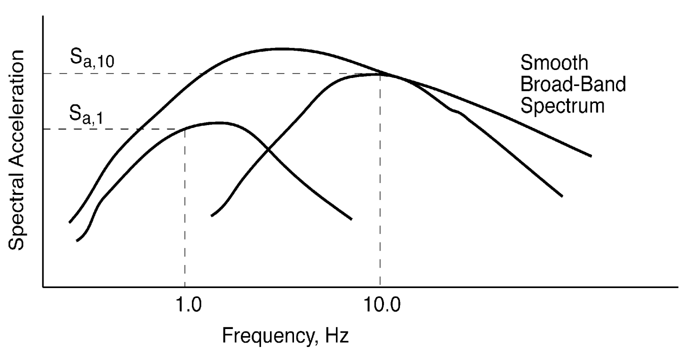

Figure E.3 Development of a Site-Specific DE Spectrum

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.

REFERENCES

E.1 U.S. Nuclear Regulatory Commission, "Design Response Spectra for Seismic Design of Nuclear Power Plants," Regulatory Guide 1.60, Revision 1, December 1973.[1]

[1] 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; e-mail <distribution@nrc.gov>. Copies are available for inspection or copying, for a fee, from the NRC Public Document Room (PDR) 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>.

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 U.S. Nuclear Regulatory Commission Public Document Room, as Attachment __ to SECY-______. The Public Document Room’s (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>.

SELECTION OF THE DESIGN EARTHQUAKE GROUND MOTION REFERENCE PROBABILITY

June 2003

SELECTION OF THE DESIGN EARTHQUAKE GROUND MOTION REFERENCE PROBABILITY

CONTENTS

SELECTION OF THE DESIGN EARTHQUAKE GROUND MOTION REFERENCE PROBABILITY

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) is amending 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 will update the seismic siting and design criteria, including geologic, seismic, and earthquake engineering considerations in 10 CFR Part 72 regulations. The final rule will allow NRC and its licensees to benefit from experience gained in the licensing of existing facilities and to incorporate rapid advances in earth sciences and earthquake engineering, using probabilistic seismic hazard analysis (PSHA). The proposed rule and the announcement on the availability of the draft Regulatory Guide, DG-3021, were published for public comments on July 22, 2002.

This paper describes the basis for recommending the reference probability that is used in Regulatory Position 3.4 of the Regulatory Guide (RG) 3.73 (draft was the aforementioned DG-3021) to determine the design earthquake ground motion (DE) for ISFSI and MRS facilities. The reference probability is the mean annual probability of exceeding the DE.

This paper is prepared in response to the Staff Requirements Memorandum (SRM) dated November 19, 2001, pertaining to the Modified Rulemaking Plan for changes to the seismological and geological requirements of Part 72, for siting and design of a dry cask ISFSI or MRS (SECY-01-0178). The SRM required the staff to seek public comments on the issue of the appropriate value of the reference probability in the range of 5E-4 and 1E-4, and to provide further analysis to support a specific recommendation.

In certain situations, the Part 72 amendments to the regulations require the use of PSHA methods or suitable sensitivity analyses for specific ISFSI or MRS facilities. In particular, a specific-license applicant for a dry cask storage ISFSI or MRS facility at a site not co-located with a nuclear power plant (NPP), in either the western U.S., or in areas of known seismic activity in the Eastern U.S., must use PSHA or suitable sensitivity analyses, to address uncertainties in determining the DE. For all other specific-license applicants for a dry cask storage ISFSI or MRS facility, the use of PSHA or suitable sensitivity analyses is optional. For instance, the applicant can use the design criteria for the most recent NPP (if applicable), or for locations in the Eastern U.S., a standardized DE described by a response spectrum anchored at 0.25 g (acceleration due to gravity), consistent with current Part 72 regulations.

To select the reference probability, the staff performed analytical studies to evaluate dry cask storage system behavior, and the potential for a cask failure and the subsequent radioactivity release during an earthquake. In addition, the staff reviewed the requirements and guidelines for siting and design of NPPs and other critical facilities contained in NRC RG 1.165; DOE-STD-1020-2002; and the International Building Code - 2000. Finally, the staff considered the public comments received in response to a specific question on an appropriate value of the reference probability, published with the proposed rule.

Based on the above-mentioned evaluations, the staff has concluded that the risk of a dry cask storage system releasing radioactivity during an earthquake is not significant, and that an ISFSI or MRS facility designed to the reference probability of 5E-4 (2000-year return period[1]) is expected to provide reasonable assurance that public radiological health and safety will be protected.

[1] The mean annual probability of exceedance, p, of an earthquake, is the reciprocal of the return period of the earthquake (i.e., p = 1/T). As an example, consider a site at which the return period for an earthquake is 2000 years. In this case, the mean annual probability of exceedance is 5E-4 (1/2000) or 0.05 percent.

SELECTION OF THE DESIGN EARTHQUAKE GROUND MOTION REFERENCE PROBABILITY

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) is amending 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 will update the seismic siting and design criteria, including geologic, seismic, and earthquake engineering considerations in 10 CFR Part 72 regulations. The final rule will 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 using probabilistic seismic hazard analysis (PSHA). The proposed rule and the announcement on the availability of the draft Regulatory Guide, DG-3021, were published for public comments on July 22, 2002 (Ref. 1).

This paper describes the basis for recommending the reference probability that is used in Regulatory Position 3.4 of Regulatory Guide (RG) 3.73 (Ref. 2, draft was DG-3021) to determine the design earthquake ground motion (DE) for ISFSI and MRS facilities. The reference probability is the mean annual probability of exceeding (MAPE) the DE. Appendix A contains the abbreviations used in this paper.

This paper is prepared in response to the Staff Requirements Memorandum (SRM) dated November 19, 2001 (Ref. 3), pertaining to the Modified Rulemaking Plan for changes to the seismological and geological requirements of Part 72, for siting and design of a dry cask ISFSI or MRS (SECY-01-0178). The SRM required the staff to seek public comments on the issue of the appropriate value of the reference probability in the range of 5E-4 and 1E-4, and to provide further analysis to support a specific recommendation.

2. BACKGROUND

In certain situations, the Part 72 amendments to the regulations require the use of PSHA or suitable sensitivity analyses for specific ISFSI or MRS facilities. In particular, a specific-license applicant for a dry cask storage ISFSI or MRS facility at a site not co-located with a nuclear power plant (NPP), in either the western U.S., or in areas of known seismic activity in the eastern U.S., must use PSHA or suitable sensitivity analyses, to address uncertainties in determining the DE. For all other specific-license applicants for a dry cask storage ISFSI or MRS facility, the use of PSHA or suitable sensitivity analyses is optional. The applicant can use the design criteria for the most recent NPP (if applicable), or for locations in the Eastern U.S., a standardized DE described by a response spectrum anchored at 0.25 g (acceleration due to gravity), consistent with the current Part 72 regulations. The amendments are not applicable to licensees operating an ISFSI under a Part 72 general license anywhere in the U.S.

In the “Statement of Considerations” accompanying the initial Part 72 rulemaking, in 1980 (Ref. 4), NRC recognized that probabilistic techniques are adequate to determine potential seismicity on a regional basis, but these techniques were not adequately developed for application to a specific site. During the past 20 years, PSHA methodology and procedures have now been developed sufficiently for the evaluation of seismic safety of nuclear facilities, and can be applied to the dry cask ISFSI and MRS, using the guidelines of Reference 5.

The NPPs, ISFSIs, and MRS facilities have been designed for earthquake loads, based on considering the greater risk factors for such facilities than for traditional buildings. The current Part 72 regulations for an ISFSI or an MRS facility require that for sites that have been evaluated under the criteria of Appendix A of 10 CFR Part 100, the DE must be equivalent to the safe shutdown earthquake ground motion (SSE) for an NPP. Recently, the seismological and geological siting criteria for an NPP were revised to require the use of PSHA methods or suitable sensitivity analyses, to account for uncertainties in the determining the ground motion used in the seismic design of structures, systems, and components (SSCs) (10 CFR 100.23, and Appendix S to 10 CFR Part 50). In addition, staff/Commission received requests for exemptions to 1o CFR 72.102(f), which requires that the DE for an ISFSI or MRS facility be determined using Appendix A of Part 100. Therefore, there is a need to change Part 72 to allow the use of PSHA and make the earthquake design level commensurate with the risk to public health and safety from an ISFSI or MRS facility.

In a risk-informed, performance-based approach, the earthquake design level of the facility is selected based on the degree of risk associated with the facility. For more than 50 years, this approach has been used in the building codes, such as the Uniform Building Codes (UBC) (Ref. 5); the National Building Codes (Ref. 6); and recently in the International Building Code -2000 (IBC-2000) (Ref. 7). These codes specify the earthquake design levels, considering the adverse consequences in terms of the hazard to human life, and the required performance of the structures. For example, specific seismic design provisions in the IBC-2000 Code are based on a graded approach, considering the function of the building, number of occupants, the post-earthquake requirement to have the facility available for use, etc.), and the hazard to the public from the contents of the building (toxic materials) (Ref. 7, section 1604.5).

3. RISK OF ISFSI/MRS FACILITY

This section discusses why an ISFSI or MRS facility does not have to be designed for NPP criteria, and how annual probability of exceeding the DE (the reference probability) was selected considering the risk of an ISFSI or MRS facility. First, the risk of an ISFSI/MRS facility is compared to an NPP. Second, the consequences of an earthquake and the likelihood of a release of radioactivity at an ISFSI/MRS facility are reviewed. Third, the industry codes for facilities similar to ISFSI or MRS facilities and the public comments are reviewed to select an appropriate reference probability for ISFSI or MRS facilities.

3.1 Comparison to NPP Risk

In the "Statement of Considerations" accompanying the initial Part 72 rulemaking, NRC recognized that the storage of spent fuel is a low-risk operation when compared to an NPP (45 FR 74697; November 12, 1980). Factors that result in lower radiological risk at an ISFSI or MRS, compared with an NPP, include the following:

- In comparison with an NPP, 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 NPP. 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 components carrying fluids at high temperatures or pressures, during normal operations, nor under design basis accident conditions, to cause the release and dispersal of radioactive materials. This is primarily because of 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 Iodine-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 an NPP.

3.2 Consequences of an Earthquake

Radiological risks to the public result from a release of radioactive materials and its dispersal to the environment. To protect the public from radiological risk, Part 72 regulations require that the SSCs in an ISFSI or MRS facility be 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.

3.2.1 Part 72 Requirements

The Dry Cask Storage Systems (DCSS') for ISFSIs or MRS', approved under Part 72 regulations, are typically self-contained, massive, concrete or steel structures, weighing approximately 90000 to 160000 kg (100 to 180 tons) when fully loaded, and are completely passive. The DCSS consists of free-standing vertical casks, or concrete Vault-Module-type storage systems. The spent fuel is contained in a steel sealed canister for both types of storage systems. An ISFSI or MRS facility also includes a Canister Transfer Building (CTB). This reinforced concrete building is considered important to safety, because the building is used for transferring the canister, containing the spent fuel assemblies, from the cask used to transport the canister from a spent-fuel pool, to the cask used for storage.

The requirements 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 DCSS design dimensions, such as thickness of various members, are governed by radiological shielding, thermal, and potential drop accidents during handling of the cask. Stresses in various cask components from natural phenomena such as earthquakes, tornadoes, floods, etc., are generally less than 5 percent of the design allowables, and do not govern the physical design of the cask. However, because the cask is free-standing, cask stability (sliding and/or overturning) is a significant design parameter. Cask movements are calculated to evaluate the potential for a cask tip-over, and a cask-to-cask impact. The effects of a cask tip-over event on the cask structural integrity are evaluated even if it is demonstrated that a cask tip-over is not probable. If a cask-to-cask impact is likely to occur, the cask structural integrity is evaluated. Applicable requirements for cask structural integrity are contained in 10 CFR 72.122 and 72.212.

3.2.2 DCSS Confirmatory Evaluations/Analyses

To evaluate DCSS behavior during an earthquake on a generic basis, typical storage systems [one a cylindrical cask, HI-STORM 100, the other a concrete module type, NUHOMS] were analyzed for a range of earthquakes (Refs. 8 -11). Site-specific properties at three ISFSI facilities, two on the West coast, and one on the East coast, were considered in the analyses. The analyses were performed for the maximum peak ground acceleration varying from 0.15 g to 1.5 g. The purpose of the studies was to determine the stability of the free-standing DCSS' during an earthquake.

Based on the results of the analyses, it has been concluded that a free-standing dry storage cask remains stable and will not tip over, or would not slide and impact the adjacent casks during an earthquake with the maximum peak ground acceleration as high as 1.5 g. The maximum earthquake SSE levels for currently licensed NPPs do not exceed 1.0 g. Even though a cask would remain stable and continue to maintain structural integrity for DE levels as high as SSE of an NPP, the current Part 72 requirements of DE, to be the same as SSE, impose unnecessary regulatory burden for the design of other structures of the ISFSI or MRS facility, such as cask pad and the foundation stability, CTB stability, and CTB structural design. Requiring these structures to be designed for SSE does not increase the safety of the facility because the consequences of an earthquake event at an ISFSI or MRS facility are not significant, as discussed earlier.

3.2.3 CTB at ISFSI/MRS Facility

Consequences of a failure of the CTB, during an earthquake magnitude greater than the DE, were analyzed (Ref. 12) to determine if the failure of the crane and the handling system, and resulting drop of the cask and the crane [approximately 16 m (51 feet)], would damage the multi-purpose canister (MPC) of the HI-STORM 100 system. Based on the evaluation, it is concluded that the MPC would not be damaged and release radioactivity to the environment. Therefore, even if the CTB were to fail during an earthquake, there are no consequences from failure of the building at a dry cask ISFSI or MRS facility (Ref. 12).

Additionally, for the CTB, the probability of the occurrence of an earthquake during the time the cask is being handled is low. 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. Moreover, 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 an earthquake is small.

Based on the above, the staff has concluded that the DCSS' for an ISFSI or MRS facility are inherently robust structures because of design requirements other than for an earthquake, and for an earthquake of a magnitude equal to the SSE for an NPP, there is relatively low probability of radioactivity release, and thus relatively low probability of adverse consequences from operation of a dry cask ISFSI or MRS facility.

3.3 Selection of an Appropriate Reference Probability

To select an appropriate reasonable value of the MAPE of an earthquake (the reference probability), or a mean return period, for a dry cask ISFSI or MRS facility, the staff reviewed the current guidelines contained in DOE-STD-1020-2002 (Ref. 13); the IBC-2000 Code (Ref. 7); RG 1.165 for an NPP (Ref. 14), and considered the public comments received in response to the specific question accompanying the proposed rule (Ref. 1).

3.3.1 DOE Design Standard

DOE requires the safety-significant or important-to-safety SSCs to be classified into one of four performance categories (PCs), based on the performance requirements (Ref. 13). The four categories are PC-1 through PC-4. The PC-1 category is for an SSC or a building/structure with potential human occupancy, the failure of which may cause a fatality or serious injuries to workers. The PC-2 category is for an SSC performing emergency functions to preserve the health and safety of workers, and is a part of a building used for assembly of more than 300 persons in one room. The PC-3 category is for an SSC whose failure would result in adverse release consequences less than the unmitigated release associated with a large-reactor severe accident. The PC-4 category is for an SSC whose failure would result in off-site release consequences greater than or equal to the unmitigated release associated with a large-reactor severe accident.

The PC-3 category is generally used for SSCs that handle significant amounts of hazardous materials. Based on the DOE classification of SSCs, the dry cask ISFSIs can be classified as PC-3 SSCs. For PC-3 SSCs, the design seismic hazard exceedance is 4E-4 (2500-years return period), except for sites which are near tectonic plate boundaries. For PC-3 SSCs at these sites, the design seismic hazard exceedance probability is 1E-3 (1000-years return period). The seismic hazard exceedance probability of 4E-4 is equivalent to a 2 percent probability of exceedance in 50 years. Design forces for these structures are multiplied by a Scale Factor of 0.9 (page A-6 of Attachment A) to bring the earthquake design levels to approximately 2000-year return period, specified in the earlier

DOE-STD-1020-94. The "Foreword" of DOE-STD-1020-2002 (Page A-2 of Attachment A), explains the change in the return period as follows:

> "It is not the intent of this revision to alter the methodology for evaluating PC-3 facilities, nor to increase the performance goal of PC-3 facilities, by increasing [the] return period for the PC-3 from a 2000-year earthquake to a 2500-year earthquake. Rather, the intention is more for convenience to provide a linkage from the NEHRP maps and DOE Standards."

It can be seen from Figure 1 that the Scale Factor of 0.9 used for the DOE PC-3 facilities would be equivalent to an approximately 2000-year return period earthquake for a facility located in New York City, and an approximately 1700-years return period for a facility located in the San Francisco area. Therefore, it can be concluded that the DOE design basis earthquake for PC-3 category structures similar to a dry cask ISFSI or MRS facility is an approximately 2000-year return period earthquake.

In summary, DOE facilities typical of ISFSIs and MRS' are designed to seismic criteria lower than the NPP design criteria, and the use of a reference probability of 5E-4 (2000-year return period for the design of an ISFSI or MRS facility DE, would be consistent with that used in DOE-STD-1020, for similar-type facilities.

3.3.2 IBC- 2000

The IBC-2000 (Ref. 7) seismic requirements are based on the 1997 edition of the NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures (Ref. 15). A graded approach is used in specifying the design levels of earthquakes, based on the degree of risk and the potential for human loss caused by failure of a structure from an earthquake. The requirements are intended to minimize the hazard to life for all buildings, increase the expected performance of higher-occupancy buildings, as compared to ordinary buildings, and improve the capability of essential facilities, such as hospitals, and infrastructure required for national defense etc., to function during and after an earthquake. For essential facilities, it is expected that damage from DE would not be so severe as to prevent continued occupancy and function of the facility. For ground motion greater than the design levels, the intent is that there would be a low likelihood of structural collapse.

The IBC-2000 defines the maximum considered earthquake (MCE) ground motion, as a collapse-level earthquake with a 2 percent probability of exceedance in 50 years. This is equivalent to an annual probability of exceedance of 4E-4 (2500-year return period). The design earthquake spectral acceleration, which is equivalent to the DE for an ISFSI or MRS facility, is specified in the IBC-2000 as two-thirds of the MCE spectral response acceleration. The purpose of specifying the MCE instead of the DE was to provide an approximately uniform margin against collapse of structures located in the Western United States (WUS) and the Eastern United States.

The earlier UBCs specified a DE at a 10 percent probability of exceedance in 50 years (an approximately 500-year return period). Because of the differences in the shapes of the seismic hazard curves of the Eastern United States and the WUS, the buildings located in the Eastern and the WUS would have different safety margins in their ability to survive a greater-level earthquake ground motion. Considering the margin of safety of 1.5 inherent in recent and current U. S. seismic design practice (Ref. 16) and using the Hazard Curves for the Eastern United States (New York City), and the WUS (San Francisco), as shown in Figure 2, it can be seen that a building in New York City designed using the 500-year earthquake return period ground motion can survive an earthquake with a return period of approximately 830 years, whereas the same building in San Francisco can survive an earthquake of return period of approximately 1670-years. Thus, there was a disparity in the seismic risk levels for the WUS and Eastern United States. A study (Ref. 17) discusses this in detail. The IBC-2000, which replaced the earlier UBCs, corrects this disparity by specifying the collapse-level earthquake MCE and requires the DE to be determined using the margin of safety of 1.5. Thus, the IBC-2000 provides for a uniform margin against collapse, but not a uniform probability of the ground motion.

To account for the degree of consequences and grading the risk to public health and safety, the IBC-2000 requires the DE to be multiplied by a seismic factor that varies from 1.00 to 1.5. The seismic factor increases with the importance of the facility, based on the nature of occupancy and the degree of adverse consequences (Table 1604.5 of Ref. 7, included as Attachment B to this report). A dry cask ISFSI or MRS facility is a passive-storage facility that does not require continuous operation, and thus represents a low hazard to human life in case of failure. Therefore, it is appropriate to use the Seismic Factor of 1.00 for a dry cask ISFSI or MRS facility, consistent with IBC-2000 Category IV buildings.

Based on the evaluation described above, the IBC-2000 would require the DE for the dry cask ISFSI or MRS facility to be equivalent to a 909-year return period for a facility located in San Francisco, CA, and a 1430-year return period for a facility located in New York City (Figure 3). The DE included in the RG (Ref. 2) is equivalent to a 2000-year return period, which exceeds the IBC-2000 Code requirement of a 1300-year return period.

3.3.3 CTB Capacity

The CTB at an ISFSI or MRS facility is designed using the load combinations, the acceptance criteria, and the design code, which are the same as for NPP safety-related seismic Category I buildings. Considering the margin of safety of 1.5 inherent in recent and current U. S. seismic design practice (Ref. 16) and using the Hazard Curves (at 0.1-second Spectral Acceleration) for New York City, in the Eastern United States, and San Francisco, in the WUS (Figure 4), it can be seen that a building structure designed for DE with a return period of 2000 years (0.1-second Spectral Acceleration, varying from 0.5 g to 1.3 g), as proposed in the regulatory amendments, has a capacity to withstand an earthquake with a return period of 4000-years in New York City, and 25000-years in San Francisco, CA, without collapse (0.1-second Spectral Acceleration, varying from 0.75 g to 3.15 g). The difference in these estimates between the Eastern United States and the WUS is caused by differences in seismic hazard curves.

