UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 22, 1996

MEMORANDUM TO: David L. Morrison, Director
Office of Nuclear Regulatory Research

FROM: David L. Meyer, Chief
Rules Review and Directives Branch
Division of Freedom of Information and Publications Services
Office of Administration

SUBJECT: OFFICE CONCURRENCE ON FINAL RULE ENTITLED "REACTOR SITE CRITERIA INCLUDING SEISMIC AND EARTHQUAKE ENGINEERING CRITERIA FOR NUCLEAR POWER PLANTS" (10 CFR PARTS 50, 52, and 100)

The Office of Administration concurs, subject to the comments provided, on the final rule that updates the criteria used for power reactor siting (including geologic, seismic, and earthquake engineering considerations) for future nuclear power plants. We have attached a marked copy of the final rule and accompanying documents that include our editorial and format corrections.

In addition to the statement included in this rule, the Small Business Regulatory Enforcement Fairness Act of 1996 requires agencies to submit a report transmitting a copy of each final rule to each House of Congress and the General Accounting Office before the rule takes effect. The report must include a concise general statement concerning the final rule, indicate whether the action is a "major" rule as defined by the legislation and determined by the Office of Management and Budget, and state the anticipated effective date of the final rule. We have attached a list of addresses for the required communication and a sample draft letter for a non-major rule. Your staff should contact Trip Rothschild, OGC, to coordinate with the Office of Information and Regulatory Affairs (OIRA), Office of Management and Budget concerning whether the action is a "major rule" as defined in Section 804 of the Act. Also, the Act requires that the final regulatory guides associated with this final rule be submitted to Congress when they are issued as final NRC actions.

Please note that when the rule is submitted for publication in the Federal Register, it must be presented as a single-sided copy. Also, please have a member of your staff include a 3.5-inch diskette that contains a copy of the final rule in WordPerfect 5.0 or 5.1 as part of the transmittal package. The diskette will be forwarded to the Office of the Federal Register and the Government Printing Office for their use in typesetting the document.

If you have any questions regarding our comments, please have a member of your staff contact Michael T. Lesar on 415-7163 or Alzonia Shepard on 415-6864.

Attachments: As stated

DFX2 1/1

Attachments:
1. Federal Register Notice of Rulemaking
2. Resolution of Public Comments on the Proposed Seismic and Earthquake Engineering Criteria for Nuclear Power Plants
3. ACRS Letter
4. Draft Public Announcement
5. Draft Congressional Letters
6. Regulatory Analysis
7. Environmental Assessment
*8. Regulatory Guide 1.165 (Seismic Sources, Draft was DG-1032)
*9. Standard Review Plan Section 2.5.1, Revision 3
*10. Standard Review Plan Section 2.5.2, Revision 3
*11. Standard Review Plan Section 2.5.3, Revision 3
*12. Regulatory Guide 1.12, Revision 2 (Instrumentation, Draft was DG-1033)
*13. Regulatory Guide 1.166 (Plant Shutdown, Draft was DG-1034)
*14. Regulatory Guide 1.167 (Plant Restart, Draft was DG-1035)
*15. Resolution of Public Comments on Draft Regulatory Guides and Standard Review Plan Sections Pertaining to the Proposed Seismic and Earthquake Engineering Criteria for Nuclear Power Plants
*16. Draft Regulatory Guide DG-4004 (General Site Suitability Criteria)

* Commissioners, SECY, OGC only

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ATTACHMENT 10

REGULATORY GUIDE 1.165
DRAFT WAS DG-1032

(SEISMIC SOURCES)

~~U.S. NUCLEAR REGULATORY COMMISSION~~ ~~February 1995~~
~~OFFICE OF NUCLEAR REGULATORY RESEARCH~~ ~~Division 1~~
~~Task DG-1032~~

~~DRAFT REGULATORY GUIDE~~

~~Contact: A.J. Murphy (301)415-6010~~

~~DRAFT~~ REGULATORY GUIDE ~~DG-1032~~1.165
(~~Previously issued~~ was Draft DG-10~~1~~532)

IDENTIFICATION AND CHARACTERIZATION OF SEISMIC SOURCES AND DETERMINATION OF SAFE SHUTDOWN EARTHQUAKE GROUND MOTION

A. INTRODUCTION

~~The NRC has recently proposed amendments to~~ In 10 CFR Part 100, "Reactor Site Criteria," ~~in the Federal Register on October 17, 1994 (59 FR 52255). In the proposed~~ Section 100.23, "Geologic and Seismic Siting Factors," paragraph (c), "Geological, Seismological, and Engineering Characteristics," ~~would~~ 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, to provide sufficient information to support evaluations performed to arrive at estimates of the Safe Shutdown Earthquake Ground Motion (SSE), and to permit adequate engineering solutions to actual or potential geologic and seismic effects at 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, water waves, and other siting factors ~~would~~ will be obtained by reviewing pertinent literature and carrying out field investigations.

~~In the proposed~~ In 10 CFR Section 100.23, paragraph (d), "Geologic and Seismic Siting Factors," ~~would~~ requires that the geologic and seismic siting factors considered for design include a determination of the SSE 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.

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

~~Public comments are being solicited on the draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules Review and Directives Branch, DFIPS, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Copies of comments received may be examined at the NRC Public Document Room, 2120 L Street NW., Washington, DC. Comments will be most helpful if received by May 12, 1995.~~

~~Requests for single copies of draft guides (which may be reproduced) or for placement on an automatic distribution list for single copies of future guides in specific divisions should be made in writing to the U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Office of Administration, Distribution and Mail Services Section.~~

~~In the proposed~~ In 10 CFR Section 100.23, paragraph (d)(1), "Determination of the Safe Shutdown Earthquake Ground Motion," ~~would~~ requires that uncertainty inherent in estimates of the SSE be addressed through an appropriate analysis, such as a probabilistic seismic hazard analysis or suitable sensitivity analysis.

This guide ~~is~~ has ~~being~~ been developed to provide general guidance on procedures acceptable to the NRC staff for ~~to~~ (1) conducting geological, geophysical, seismological, and geotechnical investigations, (2) identifying and characterizinge seismic sources, (3) conducting probabilistic seismic hazard analyses, and (4) determininge the SSE for satisfying the requirements of ~~the proposed Section~~10 CFR 100.23.

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

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

Any information collection activities mentioned in this regulatory guide are contained as requirements ~~in the proposed amendments to~~ in 10 CFR Part 100, ~~that would~~ which provides the regulatory basis for this guide. The ~~proposed amendments have been submitted to the~~ information collection requirements in 10 CFR Part 100 have been approved by the Office of Management and Budget~~ for clearance that may be appropriate under the Paperwork Reduction Act. Such clearance, if obtained, would also apply to any information collection activities mentioned in this guide.~~, Approval No. 3150-0093.

B. DISCUSSION

BACKGROUND

A probabilistic seismic hazard analysis (PSHA) has been identified in ~~the proposed Section~~10 CFR 100.23 as ~~one of the~~ a means to ~~address~~ determine the SSE and account for uncertainties in ~~estimates of the SSE~~ the seismological and geological evaluations. The ~~proposed~~ rule further recognizes that the nature of uncertainty and the appropriate approach to account for it depend on the tectonic regime and parameters such as the knowledge of seismic sources, the existence of historical and recorded data, and the level of understanding of the tectonics. Therefore, methods other than probabilistic methods such as sensitivity analyses may be adequate for some sites to account for uncertainties.

Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100 is primarily based on a deterministic methodology. Past licensing experience in applying Appendix A has demonstrated the need to formulate procedures that quantitatively incorporate uncertainty (including alternative scientific interpretations) in the evaluation of seismic hazards. A single deterministic representation of seismic sources and ground motions at a site ~~does~~ may not explicitly provide a quantitative representation of the uncertainties in ~~scientific interpretations of~~ geological, seismological, and geophysical data and alternative scientific interpretations.

Probabilistic procedures were developed during the past 10-15 years specifically for nuclear power plant seismic hazard assessments in the Central and Eastern United States (CEUS) (the area east of the Rocky Mountains), also referred to as the Stable Continent Region (SCR). These procedures provide a structured approach for decision making with respect to the SSE when performed together with site-specific investigations. A PSHA provides a framework to address the uncertainties associated with the identification and characterization of seismic sources by incorporating multiple interpretations of seismological parameters. A PSHA also provides an evaluation of the likelihood of SSE recurrence during the design life time of a given facility, given the recurrence interval and recurrence pattern of pertinent seismic sources. Within the framework of a probabilistic analysis, uncertainties in the characterization of seismic sources and ground motions are identified and incorporated in the procedure at each step of the process for estimating the SSE. The role of ~~site specific regional and site~~ geological, seismological, and geophysical investigations is to develop geosciences information about the site for use in the detailed design analysis of the facility, as well as to ensure that the seismic hazard analysis is based on up-to-date information.

Experience in performing seismic hazard evaluations in active plate-margin regions in the Western United States (for example, the San Gregorio-Hosgri fault zone and the Cascadia Subduction Zone) has also identified uncertainties associated with the characterization of seismic sources (Refs. 1, 2, and 3). Sources of uncertainty include fault geometry, rupture segmentation, rupture extent, seismic-activity rate, ground motion, and earthquake occurrence modeling. As is the case for sites in the CEUS, alternative hypotheses and parameters must be considered to account for these uncertainties.

Uncertainties associated with the identification and characterization of seismic sources in tectonic environments in both the CEUS and the Western United States should be evaluated. Therefore, the same basic approach can be applied to determine the SSE.

APPROACH

The general process to determine the SSE at a site ~~should in general~~ includes:

1. Site- and region-specific geological, seismological, geophysical, and geotechnical investigations, and
2. A probabilistic seismic hazard assessment.

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 105° West (Refs. 4 and 5). To determine the SSE 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, and 6) and the Electric Power Research Institute (EPRI) (Ref. 7) have been reviewed and accepted by the staff. The LLNL and EPRI studies developed data bases and scientific interpretations of available information and determined seismic sources and source characterizations for the CEUS (e.g., earthquake occurrence rates, estimates of maximum magnitude).

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

The identification of seismic sources and reasonable alternatives in the CEUS considers hypotheses presently advocated for the occurrence of earthquakes in the CEUS (for example, 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 ~~in that region~~, it may be more appropriate to evaluate those seismic sources by using procedures similar to those normally ~~applicable~~ applied in the Western United States.