3.3.4 NPP Design

For the siting of an NPP, RG 1.165 recommends the reference probability of 1E-5, as the “median” annual probability of exceeding the SSE. The “median” annual probability of exceedance of 1E-5 is approximately equal to a “mean” annual probability of exceedance of 1E-4 (10,000 years return period) for the SSE, at sites in the Eastern United States (Ref. 18). Because the uncertainty associated with the seismic hazard evaluations at sites in the WUS is less than at Eastern United States sites, “mean” values normally are closer to “median” values at the WUS sites. Thus, choosing a “mean” annual probability of exceedance of 1E-4 would be consistent with the “mean” hazard level associated with the “mean” hazard levels of nuclear power plants in the Eastern United States, but choosing a “median” annual probability of exceedance of 1E-5 would not be. Based on the recent work in NUREG/CR-6728 (Ref. 19), the staff has determined that the use of a “mean” annual probability of exceedance for the reference probability of the seismic hazard is an appropriate method for the design of an ISFSI or MRS facility.

3.3.5 Public Comments

There were seven public comments on an appropriate reference probability for DE. Four of the comments from the nuclear industry and DOE, strongly endorse the referenced probability of 5E-4, whereas two comments (State of Utah and the California Energy Commission) appear to imply that, as a minimum, NRC should use the reference probability of 4E-4, consistent with the IBC-2000. One comment from the State of Nevada suggests that 10 CFR 100.23 should be adopted in its entirety, including conforming the DE to the SSE criteria.

The discussions in sections 3.1 and 3.3.1 through 3.3.5 provide the bases for the DE reference probability of 5E-4. It also demonstrates that the DE reference probability is reasonable, considering the relative risks of an ISFSI or MRS facility and an NPP, and is consistent with the design-level ground motions specified by the codes for similar facilities.

3.4 Summary

1. Based on the fact that the risk from an earthquake at a dry cask ISFSI or MRS facility is lower than at an NPP, the reference probability for such a facility should be higher than the reference probability of 1E-4 for an NPP. In other words, the design-mean-earthquake return period for such a facility should be less than 10000 years.

2. The reference probability of 5E-4 (2000-year return period), for an ISFSI or MRS facility DE, is consistent with that used in DOE-STD-1020, for similar-type facilities.

3. The IBC-2000 requires the buildings, similar to a dry cask ISFSI or MRS facility, to be designed for earthquakes for a return period varying from 500 to 1300 years. Therefore, the recommended reference probability of 5E-4 (2000-year return period) provides more stringent seismic design criteria than the IBC-2000 seismic design requirements.

Requirements of the DOE-STD-1020-2002, IBC-2000, and ISFSI or MRS facility for DE are compared in Figure 5.

4. REFERENCES

1. U. S. Nuclear Regulatory Commission, "Geological and Seismological Characteristics for Siting and Design of Dry Cask Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations," 67 *Federal Register*, 47745, July 22, 2002.

2. U. S. Nuclear Regulatory Commission, Regulatory Guide 3.73, "Site Evaluations and Determination of Design Earthquake Ground Motion for Independent Spent Fuel Storage and Monitored Retrievable Storage Installations," June 2003.

3. U. S. Nuclear Regulatory Commission, "Staff Requirements Memorandum, 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," November 19, 2001.

4. U. S. Nuclear Regulatory Commission, "Licensing Requirements for the storage of Spent Fuel in An Independent Spent Fuel Storage Installation," 45 *Federal Register*, 74693, November 12, 1980.

5. International Conference of Building Officials, "Uniform Building Code," 1994, 1997.

6. Building Officials and Code Administrators, "National Building Code," 1999.

7. International Code Council, "International Building Code," 2000.

8. Sandia National Laboratories, "Seismic Analysis of HI-STORM 100 Casks at Hatch Nuclear Power Plant," V. Luk, et al., Albuquerque, NM, June 28, 2001.

9. Sandia National Laboratories, "Seismic Analysis of Three Module Rectangular Trans-Nuclear West Module/cask," V. Luk, et al., Albuquerque, NM, December 21, 2001.

10. Sandia National Laboratories, "Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage Facility," Rev. 1, V. Luk, et al., Albuquerque, NM, March 31, 2002.

11. Center for Nuclear Waste Regulatory Analyses, "Dynamic Soil-Structure Interaction Analysis of a Storage-Cask Foundation Design," G. I. Ofoegbu, G. D. Gute, San Antonio, TX, October 2002.

12. Brookhaven National Laboratory, "Analysis of Dry Cask Drop Scenarios onto a Reinforced Concrete Floor," J. Braverman, et al., April 24, 2002.

13. U.S. Department of Energy, DOE-STD-1020-2002, "Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities," January 2002.

14. U.S. Nuclear Regulatory Commission, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," Regulatory

Guide 1.165, Washington, DC, March 1997.

15. National Institute of Building Sciences - Buildings Seismic Safety Council, "NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures,", 1997 Edition, FEMA 302, February 1998.

16. International Code Council, "Commentary to the International Building Code," Vol. II, Falls Church, VA, pp. 16-69.

17. E. V. Leyendecker,, J. R. Hunt, A. D. Frankel, and K. S. Rukstales, "Development of Maximum Considered Earthquake Ground Motion Maps," *Earthquake Spectra*, Vol. 16, No. 1, February 2000, pp. 21-40.

18. U.S. Nuclear Regulatory Commission, NUREG-1488, "Revised Livermore Seismic Hazard Estimates for Sixty-Nine Nuclear Power Plant Sites East of the Rocky Mountains," P. Sobel, April 1994.

19. U.S. Nuclear Regulatory Commission, NUREG/CR-6728, "Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines," R. K. McGuire, W. J. Silva, and C. J. Constantino, October 2001.

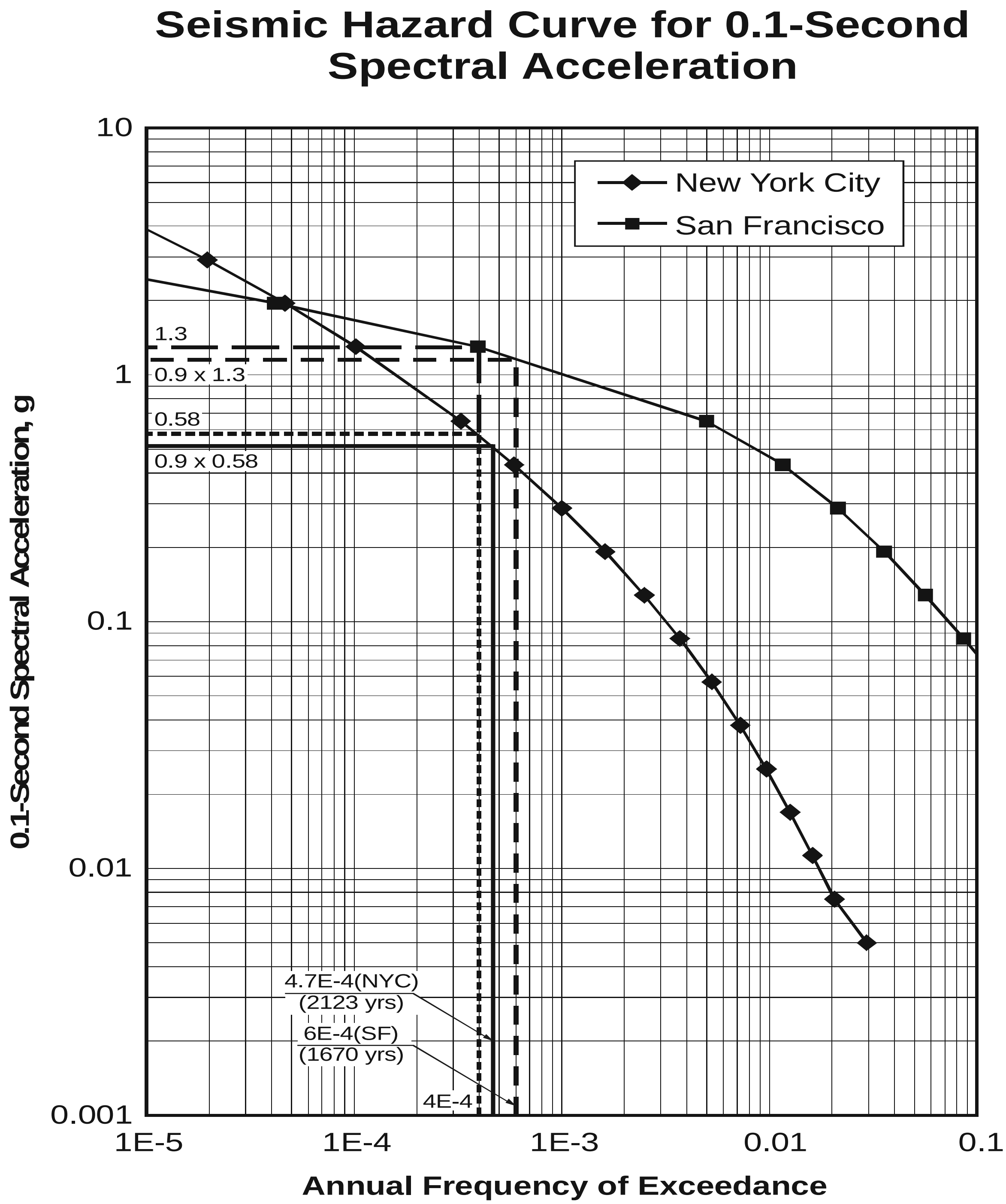

Figure 1 DOE-STD-1020-2002 DE for PC-3 SSCs

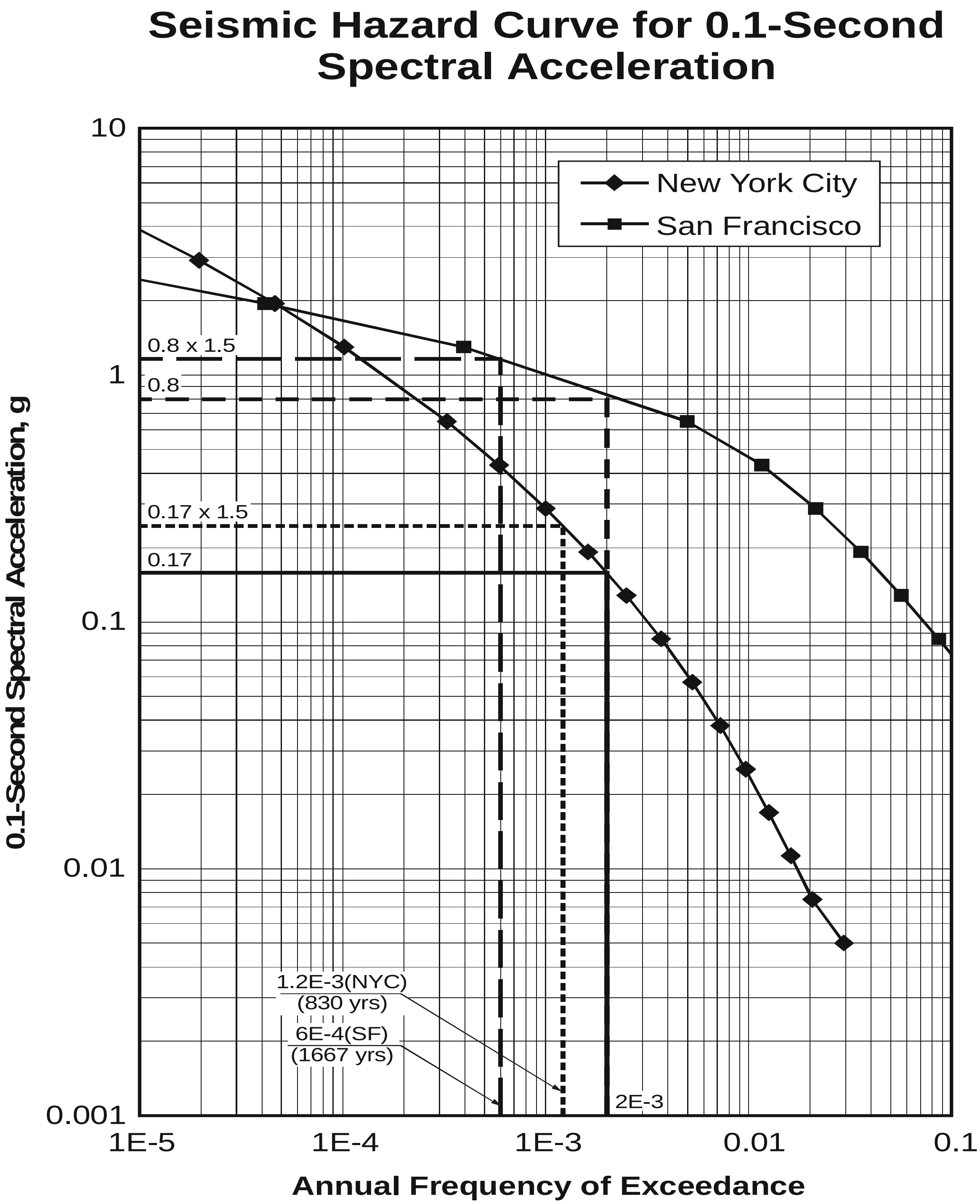

Figure 2 Capacity of Buildings Designed to Earlier UBCs (prior to IBC-2000)

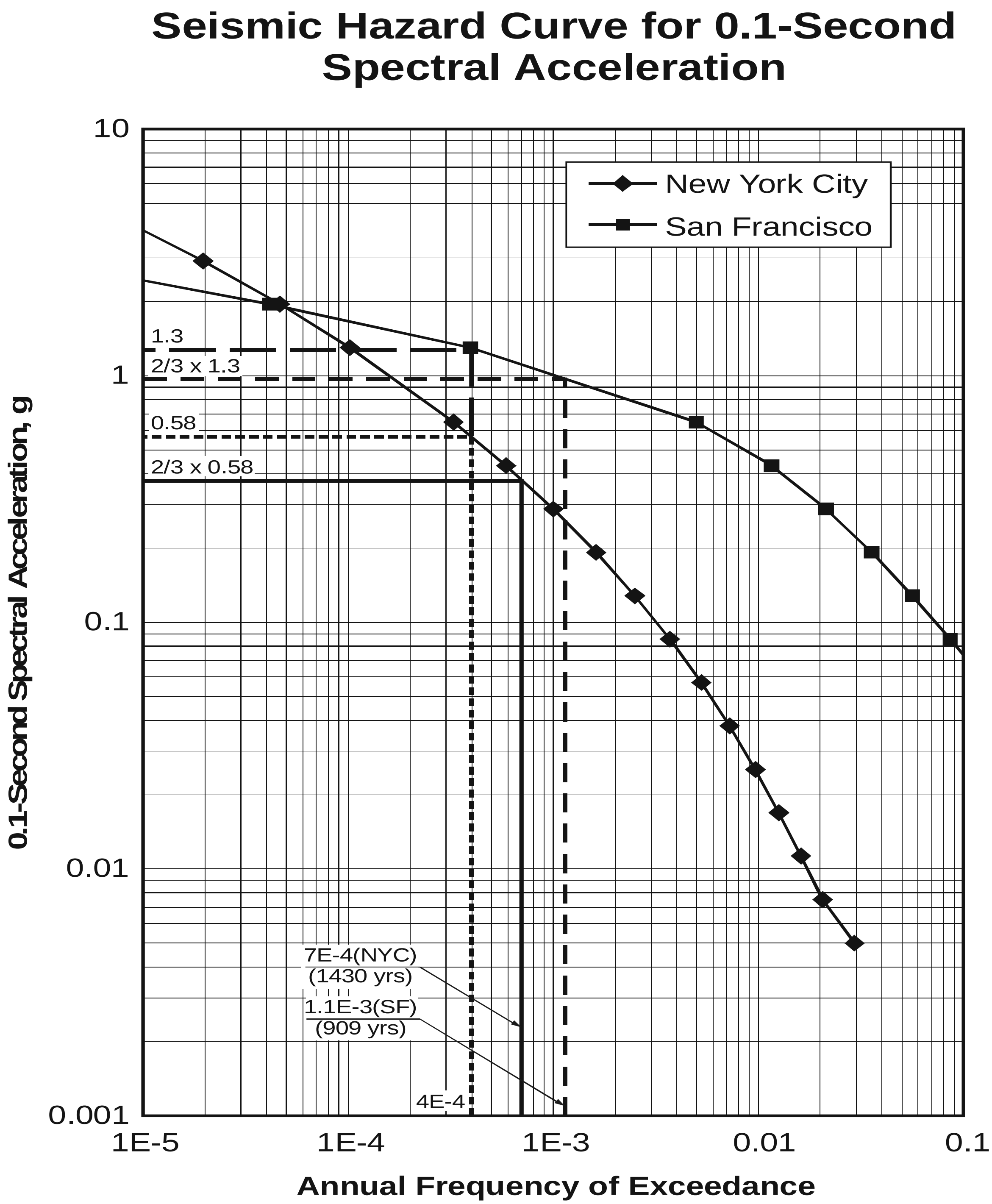

Figure 3 IBC-2000 DE

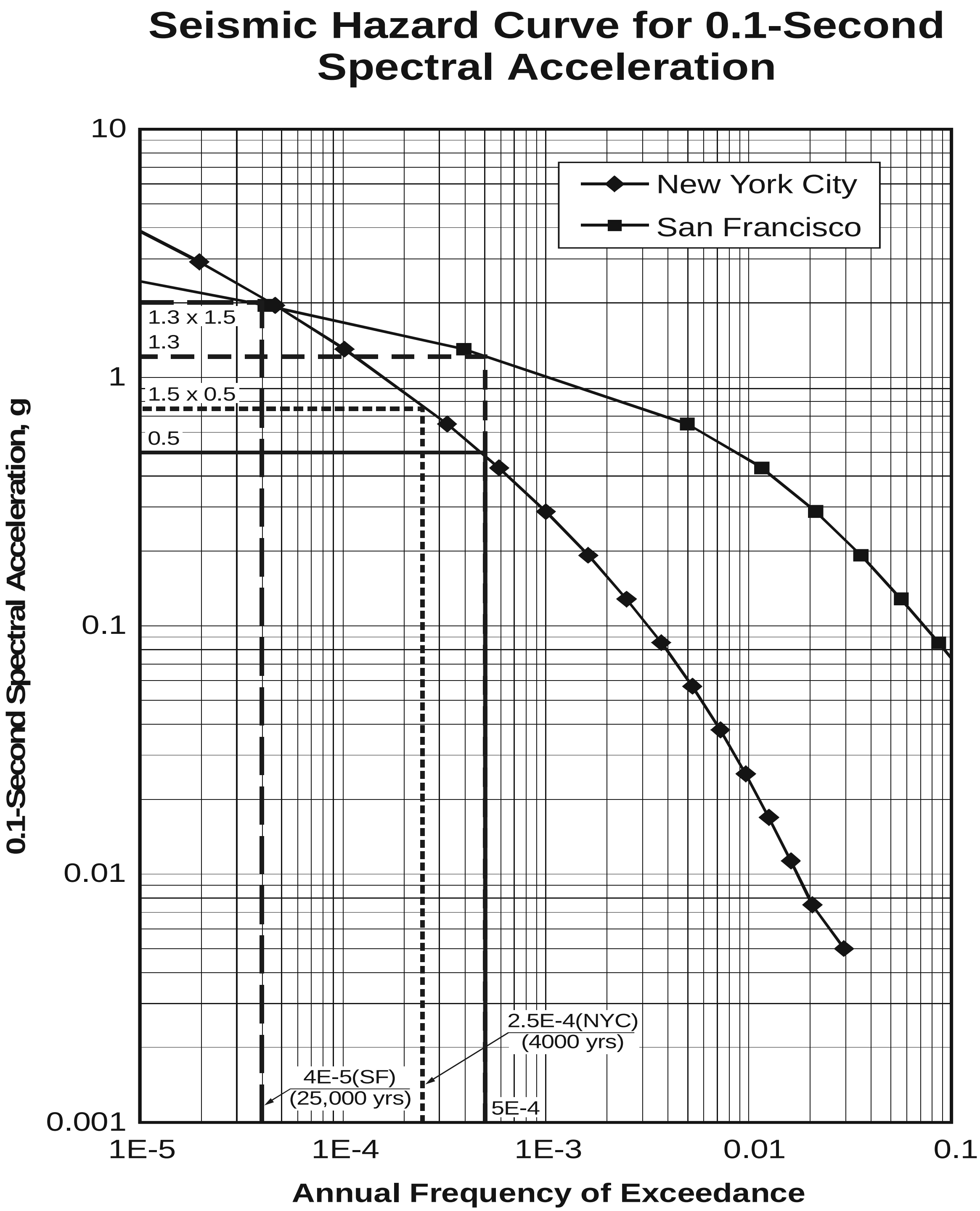

Figure 4 Capacity of Buildings Designed for DE at Reference Probability

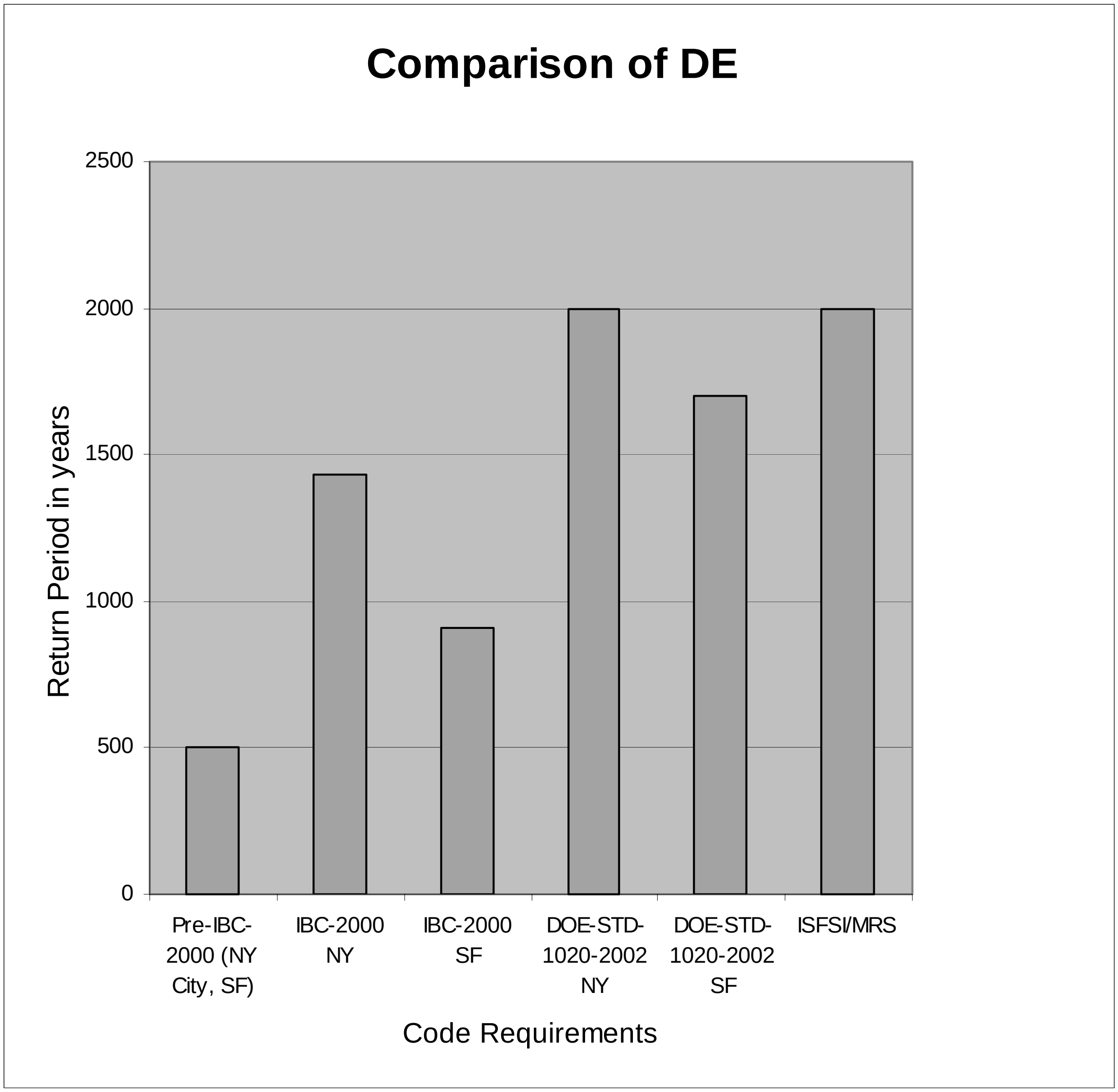

Figure 5 Comparison of DE

ABBREVIATIONS

CEUS	Central and Eastern United States
CTB	Canister Transfer Building
DCSS	Dry Cask Storage System
DE	Design Earthquake Ground Motion
DG	Draft Regulatory Guide
DOE	Department of Energy
g	Acceleration due to gravity
IBC-2000	International Building Code -2000
ISFSI	Independent Spent Fuel Storage Installation
MAPE	Mean Annual Probability of Exceedance
MCE	Maximum Considered Earthquake
MPC	Multi-purpose Canister
MRS	Monitored Retrievable Storage Installation
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
PCs	Performance Categories
PSHA	Probabilistic Seismic Hazard Analysis
RG	Regulatory Guide
SRM	Staff Requirements Memorandum
SSC	Structures, Systems and Components
SSE	Safe Shutdown Earthquake Ground Motion
UBC	Uniform Building Code
WUS	Western United States

SELECTED PAGES FROM
DOE STANDARD DOE-STD-1020-2002

TS

NOT MEASUREMENT SENSITIVE

DOE-STD-1020-2002
January 2002

Superseding
DOE-STD-1020-94
April 1994

DOE STANDARD

NATURAL PHENOMENA HAZARDS DESIGN AND EVALUATION CRITERIA FOR DEPARTMENT OF ENERGY FACILITIES

U.S. Department of Energy
Washington, D.C. 20585

AREA NPHZ

Foreword

This revision provides information to help meet the requirements of 10 CFR Part 830, "Nuclear Safety Management," (for Nuclear Facilities), DOE 0 420.1 and its associated Guides, accounting for cancellation of DOE 0 6430. 1 A and updating this standard to most current references. This standard has also been brought up-to-date to match the requirements of current model building codes such as IBC 2000 and current industry standards.

Since the publication of DOE-STD-1020-94 several new documents have been published which made the seismic design standards of DOE-1020-94 outdated.

- The 1997 NEHRP *Recommended Provisions for Seismic Regulations for New Buildings and Other Structures Parts I and 2* introduced new seismic maps for evaluating the seismic hazard.

- The three model building codes UBC, BOCA, and SBCCI were replaced by the *International Building Code* (IBC 2000), which adopted the 1997 NEBPP seismic provisions.

- DOE Order 420.1 and the associated guide, DOE G 420.1-2, were approved and adopted the use of IBC 2000 for PC- I and PC-2 facilities.

Since DOE-STD- 1020-94 adopted the LJBC for the seismic design and evaluation of PC- I and PC-2 structures, it was necessary to accommodate the use of the IBC 2000 instead of the UBC for DOE facilities. The seismic hazard in the IBC 2000 is provided by maps that define the seismic hazard in terms of the Maximum Considered Earthquake (MCE) ground motions. Except for locations on or near very active known faults, the maps contain accelerations that are associated with a 2500-year return period earthquake. The ground motions associated with MCE ground motions as modified by the site conditions are used for the design and evaluation of PC- I and PC-2 structures in this revised DOE standard. The graded approach is maintained by applying a 2/3 factor for PC- I facilities, and a factor of unity for PC-2 facilities. At the same time PC-3 design ground motions have been adjusted from a 2,000 year return period to a 2,500 year return period.

This differs from DOE-STD-1020-94 where different return periods of 500, 1000, 2000 (1000)[1], and 10,000 (5000)[1] years were used for PC-1, PC-2, PC-3, and PC-4, respectively. Also, specific performance goals were established for each performance category (PC- I thru PC-4). These performance goals (in terms of a mean annual probability of failure) were based on a combination of the seismic hazard exceedance levels and accounting for the level of conservatism used in the design/evaluation. In this revised standard the performance goals for PC- I and PC-2 facilities are not explicitly calculated but are consistent with those of the IBC

[1] Numbers in parenthesis are for locations near tectonic plate boundaries.

2000 for Seismic Use Group I and IR, respectively[2]. For PC-3 SSCS there is no change to the performance goal when compared to the previous version of this standard. This was accomplished by making a slight adjustment to the PC-3 scale factor. Thus, it is not the intent of this revision to alter the methodology for evaluating PC-3 facilities nor to increase the performance goal of PC-3 facilities by increasing return period for the PC-3 DBE from a 2000-year earthquake to a 2500-year earthquake. Rather, the intention is more for convenience to provide a linkage from the NEBRP maps and DOE Standards. All PC-3 SSCs which have been evaluated for compliance with the previous version of this standard do not require any re-evaluation considering that the PC-3 level of performance has not changed.

Major revisions to DOE-STD-1020-94 were not attempted because of ongoing efforts to develop an ASCE standard for seismic design criteria for Nuclear Facilities. Referring the design of PC-1 and PC-2 facilities to building codes (such as the IBC 2000) is consistent with design criteria in the proposed ASCE standard.

Some of the major impacts of the above changes are identified below:

1. Use of IBC 2000, International Building Code for PC- I to be designed as Seismic Use Group I and PC-2 to be designed as Seismic Use Group III.
2. Use of seismic hazard exceedance probability of $4x\ 10^{-4}$ in place of $5x\ 10^{-5}$ in current STD for PC-3 facilities.
3. Use of wind advisory for design of SSCs for straight wind referenced in DOE G 420.1-2. In addition tornados wind speeds should be based on the tornado hazards methodology of LLNL (Ref. 3-14). For steel structures, guidance per SAC (see Chapter 1) should be followed based on Northridge experience. For existing buildings evaluation and upgrades, RP-6 is minimum criteria. In addition, the references in Chapter I have been updated for current use.

There is an established hierarchy in the set of documents that specify NPH requirements. In this hierarchy, 10 CFR Part 830 (for Nuclear Facilities only) has the highest authority followed by DOE 0 420.1 and the associated Guides DOE G 420. 1-1 and DOE G 420.1-2. The four NPH standards (DOE-STDS-1020, 1021, 1022, 1023) are the last set of documents in this hierarchy.
In the event of conflicts in the information provided, the document of higher authority should be utilized (e.g., the definitions provided in the Guides should be utilized even though corresponding definitions are provided in the NPH standards).

The Department of Energy (DOE) has issued DOE 0 420.1 which establishes policy for its facilities in the event of natural phenomena hazards (NPH) along with associated NPH mitigation requirements. This DOE Standard gives design and evaluation criteria for NPH effects as guidance for implementing the NPH mitigation requirements of DOE 0 420.1 and the associated Guides. These are intended to be consistent design and evaluation criteria for

[2] Refer to the 1997 NEHRP Provisions for a description of the performance goals associated with Seismic Use Groups.

protection against natural phenomena hazards at DOF, sites throughout the United States. The goal of these criteria is to assure that DOF, facilities can withstand the effects of natural phenomena such as earthquakes, extreme winds, tornadoes, and flooding. These criteria apply to the design of new facilities and the evaluation of existing facilities. They may also be used for modification and upgrading of existing facilities as appropriate. It is recognized that it is likely not cost-effective to upgrade existing facilities which do not meet these criteria by a small margin. Hence, flexibility in the criteria for existing facilities is provided by permitting limited relief from the criteria for new design. The intended audience is primarily the civil/structural or mechanical engineers farnfliar with building code methods who are conducting the design or evaluation of DOF, facilities.

The design and evaluation criteria presented herein control the level of conservatism introduced in the design/evaluation process such that earthquake, wind, and flood hazards are treated on a consistent basis. These criteria also employ a graded approach to ensure that the level of conservatism and rigor in design/evaluation is appropriate for facility characteristics such as importance, hazards to people on and off site, and threat to the environment. For each natural phenomena hazard covered, these criteria consist of the following:

1. Performance Categories and target performance goals as specified in the Appendices B and C of this standard.

2. Specified probability levels from which natural phenomena hazard loading on structures, equipment, and systems is developed.

3. Design and evaluation procedures to evaluate response to NPH loads and criteria to assess whether or not computed response is permissible.

Table 2-1 Seismic Performance Categories and Seismic Hazard Exceedance Levels

Performance Category	Mean Seismic Hazard Exceedance Levels, PH	Remarks
0	No Requirements	
1	Follow IBC 2000 in its Entirety*	Use IBC 2000 Seismic Use Group I Criteria-2/3 MCI, Ground Motion
2	Follow IBC 2000 in its Entirety*	Use IBC 2000 Seismic Use Group III Criteria 2/3 MCI, Ground Motion with Importance Factor of 1.5
3	4×10^{-4} (1×10^{-3})[1]	Establish DBE Per DOE-STD-1023 Analysis Per DOE-Std. 1020
4	1×10^{-4} (2×10^{-4})[1]	Establish DBE Per DOE-STD-1023 Analysis Per DOE-Std. 1020

* Based on Maximum Considered Earthquake (MCE) Ground Motion - generally 2% Exceedance Probability in 50 years from the seismic hazard maps, modified to account for site effects. $P_H = 4 \times 10^{-4}$

[1] For sites such as LLNL, SNL-Livermore, SLAC, LJ3NL, and ETEC, which are near tectonic plate boundaries.

Performance Category 2 and lower SSCs may be designed or evaluated using the approaches specified in IBC 2000 seismic provisions. Common cause effects and interaction effects per DOE- STD-1021 should be taken into account. However, for Performance Category 3 or higher, the seismic evaluation must be performed by a dynamic analysis approach. A dynamic analysis approach requires that:

1. The input to the SSC model be defined by either a design response spectrum, or a compatible time history input motion.

2. The important natural frequencies of the SSC be estimated, or the peak of the design response spectrum be used as input. Multi-mode effects must be considered.

contribution from seismic anchor motion. To determine response of SSCs which use Fμ > 1, the maximum spectral acceleration should be used for fundamental periods lower than the period at which the maximum spectral amplification occurs (See Figure 2-4). For higher modes, the actual spectral accelerations should be used.

Calculate the inelastic seismic demand element forces, DSI, as

$$D_{SI} = SF*DS/F\mu \quad (2\text{-}1)$$

where: Fμ = Inelastic energy absorption factor from Table 2-3 for the appropriate structural system and elements having adequate ductile detailing

SF = Scale factor related to Performance Category
= 1.25 for PC-4
= 0.9 for PC-3

Variable scale factors, based on the slope of site-specific hazard curves are discussed in Appendix C, to result in improved achievement of performance goals. Site specific scale factors for low seisn-iicity sites should be quantified to ensure that use of
S.F = 0.9 is adequately conservative. SF is applied for evaluation of structures, systems, and components. At this time, Fμ values are not provided for systems and components. It is recognized that many systems and components exhibit ductile behavior for which Fμ values greater than unity would be appropriate (see Section C.4.4.2). Low Fμ values in Table 2-3 are intentionally specified to avoid brittle failure modes.

- Evaluate the total inelastic-factored demand D_{TI} as the sum of D_{SI} and D_{NS} (the best-estimate of all non-seismic demands expected to occur concurrently with the DBE).

$$D_{TI} = D_{NS} + D_{SI}, \quad (2\text{-}2)$$

- Evaluate capacities of elements, C_c, from code ultimate or yield values

Reinforced Concrete

Use IBC 2000, ACI 318 & ACI-349

Steel

Use IBC 2000 and AISC

TABLE 1604.5 FROM
THE INTERNATIONAL BUILDING CODE - 2000

TABLE 1604.5
CLASSIFICATION OF BUILDINGS AND OTHER STRUCTURES FOR IMPORTANCE FACTORS

CATEGORY[a]	NATURE OF OCCUPANCY	SEISMIC FACTOR I_E	SNOW FACTOR I_S	WIND FACTOR I_W
I	Buildings and other structures except those listed in Categories II, III and IV	1.00	1.0	1.00
II	Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to: • Buildings and other structures where more than 300 people congregate in one area • Buildings and other structures with elementary school, secondary school or day-care facilities with capacity greater than 250 • Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities • Jails and detention facilities • Any other occupancy with an occupant load greater than 5,000 • Power-generating stations, water treatment for potable water, waste water treatment facilities and other public utility facilities not included in Category III • Buildings and other structures not included in Category III containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released	1.25	1.1	1.15
III	Buildings and other structures designated as essential facilities including, but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities • Fire, rescue and police stations and emergency vehicle garages • Designated earthquake, hurricane or other emergency shelters • Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response • Power-generating stations and other public utility facilities required as emergency back-up facilities for Category III structures • Structures containing highly toxic materials as defined by Section 307 where the quantity of the material exceeds the exempt amounts of Table 307.7(2) • Aviation control towers, air traffic control centers and emergency aircraft hangars • Buildings and other structures having critical national defense functions • Water treatment facilities required to maintain water pressure for fire suppression	1.50	1.2	1.15
IV	Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities	1.00	0.8	0.87[b]

a. "Category" is equivalent to "Seismic Use Group" for the purposes of Section 1616.2.
b. In hurricane-prone regions with V >100 miles per hour, I_w shall be 0.77.

structures and portions thereof shall resist the most critical effects from the following combinations of factored loads:

$1.4D$ **(Formula 16-1)**
$1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$ **(Formula 16-2)**
$1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (f_1L \text{ or } 0.8W)$ **(Formula 16-3)**
$1.2D + 1.6W + f_1L + 0.5(L_r \text{ or } S \text{ or } R)$ **(Formula 16-4)**
$1.2D + 1.0E + f_1L + f_2S$ **(Formula 16-5)**
$0.9D + (1.0E \text{ or } 1.6W)$ **(Formula 16-6)**

where:
$f_1 = 1.0$ for floors in places of public assembly, for live loads in excess of 100 pounds per square foot (4.79 kN/m²), and for parking garage live load.
$= 0.5$ for other live loads.

B-1

ATTACHMENT B

ML031350597.wpd

SUMMARY OF PUBLIC COMMENTS ON SPECIFIC QUESTION POSED IN PROPOSED RULE

Eight organizations commented on various aspects of the proposed revisions to 10 CFR Part 72. Comments were divided in addressing the specific question posed by the Commission in the proposed rule regarding the appropriate mean annual probability of exceedance (MAPE) for the design earthquake ground motion (DE). While the industry organizations supported the proposed DE at a MAPE of 5E-4 (2,000 year return period), the State organizations stated that the rationale in draft regulatory guide DG-3021 did not provide a sufficient quantitative technical basis for the proposed MAPE. They suggested MAPE values varying from 4E-4 (2,500 year return period) to 1E-4 (10,000 year return period use for nuclear power plants (NPPs)).

All of the commenters agreed with the proposal to address uncertainty by requiring the use of a probabilistic seismic hazard analysis (PSHA) or suitable sensitivity analysis for independent spent fuel storage installations (ISFSIs) or U.S. Department of Energy (DOE) monitored retrievable storage installations (MRSs) in the western U.S., not co-located with an NPP, and in areas of known seismic activity in the eastern U.S.

All commenters supported the concept of requiring general licensees to evaluate both dynamic loads and static loads for ISFSI and MRS cask storage pads and areas. Section 72.212(b)(2)(i)(B) will be revised, as shown in the proposed rule, to require general licensees to address the dynamic loads of the stored casks in addition to the static loads.

Some of the more contentious public comments (and NRC responses) that relate to the specific question for public comment posed by the Commission in the proposed rule regarding the appropriate MAPE value for the DE are discussed below. A more comprehensive discussion of all the public comments are in the final rule.

Comment:

One commenter stated that a DE at a MAPE of 5E-4 (2,000 year return period) is not defensible. The commenter said that there are numerous standards that already use a DE at a MAPE of 4E-4 (2,500 year return period), including DOE Standard 1020-2000. The commenter noted that DOE’s standard is inextricably tied to meeting performance and risk goals. Further, the commenter indicated that certain buildings, such as hospitals, must meet a DE at a MAPE of 4E-4 (2,500 year return period), as must interstate bridges in the State of Utah. The commenter stated that, at a minimum, a standard lower than these cannot be adopted.

Response:

The NRC disagrees with the commenter that the proposed standard for the DE at a MAPE of 5E-4 (2,000 year return period) is lower than the DOE Standard DOE-STD-1020-2002, or the other standards, such as the International Building Code (IBC-2000 Code).

According to the DOE Standard DOE-STD-1020-2002, ISFSIs can be classified as Performance Category 3 (PC-3) facilities. For PC-3 facilities, the seismic design forces for the

DE are initially determined at 90 percent of the DE at a MAPE of 4E-4 (2,500 years return period). This brings the DE levels to approximately a MAPE of 5E-4 (2,000 year return period), specified in the earlier DOE 1020 standard, DOE-STD-1020-94. The Foreword of the DOE-STD-1020-2002 explains the change in the return period as follows:

> "It is not the intent of this revision to alter the methodology for evaluating PC-3 facilities, nor to increase the performance goal of PC-3 facilities, by increasing return period for the PC-3 from a 2,000-year earthquake to a 2,500-year earthquake. Rather, the intention is more for convenience to provide a linkage from the NEHRP maps and DOE Standards".

Therefore, use of the reference probability of 5E-4/yr (2,000 year return period), for the ISFSI or MRS facility DE, would be consistent with that used in the DOE Standard DOE-STD-1020, for similar type facilities.

For the IBC-2000 Code, the commenter is incorrectly comparing the ISFSI or MRS DE at a MAPE of 5E-4 (2,000 year return period), with the Maximum Considered Earthquake (MCE) at a MAPE of 4E-4 (2,500 year return period). The DE, according to the IBC-2000 Code, is two-thirds of the MCE, which is equivalent to a DE at a MAPE of 1.1E-3 (909 year return period) earthquake in the western United States, and a DE at a MAPE of 7E-4 (1,430 year return period) in the eastern United States. Thus, the DE for the ISFSI or MRS facility included in DG-3021 at a MAPE of 5E-4 is greater than the IBC Code DE design level.