WESTERN UNITED STATES

The Western United States is considered to be that part of the United States that lies west of the Rocky Mountain front, or west of approximately 105° West Longitude. For the Western United States, 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 does not exist. For this region, specific interpretations on a site-by-site basis should be applied (Ref. 1).

The active plate-margin region includes, for example, coastal California, Oregon, and Washington. For the active plate-margin region, where earthquakes can often be correlated with known tectonic structures, those structures should be assessed for their earthquake and surface deformation potential. In this region, at least three types of sources 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 ~~strike~~ orientation, geometry, sense of displacements, length of rupture, Quaternary history, etc.

Buried (blind) faults are often ~~accompanied by coseismic~~ 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 core borings and geophysical techniques.

Continental United States 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 ~~intraslab sources~~ in the interior of the downgoing oceanic slab. The characterization of subduction zone seismic sources includes consideration of the~~ following:~~ three-dimensional geometry of the subducting plate, rupture segmentation of subduction zones, geometry of historical ruptures, constraints on the up-dip and down-dip extent of rupture, and comparisons with other subduction zones worldwide.

The Basin and Range region of the Western United States, and to a lesser extent the Pacific Northwest and the Central United States, ~~include~~ 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 thousand years. Temporal clustering should be considered in these regions or wherever paleoseismic evidence indicates that it has occurred.

C. REGULATORY POSITION

1. GEOLOGICAL, GEOPHYSICAL, SEISMOLOGICAL, AND GEOTECHNICAL INVESTIGATIONS

1.1 Comprehensive geological, seismological, geophysical, and geotechnical investigations of the site and regions around the site should be performed. For existing nuclear power plant sites where additional units are planned, the geosciences technical information ~~used~~ originally used to validate those sites may be inadequate, depending on how much new or additional information has become available since the initial investigations and analyses were performed, the quality of the investigations performed at the time, and the complexity of the site and regional geology and seismology. This technical information should be utilized along with all other available information to plan and determine the scope of additional investigations. The~~se~~ investigations described in this regulatory guide are performed primarily to gather information needed to confirm the suitability of the site and to gather data pertinent to the safe design and construction of the nuclear power plant. Appropriate geological, seismological, and geophysical investigations are described in Appendix D to this ~~draft~~ guide. Geotechnical investigations are described in Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" (Ref. 8). Another important purpose for the site-specific investigations is to determine whether there are new data or interpretations that are not adequately incorporated in the existing PSHA databases. Appendix E describes a method for~~to~~ evaluating~~e~~ new information derived from the site-specific investigations in the context of the PSHA.

These investigations should be performed at four levels, with the degree of their 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 deformations, etc. A more detailed discussion of the areas and levels of investigations and the bases for them is presented in Appendix D to this regulatory guide. The levels of investigation are~~:~~ characterized as follows.

1. Regional geological and seismological investigations ~~such as geological reconnaissances and literature reviews should be~~ are not expected to be extensive nor in great detail, but should

include literature reviews, the study of maps and remote sensing data, and, if necessary, ground truth reconnaissances conducted within a radius of 320 km (200 miles) of the site to identify seismic sources (seismogenic and capable tectonic sources).

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).

3. Detailed geological, 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 ground motion transmission characteristics of soils and rocks in the site vicinity. Investigations should include monitoring by a network of seismic stations.

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 Regulatory Guide 1.132 (Ref. 8).

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

1.3 It should be demonstrated that deformation features discovered during construction, particularly faults, do not have the potential to compromise the safety of the plant. The two-step licensing practice, which~~of~~ requir~~ing~~ed applicants to acquire a Construction Perm[illegible] P), and then during construction apply for an Operating License (OL), ha[illegible] ~~expanded~~ modified to allow for an alternative procedure. The requirements and procedures applicable to NRC's issuance of combined licenses for nuclear power facilities are in 10 CFR 52.71. Applying the combined licensing procedure to a site could result in the award of a license prior to the start of construction. During the construction of nuclear power plants licensed in the past two decades, previously unknown faults were often discovered in site excavations. Before issuance~~ing~~ of the ~~an~~ OL~~would be issued~~, it was necessary to demonstrate that the faults in the excavation posed no hazard to the facility. Under the combined license procedure, these kinds of features should be mapped and assessed as to their rupture and ground motion generating potential while the excavations' walls and bases are exposed. Therefore, a commitment should be made, in documents (Safety Analysis Reports) supporting the license application, to geologically map all excavations and to notify the NRC staff when excavations are open for inspection~~ and to geologically map all excavations~~.

1.4 Data ~~S~~sufficient~~ data~~ to clearly justify all conclusions should be presented. Because engineering solutions cannot always be satisfactorily~~ally~~ 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 normall[illegible] require extensive additional investigations.

1.5 For the site and for the area surrounding the site, the 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 physical evidence concerning the behavior during prior earthquakes of the surficial materials and the substrata underlying the site. The properties needed to assess the behavior of the underlying material during earthquakes, including the potential for liquefaction, and the characteristics of the underlying material in transmitting earthquake ground motions to the foundations of the plant (such as seismic wave velocities, density, water content, porosity, elastic moduli, and strength) should be measured.

2. SEISMIC SOURCES SIGNIFICANT TO THE SITE SEISMIC HAZARD

2.1 For sites ~~located~~ in the CEUS, when the EPRI and LLNL PSHA methodologies are used to determine the SSE, it still may be necessary to investigate and characterize potential seismic sources that were previously unknown or uncharacterized~~,~~ and to perform sensitivity analyses to assess their significance to the seismic hazard estimate. ~~However, it is expected that newly discovered seismic sources along with their uncertainties are enveloped by the data base of the PSHA method used.~~ The results of investigations discussed in Regulatory Position 1 should~~are to~~ be used, in accordance with Appendix E, to determine whether ~~updating of~~ the LLNL or EPRI seismic sources and their characterization should be updated~~is needed~~. The guidance in ~~Subsections~~ Regulatory Positions 2.2 and 2.3 below and in Appendix D of this guide may be used if additional seismic sources are to be developed as a result of investigations.

2.~~1~~2 When the LLNL and EPRI methods are not used or are not applicable, the guidance in Regulatory Positions 2.2 and 2.3 should be used~~this and the following Subsection 2.3 provide general guidance~~ for identification and characterization of seismic sources. The uncertainties in the characterization of seismic sources should be addressed as appropriate. A seismic source is a general term referring to both seismogenic sources and capable tectonic sources. The main distinction between these two types of seismic sources is that a seismogenic source would not cause surface displacement, but a capable tectonic source causes surface or near-surface displacement.

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

2.~~2~~3 As part of the seismic source characterization, the seismic potential ~~(magnitude and recurrence rate)~~ for each source should be ~~determined~~evaluated. Typically, characterization of the seismic potential consists of four equally important elements:

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

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

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

4.~~)~~ A complete description of the uncertainty.

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

For a general discussion of evaluating the earthquake potential and characterizing the uncertainty, refer to the Senior Seismic Hazard Analysis Committee Report (1995) (Ref. 9).

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 Seismic Zone~~, etc.~~),~~ then~~ it is necessary to evaluate the seismic potential for each source. The seismic sources and data that have been accepted by the NRC in past liecensing decisions may be used, along with the data gathered from~~as the result of~~ the investigations carried out~~s~~ as described in Section 1.

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

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

~~For sites located in the CEUS (when the LLNL or EPRI method is not used or not applicable), the seismic sources and data that have been accepted by the NRC staff in past licensing decisions may be used to estimate seismic potential. It is necessary to use a variety of approaches to estimate the maximum magnitude for a seismic source in the CEUS because there is uncertainty about the underlying causes of earthquakes because ofdue to the lack of active surface faulting. Also, there is a short historical record and low seismicity rate. The determination of the maximum magnitude for each identified seismic source is based on the maximum historical earthquake, 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 the known tectonic structures in the source), and paleoseismic~~

~~data. These seismic sources and their parameters should be used to judge the adequacy of seismic sources and parameters used in the LLNL or EPRI PSHA.~~

2.23.2 For sites located within the Western United States, earthquakes can often be associated with known tectonic structures. For faults, the ~~maximum magnitude~~ earthquake potential is related to the characteristics of the estimatedd ~~rupture, such as the length or the amount of fault displacement~~ ~~for the~~ future rupture, such as the total rupture area, ~~or~~ 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 these different relations to obtain an estimate of the earthquake magnitude.

1. Surface rupture length versus magnitude (Refs. ~~9-12~~ 10-13).

2. Subsurface rupture length versus magnitude (Ref. 143).

3. Rupture area versus magnitude (Ref. 154).

4. Maximum and average displacement versus magnitude (Ref. 143).

5. Slip rate versus magnitude (Ref. 165).

~~Fault hazard analyses in the Western United States using these and other methods should consider the frequency of occurrence and calculated slip rates on faults based on the geochronology of strata and crosscutting relationships. Additionally, the phenomenon of temporal clustering should be considered when there is geological evidence of its past occurrence.~~

When such correlations as rReferences ~~9-15~~ 10-16 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 judgemental process based on geological data for the fault in question and the behavior of other regional fault systems of the same type.

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

2.23.3 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 ~~(PSHA)~~ PROCEDURES

A PSHA should be performed for the site as it allows the use of multiple models to estimate the likelihood of earthquake ground motions occurring at a site, and a PSHA 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.~~. The PSHA, and~~ Alternative hypotheses can also be ~~also~~ used to evaluate the ~~hazard~~ sensitivity of the hazard to the uncertainties in the~~to the varying~~ significant parameters and to identify the relative contribution of each seismic source to the hazard. Reference 9 provides guidance for~~on how to~~ conducting a PSHA.

The following steps describe a~~PSHA~~ procedure that is acceptable to the NRC staff for performing a PSHA. The details of the calculational aspects of deriving controlling earthquakes from the PSHA are included in Appendix C.

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

2. For CEUS sites, perform an evaluation of LLNL or EPRI seismic sources in accordance with Appendix E to determine whether they are consistent with the site-specific data gathered in Step 1 or require updating.