The NRC agrees that hospital building structures and bridges having critical national defense functions are designed for the DE at a MAPE of 4E-4 (2,500 year return period). These structures are generally occupied by a significant number of people. Therefore, these structures are designed for loads greater than those for traditional buildings to limit building deformations, and to minimize human losses due to an earthquake. The ISFSI or MRS facility, on the other hand, has a relatively small number of people occupying the Canister Transfer Building at any one time.

Comment:

Two commenters stated that the seismic design standard (MAPE of 5E-4 (2,000 year return period)) is less protective than the seismic standard for municipal solid waste landfills in California (maximum credible earthquake (MCE) of 4E-4 (2,500 year return period)), and the International Building Code (MCE of 4E-4 (2,500 year return period)), both of which are more stringent than the proposed rule. One commenter is concerned that a DE at a MAPE of 5E-4 (2,000 year return period) may not provide an adequate margin of safety to protect the public.

However, two other commenters stated that the rigor of the seismic evaluation criteria and the conservatism of the seismic design requirements significantly exceed those in modern conventional building codes. One of the commenters stated that the annual probability of unacceptable seismic performance for a dry cask ISFSI designed to a DE at a MAPE of 5E-4 (2,000 year return period) will be substantially less than that of an essential or hazardous facility designed to the modern conventional building code for which the DE was established at 67 percent of the MCE of 4E-4. Another commenter stated that the level of safety for a dry cask storage facility designed to a DE at a MAPE of 5E-4 (2,000 year return period) provides at least twice the level of safety attained by facilities designed under the International Building Code.

Response:

The NRC disagrees with the commenters that the seismic design standard (MAPE of 5E-4) is less protective than the seismic standard for municipal solid waste landfills in California (Code of Regulations Section 66264.25(b), and the International Building Code -2000 (IBC-2000). The California standard requires the municipal waste landfills to be designed to withstand the maximum credible earthquake (MAPE of 4E-4) of the IBC-2000 without decreasing the level of public health and environmental protection. The cask and the cask transfer building at an ISFSI or MRS facility, designed to a DE at a MAPE of 5E-4, has the capacity to withstand earthquakes of greater magnitude than the one associated with the MAPE of 4E-4. This is because of the conservatism in the seismic evaluation criteria of NRC's NUREG-1536 and NUREG-1567, which significantly exceed those in modern conventional building codes. Additionally, the risk of the ISFSI or MRS facility to public health and safety is lower than the risk for hazardous waste and municipal solid waste landfills because the spent nuclear fuel is contained within a sealed steel cask in an isolated facility away from the public, with a controlled boundary at a minimum distance of 100 m. Landfills, on the other hand, may be open and in close proximity to public areas.

Comment:

Three commenters stated that the proposed rule provided no basis or quantitative analysis to justify lowering the DE to any particular value. One of these commenters indicated that absent any quantitative evidence justifying a particular value, the conservative, precautionary approach of requiring ISFSIs and MRSs to meet the same design standard as a nuclear power plant is most appropriate. One of these commenters noted that the adequacy of the MAPE should be addressed with respect to the change in the design earthquake ground motion. The commenter stated that this could be addressed by using the higher proposed MAPE versus what is currently required and then determining if the change in the level of risk of a release is significant or not.

Response:

The DE level proposed in the draft regulatory guide was selected based on the fact that the ISFSI or MRS risk is lower than that of an NPP and on the fact that this level is consistent with the hazard levels used in the nuclear industry for similar facilities. Details of the NRC's analyses for establishing the DE level are provided in the report, "Selection of Design Earthquake Ground Motion Reference Probability". This report 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.

Comment:

A commenter requested a rule to establish a definitive design basis earthquake at a return period level [the return period of an earthquake is an inverse of the MAPE of the earthquake] greater than 2,000 years that is tied to defined risk and performance goals.

Response:

The NRC does not agree that we must establish a definitive design basis earthquake by rule. The current regulations in § 72.122(b)(2)(i), require that the structures, systems, and components of an ISFSI or MRS must be designed to withstand the effects of natural phenomena, such as earthquakes, without impairing their capability to perform their intended design functions. For earthquakes, these requirements are then supplemented by the requirements at §§ 72.102, 72.103, and 72.122 for detailed site investigations and appropriate consideration of the most severe of the natural phenomena and associated probability of occurrence, including consideration of uncertainties, in the prediction of earthquakes. This approach is consistent with the NRC's philosophy of using risk-informed, performance-based regulations. In a risk-informed, performance-based approach, the design of the ISFSI or MRS facility is based on an assessment of the radiological risk (potential for adverse consequences) due to an earthquake. Thus, specifying a value for the reference probability in the rule would preclude applicants from considering structures, systems, and components with risks other than the risk associated with the specified reference probability.

Comment:

A commenter stated that Draft Regulatory Guide DG-3021 "is short on firm standards" because, although it recommends a DE at a MAPE of 5E-4, it also allows an applicant to demonstrate that the use of a higher probability of exceedance value would not impose any undue radiological risk to public health and safety. Thus, the draft guidance, in the commenter's view, "leaves open the possibility of an even lower standard for seismic sites." Another commenter defends the guidance that an applicant could propose a higher probability of exceedance value as being an exemption to what the commenter sees as the norm being established in DG-3021.

Response:

Section 72.103(f)(2)(i) of the rule requires that an applicant include a determination of the DE for the site, considering the results of the investigations required by paragraph (f)(1) and addressing uncertainties through an appropriate analysis, such as a PSHA or suitable sensitivity analyses. Regulatory Guide 3.73 (formerly DG-3021) states that a mean annual probability of exceeding the DE of 5E-4 is recommended to be used in conjunction with the PSHA for determining the DE. As the commenter notes, the draft guidance also indicated that "[t]he use of a higher reference probability will be reviewed and accepted on a case-by-case basis." This statement was made in recognition of the fact that a regulatory guide does not establish legally-binding requirements. An alternative reference probability would not be an exemption from a requirement, but would be an alternative proposal which would need to be demonstrated to be acceptable. Thus, it is conceivable that an applicant could propose a higher MAPE value that the NRC staff would then have to consider. Although this is necessarily the case for recommendations suggested in guidance documents, the NRC did not mean to imply that it viewed an applicant's ability to make the necessary safety case for a higher MAPE as being a likely prospect. To avoid any such implication, that sentence has been removed from the final guidance.

[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: Final rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is amending 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 (GTCC) 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 update the seismic siting and design criteria, including geologic, seismic, and earthquake engineering considerations. The final rule allows the NRC and its licensees to benefit from experience gained in the licensing of existing facilities and to incorporate rapid advancements in the earth sciences and earthquake engineering. The amendments make the NRC regulations that govern certain ISFSIs and MRSs more compatible with the 1996 amendments that addressed uncertainties in seismic hazard analysis for nuclear power plants. The amendments allow certain ISFSI or MRS applicants to use a design earthquake level commensurate with the risk associated with an ISFSI or MRS.

EFFECTIVE DATE: This final rule is effective on **(insert 30 days from date of publication)**.

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 and Standard Review Plans

VI. Summary of Public Comments on the Proposed Rule

VII. Summary of Final Revisions

VIII. Criminal Penalties

IX. Agreement State Compatibility

X. Voluntary Consensus Standards

XI. Finding of No Significant Environmental Impact: Availability

XII. Paperwork Reduction Act Statement

XIII. Regulatory Analysis

XIV. Regulatory Flexibility Certification

XV. Backfit Analysis

XVI. Small Business Regulatory Enforcement Fairness Act

I. Background

In 1980, the NRC 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 NRC 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, other solidified radioactive materials associated with spent fuel storage, and power reactor-related GTCC waste, that are pending shipment to a high-level radioactive waste repository or other disposal site.

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 the 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 the eastern U.S. A seismic design requirement, equivalent to the requirements for an 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 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 NRC explained that for ISFSIs which do not involve massive structures, such as dry storage casks and canisters, the required design earthquake 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.

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. Specific problematic areas include the following:

1. 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. Appendix A to Part 100 does not allow this application.

2. The limitations in data and geologic/seismic analyses, and the rapid evolution in geosciences have required considerable latitude in technical judgment. The inclusion of detailed geoscience assessments in Appendix A has inhibited the use of needed judgment and flexibility in applying basic principles to new situations; and

3. 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 NRC 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 technical field over the past two decades. Further, regulatory guides have been used to address implementation issues. For example, the NRC 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 NRC 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.

The NRC is now amending 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 design earthquake ground motion (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 an 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 an 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 than those that could arise at an NPP. 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.

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 have substantial design margins to withstand forces from a seismic event greater than the design earthquake.

Hence, the seismically induced risk from the operation of an ISFSI or MRS is less than at an operating NPP. As a result, the NRC is revising the DE requirements for ISFSI and MRS facilities from the current Part 72 requirements, which are equivalent to the SSE for an NPP.

As an additional minor change, the NRC is modifying § 72.212(b)(2)(i)(B) to require general licensees to 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 will 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 § 72.212(b)(2)(i)(A). Therefore, the rule will not actually require any general licensees operating an ISFSI to re-perform any written evaluations previously undertaken. 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.

The NRC published the proposed rule, "Geological and Seismological Characteristics for Siting and Design of Dry Cask Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations" in the Federal Register on July 22, 2002 (67 FR 47745) for public comment. The NRC stated on September 5, 2002 (67 FR 56876) that it intended to extend the comment period for an additional 15 days to allow interested persons additional time to provide meaningful comments. The public comment period expired on October 22, 2002.

The NRC received nine comment letters on the proposed rule. These comments and the NRC responses are discussed in Section VI of this document, “Summary of Public Comments on the Proposed Rule”.

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 an 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 final rule reflects changes that are intended to (1) provide benefit from the experience gained in applying the existing regulation and from research; (2) provide needed regulatory flexibility to incorporate into licensing state-of-the-art improvements in the geosciences and earthquake engineering; and (3) make the regulations more risk informed, consistent with the Commission’s recent policy.

The objectives of this final 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 an 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 will have the option of complying with the 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 specific-license applicants using a PSHA to select a DE appropriate for and commensurate with the risk associated with an ISFSI or MRS; and

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

III. Applicability

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

Applicability of new § 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 an NPP, will 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 an NPP, will 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, will have the option of addressing uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, or using a standardized DE described by an appropriate response spectrum anchored at 0.25 g (subject to the conditions in new § 72.103(a)(1)), or using the existing design criteria for the most recent NPP (if applicable), for determining the DE.

(4) The new § 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 changes apply to the design basis of both a dry cask storage type ISFSI and MRS, because these facilities are similar in design. The NRC does not intend to revise the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because applications for this means of storage are not expected and it is not cost-effective to allocate resources to develop the technical bases for such an expansion of the rulemaking. The NRC 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 in licensing these types of facilities.

The applicability of § 72.103 is summarized in the table below.

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

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

The applicability of the 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 Applicant[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 new § 72.103(a)(1)).

1. New § 72.103 does not apply to general licensees. General licensees must satisfy the conditions specified 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 NRC is amending certain sections of Part 72 dealing with seismic siting and design criteria for a dry cask ISFSI or MRS. The NRC 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 NRC is changing the heading of § 72.102, adding a new § 72.103, and modifying § 72.212(b)(2)(i)(B).

A. Change to 10 CFR 72.102

The heading of § 72.102 will be changed to clarify that the present requirements are applicable to ISFSI or MRS specific licensees or specific-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 will continue to apply.

B. New 10 CFR 72.103

New § 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 known 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) changing state-of-the-art of geologic and seismic analyses; (c) rapid accumulation of knowledge; and (d) evolution in geoscience concepts. The NRC 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 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 NRC is adding a new section in Part 72 that will provide specific siting requirements for an ISFSI or MRS instead of referencing another part of the regulations. The amended regulation will 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 revised regulation contains requirements to:

(i) Evaluate 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 are provided in Regulatory Guide 3.73, "Site Evaluations and Design Earthquake

Ground Motion for Dry Cask Independent Spent Fuel Storage 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 the 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 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 NRC 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 NRC 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. Methods other than probabilistic methods (PSHA), such as sensitivity analyses, may be adequate for some sites to account for uncertainties. The NRC believes that certain new applicants for ISFSI or MRS specific licenses, as described in Section III, “Applicability,” of this document, must use probabilistic methods or other sensitivity analyses to account for uncertainties instead of using Appendix A to Part 100. The NRC does not intend to require new ISFSI or MRS specific-license applicants that are co-located with an 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 considerably lower than that of an NPP, as described in Section IV of this document.

The key elements of the NRC’s 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 will review the application using all available data including insights and information from previous licensing experience. Thus, the revised 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 revised regulation related to the PSHA or suitable sensitivity analyses are described in RG 3.73.

3. Revise the Design Earthquake Ground Motion.

The present DE in Part 72 is based on the deterministic requirements contained in Appendix A to 10 CFR Part 100 for NPPs. In the Statement of Considerations accompanying the initial Part 72 rulemaking, the NRC recognized that the required design earthquake need not be as high as for an 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 the advances in probabilistic seismic hazard evaluation techniques, over 10 years of experience in licensing dry cask storage (10 specific licenses have been issued and 9 locations use the general license provisions), and analyses demonstrating robust behavior of dry cask storage systems (DCSSs) in accident scenarios, the NRC now has a reasonable basis to consider more appropriate DE parameters for a dry cask ISFSI or MRS. Therefore, in those instances when an ISFSI or MRS specific-license applicant uses PSHA methods, the NRC will allow a DE 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 an NPP include the following:

a. In comparison with an 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 components carrying fluids at high temperatures or pressures 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 NRC believes that the seismically induced radiological risk associated with an ISFSI or MRS is significantly less than the risk associated with an NPP.

II. Additional rationale for allowing the use of a DE level commensurate with the risk associated with an ISFSI or MRS includes the following:

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

b. To evaluate dry cask storage systems' behavior during an earthquake, typical storage systems (one a cylindrical cask, HI-STORM 100, the other a concrete module type, NUHOMS) were analyzed for a range of earthquakes. Based on the results of the analyses, the NRC has concluded that a free-standing dry storage cask remains stable and will not tip-over, or would not slide and impact the adjacent casks during an earthquake approximately equal to the magnitude of a SSE for an NPP. Additionally, parametric studies indicated that dry cask storage systems have significant margins against tip-over and sliding, to withstand an earthquake significantly higher in magnitude than the SSE for an NPP, without releasing radioactivity. Further, a cask is analyzed for a non-mechanistic tip-over event during an earthquake, to verify that it would maintain its structural integrity, and radioactivity from spent fuel would not be released to the environment. Therefore, based on drop accident analyses and non-mechanistic tip-over event evaluations, and on the results of the generic studies for the cask behavior during an earthquake, it can be concluded that there would be no radiological consequences at a dry cask ISFSI or MRS facility due to an earthquake.

c. The rational for allowing a DE for an ISFSI or MRS to be lower than a DE for an NPP is consistent with the approach used in DOE Standard DOE-STD-1020, "Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities."

Regulatory Guide 3.73 (formerly DG-3021) recommends an acceptable mean annual probability of exceedance (MAPE) for the DE that is commensurate with the lower risk associated with an ISFSI or MRS as compared to an NPP. The basis for the recommendation is provided in a report entitled, "Selection of the Design Earthquake Ground Motion Reference Probability". This report 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. Discussion on the recommended mean annual probability of exceedance is also in Section VI of this FRN, "Summary of Public Comments on the Proposed Rule".

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

The NRC is modifying § 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, will ensure that the cask storage pads and areas will perform satisfactorily during a seismic event.

The revision will also require consideration of potential amplification of earthquakes through soil-structure interaction, and soil liquefaction potential or other soil instability due to vibratory ground motions. 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 vibratory motion due to an earthquake may affect the cask stability.

The changes to § 72.212 will not actually impose a 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. These Certificates of Compliance 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 and Standard Review Plans

On July 22, 2002, the NRC published 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" for public comment (67 FR 48956; July 26, 2002). Regulatory Guide 3.73, *Site Evaluations and Design Earthquake Ground Motion for Dry Cask Independent Spent Fuel Storage and Monitored Retrievable Storage Installations* (formerly DG-3021), provides guidance to licensees for 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 probabilistic seismic hazard analysis (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 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 of the regulatory guide. A document announcing the availability of Regulatory Guide 3.73 will be published in the Federal Register in the near future.

Requests for single copies of active regulatory guides (which may be reproduced) or for placement on an automatic distribution list for single copies of future guides 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 U.S. NRC 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," will be made. For example, the standard review plans will be updated to reference the new § 72.103 and Regulatory Guide 3.73.

VI. Summary of Public Comments on the Proposed Rule

This section presents a summary of the public comments received on the proposed rule and supporting documents, the NRC’s response to the comments, and changes made in the final rule and supporting documents as a result of these comments.

The NRC received nine comment letters on the proposed rule from eight commenters. The commenters were the Nuclear Energy Institute (NEI), the U.S. Department of Energy (DOE), two nuclear power utilities, three State agencies, and one license applicant for an independent spent fuel storage installation. All the commenters agreed with the proposal to address uncertainty by requiring the use of a PSHA or suitable sensitivity analyses for an ISFSI or MRS in the western U.S., not co-located with an NPP, and in areas of known seismic activity in the eastern U.S. However, commenters were divided on the specific question for public comment related to the appropriate value for the MAPE posed by the Commission in the proposed rule. These comments are summarized in this section under the heading “Related Regulatory Guide.” All commenters supported the concept of requiring general licensees to evaluate both dynamic loads and static loads for ISFSI and MRS cask storage pads and areas.

Copies of the public comments are available for review in the NRC Public Document Room, 11555 Rockville Pike, Rockville, MD. A review of the comments and the NRC responses follow:

GENERAL COMMENTS

Comment 1:

A commenter stated that proposed 10 CFR 72.103(f)(1) does not comply with the notice and comment requirements of Section 553 of the Administrative Procedure Act (APA) because of the way the rule is structured. The commenter believes that the proposed rule "is in the guise of a substantive rule," but that the substantive requirements are found in the draft guidance, a document which is not a rule. In the commenter's view, "the Commission attempts to give concrete form to its proposed rule through an interpretative document, DG-3021, and the Commission thereby circumvents [APA] § 553 notice and comment rulemaking procedures," citing Paralyzed Veterans of America v. D.C. Arena L.P., 117 F.3d 579 (D.C. Cir. 1997). According to the commenter, a significant defect of this structure is that the rule gives no standards against which a licensing board or intervenors may evaluate whether an applicant has complied with the rule and, instead, gives "unbridled and unchecked discretion to the staff in determining the seismic design standard for ISFSIs sited in seismic areas." The proposed rule, in the commenter's view, has no force of law because it has no binding standards and thus is unenforceable. Another commenter disagreed and supported the NRC's view that the rule is substantive and in compliance with the APA.

Response:

First, the NRC rejects the claim that the rule is not being promulgated in compliance with § 553 of the APA. Section 553 requires that notice of a proposed rulemaking be published in the *Federal Register*, including the terms or substance of the proposed rule, and that interested persons be given an opportunity to comment. The APA also provides an exception for interpretative rules and general statements of policy enabling those documents to be issued as final rules without prior notice and comment. In this case, the NRC has not availed itself of the exception but rather has issued both the draft guidance and the proposed rule for public comment. Thus, there has been no violation of the notice and comment requirements of Section 553 of the APA even if the guidance were to be considered part of the rule. The Paralyzed Veterans case, cited by the petitioner, concerned a guidance document issued by the Department of Justice which had been issued without prior notice and comment and raised the issue whether the Government could rely upon the guidance in an enforcement action. The court ultimately found that there was no need for the Government to rely on the guidance to enforce the regulation. Here, the guidance has been issued for comment and the NRC does not contend, as explained below, that the guidance is legally enforceable.

Second, the NRC does not agree that "substantive requirements" have been placed in the guidance document. Regulatory Guide 3.73 (formerly DG-3021) provides information on methods acceptable to the NRC for implementing specific parts of the rule, but it does not place any particular requirements on applicants. As the commenter points out, "staff regulatory guides are not regulations, do not have the force of regulations, and when challenged, are considered only one way in which an applicant may meet the regulations."

Finally, the commenter really appears to be objecting to the NRC's risk-informed, performance-based approach in this rulemaking in lieu of the deterministic approach for determining a design earthquake embodied in Appendix A to 10 CFR Part 100. The overall performance criteria for protection against environmental conditions and natural phenomena in the design of Part 72 facilities are contained in 10 CFR 72.122(b) of the NRC's regulations. In particular, § 72.122(b)(2)(i) provides:

> Structures, systems, and components important to safety must be designed to withstand the effects of natural phenomena such as earthquakes . . . without impairing their capability to perform their intended design functions. The design bases for these structures, systems, and components must reflect:
>
> (A) Appropriate consideration of the most severe of the natural phenomena reported for the site and surrounding area, with appropriate margins to take into account the limitations of the data and the period of time in which the data have accumulated; and
>
> (B) Appropriate combinations of the effects of normal and accident conditions and the effects of natural phenomena.

These performance criteria are supplemented by the requirements of 10 CFR 72.103 governing selection of a site and determination of a DE. This new regulation provides specific siting requirements for an ISFSI or MRS instead of referencing another part of the regulations (Appendix A to Part 100). This new regulation also reduces 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 new 10 CFR 72.103(f) establishes basic requirements for determining a DE for use in the design of structures, systems, and components of the ISFSI or MRS. These regulations include a requirement that the geological, seismological, and engineering characteristics of a proposed site and its environs be investigated in sufficient scope and detail to provide sufficient information to support evaluations performed to arrive at estimates of the DE (§ 72.103(f)(1)); a requirement that a DE be determined for the site (§ 72.103(f)(2)); and a requirement that uncertainties be addressed through an appropriate analysis, such as a probabilistic seismic hazard analysis or suitable sensitivity analyses (§ 72.103(f)(2)(i)). The regulation further requires determinations of the potential for surface tectonic and nontectonic deformations (§ 72.103(f)(2)(ii)); the design bases for seismically induced floods and water waves (§ 72.103(f)(2)(iii)); and the siting factors for other design conditions, such as liquefaction potential (§ 72.103(f)(2)(iv)), as well as a requirement that the DE must have a value for the horizontal ground motion of no less than 0.10 g with the appropriate response spectrum (§ 72.103(f)(3)). More specific guidance for meeting these standards, including guidance on an acceptable reference probability, is provided in Regulatory Guide 3.73 (formerly DG-3021).

Determining whether an applicant has complied with these performance standards may be more difficult than would be the case with a prescriptive regulation; however, that does not mean that the NRC has “unbridled discretion” in deciding whether the standards are met nor that the standards (as opposed to the guidance) are not binding. The NRC uses informed technical judgment to determine if an application has satisfactorily met the standards. The NRC’s rationale and judgment are expressed in a safety evaluation report (SER) subject to evaluation and potential challenge by members of the public. In the event of a hearing, a licensing board would have the technical skills necessary to evaluate any conflicting claims.

Comment 2:

A commenter noted that, although the NRC’s approach is similar to that used in the amendments issued for seismic evaluation for the siting of NPPs, the NRC has no compelling reason to follow that approach. First, the commenter argued, if the approach violates the APA, it should be rejected. Second, the commenter stated that because no new applications for siting NPPs have been submitted using the new requirements, the rule has not been put to the test. Finally, the commenter indicated that there are no data for ISFSIs that establish design basis ground motions, unlike the SSE for a nuclear power plant, which has at least some data to provide guidance to the NRC and the public.

Response:

First, the NRC disagrees that either the amendments issued for the seismic evaluation of siting of NPPs or these Part 72 amendments have been issued in violation of the APA. See comment 1. Second, although no new license applications for siting of NPPs have been received to test the new requirements in 10 CFR § 100.23, the guidance associated with the use of probabilistic methods for siting of NPPs (Regulatory Guide 1.165) has been used in the PSHA prepared for a proposed ISFSI site. It is also being followed by applicants for an early site permit under to 10 CFR Part 52. Finally, the NRC agrees that there are limited data for ISFSIs that establish design basis ground motions because the current Part 72 regulations for seismic design of ISFSIs are conservatively based on the nuclear power plant seismic design criteria, and thus, are not risk-informed. However, experience has been gained in the design and construction of numerous facilities using the philosophy of a graded, risk-informed approach described in the standard building codes, similar to the approach proposed in the rule for ISFSIs. The graded risk-informed approach is also used by the Department of Energy in designing its facilities for seismic loads with risks varying from conventional facilities to NPPs.

Comment 3:

A commenter noted that if clear seismic standards are not established in the rule, the opportunity for interested persons to participate in a licensing proceeding involving the seismic design of an ISFSI will become essentially prohibited. This is because a panoply of specific expertise is needed to evaluate the seismic design and there is only a small universe of seismic experts. Utilizing these experts is often not feasible because of the financial burden on intervenors in obtaining highly specialized expertise to analyze probabilistic seismic risks and design of nuclear facilities.

Response:

The NRC believes the standards for ISFSI or MRS facility earthquake designs are clear. See the response to Comment 1. However, the NRC recognizes that the proposed use of the probabilistic methods in seismic design of ISFSIs is more complex than the current deterministic methods of 10 CFR Part 100 Appendix A, and would require specific expertise to participate in the licensing proceedings. The NRC staff's safety evaluation report (SER) that independently assesses the applicant's method of compliance with regulations is available to assist the public in evaluating the risk of the facility and could help intervenors to focus their resources. The NRC does not intend to limit public participation in the licensing process; however, the Congress has barred the use of appropriated funds to pay the expenses of, or otherwise compensate, parties who intervene in NRC regulatory or adjudicatory proceedings.

Comment 4:

A commenter stated that the proposed rule placed too much stock on the integrity of the dry storage cask. The commenter indicated that of the 19 ISFSI licenses issued in the past decade, none were in seismic areas. The NRC has not licensed unanchored cylindrical casks in any seismic areas. The commenter noted that there are no performance data, test data, or earthquake experience data for dry casks or for ISFSIs. The commenter further stated that the rule is based on principles that are antithetical to earthquake engineering principles because, for unanchored casks, the NRC relies solely on the predictions of non-linear computer models. The commenter also stated that, up to this point, the non-linear computer model predictions of the seismic behavior of casks have not been validated with shake table data or actual performance data. The commenter also stated that without adequate and reliable performance and test data, it cannot be determined if the casks will actually provide the critical barrier described and relied upon in the rule. Another commenter stated that non-linear dynamic analyses are inherently reliable. Further, the commenter noted that proper input parameters for cask stability analyses are not elusive unknowns but can be determined from basic physical principles, and that these analyses have been shown not to be highly sensitive to changes in input parameters. Therefore, the commenter argued, shake table testing is unnecessary.

Response:

The integrity of the dry storage cask during an earthquake is a key to protecting the health and safety of the public because it confines the radioactivity during a potential accident event, such as an earthquake, and prevents it from being dispersed into the environment. Contrary to traditional building designs, the cask design is not governed by stresses resulting from an earthquake, but is governed by requirements resulting from shielding, thermal, criticality, and postulated handling accidents. Therefore, the critical performance requirement for a cask is that it would remain stable and not displace excessively to impact adjacent casks. The cask stability can be determined by nonlinear dynamic analyses, considering uncertainties in engineering parameters, and using multiple computer codes. The NRC has also performed structural analyses of casks tipping and sliding. In neither case did the canister fail.

It is a common engineering practice to design and build structures, including new design concepts, based on detailed structural analyses using sound engineering principles and laws of physics, without performing confirmatory experiments. For example, new concepts in structural designs and construction of landmark structures, such as the Sears Tower, Hancock Tower, Eiffel Tower, and space vehicles were based solely on analyses.

The advent of computers has helped in the development of analytical tools, including the non-linear dynamic analyses. Results of these analyses are being used to design structures more complex than a dry storage cask. The concept of free-standing casks is not new. The buildings the NRC uses every day are free-standing on a foundation, and thus would move during an earthquake. The analytical tools for non-linear structural analyses are verified and validated using multiple computer codes and available experimental data. Therefore, shake table tests or actual performance data are not necessary.

Comment 5:

A commenter requested a rule to establish a definitive design basis earthquake at a return period level [the return period of an earthquake is an inverse of the mean annual probability of exceedance (MAPE) of the earthquake] greater than 2,000 years that is tied to defined risk and performance goals.

Response:

The NRC does not agree that we must establish a definitive design basis earthquake by rule. The current regulations in § 72.122(b)(2)(i), require that the structures, systems, and components of an ISFSI or MRS must be designed to withstand the effects of natural phenomena, such as earthquakes, without impairing their capability to perform their intended design functions. For earthquakes, these requirements are then supplemented by the requirements at §§ 72.102, 72.103, and 72.122 for detailed site investigations and appropriate consideration of the most severe of the natural phenomena and associated probability of occurrence, including consideration of uncertainties, in the prediction of earthquakes. This approach is consistent with the NRC's philosophy of using risk-informed, performance-based regulations. In a risk-informed, performance-based approach, the design of the ISFSI or MRS facility is based on an assessment of the radiological risk (potential for adverse consequences) due to an earthquake. Thus, specifying a value for the reference probability in the rule would preclude applicants from considering structures, systems, and components with risks other than the risk associated with the specified reference probability.

Comment 6:

A commenter stated that the supplementary information in the final rule should state that the NRC’s policy for promulgating risk-informed regulations was a primary motivation for the rule changes.

Response:

The NRC agrees that the supplementary information for the final rule should more clearly state that the rule was amended, in part, to conform to the Commission's recent policy to increase the use of risk insights and information in its regulatory applications. An additional statement has been added to Section II, Objectives, of the Supplementary Information portion of this document, that states the intent to revise the regulation in accordance with this policy.

APPLICABILITY OF PROPOSED § 72.103

Comment 7:

A commenter requested clarification of the proposed rule so that applicants for an ISFSI co-located with an NPP have the option of using the existing DE of the NPP without any further evaluations and that this applies to all sections of the rule. The commenter pointed out that the proposed amendments at §§ 72.103(a)(2) and 72.103(b), as well as explanatory statements made in the proposed rule indicate that applicants for an ISFSI that are co-located with an NPP have the option of using the existing NPP design criteria without additional evaluations, but that this option is not identified in § 72.103(f).

Response:

To further clarify the NRC's intent that an applicant for an ISFSI that is co-located with an NPP has the option of using the existing DE of the NPP without the need to undertake any additional evaluations of the sort described in § 72.103(f), the introductory phrase of that section has been modified so that it now reads: "Except as provided in paragraphs (a)(2) and (b) of this section, the DE for use in the design of structures, systems, and components must be determined as follows."

Comment 8:

Two commenters stated that the criteria presented for establishing the DE for ISFSI and MRS sites at existing NPPs allows for the use of the existing NPP SSE as one alternative. This alternative is key to ensuring that significant new probabilistic ground motion studies are not required at existing NPP sites.

Response:

The commenters are correct. The regulatory changes allowing the licensee flexibility to use the existing SSE for an NPP at co-located ISFSIs or MRSs means that new studies are not required at ISFSIs or MRSs co-located with NPPs.

ALTERNATIVE OF ADOPTING 10 CFR 100.23

Comment 9:

One commenter recommended withdrawing the proposed rule and adopting the option of directing new applicants for specific licenses to comply with 10 CFR § 100.23 in its entirety, including conforming the DE to the SSE criteria. The commenter noted that by adopting § 100.23 in its entirety, there would be no need to make distinctions among locations of facilities and the rule would incorporate state-of-the-art improvements in the geosciences and earthquake engineering and would allow uncertainty to be addressed. The commenter further noted that NRC had cited its 10 years of experience in reviewing dry cask storage installation applications as a reasonable basis for allowing an exceedance probability greater than that applied to a nuclear power plant, but pointed out that this was 10 years of analytical, not practical experience. In the commenter's view, this lack of practical experience, and the fact that a probabilistic analysis is, by its very nature, risk-informed with respect to uncertainty, means that there does not seem to be a quantifiable safety basis for any exceedance margin other than that now applied to seismic analysis for nuclear power plant proposals. The commenter stated that, absent any definitive experience, the seismic design criteria for an ISFSI should be no less protective than that of a nuclear power plant.

Response:

The NRC disagrees that new applicants for specific licenses should comply with § 100.23 in its entirety, including conforming the DE to the SSE criteria. Adopting the recommendation would fail to recognize the differences in risk between an NPP and an ISFSI or MRS facility in seismic design requirements. This is counter to the Commission policy encouraging development of risk-informed, performance-based regulations, and the Commission's Performance Goals.

The NRC acknowledges that actual earthquake performance data for ISFSI facilities are not available and thus that NRC's decision to allow an exceedance probability greater than that applied to a nuclear power plant is not based on practical experience. However, NRC has gained sufficient analytical experience to understand the performance of these facilities, by reviewing the analyses of these facilities performed by the licensees, and by performance of independent analyses. Additionally, experience has been gained in the design and construction of numerous facilities using the philosophy of a risk-informed approach described in the standard building codes, similar to the one proposed in the rule for ISFSIs. The risk-informed approach is also used by the Department of Energy in designing its facilities for seismic loads with risks varying from conventional facilities to NPPs. NRC staff's analyses show that ISFSI storage casks are sufficiently robust, due to design requirements other than for earthquakes, that there is no release of radioactivity at an ISFSI site with a DE at a magnitude equal to the SSE for a NPP. This analytical experience provides a basis for allowing an exceedance probability greater than that applied to a nuclear power plant.

PROPOSED CHANGE TO 10 CFR 72.103

Comment 10:

With respect to the provision in § 72.103(b) that sites "that lie within the range of strong near-field ground motion from historical earthquakes on large capable faults should be avoided," a commenter stated that the definition of "range of strong near-field ground motion" is not well defined but is often believed to be about 15 km. The commenter noted that this is a very large set-back from faults. The commenter argued that the key issue is that the design ground motion should represent the conditions at the site. If a site is located close to a large capable fault, then near-fault effects should be incorporated into the design ground motions rather than excluding these site locations.

Response:

The NRC agrees with the comment. The sentence: "Sites that lie within the range of strong near-field ground motion from historical earthquakes on large capable faults should be avoided." has been removed from § 72.103(b). Section 72.103(f)(2)(iv) requires an evaluation of the effects of vibratory ground motion that may affect the design and operation of the proposed ISFSI or MRS. Therefore, near-fault effects must be included in the development of the ground motion used in design.

Comment 11:

One commenter suggested removing the distinction in § 72.103 between western U.S. and eastern U.S. The commenter stated that the characterization of areas of known seismicity east of the Rocky Mountain Front as including three specific areas is misleading. The commenter argued that the entire region of the U.S. east of the Rocky Mountain Front is subject to earthquake occurrence and that one area should not be treated differently from another for the purpose of assessing seismic sources. Further, the commenter stated that 10 CFR Part 100, Appendix A, does not allow for less stringent alternatives for any area. Rather, the commenter noted, the fundamental requirements of that regulation apply uniformly to all regions of the U.S., independent of variations in the local rate of seismicity.

Response:

In specifying the criteria for determining the DE, the current Part 72 regulations distinguish between the western U. S. and the eastern U. S. Although the entire eastern U.S. is subject to earthquake occurrence, the areas east of the Rocky Mountain Front, except in specific areas of known seismic activity, do not experience significant seismic activity. Therefore, the use of an appropriate seismic response anchored at 0.25 g is considered as bounding for the design. However, for the western U. S. there is significant seismic activity varying from region to region. Therefore, it is not practical to use a bounding approach in specifying the DE for those sites.

However, if the applicant chooses the option of performing the PSHA for a site located in the eastern U. S., as allowed in § 72.103(a)(2), the seismic sources are assessed with the same rigor as the seismic sources for the PSHA performed for a site located in the western U.S. (§ 72.103(f)). In this case, the regulatory requirements of assessing the seismic sources for the PSHA method would apply uniformly to all regions of the U.S., independent of variations in the local rate of seismicity.

Comment 12:

One commenter suggested inserting the word “sites” after “NY” in the first sentence of § 72.103(a)(1) to be consistent with language in § 72.102.

Response:

The NRC agrees with the commenter’s suggestion. The word “sites” will be inserted after “NY” in the first sentence of § 72.103(a)(1) to be consistent with language in § 72.102. In addition, other minor editorial changes have been made to this sentence.

REMOVE DETAILED GUIDANCE FROM THE REGULATION

Comment 13:

One commenter stated that removing detailed guidance from the regulation that is related to analyzing non-seismic factors affecting geologic stability of the site would allow excessive discretion for the applicant and would result in too much uncertainty for a safety evaluation. This commenter noted that removing requirements for specific types of evaluation also removes the certainty for both the license applicant and the public as to what is expected during a review. The commenter requested retaining Appendix A of Part 100 as requirements for licensing.

Response:

See the response to Comment 1.

Comment 14:

A commenter questioned NRC's statement explaining that NRC proposed to remove detailed guidance from the regulation, in part, because "specifying geoscience assessments in detail in a regulation has created difficulties for applicants and the NRC by inhibiting needed latitude in judgment [and] [i]t has inhibited the flexibility needed in applying basic principles to new situations." This commenter asked for an explanation as to how and when latitude and flexibility in judgment and in applying basic principles to new situations because geoscience assessments were specified in detail in a regulation, were inhibited.

Response:

The current regulation (§ 72.102) requires that for areas of known potential seismic activity, seismicity will be evaluated by the techniques of Appendix A to Part 100. Appendix A contains both requirements and guidance on how to satisfy the 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. Such investigations require considerable latitude in judgment. This latitude in judgment is needed because of limitations in data and rapidly evolving state-of-the-art geologic and seismic analyses.

However, having geoscience assessments detailed and cast in a regulation has created difficulty for applicants and the NRC in terms of inhibiting the use of needed latitude in judgment. Also, it has inhibited flexibility in applying basic principles to new situations and the use of evolving methods of analyses (for instance, probabilistic) in the licensing process.

As an example, a prescriptive requirement of applying the capable fault criteria (see Part 100, Appendix A, § III(g)) to sites in California meant conducting investigations and analyses for surface rupture potential. If a fault does not cause a surface rupture (blind fault), the fault would not be considered a capable fault under the Appendix A criteria, and thus would not be considered in determining the DE. This would lead to seismic hazard at a facility which would be not conservative. This has been demonstrated by the occurrences of the 1989 Loma Prieta, 1992 Petrolia, and 1994 Northridge earthquakes during which the causative faults did not rupture ground surface. On the other hand, the young faults, the last movements of which may satisfy the Appendix A criteria for classifying them as capable faults, may not be capable faults in the true meaning of the criteria because the most recent displacements on them may be related to non-tectonic natural phenomena. In this case, use of the Appendix A criteria would lead to a finding of seismic hazard at a facility which would be overly conservative. Inclusion of detailed criteria or specific numbers in the regulation prevents a scientific evaluation of methodologies and approaches that advance with the state of the art, and the rule eventually becomes a hindrance to the exercise of rational judgement.

ADDRESS UNCERTAINTIES AND USE PROBABILISTIC METHODS

Comment 15:

A commenter urged revision of § 72.103 to continue to allow an applicant located in the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with an NPP, to use a deterministic analysis similar to the analysis specified in Appendix A to 10 CFR Part 100, for developing design earthquake ground motions because a utility may decide to perform seismic hazards analysis on deterministic bases that are more conservative than the proposed rule.

Response:

In using the deterministic approach for determining a SSE for a nuclear reactor site embodied in Appendix A to 10 CFR Part 100, 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. This often makes the licensing process relatively unstable. Over the past decade, analysis methods for incorporating these different interpretations have been developed and used. These "probabilistic" methods have been designed to allow explicit incorporation of different models for zonation, earthquake size, ground motion, and other parameters. The advantage of using these probabilistic methods is the ability to incorporate different models and different data sets and weight them using judgments as to the validity of the different models and data sets. This process provides an explicit expression for the uncertainty in the ground motion estimates and a means of assessing sensitivity to various input parameters.

Section 72.103 explicitly recognizes that there are inherent uncertainties in establishing the seismic and geologic design parameters and requires the use of a probabilistic seismic hazard methodology capable of propagating uncertainties to address these uncertainties. The rule further recognizes that the nature of uncertainty and the appropriate approach to account for it depend greatly on the tectonic regime and parameters, such as the knowledge of seismic sources, the existence of historical and recorded data, and the understanding of tectonics. Therefore, methods other than the probabilistic methods, such as sensitivity analyses, may be adequate for some sites to account for uncertainties.

Consistent with § 100.23 for an NPP, § 72.103 does not allow the use of the deterministic methods in Appendix A to 10 CFR Part 100, to determine the DE because the deterministic methods do not account for the uncertainties in the seismic hazard analysis. However, § 72.103 allows the applicant to use methods other than the probabilistic methods, such as sensitivity analyses, to account for uncertainties. Additionally, § 72.103 allows a utility applying for a specific license for an ISFSI co-located at an NPP, the option of using the seismic design criteria of the NPP, which may be based on the deterministic methods of Appendix A to 10 CFR 100.

For these reasons, the NRC declines to amend § 72.103 as suggested by the commenter. However, a utility applying for a specific license for an ISFSI co-located at an NPP has the option of using the seismic design criteria of the NPP.

Comment 16:

A commenter stated that the use of the term "uncertainty" in the Background section of the proposed rule (67 FR 47746) is ambiguous, and suggested that the term be revised to "aleatory uncertainty". The commenter stated that the report "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," NUREG/CR-6372 (SSHAC), distinguishes between "aleatory" and "epistemic" uncertainties. The deterministic approach can explicitly recognize epistemic uncertainty just as in the probabilistic approach. The deterministic approach does not explicitly include all components of aleatory variability. The commenter noted that sensitivity analyses are generally intended for addressing epistemic uncertainty, not aleatory variability.

Response:

Despite extensive advances in seismic knowledge in recent years by a large and active community of researchers around the world, there are still major gaps in the understanding of the mechanisms that cause earthquakes. These gaps in understanding mean that in any seismic hazard analysis, either deterministic or probabilistic, there are inevitably significant uncertainties in the numerical results. These uncertainties can be classified into two different categories: (1) epistemic uncertainty which is due to lack of knowledge because the scientific understanding is imperfect for the present, but is of a character that in principle is reducible through further research; and (2) aleatory uncertainty which is due to the randomness of seismic events and, in principle, cannot be reduced. As stated in the SSHAC report, "The division between the two different types of uncertainty, epistemic and aleatory, is somewhat arbitrary, especially at the border between the two. This is because, conceptually, some of the processes and parameters whose uncertainties the NRC will characterize here as aleatory ("random") may be partially reducible through more elaborate models and/or further study". As stated further in the SSHAC report, "the PSHA that does not deal appropriately with both the epistemic and the aleatory uncertainties must be considered inadequate." Based on this, the term "uncertainty' included in the proposed rule is appropriate.