The PSHA should only be updated if ~~it will lead to higher hazard estimates.~~ the new information indicates that the current version significantly underestimates the hazard and there is a strong technical basis that supports such a revision. It may be possible to justify a lower hazard estimate with an exceptionally strong technical basis. However, it is expected that large uncertainties in estimating seismic hazard in the CEUS will continue to exist in the future, and substantial delays in the licensing process will result in trying to address them with respect to a specific site. For these reasons the NRC staff discourages efforts to justify a lower hazard estimate. ~~For~~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, ~~the~~ significant revisions to the LLNL and EPRI data base are~~is~~ to be ~~only~~ undertaken only periodically (every ten years), or when there is an important new finding or occurrence ~~that has, based on sensitivity studies, resulted in a significant increase in the hazard estimate~~. ~~The~~An overall revision of the data base would~~will~~ also require a reexamination of the acceptability of the reference probability discussed in Appendix B and used in Step 4 below. Any significant update should follow the guidance of Reference 9.

3. For CEUS sites only, ~~P~~perform the LLNL or EPRI probabilistic seismic hazard analysis ~~(for CEUS sites only)~~ using original or updated sources as determined in Step 2. ~~or a site-specific PSHA~~ ~~f~~For sites in other parts of the country, perform a site-specific PSHA (Reference 9). The ground motion estimates should be made for rock conditions in the free-field or by assuming hypothetical rock conditions for a nonrock site to develop the seismic hazard information base discussed in Appendix C.

4. Using the reference probability (1E-5 per year) described in Appendix B, ~~which is applicable to all sites,~~ determine 5% of the critically damped median spectral ground motion levels for the average of 5 and 10 Hz, $S_{a,5-10}$, and for the average of 1 and 2.5 Hz, $S_{a,1-2.5}$. Appendix B discusses situations in which an alternative reference probability may be more appropriate. The alternative reference probability is reviewed and accepted on a case-by-case basis. Appendix B also describes a procedure that should be used when a general revision to the reference probability is needed.

5. Deaggregate~~ion of~~ the median probabilistic ~~the~~ hazard characterization in accordance with Appendix C to determine the controlling earthquakes (i.e., magnitudes and distances). Document the hazard information base as discussed in Appendix C.

4. PROCEDURES FOR DETERMINING THE SSE

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

1. With the controlling earthquakes determined as described in Regulatory Position 3 and by using the procedures in ~~Draft~~ Standard Review Plan (SRP) Section 2.5.2 (which may include the use of ground motion models not included in the PSHA~~probabilistic seismic hazard analysis~~ but that are more appropriate for the source, region, and site under consideration or that represent the latest scientific development), develop 5% of critical damping response spectral <u>shapes</u> for the actual or assumed rock conditions. The same controlling earthquakes are also used to derive vertical response spectral shapes.

2. Use $S_{a,.5-10}$ to scale the response spectrum shape corresponding to the controlling earthquake. If, as described in Appendix C, there is a controlling earthquake for $S_{a,.1-2.5}$, determine that the $S_{a,.5-10}$ scaled response spectrum also envelopes the ground motion spectrum for the controlling earthquake for $S_{a,.1-2.5}$. Otherwise, modify the shape to envelope the low-frequency spectrum or use two spectra in the following steps. See additional discussion in Appendix F. For a ~~the~~ rock site go to Step 4.

3. For~~ the~~ nonrock 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.

4. Compare the smooth SSE spectrum or spectra used in design (e.g., 0.3g, broad-band spectra used in ~~A~~advanced ~~L~~light ~~W~~water ~~R~~reactor designs) with the spectrum or spectra determined in Step 2 for rock sites or determined in Step 3 for the nonrock sites to assess the adequacy of the SSE spectrum or spectra.

   ~~For situations where~~When site-specific design response spectra are needed, ~~T~~ to obtain an adequate design SSE 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 Step 2 or Step 3.

   Additional discussion of this step is provided in Appendix F.

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.

~~This proposed revision has been released to encourage public participation in its development.~~ Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, ~~the method to be described in~~ thise ~~active~~ guide ~~reflecting public comments~~ will be used in the evaluation of applications for construction permits, operating licenses, early site permits, or combined licenses submitted after ~~the implementation date to be specified in the active guide~~ EFFECTIVE DATE OF THE FINAL RULE. This guide ~~would~~ will not be used in the evaluation of an application for an operating license submitted after ~~the implementation date to be specified in the active guide~~ EFFECTIVE DATE OF THE FINAL RULE if the construction permit was issued prior to that date.

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[1]Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343.

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APPENDIX A

DEFINITIONS

Controlling Earthquakes -- ~~The c~~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. ~~In~~ As a result of the probabilistic seismic hazard analysis (PSHA), ~~the~~ controlling earthquakes are characterized as mean magnitudes and distances derived from a deaggregation analysis of the median estimate of the PSHA. ~~The 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.~~

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

Intensity -- The intensity of an earthquake is a measure of vibratory ground motion effects on humans, human-built structures, and on the earth's surface at a particular location. Intensity is described by a numerical value on the Modified Mercalli scale.

Magnitude -- An earthquake's magnitude is a measure of the strength of the earthquake as determined from seismographic observations.

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

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 terrane, glaciation or deglaciation, and growth faulting.

Safe Shutdown Earthquake Ground Motion (SSE) -- The Safe Shutdown Earthquake Ground Motion is the free-field vibratory ground motion for which certain structures, systems, and components ~~would be~~are designed, pursuant to ~~the proposed~~ Appendix S to 10 CFR Part 50, to remain functional.

Seismic Potential -- A model giving a~~the~~ 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 -- ~~A~~ "~~s~~Seismic source" is a general term referring to both seismogenic sources and capable tectonic sources.

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 large earthquakes or sustained earthquake activity that are usually accompanied by significant surface deformation.

c. A structural association with a capable tectonic source having characteristics of section a in this paragraph 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 particular 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, ~~structural~~the association of a structure with the geological structures~~al~~ ~~features~~that are ~~geologically old (at~~ least pre-Quaternary~~)~~, such as many of those found in the Central and Eastern region of the United States~~ will,~~ in the absence of conflicting evidence~~,~~ will demonstrate that the structure is not a capable tectonic source within this definition.

Seismogenic Source -- A "seismogenic source" is a portion of the earth that ~~has~~ ~~we assumed~~ has uniform earthquake potential (same expected maximum earthquake and recurrence frequency~~ of recurrence~~), distinct from ~~other~~ the seismicity of the surrounding regions. A seismogenic source will generate vibratory ground motion but is assumed not to cause surface displacement. Seismogenic sources cover a wide range of possibilities from a well-defined tectonic structure to simply a large region of diffuse seismicity (seismotectonic province) thought to be characterized by the same earthquake recurrence model. A seismogenic source is also characterized by its involvement in the current tectonic regime (the Quaternary, or approximately the last 2 million years).

Stable Continental Region -- A "stable continental region" (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 (space) that is characterized by~~ the following properties:~~ (1)

the occurrence of the event in small interval is constant over time (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. ~~This~~

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

APPENDIX B

REFERENCE PROBABILITY FOR THE EXCEEDANCE LEVEL OF THE SAFE SHUTDOWN EARTHQUAKE GROUND MOTION

B.1 INTRODUCTION

This appendix describes the procedure that is acceptable to~~used by~~ the NRC staff to determine the reference probability, an annual probability of exceeding the Safe Shutdown Earthquake Ground Motion (SSE) at future nuclear power plant sites~~, that is acceptable to the NRC staff~~. The reference probability is used in Appendix C in conjunction with the probabilistic seismic hazard analysis (PSHA).

B.2 REFERENCE PROBABILITY FOR THE SSE

The reference probability is the annual probability level such that 50% of a set of currently operating plants (selected by the NRC, see Table B.1) has an annual median probability of exceeding the SSE that is below this level. The reference probability is determined for the annual probability of exceeding the average of the 5 and 10 Hz SSE response spectrum ordinates associated with 5% of critical damping.

B.3 PROCEDURE TO DETERMINE THE REFERENCE PROBABILITY

The following procedure was used to determine the reference probability and should be used in the future if general revisions to PSHA methods or data bases result in significant changes in hazard predictions for the selected plant sites in Table B.1.

The reference probability is calculated using the Lawrence Livermore National Laboratory (LLNL) methodology and results (Refs. B.1 and B.2) but is also considered applicable for the Electric Power Research Institute (EPRI) study (Refs. B.3 and B.4). This reference probability is also to be used in conjunction with sites not in the Central and Eastern United States (CEUS) and for sites for which LLNL and EPRI methods and data have not been used or are not available. However, ~~T~~the final SSE ground motion at a higher reference probability may be more appropriate and acceptable[1] for some sites considering the slope characteristics of the site hazard curves, the overall uncertainty in calculations (i.e., differences between mean and median hazard estimates), and the knowledge of the seismic sources that contribute to the hazard. Reference B.4 includes a procedure to determine an alternative reference probability on the risk-based considerations; its application will also be reviewed on a case-by-case basis.

B.3.1 Selection of Current Plants for Reference Probability Calculations

Table B.1 identifies plants, along with their site characteristics, used in calculating the reference probability. These plants represent relatively recent designs that used Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants" (Ref. B.5), or similar spectra as their design bases. The use of these plants should ensure an adequate level of conservatism in determining an SSE consistent with recent licensing decisions.

B.3.2 Procedure To Establish Reference Probability

Step 1

Using LLNL, EPRI, or a comparable methodology that is acceptable to the NRC staff, ~~an accepted methodology,~~ calculate the seismic hazard results for the site for spectral responses at 5 and 10 Hz (as stated earlier, the staff used the LLNL methodology and associated results as documented in Refs. B.1 and B.2).

Step 2

Calculate the ~~median~~ composite annual probability of exceeding the SSE for spectral responses at 5 and 10 Hz using median hazard estimates. The composite annual probability is determined as:

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[1] The use of a higher reference probability will be reviewed and accepted on a case-by-case basis.

Composite probability = 1/2(a1) + 1/2(a2)

where a1 and a2 represent median annual probabilities of exceeding SSE spectral ordinates at 5 and 10 Hz, respectively. The procedure is illustrated in Figure B-1.

Step 3

Figure B-2 illustrates the distribution of median probabilities of exceeding the SSEs for the plants in Table B.1 based on the LLNL methodology (Refs. B.1 and B.2). The reference probability is simply the median probability of this distribution.

For the LLNL methodology, this reference probability is 1E-5/yr and, as stated earlier, is also to be used in conjunction with the current EPRI methodology (Ref. B.3) or for sites not in the CEUS.