REVISE THE DESIGN EARTHQUAKE GROUND MOTION

Comment 17:

A commenter stated that performance standards are not clearly articulated in the proposed rule. The commenter also stated that before the design standard is lowered, the performance standards or goals by which the proposed changes were evaluated should first be identified.

Response:

The current regulations in § 72.122(b)(2)(i) require that the structures, systems, and components of an ISFSI or MRS must be designed to withstand the effects of natural phenomena, such as earthquakes, without impairing their capability to perform their intended design functions. For earthquakes, these requirements are then supplemented by the §§ 72.102 and 72.103 requirements for the detailed site investigations and consideration of uncertainties in the prediction of earthquakes. This approach is consistent with the Commission's philosophy of using risk-informed, performance-based regulations. In a risk-informed, performance-based approach, the design of the facility is based on considering the risk (potential for adverse consequences) due to an earthquake.

Comment 18:

One commenter is concerned that lowering the existing DE may result in a concomitant lowering of the design basis for locally-sourced tsunamis. The commenter is concerned because the most likely scenario for release of radiation in a coastal setting would be damage to an ISFSI or MRS during a major earthquake, followed by inundation of the facility by a tsunami.

Response:

Section 72.103(f)(1) requires consideration of actual or potential geologic and seismic effects at the proposed site, including locally-sourced tsunamis. Potential inundation of the facility by a tsunami is required to be addressed in the design of the facility under § 72.122(b)(2). Under the amended rule, the tsunami magnitudes corresponding to the DE would be lower than for a nuclear power plant. However, an earthquake similar in magnitude to the SSE for an NPP would not damage an ISFSI or MRS facility, thus no release of radioactivity would occur even if the facility were inundated by a resulting locally-sourced tsunami.

Comment 19:

A commenter stated that in order to issue a coastal development permit in California the State or a local government must make a finding that the proposed ISFSI will minimize risks to life and property in areas of high geologic hazard, and assure stability and structural integrity of the proposed coastal development. The commenter noted that, for the San Onofre Nuclear Generating Station (SONGS) ISFSI, the required finding was able to be made by the State only because the applicant proposed a seismic design standard far in excess of the SSE for the co-located NPP. The commenter indicated that such a finding may not be possible at future ISFSI sites if the applicant submits a design standard lower than those required for an NPP. The commenter stated that the proposed rule change makes approval of coastal development permits in California for future ISFSIs difficult at best.

Response:

The NRC sees no reason why the rule would make this finding difficult. The rule ensures adequate protection of public health and safety in all environs. The close proximity of faults or populations are considered in the regulations (for example, the dose requirements contained in §§ 72.104(a) and 72.106(b)). Applying a risk-informed approach to seismic design of ISFSIs takes these factors into account and the analyses indicate that protection of public health and safety are adequately addressed.

PROPOSED CHANGE TO 10 CFR 72.212(b)(2)(i)(B)

Comment 20:

Two commenters noted that although the proposed change to 10 CFR 72.212(b)(2)(i)(B) to require that the cask storage pads and areas be designed to adequately support dynamic loads, as well as static loads, of the stored casks, may require more analytical effort than the static load evaluations that some licensees had attempted to utilize in the past, they find the new requirements to be technically correct and support the concept that the seismic evaluation should be conducted using state-of-the-art structural dynamics principles, including consideration of dynamic loads. One commenter had no objection to the portion of the proposed rule that would require design of cask storage pads and areas to adequately account for dynamic loads. Another commenter stated that requiring this evaluation for storage pads and areas clearly improves the assurance of safety.

Response:

The commenters support the NRC's decision to require evaluation of dynamic loads for storage cask pads and areas. Further, general licensees currently consider 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 rule change will not actually impose a new burden on the general licensees.

RELATED REGULATORY GUIDE

Comment 21:

A commenter stated that Draft Regulatory Guide DG-3021 “is short on firm standards” because, although it recommends a DE at a MAPE of 5E-4, it also allows an applicant to demonstrate that the use of a higher probability of exceedance value would not impose any undue radiological risk to public health and safety. Thus, the draft guidance, in the commenter’s view, “leaves open the possibility of an even lower standard for seismic sites.” Another commenter defends the guidance that an applicant could propose a higher probability of exceedance value as being an exemption to what the commenter sees as the norm being established in DG-3021.

Response:

Section 72.103(f)(2)(i) of the rule requires that an applicant include a determination of the DE for the site, considering the results of the investigations required by paragraph (f)(1) and addressing uncertainties through an appropriate analysis, such as a PSHA or suitable sensitivity analyses. Regulatory Guide 3.73 (formerly DG-3021) states that a mean annual probability of exceeding the DE of 5E-4 is recommended to be used in conjunction with the PSHA for determining the DE. As the commenter notes, the draft guidance also indicated that “[t]he use of a higher reference probability will be reviewed and accepted on a case-by-case basis.” This statement was made in recognition of the fact that a regulatory guide does not establish legally-binding requirements. An alternative reference probability would not be an exemption from a requirement, but would be an alternative proposal which would need to be demonstrated to be acceptable. Thus, it is conceivable that an applicant could propose a higher MAPE value that the NRC staff would then have to consider. Although this is necessarily the case for recommendations suggested in guidance documents, the NRC did not mean to imply that it viewed an applicant's ability to make the necessary safety case for a higher MAPE as being a likely prospect. To avoid any such implication, that sentence has been removed from the final guidance.

Comment 22:

One commenter stated that a DE at a MAPE of 5E-4 (2,000 year return period) is not defensible. The commenter said that there are numerous standards that already use a DE at a MAPE of 4E-4 (2,500 year return period), including DOE Standard 1020-2000. The commenter noted that DOE's standard is inextricably tied to meeting performance and risk goals. Further, the commenter indicated that certain buildings, such as hospitals, must meet a DE at a MAPE of 4E-4 (2,500 year return period), as must interstate bridges in the State of Utah. The commenter stated that, at a minimum, a standard lower than these cannot be adopted.

Response:

The NRC disagrees with the commenter that the proposed standard for the DE at a MAPE of 5E-4 (2,000 year return period) is lower than the DOE Standard DOE-STD-1020-2002, or the other standards, such as the International Building Code (IBC-2000 Code).

According to the DOE Standard DOE-STD-1020-2002, ISFSIs can be classified as Performance Category 3 (PC-3) facilities. For PC-3 facilities, the seismic design forces for the DE are initially determined at 90 percent of the DE at a MAPE of 4E-4 (2,500 years return period). This brings the DE levels to approximately a MAPE of 5E-4 (2,000 year return period), specified in the earlier DOE 1020 standard, DOE-STD-1020-94. The Foreword of the DOE-STD-1020-2002 explains the change in the return period as follows:

"It is not the intent of this revision to alter the methodology for evaluating PC-3 facilities, nor to increase the performance goal of PC-3 facilities, by increasing return period for the PC-3 from a 2,000-year earthquake to a 2,500-year earthquake. Rather, the intention is more for convenience to provide a linkage from the NEHRP maps and DOE Standards".

Therefore, use of the reference probability of 5E-4/yr (2,000 year return period), for the ISFSI or MRS facility DE, would be consistent with that used in the DOE Standard DOE-STD-1020, for similar type facilities.

For the IBC-2000 Code, the commenter is incorrectly comparing the ISFSI or MRS DE at a MAPE of 5E-4 (2,000 year return period), with the Maximum Considered Earthquake (MCE) at a MAPE of 4E-4 (2,500 year return period). The DE, according to the IBC-2000 Code, is two-thirds of the MCE, which is equivalent to a DE at a MAPE of 1.1E-3 (909 year return period) earthquake in the western United States, and a DE at a MAPE of 7E-4 (1,430 year return period) in the eastern United States. Thus, the DE for the ISFSI or MRS facility included in DG-3021 at a MAPE of 5E-4 is greater than the IBC Code DE design level.

The NRC agrees that hospital building structures and bridges having critical national defense functions are designed for the DE at a MAPE of 4E-4 (2,500 year return period). These structures are generally occupied by a significant number of people. Therefore, these structures are designed for loads greater than those for traditional buildings to limit building deformations, and to minimize human losses due to an earthquake. The ISFSI or MRS facility, on the other hand, has a relatively small number of people occupying the Canister Transfer Building at any one time.

Comment 23:

A commenter requested that the regulatory guide specify a DE at a MAPE of 1E-4 (10,000 year return period), consistent with the requirement for NPPs. This commenter believes that meeting NPP standards would be easier at an ISFSI or MRS due to the relative simplicity of construction and robust character of the structures as compared to an NPP.

Response:

The NRC disagrees with the commenter and believes that the proposed DE at a MAPE of 5E-4 (2,000 year return period) for an ISFSI or MRS facility is adequate for protecting public health and safety. The seismically induced risk from the operation of an ISFSI or MRS is less than from the operation of an NPP, and based on the review of the current seismic design practice, the proposed DE design level is reasonable and consistent with the NRC's policy of risk-informed, performance-based regulations. Details of the NRC's review for the proposed DE level are provided in the report, "Selection of Design Earthquake Ground Motion Reference Probability". This report 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.

The NRC agrees with the commenter that the cask structure is simple in construction and robust in character resulting from the design considerations other than earthquake effects. Earthquake loads and the DE level would not govern the cask design. However, this is not the case in the design and stability evaluation of other ISFSI or MRS facility structures, systems, and components, such as the concrete pad, foundation, and the canister transfer building. Designs of these structures, systems, and components depend on the DE level. Further, because of the inherent safety margins in the design criteria in NUREG-1536 and NUREG-1567, the structures, systems, and components designed for a DE at a MAPE of 5E-4 (2,000 year return period) would be able to withstand a DE at a MAPE of 1E-4 (10,000 year return period consistent with the NPP requirements) without impairing the ability to meet the Part 72 dose limits for protecting public health and safety. Therefore, it is an unnecessary burden on the applicant to require the ISFSI or MRS facility to design for a DE at a level consistent with NPP requirements.

Comment 24:

Two commenters stated that the seismic design standard (MAPE of 5E-4 (2,000 year return period)) is less protective than the seismic standard for municipal solid waste landfills in California (maximum credible earthquake (MCE) of 4E-4 (2,500 year return period)), and the International Building Code (MCE of 4E-4 (2,500 year return period)), both of which are more stringent than the proposed rule. One commenter is concerned that a DE at a MAPE of 5E-4 (2,000 year return period) may not provide an adequate margin of safety to protect the public.

However, two other commenters stated that the rigor of the seismic evaluation criteria and the conservatism of the seismic design requirements significantly exceed those in modern conventional building codes. One of the commenters stated that the annual probability of unacceptable seismic performance for a dry cask ISFSI designed to a DE at a MAPE of 5E-4 (2,000 year return period) will be substantially less than that of an essential or hazardous facility designed to the modern conventional building code for which the DE was established at 67 percent of the MCE of 4E-4. Another commenter stated that the level of safety for a dry cask storage facility designed to a DE at a MAPE of 5E-4 (2,000 year return period) provides at least twice the level of safety attained by facilities designed under the International Building Code.

Response:

The NRC disagrees with the commenters that the seismic design standard (MAPE of 5E-4) is less protective than the seismic standard for municipal solid waste landfills in California (Code of Regulations Section 66264.25(b), and the International Building Code - 2000 (IBC-2000). The California standard requires the municipal waste landfills to be designed to withstand the maximum credible earthquake (MAPE of 4E-4) of the IBC-2000 without decreasing the level of public health and environmental protection. The cask and the cask transfer building at an ISFSI or MRS facility, designed to a DE at a MAPE of 5E-4, has the capacity to withstand earthquakes of greater magnitude than the one associated with the MAPE of 4E-4. This is because of the conservatism in the seismic evaluation criteria and of NRC's NUREG-1536 and NUREG-1567, which significantly exceed those in modern conventional building codes. Additionally, the risk of the ISFSI or MRS facility to public health and safety is lower than the risk for hazardous waste and municipal solid waste landfills because the spent nuclear fuel is contained within a sealed steel cask in an isolated facility away from the public, with a controlled boundary at a minimum distance of 100 m. Landfills, on the other hand, may be open and in close proximity to public areas.

Comment 25:

Three commenters stated that the proposed rule provided no basis or quantitative analysis to justify lowering the DE to any particular value. One of these commenters indicated that absent any quantitative evidence justifying a particular value, the conservative, precautionary approach of requiring ISFSIs and MRSs to meet the same design standard as a nuclear power plant is most appropriate. One of these commenters noted that the adequacy of the MAPE should be addressed with respect to the change in the DE. The commenter stated that this could be addressed by using the higher proposed MAPE versus what is currently required and then determining if the change in the level of risk of a release is significant or not.

Response:

The DE level proposed in the draft regulatory guide was selected based on the fact that the ISFSI or MRS risk is lower than that of an NPP and on the fact that this level is consistent with the hazard levels used in the nuclear industry for similar facilities. Details of the NRC's analyses for establishing the DE level are provided in the report, "Selection of Design Earthquake Ground Motion Reference Probability". This report 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.

Comment 26:

Two commenters strongly endorsed the proposal to lower the DE. The commenters stated that the DE provided in the draft regulatory guide at a MAPE of 5E-4 (2,000 year return period) provides a level of relief in establishing the DE that is completely consistent with the risk-informed regulation policy and is an excellent example of the application of the policy. One commenter stated that the philosophy of applying a graded approach to seismic design requirements for facilities of differing risks has been in existence for more than 30 years. The commenter described DOE's approach for seismic design requirements for DOE facilities, which span a range of potential risks. The commenter went on to state that based on the amount of radioactive material stored in a large dry cask ISFSI, the resulting classification using the DOE approach would result in a design standard with a MAPE of 5E-4. The commenter stated that considering the minor radiological consequences from a single canister failure and a lack of a credible mechanism to cause such a failure from a seismic event would suggest that this design criteria level is more than adequately conservative for a dry cask ISFSI.

Response:

The commenters support the NRC's recommendation of the seismic design earthquake level to a MAPE of 5E-4 (2,000 year return period).

FINDING OF NO SIGNIFICANT ENVIRONMENTAL IMPACT: AVAILABILITY

Comment 27:

Three commenters challenged the assertion that the NRC has considerable experience in licensing dry cask storage systems and analyzing cask behavior. One commenter noted that the NRC has licensed only four ISFSIs in the western U.S., the most seismically active part of the country, and none as close to major plate-boundary faults as the three planned for coastal California. The commenters also said that analytical experience in licensing does not equate with practical experience. One commenter stated that this will only be achieved when an ISFSI experiences strong ground motions as a result of a major earthquake. As a result, the commenter believes that neither the specific nor general licenses issued have been tested.

Response:

As discussed in the NRC response to Comment 4, cask stability can be evaluated with adequate reliability by using non-linear dynamic analyses because the concept of free-standing structures is not a new one. One does not need to test all structures prior to using them, provided structures are simple and can be reliably analyzed.

REGULATORY ANALYSIS

Comment 28:

A commenter noted that the proposed changes impose no new burdens on establishing the DE for an ISFSI over the current requirements in 10 CFR Part 72.

Response:

The NRC's analysis actually indicates that there would be an overall reduction in the total burden placed on licensees from these changes. The estimate of values and impacts to a specific-license applicant indicates additional costs of $100,000 for addressing uncertainties in seismic hazard analysis. In some cases, ISFSI specific-license applicants have sought exemptions from the design requirements contained in § 72.102, considering site characteristics and other factors. The rule would reduce or eliminate the need for these exemption requests by reducing the DE level for certain structures, systems, and components, resulting in a savings of $150,000 per license applicant. Further, no structures, systems, and components would be required to be designed to withstand a DE at a MAPE of 1E-4 (equivalent to the SSE of an NPP), resulting in lower analytical and certain capital costs. The overall effect of the rule would be a cost savings to new specific-license applicants. However, the amount of these savings is highly site-specific, depending on site characteristics and the specified DE level.

Finally, the rule will 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 under § 72.212(b)(i)(A).

VII. Summary of Final Revisions

This final rule will make the following changes to 10 CFR Part 72:

Section 72.9 Information collection requirements: OMB approval.

In § 72.9, the list of sections where approved information collection requirements appear is amended to add § 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. (New Heading)

The heading of § 72.102 is revised because § 72.103 is added for ISFSI or MRS applications after the effective date of the rule. Section 72.103 will 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 will continue to apply for an ISFSI or MRS using wet modes of storage or dry modes of storage that do not use casks.

The NRC 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 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 an NPP. The 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 an NPP. By making § 72.102 applicable only to existing ISFSIs and by providing a new § 72.103, the revised rule is intended to preclude the need for exemption requests from new specific-license applicants.

The new requirements in § 72.103 parallel the requirements in § 72.102. However, new specific-license 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 an NPP, for dry cask storage applications, on or after the effective date of this rule, will 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 the eastern U.S., and co-located with an NPP, have the option of using the PSHA methodology or suitable sensitivity analyses for determining the DE, or using the existing design criteria for the NPP. This change to require an understanding of the uncertainties in the determination of the DE will make the regulations compatible with 10 CFR 100.23 for NPPs and will allow the geological and seismological criteria for ISFSI or MRS dry cask storage facilities to be risk-informed.

New § 72.103(a)(1) provides that sites located in eastern U.S. and not in areas of known seismic activity, 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. Section 72.103(a)(1) will parallel the requirements currently included in § 72.102(a)(1).

New § 72.103(a)(2) provides 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. New § 72.103(a)(2) also provides, as an alternative, that a site-specific DE may be determined by using the criteria and level of investigations in new § 72.103(f). Section 72.103(f) is a new provision that requires 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.

New § 72.103(a)(2) also provides that if an ISFSI or MRS is located at an NPP site, the existing geological and seismological design criteria for the NPP may be used instead of PSHA techniques or suitable sensitivity analyses because the risk due to a seismic event at an ISFSI or MRS is less than that of an 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.

New § 72.103(b) provides 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 analyses of new § 72.103(f). If an ISFSI or MRS is located at an NPP site, the existing geological and seismological design criteria for the NPP may be used instead of PSHA techniques or suitable sensitivity analyses because the risk due to a seismic event at an ISFSI or MRS is less than that of an 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.

New § 72.103(c) is identical to § 72.102(c). Section 72.103(c) requires 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 an ISFSI or MRS will be adequately supported on a stable foundation during a seismic event.

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

New § 72.103(e) is identical to § 72.102(e). Section 72.103(e) requires 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 an ISFSI or MRS will be adequately supported on a stable foundation during a seismic event.

New § 72.103(f) describes 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 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 the use of the deterministic method of Appendix A to Part 100, new § 72.103(f) requires evaluating uncertainty in seismic hazard analysis by using a probabilistic method, such as the PSHA, or suitable sensitivity analyses, similar to § 100.23 requirements for an NPP.

New § 72.103(f)(1) requires 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).

New §§ 72.103(f)(2)(i) through (iv) 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) provides that a specific-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 new § 72.103(f)(3) provides 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 is identical to the requirement currently included in § 72.102(f)(2).

Section 72.212 Conditions of general license issued under § 72.210.

Section 72.212(b)(2)(i)(B) is revised to require general licensees to address the dynamic loads of the stored casks in addition to the static loads. The requirements are 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 will ensure that the pad would perform satisfactorily during a seismic event.

The new paragraph also requires 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 may affect the cask stability, and thus must be addressed.

The 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 now in § 72.103(c).

VIII. Criminal Penalties

For the purpose of Section 223 of the Atomic Energy Act (AEA), the Commission is issuing this final rule to amend 10 CFR Part 72 under one or more of sections 161b, 161i, or 161o of the AEA. Willful violations of the rule will 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 (AEA), or the provisions of Title 10 of the Code of Federal Regulations. Although an Agreement State may not adopt program elements reserved to the 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. 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 final 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.

XI. 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, that this rule is not a major Federal action significantly affecting the quality of the human environment and therefore an environmental impact statement is not required.

The Commission concluded, based on an environmental assessment, that no significant environmental impact would result from this rulemaking. In comparison with an 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 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.

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 have substantial design margins to withstand forces from a seismic event greater than the design earthquake.

Hence, the seismically induced radiological risk associated with an ISFSI or MRS is less than the risk associated with an NPP.

The determination of the environmental assessment is that there will be no significant environmental impact due to the rule 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.

The NRC requested public comments on the environmental assessment for this rule.

XII. Paperwork Reduction Act Statement

This final rule amends information collection requirements that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq). These requirements were approved by the Office of Management and Budget, approval number 3150-0132.

Because the rule will reduce existing information collection requirements, the public burden for these information collections is expected to be decreased by 55 hours per licensee. This reduction includes the time required for reviewing instructions, searching existing data sources, gathering and maintaining the data needed and completing and reviewing the information collection. Send comments on any aspect of these information collections, including suggestions for further 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.

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.

XIII. Regulatory Analysis

The Commission has prepared a 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 RA 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.

XIV. Regulatory Flexibility Certification

In accordance with the Regulatory Flexibility Act of 1980 (5 U.S.C. 605(b)), the Commission certifies that this rule does not have a significant economic impact on a substantial number of small entities. This 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.

XV. Backfit Analysis

The NRC 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 the backfit rule. Therefore, a backfit analysis is not required for these provisions.

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 revision to this section will 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 will ensure that the cask storage pads and areas will perform satisfactorily in the event of an earthquake.

The revision will 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. The soil liquefaction and instability during a vibratory motion due to an earthquake may affect the cask stability.

The changes to § 72.212(b)(2)(i)(B) will impact procedures required to operate an ISFSI and, therefore, implicate the backfit rule. The changes will 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 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 changes to § 72.212 will 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 general licensees to perform written evaluations to meet conditions set forth in the cask Certificate of Compliance. These Certificates of Compliance require that dynamic loads, such as seismic and tornado loads, be evaluated to meet the cask design bases. Because the general licensees currently evaluate dynamic loads for evaluating the casks, pads and areas, the changes to § 72.212(b)(2)(i)(B) will not actually require any general licensees presently operating an ISFSI to re-perform any written evaluations previously undertaken.

XVI. Small Business Regulatory Enforcement Fairness Act

In accordance with the Small Business Regulatory Enforcement Fairness Act of 1996, the NRC has determined that this action is not a major rule and has verified this determination with the Office of Information and Regulatory Affairs of OMB.

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. 552 and 553; the NRC is adopting 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° west longitude), except in areas of known seismic activity including but not limited to the regions around New Madrid, MO; Charleston, SC; and Attica, NY; sites 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. If an ISFSI or MRS is located on an 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) Except as provided in paragraphs (a)(2) and (b) of this section, 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 _____________, 2003.

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

Final Report

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

June 2003

TABLE OF CONTENTS

Executive Summary

The Nuclear Regulatory Commission (NRC) is amending 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 is not revising the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because applications for this means of storage are not expected and it is not cost-effective to allocate resources to develop the technical bases for such an expansion of the rulemaking. The Commission is not revising 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 in licensing these facilities.

The Commission considered a number of options to change the siting and design requirements in Part 72. This Regulatory Analysis (RA) is part of the Commission's analysis of the options considered.

In its proposed rule (67 FR 47745, July 22, 2002), the Commission proposed 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 (NPP), 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). Regulatory Guide 3.73 (RG 3.73, draft was DG-3021), "Site Evaluations and Design Earthquake Ground Motion for Dry Cask Independent Spent Fuel Storage and Monitored Retrievable Storage Installations," accompanying the final rule, recommended a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the safe shutdown earthquake (SSE) of an 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 changes are consistent with the Commission's strategic goals in that

– The rule 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 a 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. 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. RG 3.73, accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4 for ISFSI applications. This recommended level is lower than the present level of approximately 1E-4 (equivalent to the SSE for an 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 1E-4 (equivalent to the SSE of an 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 NRC's risk-informed approach to regulation.

Additional Change

The Commission also proposed 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 change is an additional modification, separate from the changes considered 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 amending 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 and 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 is not revising the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because applications for this means of storage are not expected and it is not cost-effective to allocate resources to develop the technical bases for such an expansion of the rulemaking. The Commission is not revising 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. In its proposed rule (67 FR 47745) NRC proposed to adopt Option 4 (described in detail in sections 2.5 and 3.3.4 of this document). The purpose of this RA is to evaluate the costs and benefits associated with the regulatory changes considered by the Commission, including public comments received on the proposed rule. This document presents background material, describes the objectives of the rule, outlines the alternatives considered, and evaluates the values and impacts of the 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 an 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 eastern U.S. A seismic design requirement, equivalent to the requirements for an 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 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 areas of known seismic activity in the eastern U.S., 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. Yet Appendix A to Part 100 does not allow this application.

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. 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.

– 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.

The NRC is amending the seismological and geological requirements of 10 CFR Part 72 for siting and design of a dry cask ISFSI or MRS. The proposed rule and the announcement on the availability of the draft Regulatory Guide, DG-3021, were published for public comment on July 22, 2002 (Ref. 4.2). The amendments to the regulations include the use of PSHA or other suitable sensitivity analyses in evaluating the hazards to the ISFSI or MRS facility due to an earthquake, instead of the deterministic methods of 10 CFR 100 Appendix A of the current Part 72 regulations.

Unlike the regulations for a new NPP, the Part 72 amendments include limited use of the PSHA or suitable sensitivity analyses in evaluating the ISFSI or MRS facility hazards due to an earthquake. Only a specific-license applicant for a dry cask storage ISFSI or MRS facility at a site not co-located with an NPP, in either the western U.S., or in areas of known seismic activity in the eastern U.S. must use the PSHA or suitable sensitivity analyses, to address uncertainties in determining the DE. For all other specific-license applicants for a dry cask storage ISFSI or

MRS facility the use of the PSHA or suitable sensitivity analyses is optional. The applicant can use the design criteria for the most recent NPP (if applicable), or the current regulations applicable to locations in the eastern U.S. of a standardized DE described by an appropriate response spectrum anchored at 0.25 g. Thus, the amendments related to the use of the PSHA or suitable sensitivity analyses would apply only to a few sites in the western U.S. The amendments are not applicable to licensees operating an ISFSI under a Part 72 general license anywhere in the U.S.

As an additional minor change, NRC would amend § 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 will 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 § 72.212(b)(2)(i)(A). Therefore, the rule 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 § 72.122(b)(2), to design ISFSIs to withstand the effects of dynamic loads, such as earthquakes and tornados.

1.2 Objectives of the Rulemaking

Part 72 currently requires siting and design of ISFSI facilities in accordance with requirements that were established for the licensing of NPPs. The changes to Part 72 are intended to (1) provide benefit from the experience gained in applying the existing regulation and from research, (2) provide needed regulatory flexibility to incorporate state-of-the-art improvements in the geosciences and earthquake engineering, and (3) make the regulations more risk-informed.

The objectives of this 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 will have the option of complying with the 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.

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 Analysis of Alternative Approaches

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

(1) The first change considered 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 an 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 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.

ISFSIs and MRS facilities have been designed for earthquakes based on the same risk as for an NPP. The current Part 72 regulations for an ISFSI or an MRS facility require that for sites that have been evaluated under the criteria of Appendix A of Part 100, the DE must be equivalent to the SSE for an NPP. Recently, the regulations for NPPs were changed from the deterministic criteria of Appendix A of Part 100 to the probabilistic seismic hazard analysis methods or suitable sensitivity analyses to account for uncertainties in determining the ground motion used in the seismic design of structures, systems and components (10 CFR 100.23, and Appendix S to 10 CFR Part 50). There is a need, therefore, to change Part 72 to allow the use of the PSHA and make the design earthquake level commensurate with the risk to public health and safety. This change is explained in a report entitled, "Selection of the Design Earthquake Ground Motion Reference Probability." This report 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.

The Commission endorses the use of risk-informed, performance-based approaches for regulating nuclear material and high-level waste licensees.[1] In the Commission's Strategic Assessment and Rebaselining initiative, one of the Direction-Setting Issues (DSIs) was Risk-Informed, Performance-Based Regulation (DSI-12).

Radiological risks to the public result from a release of radioactive materials and their dispersal to the environment. To protect the public from the radiological risk, Part 72 requires that the SSCs in an ISFSI or MRS facility be 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.

[1] The Commission's endorsement of the use of risk-informed approaches to regulation are described in the following three documents: (1) "Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities; Final Policy Statement, 60 FR 42622, August 16, 1995;" (2) "Framework for Risk-Informed Regulation in the Office of Nuclear Material Safety and Safeguards, SECY-99-100, March 31, 1999;" and (3) "Staff Requirements - SECY-99-100, from Annette Vietti-Cook, Secretary to the Commission, June 28, 1999."

The Dry Cask Storage Systems (DCSSs) for ISFSIs or MRSs, approved under Part 72 regulations, are typically self-contained massive concrete or steel structures, weighing approximately 100 to 180 tons when fully loaded. There are very few, if any, moving parts. The dry cask storage systems consist of free-standing vertical casks with a diameter ranging from 88 inches to 132 inches and a height to diameter ratio of 1.6 to 2.1, or a concrete Vault/Module type (NUHOMS cask storage systems). The spent-fuel is contained in a steel sealed canister for both types of storage systems.

The critical element for protection against radiation release is the sealed canister containing the spent fuel assemblies. The requirements 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 dry cask storage system design dimensions, such as thickness of various members are governed by radiological shielding, thermal, and potential drop accidents during handling of the cask. Effects of natural phenomena such as earthquakes, tornadoes, floods etc. are insignificant contributors to the stresses in various cask components, but are required to be considered for the cask stability. The cask stability parameters are the rigid body displacements and the rotations about the cask base on the pad. Cask rigid body displacements and rotations are calculated to evaluate the potential for a cask tip-over event, and a cask-to-cask impact. Even if it is demonstrated that a cask would not tip-over, the effects of a cask tip-over event on the cask's structural integrity are evaluated to meet the requirements of § 72.106(b) for limiting the radioactive release dose to 5 rem to protect public health and safety. If a cask-to-cask impact is likely to occur, the cask structural integrity is evaluated to meet the § 72.106(b) requirements.

To evaluate dry cask storage systems behavior during an earthquake, typical storage systems (one a cylindrical cask, HI-STORM 100, the other a concrete module type, NUHOMS) were analyzed using coupled non-linear finite-element analyses for a range of earthquakes.[2, 3, 4, 5] Site specific properties at three ISFSI facilities, two on the West coast, and one on the East coast were considered in the analyses. The analyses were performed for artificial earthquakes to match the DE for a plant and Regulatory Guide 1.60 spectra, and real earthquake records with maximum peak ground acceleration varying from 0.15 g to 1.5 g. The purpose of the studies was to determine the stability of the free-standing dry cask storage systems during an earthquake.

Based on the results of the analyses, NRC has concluded that a free-standing dry storage cask remains stable and will not tip-over, or would not slide and impact the adjacent casks during an earthquake, approximately equal to the magnitude of a SSE for an NPP, defined as the mean

---

[2] "Seismic Analysis of HI-STORM 100 Casks at Private Fuel Storage Facility, Rev. 1," Luk, V. et al., Sandia National Laboratories, Albuquerque, NM, June 28, 2001.

[3] "Seismic Analysis of Three Module Rectangular Trans-Nuclear West Module/cask," Luk, V. et al., Sandia National Laboratories, Albuquerque, NM, December 21, 2001.

[4] "Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage Facility, Rev. 1," Luk, V. et al., Sandia National Laboratories, Albuquerque, NM, March 31, 2001.

[5] "Dynamic Soil-Structure Interaction Analysis of a Storage-Cask Foundation Design," Ofoegbu, G. I., Gute, G. D., Center for Nuclear Waste Regulatory Analyses, San Antonio, TX, October, 2002.

probability of exceedance level of 1E-4. Additionally, the parametric studies indicated that the dry cask storage systems have significant margins against the tip-over and sliding, to withstand an earthquake significantly higher in magnitude than the SSE for an NPP, without releasing radioactivity. Further, a cask is analyzed for a non-mechanistic tip-over event during an earthquake, to verify that the cask and MPC would remain structurally integral, and radioactivity from spent fuel would not be released to the environment.

In addition to the dry casks containing the spent fuel, the ISFSI or MRS facility includes a reinforced concrete building. The building is generally referred to as the Canister Transfer Building, and is considered as important to safety because the building is used for transferring the multi-purpose steel sealed canister (MPC), containing the spent fuel assemblies, from the transfer cask to the storage cask. The building is designed using the same load combinations, acceptance criteria, and design code, as for NPP safety related seismic Category I buildings. The considered amendments do not change the load combinations or the acceptance criteria for the design of the building. As a result of using these criteria, a building designed to DE can withstand a greater level earthquake without failing to perform its function. Using a minimum margin of safety of 1.5 and using the Hazard Curves for spectral acceleration at 0.1 second period, the building designed for a DE with a mean annual probability of exceedance of 5E-4, as proposed in RG 3.73, can withstand an earthquake with a return period of approximately 4,000 years in New York City, and 25,000 years in San Francisco, CA.

Consequences of a failure of the Canister Transfer Building during an earthquake magnitude greater than the DE, were analytically evaluated to determine if the failure of the crane and the handling system, and resulting drop of the cask and the crane, would damage the MPC of the HI-STORM 100 system.[6] Based on the evaluation, NRC concluded that the MPC would not be damaged and release radioactivity to the environment.

Additionally, for the Canister Transfer Building, 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. Moreover, 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.

Based on the above, the staff has concluded that the dry cask storage systems for an ISFSI or MRS facility are inherently robust structures because of the design requirements other than for an earthquake there are no adverse consequences due to operation of a dry cask ISFSI or MRS facility during an earthquake.

Since there are no adverse consequences to public health and safety at a dry cask ISFSI or MRS facility during an earthquake of a magnitude equivalent to the NPP SSE or greater, one can conclude that the current Part 72 regulations requiring the DE to be equivalent to the SSE for an NPP are excessive, and not performance-based or risk-informed. Therefore, there is a need to determine an appropriate minimum level of earthquake for a dry cask ISFSI or MRS facility, consistent with the criteria for the design of structures in industrial facilities, to verify

---

[6] "Analysis of Dry Cask Drop Scenarios onto a Reinforced Concrete Floor," Braverman, J., et al., Brookhaven National Laboratory, April 24, 2002.

cask/foundation stability and the Canister Transfer Building design/stability during an earthquake.

To determine an appropriate reasonable value of the mean annual probability of exceedance of an earthquake (the reference probability), or a mean return period, for a dry cask ISFSI or MRS facility, NRC staff reviewed the current guidelines contained in Regulatory Guide 1.165 for a nuclear power plant, the U. S. Department of Energy (DOE) guidelines in DOE-1020-2002,[7] and the International Building Code-2000,[8] and considered the public comments received in response to the proposed rule.

For the siting of a new nuclear power plant, Regulatory Guide 1.165 recommends the reference probability of 1E-5/yr, as the "median" annual probability of exceeding the SSE. The "median" annual probability of exceedance of 1E-5 is approximately equal to a "mean" annual probability of exceedance for the SSE, at sites in the Continental Eastern United States (CEUS). Because the uncertainty associated with the seismic hazard evaluations at sites in the Western United States (WUS) is less than at CEUS sites, "mean" values normally are closer to "median" values at the WUS sites. Thus, choosing a "mean" annual probability of exceedance of 1E-4 would be consistent with the "mean" hazard level associated with the "mean" hazard levels of nuclear power plants in the CEUS, but choosing a "median" annual probability of exceedance of 1E-5 would not be. Based on the recent work in NUREG/CR-6728,[9] the staff has determined that the use of a "mean" annual probability of exceedance for the reference probability of the seismic hazard is an appropriate method for the design of an ISFSI or MRS facility.

(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 proposed a change to clarify that 10 CFR Part 72 general licensees must perform both static and dynamic analyses 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.

The specific options considered were:

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

<u>Option 2</u>. 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

---

[7] "Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities, DOE-STD-1020-2002, U.S. Department of Energy, January, 2002.

[8] "International Building Code 2000," International Code Council, 2002.

[9] ""Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines," NUREG/CR-6728, October, 2001.

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. RG 3.73, accompanying this final rule, recommends a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the SSE of an NPP, for ISFSI applications.

Additional Proposed Change. The Commission also proposed 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 Options

This section compares the requirements of the options considered. 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 considered options is provided in Table 2-1.

Table 2-1. Comparison of Requirements Under Considered 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 an 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 = 1E-3, Category 2 event annual probability = 1E-4.
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 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 0.25 g) 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 an 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 an 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 an 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 NRC staff 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 1E-3. Category 2 design basis ground motion refers to a mean annual probability of exceedance of 1E-4.

Individual SSCs that are required to maintain the annual dose within the regulatory limits of 10 CFR Part 20 would be designed to a Frequency 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 Frequency 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. Regulatory guide 3.73, accompanying the proposed rule, recommended a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the SSE of an 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 an 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 an 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. RG 3.73, accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the SSE of an 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 1E-4. Part 72 regulations classify ISFSI facility 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).

In the Statement of Considerations accompanying the initial Part 72 rulemaking, the NRC recognized that the storage of spent fuel is a low risk operation when compared to a nuclear power plant (45 FR 74697; November 12, 1980). Factors that result in lower radiological risk at an ISFSI or MRS compared to a nuclear power plant include the following:

- In comparison with an NPP, 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 components carrying fluids at high temperatures or pressures 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.

- 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.

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 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 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. These SSCs have significant margins of safety during a seismic event, as discussed earlier in this section. Because of the significant safety margins, the 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 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 rule can be issued with assurance that licensees will have flexibility in implementing the requirements and the 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 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 considered changes to revise the siting and design requirements for ISFSIs.

The NRC rulemaking would amend 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 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 considered changes would result in certain values and/or impacts. Thus, the values and impacts of the Commission's rulemaking as a whole consist of the sum of all values and impacts associated with each of the considered changes. 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 considered (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*.[10] 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 regulatory options considered 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 an NPP. The regulatory change considered to require written evaluations of analysis of dynamic loads would not result in additional costs to general licensees.

– 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

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

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.

– NRC Implementation -- The regulatory options considered 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 considered 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 considered, with the exception of Option 1, the No-Action alternative, would be expected to result in enhanced regulatory efficiency by increasing the level of consistency among different regulations.

– Improvements in Knowledge -- The regulatory options considered, with the exception of Option 1, the No-Action alternative, 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 considered changes.

– Off-site Property -- Effects on off-site property are not expected to be impacted by any of the considered changes.

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

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

– Other Government -- The regulatory options considered 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 changes considered.

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

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

– Antitrust Considerations -- The regulatory options considered 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 considered. 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 5E-4;
- Industry costs of designing SSCs important to safety with a mean annual probability of exceedance of 1E-4;
- 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. Further, NRC considered information received during the public comment period on the proposed rule as part of this analysis.

Assumptions

NRC is making certain assumptions with respect to the values and impacts associated with the options considered for this rule.

Option 4 is the only option that considers whether a site is located with an 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, that the Humboldt Bay (CA), 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. § 72.103 would 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 Regulatory Alternatives Considered

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 an 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. RG 3.73, accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the SSE of an 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. RG 3.73, accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the SSE of an 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 5E-4. 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 1E-4 (equivalent to the SSE of an 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 considered 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 revisions considered 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 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 may affect the cask stability.

The considered changes to § 72.212(b)(2)(i)(B) will impact procedures required to operate an ISFSI and; therefore, implicate the backfit rule. The 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 considered 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 amending 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 1E-4 (equivalent to the SSE of an 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 improved.

6.0 Implementation

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 changes to § 72.212(b)(2)(i)(B) will impact procedures required to operate an ISFSI and; therefore, implicate the backfit rule. The changes will 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 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 changes to § 72.212 will 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 is 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 the proposed and final rule for this rulemaking are on the order of 3.8 FTEs. These resources will come principally from NMSS, NRR, RES, and OGC. These resources are within FY 2003 budget allocations.

NMSS . . 3.0 FTE
Other . . 0.8 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

Final Report

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

June 2003

C:\ORPCheckout\FileNET\ML031400820.wpd

TABLE OF CONTENTS

Executive Summary

The Nuclear Regulatory Commission (NRC) is amending 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 is not revising the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because applications for this means of storage are not expected and it is not cost-effective to allocate resources to develop the technical bases for such an expansion of the rulemaking. The Commission also is not revising 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 in licensing these facilities.

The Commission considered a number of options to change the siting and design requirements in Part 72. This Environmental Assessment (EA) is part of the Commission's analysis of the options considered.

In its proposed rule (67 FR 47745, July 22, 2002), the Commission proposed 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 (NPP), 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). Regulatory Guide 3.73 (RG 3.73, draft was DG-3021), "Site Evaluations and Design Earthquake Ground Motion for Dry Cask Independent Spent Fuel Storage and Monitored Retrievable Storage Installations," accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the safe shutdown earthquake (SSE) of an 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 new provisions would be added as a new § 72.103, which would provide the requirements that would be utilized for new specific-license applicants.

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

– The rule 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 a 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, 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 an 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. RG 3.73, accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4 for ISFSI applications. This recommended level is lower than the present level of approximately 1E-4 (equivalent to the SSE for an 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 3 in that specific licensees would not be required to design any SSCs to withstand a DE as high as the SSE of an NPP.

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 changes considered will significantly affect the construction or operation of an ISFSI facility.

Additional Change

The Commission also proposed 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 change is an additional modification, separate from the changes considered 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 NRC is amending 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 is not revising the 10 CFR Part 72 geological and seismological criteria as they apply to wet modes of storage because applications for this means of storage are not expected and it is not cost-effective to allocate resources to develop the technical bases for such an expansion of the rulemaking. The Commission also is not revising 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. In its proposed rule (67 FR 47745) NRC proposed to adopt Option 4 (described in detail in sections 3.1.4 and 4.4 of this document). The purpose of this 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 an 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 eastern U.S. A seismic design requirement, equivalent to the requirements for an 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 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 areas of known seismic activity in the eastern U.S., 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. Yet Appendix A to Part 100 does not allow this application.

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. 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.

– 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.

The NRC is amending the seismological and geological requirements of 10 CFR Part 72 for siting and design of a dry cask ISFSI or MRS. The proposed rule and the announcement on the availability of the draft Regulatory Guide, DG-3021, were published for public comment on July 22, 2002 (Ref. 4.2). The amendments to the regulations include the use of PSHA or other suitable sensitivity analyses in evaluating the hazards to the ISFSI or MRS facility due to an earthquake, instead of the deterministic methods of 10 CFR 100 Appendix A of the current Part 72 regulations.