Table B.1 Plants/Sites Used in Determining Reference Probability

Plant/Site Name	Soil Condition Primary/Secondary*
Limerick	Rock
Shearon Harris	Sand - S1
Braidwood	Rock
River Bend	Deep Soil
Wolf Creek	Rock
Watts Bar	Rock
Vogtle	Deep Soil
Seabrook	Rock
Three Mile Is.	Rock/Sand - S1
Catawba	Rock/Sand - S1
Hope Creek	Deep Soil
McGuire	Rock
North Anna	Rock/Sand - S1
Summer	Rock/Sand - S1
Beaver Valley	Sand - S1
Byron	Rock
Clinton	Till - T3
Davis Besse	Rock
LaSalle	Till - T2
Perry	Rock
Bellefonte	Rock
Callaway	Rock/Sand - S1
Commanche Peak	Rock
Grand Gulf	Deep Soil
South Texas	Deep Soil
Waterford	Deep Soil
Millstone 3	Rock
Nine Mile Point	Rock/Sand - S1
Brunswick	Sand - S1

* If two soil conditions are listed, the first is the primary and the second is the secondary soil condition. See Ref. B.1 for a discussion of soil conditions.

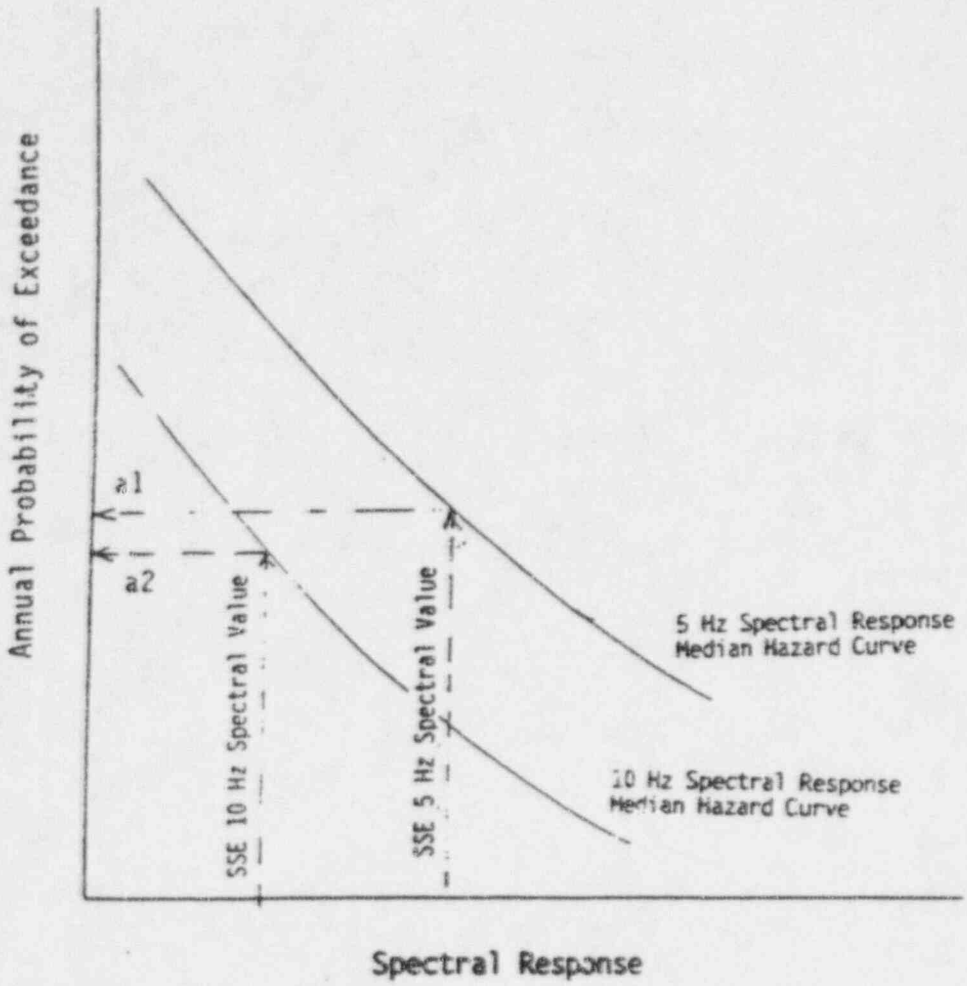
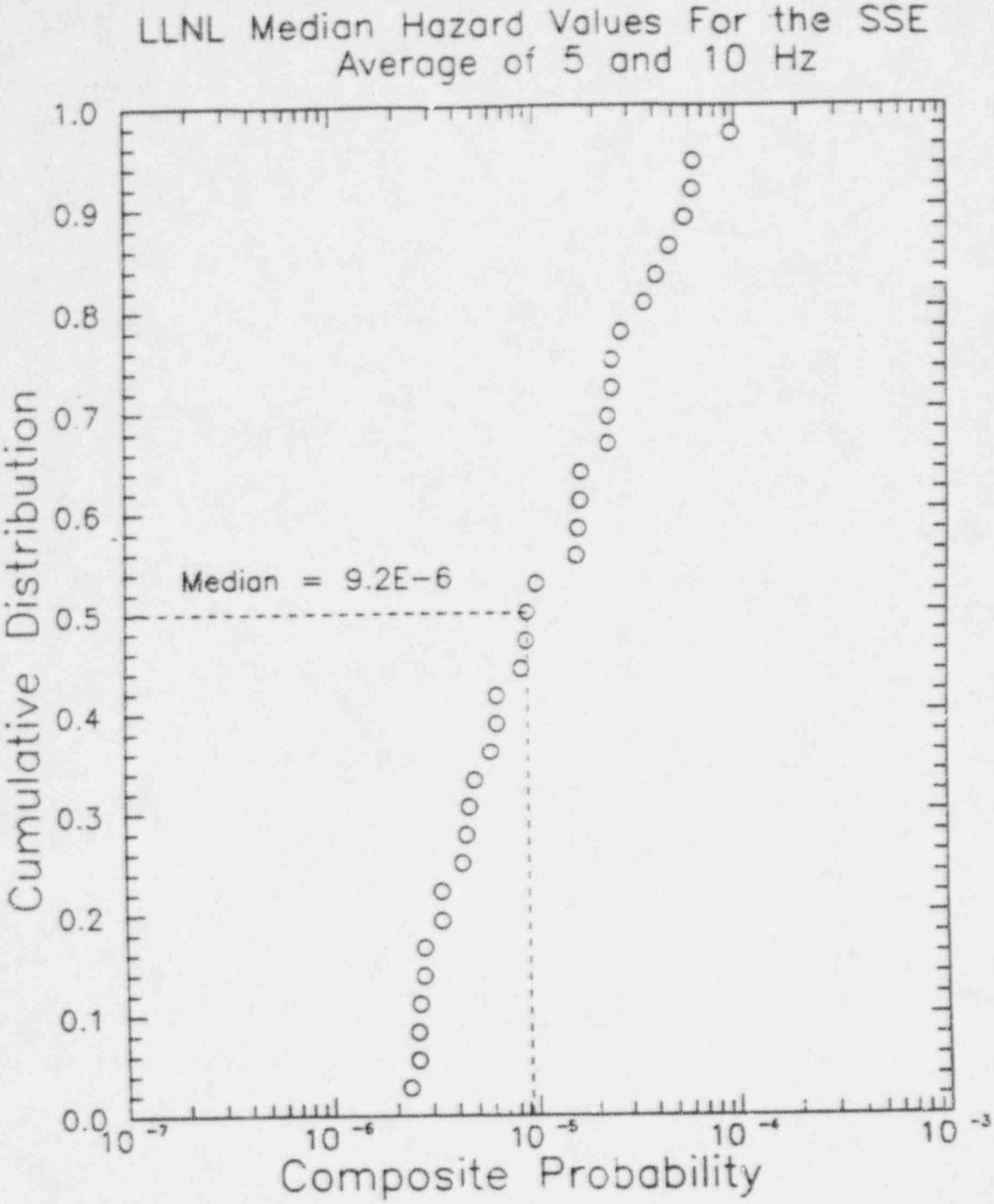


Figure B.1 Procedure to Compute Probability of Exceeding Design Basis

Comp. Prob. = 1/2(a1) + 1/2(a2)



Probability of Exceeding SSE

Figure B.2 Probability of Exceeding SSE using Median LLNL Hazard Estimates

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B.3 Electric Power Research Institute, "Probabilistic Seismic Hazard Evaluations at Nuclear Power Plant Sites in the Central and Eastern United States: Resolution of the Charleston Earthquake Issue," Report NP-6395-D, April 1989.

B.4 Attachment to Letter from D. J. Modeen, Nuclear Energy Institute, to A.J. Murphy, USNRC, Subject: Seismic Siting Decision Process, May 25, 1994.[3]

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[2] Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343. Copies may be purchased at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-2249); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161.

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APPENDIX C

DETERMINATION OF CONTROLLING EARTHQUAKES AND DEVELOPMENT OF SEISMIC HAZARD INFORMATION BASE

C.1 INTRODUCTION

This appendix elaborates on the steps described in Regulatory Position 3 of this regulatory guide~~Draft Regulatory Guide DG 1032~~ to determine the controlling earthquakes used to define the Safe Shutdown Earthquake Ground Motion (SSE) 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 the average of 1 and 2.5 Hz and the average of 5 and 10 Hz. They are developed for the ground motion level corresponding to the reference probability as defined in Appendix B to this regulatory guide.

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

C.2 PROCEDURE TO DETERMINE CONTROLLING EARTHQUAKES

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

Step 1

~~(a)~~ Perform a site-specific PSHA using the Lawrence Livermore National Laboratory (LLNL) or Electric Power Research Institute (EPRI) methodologies 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~~available~~, for actual or assumed rock conditions. The hazard assessment (mean, median, 85th percentile, and 15th percentile) should be performed for spectral accelerations at 1, 2.5, 5, 10, and 25 Hz, and the peak ground acceleration. A lower-bound magnitude of 5.0 is recommended. ~~The PSHA should include an uncertainty assessment.~~

~~(b) Determine the following parameters as part of the assessment for each ground motion measure:~~

- ~~Total hazard in terms of the median (50th percentile), mean, 85th, and 15th percentile hazard curves.~~

- ~~De aggregated median hazard results for a matrix of magnitude distance pairs discussed in Step 3. As a part of the information base, de aggregated results for mean hazard results may also be useful.~~

~~These results obtained from the de aggregation of the median hazard are used to determine the SSE and to develop the seismic hazard information base.~~

Step 2

(a) Using the reference probability as defined in Appendix B to this regulatory guide, determine the ground motion levels for the spectral accelerations at 1, 2.5, 5, and 10 Hz from the total median hazard obtained in Step 1.