Unlike the regulations for a new NPP, the Part 72 amendments include limited use of the PSHA or suitable sensitivity analyses in evaluating the ISFSI or MRS facility hazards due to an earthquake. Only a specific-license applicant for a dry cask storage ISFSI or MRS facility at a site not co-located with an NPP, in either the western U.S., or in areas of known seismic activity in the eastern U.S. must use the PSHA or suitable sensitivity analyses, to address uncertainties in determining the DE. For all other specific-license applicants for a dry cask storage ISFSI or MRS facility the use of the PSHA or suitable sensitivity analyses is optional. The applicant can use the design criteria for the most recent NPP (if applicable), or the current regulations applicable to locations in the eastern U.S. of a standardized DE described by an appropriate response spectrum anchored at 0.25 g. Thus, the amendments related to the use of the PSHA or suitable sensitivity analyses would apply only to a few sites in the western U.S. The amendments are not applicable to licensees operating an ISFSI under a Part 72 general license anywhere in the U.S.

As an additional minor change, NRC would amend § 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 will 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 § 72.212(b)(2)(i)(A). Therefore, the rule 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 § 72.122(b)(2), to design ISFSIs to withstand the effects of dynamic loads, such as earthquakes and tornados.

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 NPPs. The changes to Part 72 are intended to (1) provide benefit from the experience gained in applying the existing regulation and from research, (2) provide needed regulatory flexibility to incorporate state-of-the-art improvements in the geosciences and earthquake engineering, and (3) make the regulations more risk-informed.

The objectives of this 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 will have the option of complying with the 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.

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).

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

(1) The first change considered 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 an 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.

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 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, November 12, 1980). The present ISFSI DE (equivalent to the SSE for an NPP) has a mean annual probability of exceedance of approximately 1E-4 (i.e., in any one year, the probability is one in ten thousand that the DE established for the site will be exceeded). Factors that result in lower radiological risk at an ISFSI or MRS compared to a nuclear power plant include the following:

- In comparison with an NPP, 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 components carrying fluids at high temperatures or pressures 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.

- 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.

(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 proposed a change to clarify that 10 CFR Part 72 general licensees must perform both static and dynamic analyses 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 specific options considered were:

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. RG 3.73, accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the SSE of an NPP, for ISFSI applications.

Option 4 is the only option that considers whether a site is located with an 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.

<u>Additional Proposed Change</u>. The Commission also proposed 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.

3.1 Comparison of 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 considered options is provided in Table 3-2.

Table 3-2. Comparison of Requirements Under Considered 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 an 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 = 1E-3, Category 2 event annual probability = 1E-4.
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 § 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 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 0.25 g) 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 an 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.

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 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 an 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 an 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.

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 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 NRC staff 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 1E-3. Category 2 design basis ground motion refers to a mean annual probability of exceedance of 1E-4.

Individual SSCs that are required to maintain the annual dose within the regulatory limits of 10 CFR Part 20 would be designed to a Frequency 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 Frequency 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.

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. RG 3.73, accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level of an SSE for an 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 an 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 an 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. RG 3.73 , accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the SSE of an 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 1E-4. Part 72 regulations classify ISFSI facility 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), earthquakes are not included.

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. This proposed change would be included with any of the 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.

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 accident conditions. Other systems, structures, and components would also be designed to standards affording a high degree of environmental protection under normal and credible accident 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 an 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 §§ 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 certain SSCs important to safety would still be the SSE for an 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. RG 3.73, accompanying the final rule, recommends a DE with a mean annual probability of exceedance of 5E-4, which is lower than the current level for the SSE of an 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 an NPP. The draft regulatory guide accompanying the proposed rule recommended a DE with a mean annual probability of exceedance of 5E-4, 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. This recommendation is explained in a report entitled, "Selection of the Design Earthquake Ground Motion Reference Probability." This report 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. The general rationale for this finding includes the following considerations:

ISFSIs and MRS facilities have been designed for earthquakes based on the same risk as for an NPP. The current Part 72 regulations for an ISFSI or an MRS facility require that for sites that have been evaluated under the criteria of Appendix A of Part 100, the DE must be equivalent to the SSE for an NPP. Recently, the regulations for NPPs were changed from the deterministic criteria of Appendix A of Part 100 to the probabilistic seismic hazard analysis methods or suitable sensitivity analyses to account for uncertainties in determining the ground motion used in the seismic design of structures, systems and components (10 CFR 100.23, and Appendix S to 10 CFR Part 50). There is a need, therefore, to change Part 72 to allow the use of the PSHA and make the design earthquake level commensurate with the risk to public health and safety.

Radiological risks to the public result from a release of radioactive materials and their dispersal to the environment. To protect the public from the radiological risk, Part 72 requires that the SSCs in an ISFSI or MRS facility be 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.

The Dry Cask Storage Systems (DCSSs) for ISFSIs or MRSs, approved under Part 72 regulations, are typically self-contained massive concrete or steel structures, weighing approximately 100 to 180 tons when fully loaded. There are very few, if any, moving parts. The dry cask storage systems consist of free-standing vertical casks with a diameter ranging from 88 inches to 132 inches and a height to diameter ratio of 1.6 to 2.1, or a concrete Vault/Module type (NUHOMS cask storage systems). The spent-fuel is contained in a steel sealed canister for both types of storage systems.

The critical element for protection against radiation release is the sealed canister containing the spent fuel assemblies. The requirements 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 dry cask storage system design dimensions, such as thickness of various members are governed by radiological shielding, thermal, and potential drop accidents during handling of the cask. Effects of natural phenomena such as earthquakes, tornadoes, floods etc. are insignificant contributors to the stresses in various cask components, but are required to be considered for the cask stability. The cask stability parameters are the rigid body displacements and the rotations about the cask base on the pad. Cask rigid body displacements and rotations are calculated to evaluate the potential for a cask tip-over event, and a cask-to-cask impact. Even if it is demonstrated that a cask would not tip-over, the effects of a cask tip-over event on the cask's structural integrity are evaluated to meet the requirements of § 72.106(b) for limiting the radioactive release dose to 5 rem to protect public health and safety. If a cask-to-cask impact is likely to occur, the cask structural integrity is evaluated to meet the § 72.106(b) requirements.

To evaluate dry cask storage systems behavior during an earthquake, typical storage systems (one a cylindrical cask, HI-STORM 100, the other a concrete module type, NUHOMS) were analyzed using coupled non-linear finite-element analyses for a range of earthquakes.[1, 2, 3, 4] Site specific properties at three ISFSI facilities, two on the West coast, and one on the East coast were considered in the analyses. The analyses were performed for artificial earthquakes to match the DE for a plant and Regulatory Guide 1.60 spectra, and real earthquake records with maximum peak ground acceleration varying from 0.15 g to 1.5 g. The purpose of the studies was to determine the stability of the free-standing dry cask storage systems during an earthquake.

Based on the results of the analyses, NRC has concluded that a free-standing dry storage cask remains stable and will not tip-over, or would not slide and impact the adjacent casks during an earthquake, approximately equal to the magnitude of a SSE for an NPP, defined as the mean probability of exceedance level of 1E-4. Additionally, the parametric studies indicated that the dry cask storage systems have significant margins against the tip-over and sliding, to withstand an earthquake significantly higher in magnitude than the SSE for an NPP, without releasing radioactivity. Further, a cask is analyzed for a non-mechanistic tip-over event during an earthquake, to verify that the cask and MPC would remain structurally integral, and radioactivity from spent fuel would not be released to the environment.

In addition to the dry casks containing the spent fuel, the ISFSI or MRS facility includes a reinforced concrete building. The building is generally referred to as the Canister Transfer Building, and is considered as important to safety because the building is used for transferring the multi-purpose steel sealed canister (MPC), containing the spent fuel assemblies, from the transfer cask to the storage cask. The building is designed using the same load combinations, acceptance criteria, and design code, as for NPP safety related seismic Category I buildings. The considered amendments do not change the load combinations or the acceptance criteria for the design of the building. As a result of using these criteria, a building designed to DE can withstand a greater level earthquake without failing to perform its function. Using a minimum margin of safety of 1.5 and using the Hazard Curves for spectral acceleration at 0.1 second period, the building designed for a DE with a mean annual probability of exceedance of 5E-4, as proposed in RG 3.73, can withstand an earthquake with a return period of approximately 4,000 years in New York City, and 25,000 years in San Francisco, CA.

Consequences of a failure of the Canister Transfer Building during an earthquake magnitude greater than the DE, were analytically evaluated to determine if the failure of the crane and the handling system, and resulting drop of the cask and the crane, would damage the MPC of the

---

[1] "Seismic Analysis of HI-STORM 100 Casks at Private Fuel Storage Facility, Rev. 1," Luk, V. et al., Sandia National Laboratories, Albuquerque, NM, June 28, 2001.

[2] "Seismic Analysis of Three Module Rectangular Trans-Nuclear West Module/cask," Luk, V. et al., Sandia National Laboratories, Albuquerque, NM, December 21, 2001.

[3] "Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage Facility, Rev. 1," Luk, V. et al., Sandia National Laboratories, Albuquerque, NM, March 31, 2001.

[4] "Dynamic Soil-Structure Interaction Analysis of a Storage-Cask Foundation Design," Ofoegbu, G. I., Gute, G. D., Center for Nuclear Waste Regulatory Analyses, San Antonio, TX, October, 2002.

HI-STORM 100 system.[5] Based on the evaluation, NRC concluded that the MPC would not be damaged and release radioactivity to the environment.

Additionally, for the Canister Transfer Building, 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. Moreover, 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.

Based on the above, the staff has concluded that the dry cask storage systems for an ISFSI or MRS facility are inherently robust structures because of the design requirements other than for an earthquake and that there is no potential for release of radioactivity at an ISFSI site with a DE at a magnitude equal to the SSE for a NPP or greater.

Since there are no adverse consequences to public health and safety at a dry cask ISFSI or MRS facility during an earthquake of a magnitude equivalent to the NPP SSE or greater, one can conclude that the current Part 72 regulations requiring the DE to be equivalent to the SSE for an NPP are excessive, and not performance-based or risk-informed. Therefore, there is a need to determine an appropriate minimum level of earthquake for a dry cask ISFSI or MRS facility, consistent with the criteria for the design of structures in industrial facilities, to verify cask/foundation stability and the Canister Transfer Building design/stability during an earthquake.

To determine an appropriate reasonable value of the mean annual probability of exceedance of an earthquake (the reference probability), or a mean return period, for a dry cask ISFSI or MRS facility, NRC staff reviewed the current guidelines contained in Regulatory Guide 1.165 for a nuclear power plant, the U. S. Department of Energy (DOE) guidelines in DOE-1020-2002,[6] and the International Building Code-2000,[7] and considered the public comments received in response to the proposed rule.

For the siting of a new nuclear power plant, Regulatory Guide 1.165 recommends the reference probability of 1E-5/yr, as the “median” annual probability of exceeding the SSE. The “median” annual probability of exceedance of 1E-5 is approximately equal to a “mean” annual probability of exceedance for the SSE, at sites in the Continental Eastern United States (CEUS). Because the uncertainty associated with the seismic hazard evaluations at sites in the Western United States (WUS) is less than at CEUS sites, “mean” values normally are closer to “median” values at the WUS sites. Thus, choosing a “mean” annual probability of exceedance of 1E-4 would be consistent with the “mean” hazard level associated with the “mean” hazard levels of nuclear power plants in the CEUS, and but choosing a “median” annual probability of exceedance of

---

[5] “Analysis of Dry Cask Drop Scenarios onto a Reinforced Concrete Floor,” Braverman, J., et al., Brookhaven National Laboratory, April 24, 2002.

[6] “Natural Phenomena Hazards Design Evaluation Criteria for Department of Energy Facilities, DOE-STD-1020-2002, U.S. Department of Energy, January, 2002.

[7] “International Building Code 2000,” International Code Council, 2002.

1E-5 would not be. Based on the recent work in NUREG/CR-6728,[8] the staff has determined that the use of a “mean” annual probability of exceedance for the reference probability of the seismic hazard is an appropriate method for the design of an ISFSI or MRS facility.

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 change to evaluate dynamic as well as static loads in the design of ISFSI storage pads and areas. The considered 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 considered changes are necessary to assure adequate protection to occupational and public health and safety. The 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.

---

[8] “”Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines,” NUREG/CR-6728, October, 2001.

5.0 Finding of No Significant Impact

Based on the foregoing 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 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. Factors that affect the radiological risk at an ISFSI or MRS compared to a nuclear power plant include the following:

- In comparison with an NPP, 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 components carrying fluids at high temperatures or pressures 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.

- 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.

Therefore, the seismically induced radiological risk associated with an ISFSI or MRS is less than the risk associated with an 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.

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 environmental assessment.

24722

Submission of Federal Rules Under the Congressional Review Act

☑ President of the Senate ☐ Speaker of the House of Representatives ☐ GAO

Please fill the circles electronically or with black pen or #2 pencil.

1. Name of Department or Agency	2. Subdivision or Office
U.S. Nuclear Regulatory Commission	**Nuclear Material Safety and Safeguards**

3. Rule Title

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

4. Regulation Identifier Number (RIN) or Other Unique Identifier (if applicabl e)

RIN 3150-AG93

5. Major Rule ○ Non-major Rule ●

6. Final Rule ● Other ○ ______

7. With respect to this rule, did your agency solicit public comments? Yes ● No ○ N/A ○

8. Priority of Regulation (fill in one)

● Economically Significant; or *Significant; or* Substantive, Non Significant

○ Routine and Frequent or *Informational/Administrative/Other* (Do not complete the other side of this form if filled in above.)

9. Effective Date (if applicable) **30 days from the date of publication in the Federal Register**

10. Concise Summary of Rule (fill in one or both) attached ○ stated in rule ●

Submitted by: ______ (signature)

Name: **Dennis Rathbun**

Title: **Director, Office of Congressional Affairs**

For Congressional Use Only:

Date Received: ______

Committee of Jurisdiction: ______

3/23/99

	Yes	No	N/A
A. With respect to this rule, did your agency prepare an analysis of costs and benefits?	●	○	○
B. With respect to this rule, by the final rulemaking stage, did your agency			
1. certify that the rule would not have a significant economic impact on a substantial number of small entities under 5 U.S.C. § 605(b)?	●	○	○
2. prepare a final Regulatory Flexibility Analysis under 5 U.S.C. § 604(a)?	○	●	○
C. With respect to this rule, did your agency prepare a written statement under § 202 of the Unfunded Mandates Reform Act of 1995?	○	●	○
D. With respect to this rule, did your agency prepare an Environmental Assessment or an Environmental Impact Statement under the National Environmental Policy Actg (NEPA)?	●	○	○
E. Does this rule contain a collection of information requiring OMB approval under the Paperwork Reduction Act of 1995?	●	○	○
F. Did you discuss any of the following in the preamble to the rule?	○	●	○
• E.O. 12612, Federalism	○	○	○
• E.O. 126630, Government Actions and Interference with Constitutionally Protected Property Rights	○	○	○
• E.O. 12866, Regulatory Planning and Review	○	○	○
• E.O. 12875, Enhancing the Intergovernmental Partnership	○	○	○
• E.O. 12988, Civil Justice Reform	○	○	○
• E.O. 13045, Protection of Children from Environmental Health Risks and Safety Risks	○	○	○

• Other statutes or executive orders discussed in the preamble concerning the rulemaking process (please specify)

Small Business Regulatory Enforcement Fairness Act of 1996

Paperwork Reduction Act

National Technology Transfer and Advancement Act

24722

Submission of Federal Rules Under the Congressional Review Act

☐ President of the Senate ☑ Speaker of the House of Representatives ☐ GAO

Please fill the circles electronically or with black pen or #2 pencil.

1. Name of Department or Agency	2. Subdivision or Office
U.S. Nuclear Regulatory Commission	**Nuclear Material Safety and Safeguards**

3. Rule Title

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

4. Regulation Identifier Number (RIN) or Other Unique Identifier (if applicabl e)

RIN 3150-AG93

5. Major Rule ○ Non-major Rule ◉

6. Final Rule ◉ Other ○ ______

7. With respect to this rule, did your agency solicit public comments? Yes ◉ No ○ N/A ○

8. Priority of Regulation (fill in one)

◉ Economically Significant; or Significant; or Substantive, Non Significant

○ Routine and Frequent or Informational/Administrative/Other (Do not complete the other side of this form if filled in above.)

9. Effective Date (if applicable) **30 days from the date of publication in the Federal Register**

10. Concise Summary of Rule (fill in one or both) attached ○ stated in rule ◉

Submitted by: ______ (signature)

Name: **Dennis Rathbun**

Title: **Director, Office of Congressional Affairs**

For Congressional Use Only:

Date Received: ______

Committee of Jurisdiction: ______

3/23/99

24722

	Yes	No	N/A
A. With respect to this rule, did your agency prepare an analysis of costs and benefits?	◉	○	○
B. With respect to this rule, by the final rulemaking stage, did your agency			
1. certify that the rule would not have a significant economic impact on a substantial number of small entities under 5 U.S.C. § 605(b)?	◉	○	○
2. prepare a final Regulatory Flexibility Analysis under 5 U.S.C. § 604(a)?	○	◉	○
C. With respect to this rule, did your agency prepare a written statement under § 202 of the Unfunded Mandates Reform Act of 1995?	○	◉	○
D. With respect to this rule, did your agency prepare an Environmental Assessment or an Environmental Impact Statement under the National Environmental Policy Actg (NEPA)?	◉	○	○
E. Does this rule contain a collection of information requiring OMB approval under the Paperwork Reduction Act of 1995?	◉	○	○
F. Did you discuss any of the following in the preamble to the rule?	○	◉	○
• E.O. 12612, Federalism	○	○	○
• E.O. 126630, Government Actions and Interference with Constitutionally Protected Property Rights	○	○	○
• E.O. 12866, Regulatory Planning and Review	○	○	○
• E.O. 12875, Enhancing the Intergovernmental Partnership	○	○	○
• E.O. 12988, Civil Justice Reform	○	○	○
• E.O. 13045, Protection of Children from Environmental Health Risks and Safety Risks	○	○	○

- Other statutes or executive orders discussed in the preamble concerning the rulemaking process (please specify)
  Small Business Regulatory Enforcement Fairness Act of 1996
  Paperwork Reduction Act
  National Technology Transfer and Advancement Act

24722

Submission of Federal Rules Under the Congressional Review Act

☐ President of the Senate ☐ Speaker of the House of Representatives ☑ GAO

Please fill the circles electronically or with black pen or #2 pencil.

1. Name of Department or Agency	2. Subdivision or Office
U.S. Nuclear Regulatory Commission	**Nuclear Material Safety and Safeguards**

3. Rule Title

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

4. Regulation Identifier Number (RIN) or Other Unique Identifier (if applicabl e)

RIN 3150-AG93

5. Major Rule ○ Non-major Rule ◉

6. Final Rule ◉ Other ○ ______

7. With respect to this rule, did your agency solicit public comments? Yes ◉ No ○ N/A ○

8. Priority of Regulation (fill in one)

◉ Economically Significant; or Significant; or Substantive, Non Significant

○ Routine and Frequent or Informational/Administrative/Other (Do not complete the other side of this form if filled in above.)

9. Effective Date (if applicable) **30 days from the date of publication in the Federal Register**

10. Concise Summary of Rule (fill in one or both) attached ○ stated in rule ◉

Submitted by: ______ (signature)

Name: **Dennis Rathbun**

Title: **Director, Office of Congressional Affairs**

For Congressional Use Only:

Date Received: ______

Committee of Jurisdiction: ______

3/23/99

24722

	Yes	No	N/A
A. With respect to this rule, did your agency prepare an analysis of costs and benefits?	●	○	○
B. With respect to this rule, by the final rulemaking stage, did your agency			
1. certify that the rule would not have a significant economic impact on a substantial number of small entities under 5 U.S.C. § 605(b)?	●	○	○
2. prepare a final Regulatory Flexibility Analysis under 5 U.S.C. § 604(a)?	○	●	○
C. With respect to this rule, did your agency prepare a written statement under § 202 of the Unfunded Mandates Reform Act of 1995?	○	●	○
D. With respect to this rule, did your agency prepare an Environmental Assessment or an Environmental Impact Statement under the National Environmental Policy Actg (NEPA)?	●	○	○
E. Does this rule contain a collection of information requiring OMB approval under the Paperwork Reduction Act of 1995?	●	○	○
F. Did you discuss any of the following in the preamble to the rule?	○	●	○
• E.O. 12612, Federalism	○	○	○
• E.O. 126630, Government Actions and Interference with Constitutionally Protected Property Rights	○	○	○
• E.O. 12866, Regulatory Planning and Review	○	○	○
• E.O. 12875, Enhancing the Intergovernmental Partnership	○	○	○
• E.O. 12988, Civil Justice Reform	○	○	○
• E.O. 13045, Protection of Children from Environmental Health Risks and Safety Risks	○	○	○

- Other statutes or executive orders discussed in the preamble concerning the rulemaking process (please specify)

Small Business Regulatory Enforcement Fairness Act of 1996

Paperwork Reduction Act

National Technology Transfer and Advancement Act