(b) Calculate the average of the ground motion level for the 1 and 2.5 Hz and the 5 and 10 Hz spectral acceleration pairs.

~~Steps 3 to 5 describe the procedure to develop the seismic hazard information base for each ground motion level determined in Step 2. This information base will consist of:~~

- ~~Fractional contribution of each magnitude distance pair to the total median seismic hazard.~~

- ~~Magnitudes and distances of the controlling earthquakes.~~

- ~~The ground motion levels for the spectral accelerations at 1, 2.5~~

~~5, and 10 Hz defined in Step 2.~~

- ~~The average of the ground motion levels listed above at the 1 and 2.5 Hz, $S_{a1-2.5}$, and 5 and 10 Hz, S_{a5-10}, spectral accelerations corresponding to the reference probability.~~

<u>Step 3</u>

Perform a complete probabilistic seismic hazard analysis ~~is performed~~for each of the magnitude-distance bins described in Table C.3.

<u>Step 4</u>

Using the de-aggregated median hazard results from Step ~~1~~3, at the ground motion levels obtained from Step 2 calculate the fractional contribution to the total median hazard of earthquakes in a selected set of magnitude and distance bins (~~Section~~Table C.3 provides magnitude and distance bins to be used in conjunction with the LLNL and EPRI methods) for the average of 1 and 2.5 Hz and 5 and 10 Hz. The median annual probability of exceeding the ground motion levels calculated in Step ~~12~~3 for each magnitude and distance bin and ground motion measure is denoted by H_{mdf}.

The fractional contribution of each magnitude and distance bin to the total hazard for the average of 1 and 2.5 Hz, $P(m,d)_1$, is computed according to:

$$P(m,d)_1 = \frac{\dfrac{(\sum_{f=1,2} H_{mdf})}{2}}{\sum_m \sum_d \dfrac{(\sum_{f=1,2} H_{mdf})}{2}} \qquad \text{(Equation 1)}$$

where f = 1 and f = 2 represent the ground motion measure at 1 and 2.5 Hz, respectively.

The fractional contribution of each magnitude and distance bin to the total hazard for the average of 5 and 10 Hz, $P(m,d)_2$, is computed according to:

$$P(m,d)_2 = \frac{\dfrac{(\sum_{f=1,2} H_{mdf})}{2}}{\sum_m \sum_d \dfrac{(\sum_{f=1,2} H_{mdf})}{2}} \qquad \textit{(Equation 2)}$$

where f = 1 and f = 2 represent the ground motion measure at 5 and 10 Hz, Step respectively.

Step 45

Review the magnitude-distance distribution for the average of 1 and 2.5 Hz to determine whether the contribution to the hazard for distances of 100 km or greater is substantial (on the order of 5% or greater).

If the contribution to the hazard for distances of 100 km or greater exceeds 5%, 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:

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

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

The distance of 100 km is chosen for CEUS sites. However, for all sites ~~CEUS sites and sites not in the CEUS~~ the results of full magnitude-distance distribution should be carefully examined to ensure that proper controlling earthquakes are clearly identified.

Step 56

Calculate the mean magnitude and distance of the controlling earthquake associated with the ground motions determined in Step 2 for the average of 5 and 10 Hz. The following relation is used to calculate the mean magnitude using results of the entire magnitude-distance bins matrix:

$$M_c\ (5\text{-}10\ Hz) = \sum_m m \sum_d P(m,d)_2 \qquad \text{(Equation 4)}$$

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:

$$Ln\ \{D_c\ (5\text{-}10\ Hz)\} = \sum_d Ln(d) \sum_m P(m,d)_2 \qquad \text{(Equation 5)}$$

where d is the centroid distance value fo[illegible]ch distance bin.

Step 67

If the contribution to the hazard calculat[illegible] in Step 45 for distances of 100 km or greater exceeds 5% for the average of 1 and 2.5 Hz, calculate the mean magnitude and distance of the controlling earthquakes associated with the ground motions determined in Step 2 for the average of 1 and 2.5 Hz. The following relation is used to calculate the mean magnitude using calculations based on magnitude-distance bins greater than distances of 100 km as discussed in Step 4:

$$M_c\ (1\text{-}2.5\ Hz) = \sum_m m \sum_{d>100} P{>}100(m,d)_1 \qquad \text{(Equation 6)}$$

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 4 and determined according to:

$$Ln\ \{D_c\ (1\text{-}2.5\ Hz)\} = \sum_{d>100} Ln(d) \sum_m P{>}100(m,d)_2 \qquad \text{(Equation 7)}$$

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

Step ~~7~~8

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

C.3 EXAMPLE FOR A CEUS SITE

To illustrate the procedure in Section C.2, calculations are shown here for a CEUS site using the 1993 LLNL hazard results (Refs. C.1 and C.2). It must be emphasized that the recommended magnitude and distance bins and procedure used to establish controlling earthquakes were developed for application in the CEUS where the nearby earthquakes generally control the response in the 5 to 10 Hz frequency range and larger but distant events can control the lower frequency range. For other situations, alternative binning schemes as well as a study of contributions from various bins will be necessary to identify controlling earthquakes consistent with the distribution of the seismicity.

Step 1

The 1993 LLNL seismic hazard methodology (Ref. C.1 and C.2) was used to determine the hazard at the site. A lower bound magnitude of 5.0 was used in this analysis. The analysis was performed for spectral acceleration at 1, 2.5, 5, and 10 Hz. The resultant hazard curves are plotted in Figure C.1.

Step 2

The hazard curves at 1, 2.5, 5, and 10 Hz obtained in Step 1 are assessed at the reference probability value of 1E-5/yr, as defined in Appendix B to this regulatory guide. The corresponding ground motion level values are given in Table C.1. See Figure C.1.

Table C.1

Ground Motion Levels

Frequency (Hz)	1	2.5	5	10
Spectral Acc. (cm/s/s)	88	258	351	551

The average of the ground motion levels at the 1 and 2.5 Hz, $S_{a1-2.5}$, and 5 and 10 Hz, S_{a5-10}, are given in Table C.2.

Table C.2

Average Ground Motion Values

$S_{a1-2.5}$ (cm/s/s)	173
S_{a5-10} (cm/s/s)	451

<u>Step 3</u>

The median seismic hazard is de-aggregated for the matrix of magnitude and distance bins as given in Table C.3.

Table C.3

Recommended Magnitude and Distance Bins

Distance Range of Bin (km)	Magnitude Range of Bin				
	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					

A complete probabilistic hazard analysis was performed for each bin to determine the contribution to the hazard from all earthquakes within the bin, e.g., all earthquakes with magnitudes 6 to 6.5 and distance 25 to 50 km from the site. ~~The hazard values corresponding to the ground motion levels defined in step 2 for the spectral acceleration at 1, 2.5, 5, and 10 Hz are listed in Tables C.4-C.7.~~See Figure C.2 where the median 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, and listed in Table C.1., are then determined from the hazard curve for each bin for spectral accelerations of 1, 2.5, 5 and 10 Hz. This process is illustrated in Figure C.1. The vertical line corresponds to the value 88 cm/s/s listed in Table C.1 for the 1 Hz hazard curve and intersects the hazard curve for the 25-50 bin, 6-6.5 bin at a hazard value (probability of exceedance) of 2.14E-08 per year. Tables C.4 to C.7 list the appropriate hazard value for each bin for 1, 2.5, 5 and 10 Hz respectively

It should be noted that if the median hazard in each of the 35 bins is added up it does not equal 1.0E-05. That is because the sum of the median of each of the bins does not equal the overall median. However, if we gave the mean hazard for each bin it would add up to the overall mean hazard curve.

Table C.4

Median Exceeding Probability Values for Spectral Accelerations at 1 Hz (88 cm/s/s)

Distance Range of Bin (km)	Magnitude Range of Bin				
	5 - 5.5	5.5 - 6	6 -6.5	6.5 - 7	>7
0-15	1.98E-08	9.44E-08	1.14E-08	0	0
15-25	4.03E-09	2.58E-08	2.40E-09	0	0
25-50	1.72E-09	3.03E-08	2.14E-08	0	0
50-100	2.35E-10	1.53E-08	7.45E-08	2.50E-08	0
100-200	1.00E-11	2.36E-09	8.53E-08	6.10E-07	0
200-300	0	1.90E-11	1.60E-09	1.84E-08	0
> 300	0	0	8.99E-12	1.03E-11	1.69E-10

Table C.5

Median Exceeding Probability Values for Spectral Accelerations at 2.5 Hz (258 cm/s/s)

Distance Range of Bin (km)	Magnitude Range of Bin				
	5 - 5.5	5.5 - 6	6 -6.5	6.5 - 7	>7
0-15	2.24E-07	3.33E-07	4.12E-08	0	0
15-25	5.39E-08	1.20E-07	1.08E-08	0	0
25-50	2.60E-08	1.68E-07	6.39E-08	0	0
50-100	3.91E-09	6.27E-08	1.46E-07	4.09E-08	0
100-200	1.50E-10	7.80E-09	1.07E-07	4.75E-07	0
200-300	7.16E-14	2.07E-11	7.47E-10	5.02E-09	0
> 300	0	1.52E-14	4.94E-13	9.05E-15	2.36E-15

Table C.6

Median Exceeding Probability Values for Spectral Accelerations at 5 Hz (351 cm/s/s)

Distance Range of Bin (km)	Magnitude Range of Bin				
	5 - 5.5	5.5 - 6	6 -6.5	6.5 - 7	>7
0-15	4.96E-07	5.85E-07	5.16E-08	0	0
15-25	9.39E-08	2.02E-07	1.36E-08	0	0
25-50	2.76E-08	1.84E-07	7.56E-08	0	0
50-100	1.23E-08	3.34E-08	9.98E-08	2.85E-08	0
100-200	8.06E-12	1.14E-09	2.54E-08	1.55E-07	0
200-300	0	2.39E-13	2.72E-11	4.02E-10	0
> 300	0	0	0	0	0

Table C.7

Median Exceeding Probability Values for Spectral Accelerations at 10 Hz (551 cm/s/s)

Distance Range of Bin (km)	Magnitude Range of Bin				
	5 - 5.5	5.5 - 6	6 -6.5	6.5 - 7	>7
0-15	1.11E-06	1.12E-06	8.30E-08	0	0
15-25	2.07E-07	3.77E-07	3.12E-08	0	0
25-50	4.12E-08	2.35E-07	1.03E-07	0	0
50-100	5.92E-10	2.30E-08	6.89E-08	2.71E-08	0
100-200	1.26E-12	1.69E-10	6.66E-09	5.43E-08	0
200-300	0	3.90E-15	6.16E-13	2.34E-11	0
> 300	0	0	0	0	0

Step 4

Using de-aggregated median hazard results, the fractional contribution of each magnitude-distance pair to the total hazard is determined.

Tables C.48 and C.59 show $P(m,d)_1$ and $P(m,d)_2$ for the average of 1 and 2.5 Hz and 5 and 10 Hz, respectively.

Table C.48

$P(m,d)_1$ for Average Spectral Accelerations 1 and 2.5 Hz Corresponding to the Reference Probability

Distance Range of Bin (km)	Magnitude Range of Bin				
	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	>7
0-15	0.083	0.146	0.018	0.000	0.000
15-25	0.020	0.050	0.005	0.000	0.000
25-50	0.009	0.067	0.029	0.000	0.000
50-100	0.001	0.027	0.075	0.022	0.000
100-200	0.000	0.003	0.066	0.370	0.000
200-300	0.000	0.000	0.001	0.008	0.000
> 300	0.000	0.000	0.000	0.000	0.000

Table C.~~5~~9

P(m,d), for Average Spectral Accelerations 5 and 10 Hz
Corresponding to the Reference Probability

Distance Range of Bin (km)	Magnitude Range of Bin				
	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	>7
0-15	0.289	0.306	0.024	0.000	0.000
15-25	0.054	0.104	0.008	0.000	0.000
25-50	0.012	0.075	0.032	0.000	0.000
50-100	0.001	0.010	0.030	0.010	0.000
100-200	0.000	0.001	0.006	0.038	0.000
200-300	0.000	0.000	0.000	0.000	0.000
> 300	0.000	0.000	0.000	0.000	0.000

Step ~~4~~5

Because the contribution of the distance bins greater than 100 km in Table C.~~4~~8 contains~~does account for~~ more than 5% of the total hazard for the average of 1 and 2.5 Hz, the controlling earthquake for the spectral average of 1 and 2.5 Hz will be calculated using magnitude-distance bins for distance greater than 100 km. Table C.~~6~~10 shows $P_{>100}(m,d)_1$ for the average of 1-2.5 Hz.

Table C.~~6~~10

$P_{>100}(m,d)_1$ for Average Spectral Accelerations 1 and 2.5 Hz
Corresponding to the Reference Probability

Distance Range of Bin (km)	Magnitude Range of Bin				
	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	>7
100-200	0.000	0.007	0.147	0.826	0.000
200-300	0.000	0.000	0.002	0.018	0.000
> 300	0.000	0.000	0.000	0.000	0.000

Figures C.1 to C.3 show the above information in terms of the relative percentage contribution.

Steps ~~5~~6 and ~~6~~7

To compute the controlling magnitudes and distances at 1-2.5 Hz and 5-10 Hz for the example site, the values of $P_{>100}(m,d)_1$ and $P(m,d)_2$ are used with m and d values corresponding to the mid-point of the magnitude of the bin (5.25, 5.75, 6.25, 6.75, 7.3) and centroid of the ring area (10, 20.4, 38.9, 77.8, 155.6, 253.3, and somewhat arbitrarily 350 km). Note that the mid-point of the last magnitude bin may change because this value is dependent on the maximum magnitudes used in the hazard analysis. For this example site, the controlling earthquake characteristics (magnitudes and distances) are given in Table C.~~7~~11.

Table C.~~7~~11

Magnitudes and Distances of Controlling Earthquakes from the LLNL Probabilistic Analysis

1-2.5 Hz	5 - 10 Hz
M_c and D_c > 100 km	M_c and D_c
6.7 and 157 km	5.7 and 17 km

Step ~~7~~8

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

C.4 SITES NOT IN THE CEUS

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

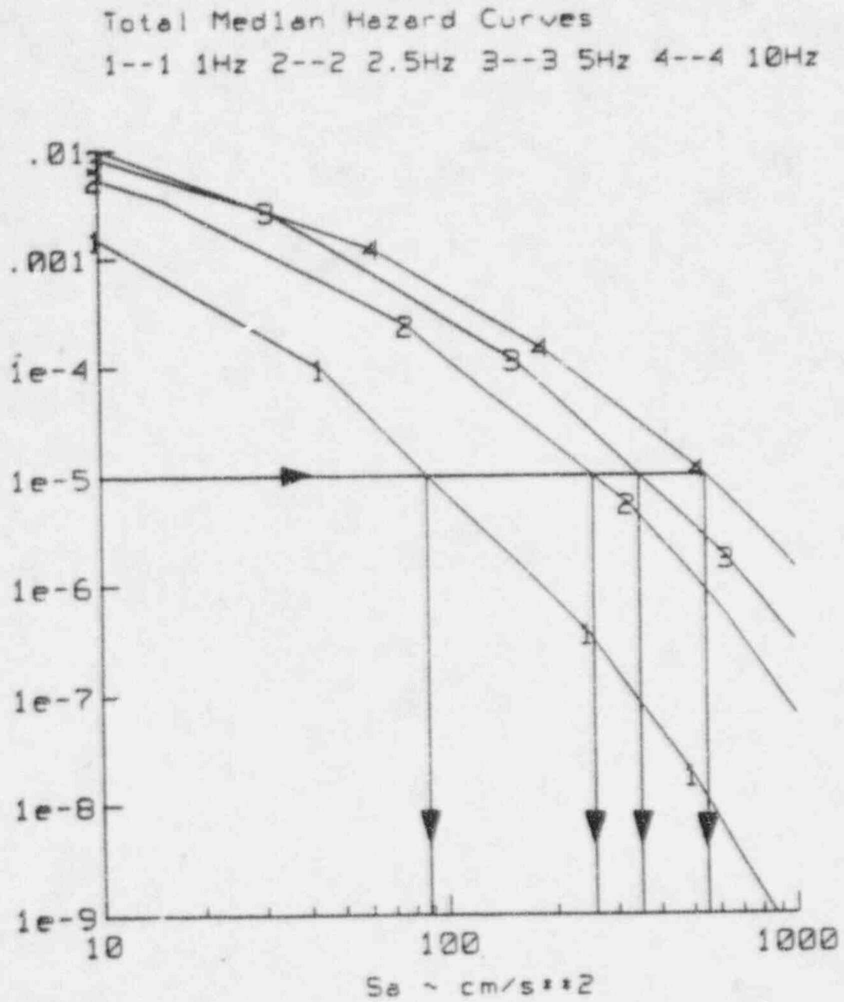


Figure C.1 Total median Hazard Curves

1--1 1 Hz, 2--2 2.5 Hz, 3--3 5 Hz, 4--4 10 Hz

1 Hz Median Hazard Curve for
Distance-bin 25-50 km & Magnitude-bin 6-6.5

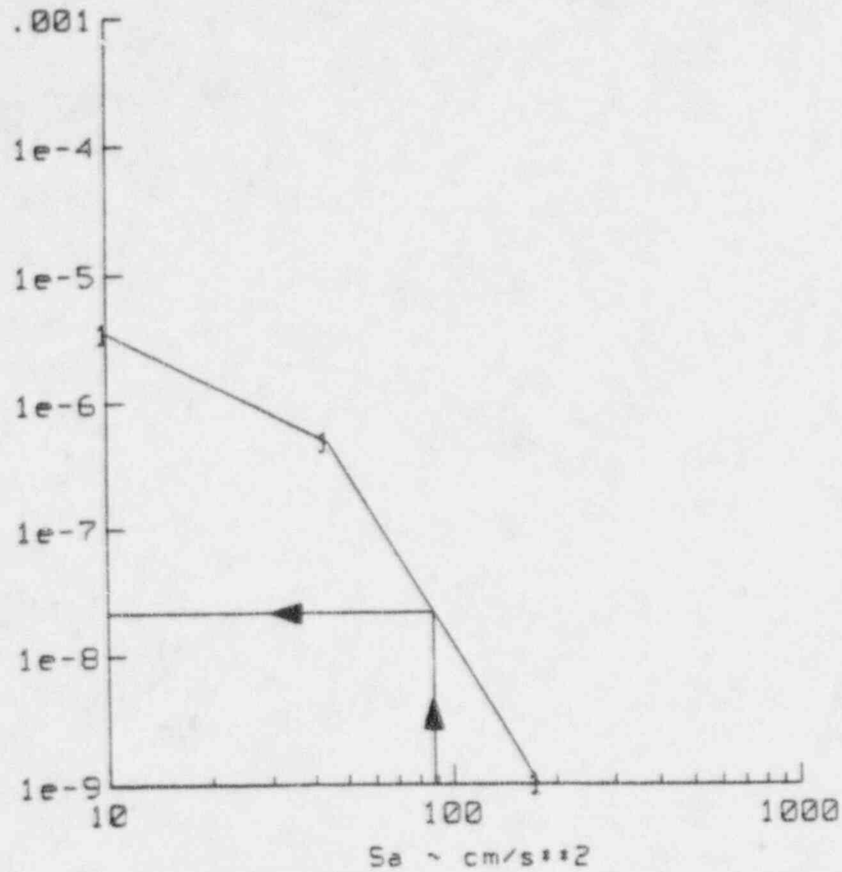


Figure C.2 1 Hz Median Hazard Curve for
Distance-bin 25-50 km & Magnitude-bin 6-6.5

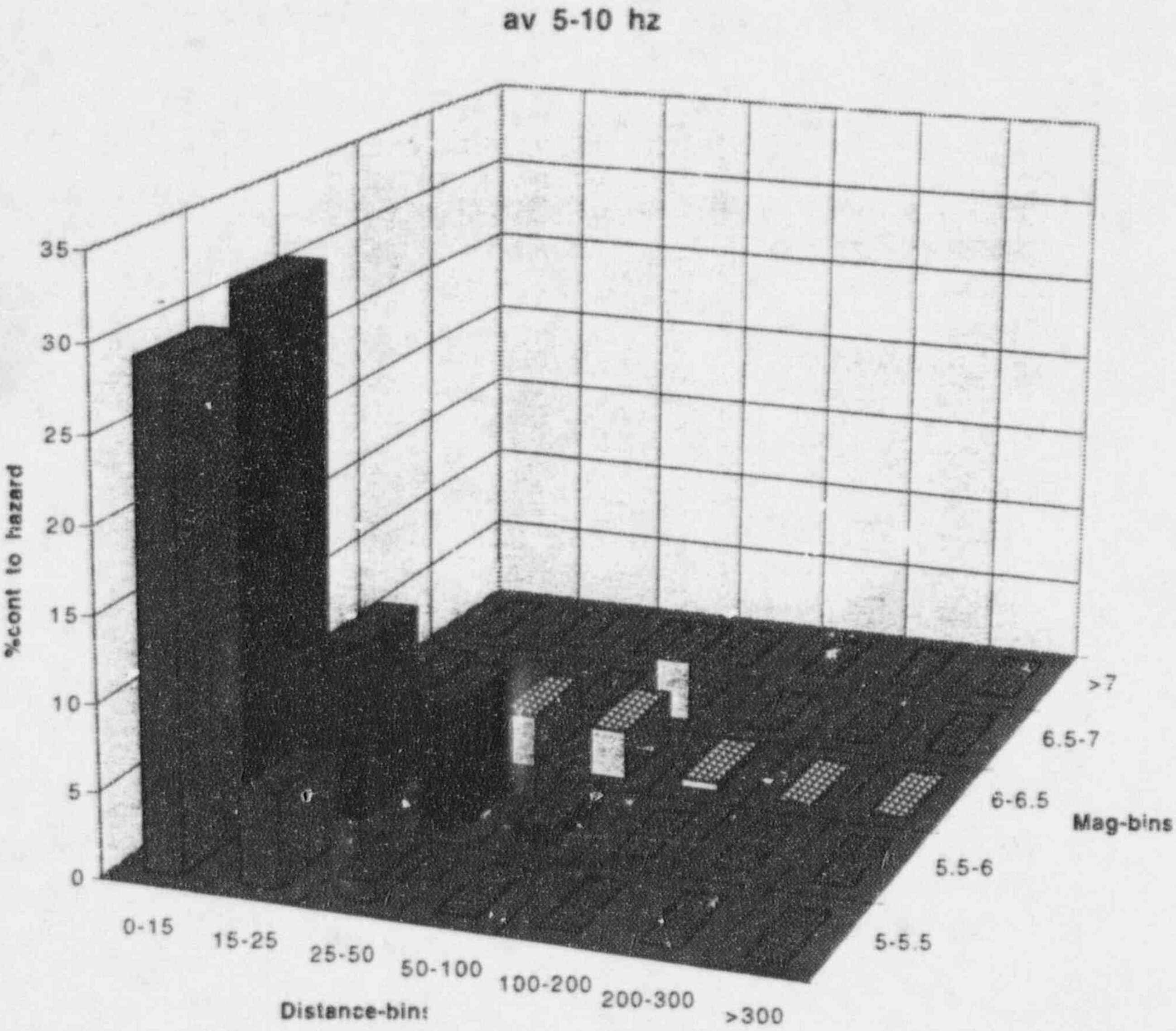
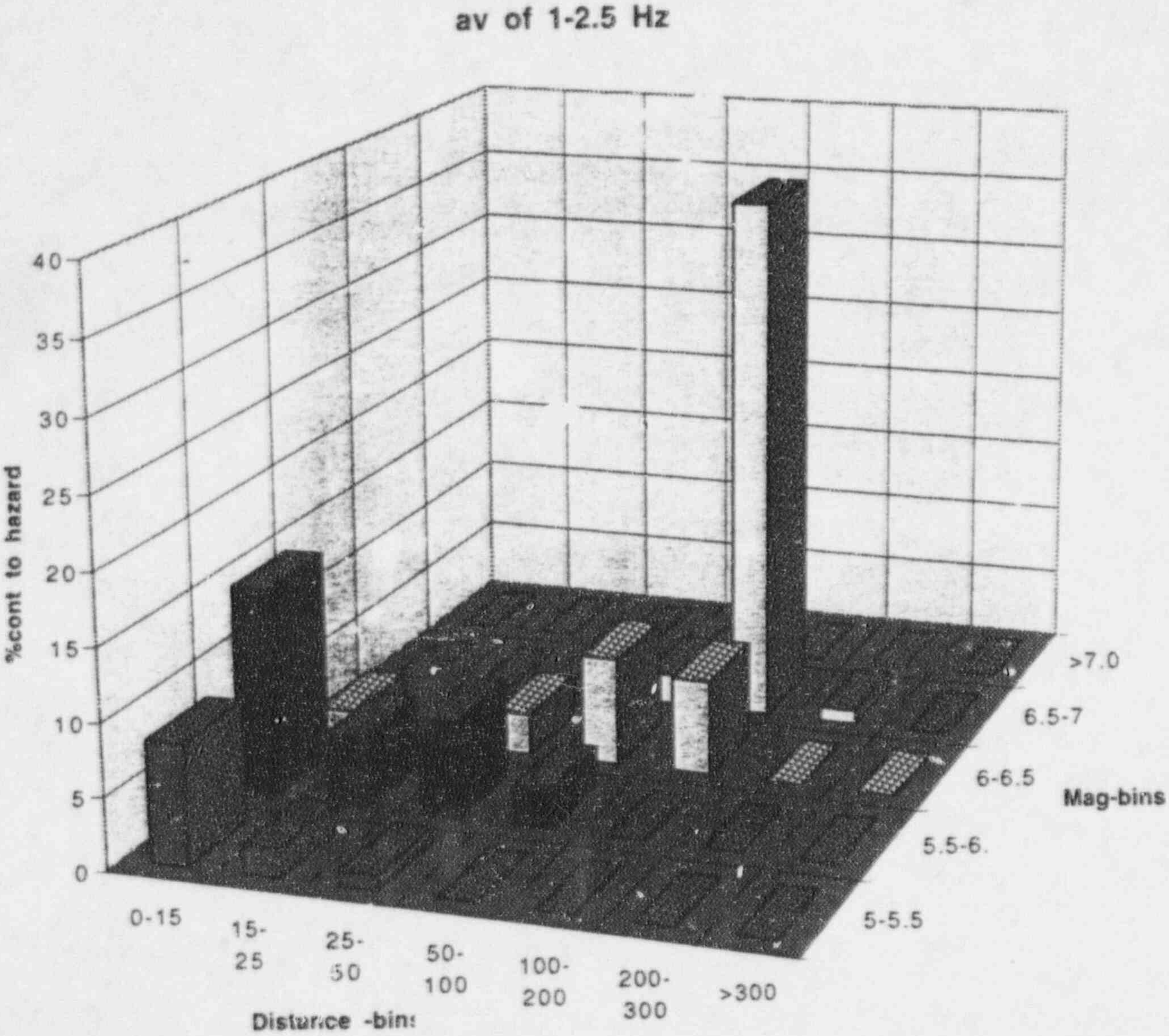


Figure C.13 Full Distribution for Average of 5 and 10 Hz



1 Figure C.24 Full Distribution for Average of 1 and 2.5 Hz

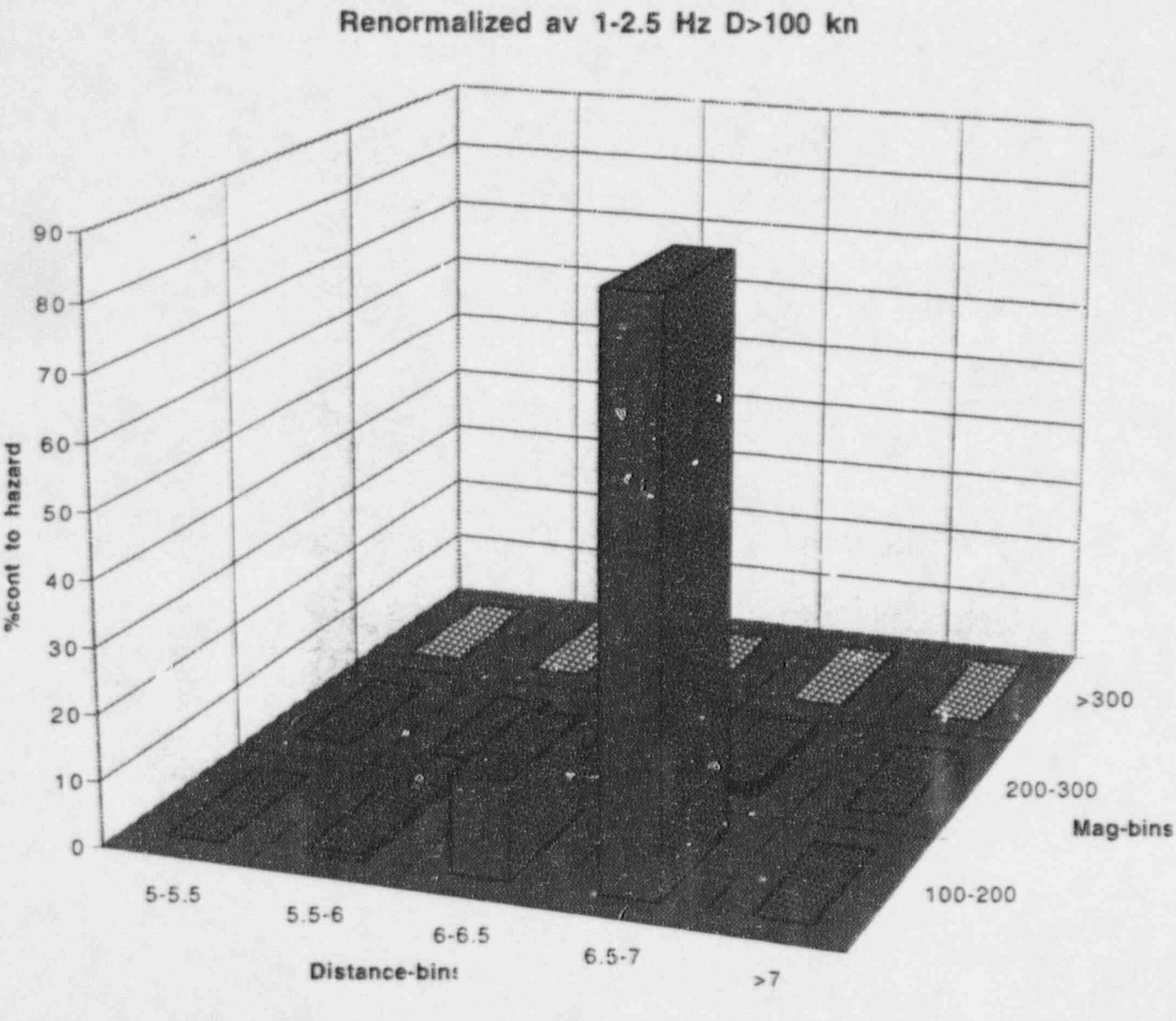


Figure C.35 Renormalized Hazard Distribution for Distances >100 km for average of 1 and 2.5 Hz

REFERENCES

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

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

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[1]Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343. Copies may be purchased at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-2249); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161.

APPENDIX D

GEOLOGICAL, SEISMOLOGICAL, AND GEOPHYSICAL INVESTIGATIONS TO CHARACTERIZE SEISMIC SOURCES

D.1 INTRODUCTION

As characterized for use in probabilistic seismic hazard analyses (PSHA)~~'s~~, ~~S~~seismic sources are ~~areas~~zones within which future earthquakes are likely to occur at ~~similar~~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 (west of the Rocky Mountain front) and the Central and Eastern United States (CEUS), or stable continental region (SCR) (east of the Rocky Mountain front). Furthermore, there are variations in the amount and quality of data within these regions. In active tectonic regions ~~the focus will be on the identification of~~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,~~ and~~ the lack of adequate knowledge about earthquake causes, and the relatively lower activity rate.

In the CEUS, several significant tectonic structures exist and some of these have been interpreted as potential seismogenic sources (e.g., New Madrid fault zone, Nemaha Ridge, and Meers fault). There is no single recommended procedure to follow to characterize maximum magnitude associated with such candidate seismogenic sources; therefore, it is most likely that the determination of the properties of the seismic source 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.~~, thus a structure's extent may not be a very meaningful indicator of the size of future earthquakes associated with the source.~~ The historical seismicity record, the results of regional and site studies, and judgment play key roles. If, on the other hand, strong correlations and data exist suggesting a relationship between seismicity and seismic sources, approaches used for more active tectonic regions can be applied.

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

- Source zone geometry (location and extent, both surface and subsurface).
- ~~Description of Quaternary (last 2 million years) displacements (sense of slip on the fault, fault length and width, area of the fault plane, age of displacements, estimated displacement per event, estimated magnitude per offset, and displacement history or uplift rates of seismogenic folds).~~
- Historical and instrumental seismicity associated with each source.
- Paleoseismicity.
- Relationship of the potential seismic source to other potential seismic sources in the region.

- Seismic potential~~Maximum magnitude earthquake that can be generated by~~ of the seismic source, based on the source's known characteristics, including seismicity.

- Recurrence model (~~F~~frequency of earthquake occurrence versus magnitude).

- Other factors that will be evaluated, depending on the geologic setting of a site, such as:

  - Quaternary (last 2 million years) displacements (sense of slip on faults, fault length and width, area of the fault plane, age of displacements, estimated displacement per event, estimated magnitude per offset, segmentation, orientations of regional tectonic stresses with respect to faults, and displacement history or uplift rates of seismogenic folds).

  - Effects of human activities such as withdrawal of fluid from or addition of fluid to the subsurface, extraction of minerals, or the construction of dams and reservoirs.

  - Volcanism. Volcanic hazard is not addressed in this regulatory guide. It will be considered on a case-by-case basis in regions where this hazard exists.

  - ~~Other factors that can contribute to characterization of seismic sources such as strike and dip of tectonic structures, orientations of regional and tectonic stresses, fault segmentation (along both strike and downdip), etc.~~

D.2. INVESTIGATIONS TO EVALUATE SEISMIC SOURCES

D.2.1 General

Investigations of the site and region around the site are necessary to identify both seismogenic sources and capable tectonic sources and to determine their potential for generating earthquakes and causing surface deformation. If it is determined that surface deformation need not be taken into account at the site, sufficient data to clearly justify the determination should be presented in the application for early site review, construction permit, operating license, or combined license. Generally, any tectonic deformation at the earth's surface within 40 km (25 miles) of the site will require ~~adequate~~ 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, ~~adequate~~engineering solutions cannot always be demonstrated to be adequate for mitigation of the effects of permanent ground displacement phenomena such as surface faulting or folding, subsidence, or ground collapse. For this reason, it is prudent to select an alternative site when the potential for permanent ground displacement exists at the proposed site (Ref. D.2).

In most of the CEUS, as determined from instrumentally ~~determined~~located earthquake hypocenters, tectonic structures at seismogenic depths ~~often~~seldom bear ~~no~~ 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 Western United States (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~~-not only~~ 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 to 8 km distance from the site). Whenever faults or other structures are encountered at a site (including sites in the CEUS) in either~~-in~~ 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 divided into three levels, Regional, Site Vicinity, and Site Area. Regional investigations should extend to a distance of 320 km (200 mi) from the site~~, and data should be presented at a scale of 1:500,000 or smaller~~. Site vicinity investigations should be conducted to a distance of 40 km (25 mi) from the site. Investigations of the site area should extend out to a radius of 8 km (5 mi). The specific site should be investigated in detail to a distance of at least 1 km (0.66 mi).

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 SSE, are identified.

The large size of the area for the regional investigations is recommended because of the possibility that all significant seismic sources, or alternate configurations, may not have been enveloped by the LLNL/EPRI data base. Thus, it will increase the chances of~~:~~ (1) identifying evidence for unkown seismic sources that might extend close enough for earthquake ground motions generated by that source to affect the site~~,~~ and (2) ~~increase the likelihood of~~ confirming the PSHA's database. 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 of 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 ~~a~~ 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 ~~also~~ 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~~,~~ the Juan de Fuca Subduction Zone~~, etc~~. 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 ~~to the~~farther east ~~beyond~~than the dominant San Andreas Fault, which is about 75 km (45 ~~km~~ mi) from the site; nor ~~to the~~ 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 in the site vicinity 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 in the site area within a radius of 8 km (5 mi) from the site, and the resulting data should be presented at a scale of 1:5000 or smaller. The level of investigations in the site vicinity should delineate the geologic regime and the potential for tectonic deformation at or near the ground surface. The investigations should use the methods described in subsections D.2.2 and D.2.3 that are appropriate for the tectonic regime to characterize seismic sources.

The site vicinity and site area investigations may be asymmetrical and may cover a larger area 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 square kilometer) 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 ~~those~~ plant structures that are characterized as Seismic Category I. In addition to geological, geophysical, and seismological investigations, ~~considerable~~ detailed geotechnical engineering investigations as described in Regulatory Guide 1.132 (Ref. D.3) should be conducted at the site.

The investigations needed to assess the ~~integrity~~ 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. Theis part of the evaluation should also consider the possible effects caused by human activities such as withdrawal of fluid from or addition of fluid to the subsurface, extraction of minerals, or the loading effects of dams and reservoirs.

D.2.2 <u>Reconnaissance Investigations, Literature Review, and Other Sources of Preliminary Information</u>

Regional literature and reconnaissance-level investigations can be planned based on reviews of available documents and the results of previous investigations. Possible sources of information may include universities, consulting firms, and government agencies. A detailed list of possible sources of information is given in Regulatory Guide 1.132 (Ref. D.3).

D.2.3 <u>Detailed Site Vicinity and Site Area Investigations</u>

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

D.2.3.1 <u>Surface Investigations</u>

Surface exploration needed to assess the neotectonic regime and the geology of the area around the site is dependent on the site location and may be carried out with the use of any appropriate combination of the ~~following~~ geological, geophysical, seismological, and geotechnical engineering techniques summarized in the following paragraphs and Ref. D.3~~, but~~. However, not all of these methods ~~will~~must be carried out at a given site.

<u>D.2.3.1.1.</u> Geological interpretations of aerial photographs and other remote-sensing imagery, 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.

<u>D.2.3.1.2.</u> Mapping of topographic, geologic, geomorphic, and hydrologic features at scales and with contour intervals suitable for analysis, stratigraphy (particularly Quaternary), surface tectonic structures such as fault zones, and Quaternary geomorphic features. For offshore sites, 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 for evaluation.

<u>D.2.3.1.3.</u> Identification and evaluation of vertical crustal movements by (1) geodetic land surveying to identify and measure short-term crustal movements (Refs. D.4 and D.5) 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 (Ref. D.6).

<u>D.2.3.1.4.</u> Analysis of offset, displaced, or anomalous landforms such as displaced stream channels or changes in stream profiles or the upstream migration of knickpoints (Refs. D.7 - D.12); abrupt changes in fluvial deposits or terraces; changes in paleochannels across a fault (Refs. D.11 and

D.12); or uplifted, downdropped, or laterally displaced marine terraces (Ref. D.12).

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

D.2.3.1.6. Identification and analysis of deformation features caused by vibratory ground motions, including seismically induced liquefaction features (sand boils, explosion craters, lateral spreads, settlement, soil flows), mud volcanoes, landslides, rockfalls, deformed lake deposits or soil horizons, shear zones, cracks or fissures (Refs. D.13 and D.14).

D.2.3.1.7. ~~Estimation of the ages of~~ Analysis of fault displacements, such as by ~~analysis~~ the interpretion of the morphology of topographic fault scarps associated with or produced by surface rupture. Fault scarp morphology is useful in estimating age of last displacement (in conjunction with the appropriate geochronological methods described in Subsection D.2.4), approximate size of the earthquake, recurrence intervals, slip rate, and the nature of the causative fault at depth (Refs. D.15 - D.18).

D.2.3.2 Seismological Investigations

D.2.3.2.1. Listing of all historically reported earthquakes having Modified Mercalli Intensity (MMI) greater than or equal to IV or magnitude greater than or equal to 3.0 that can reasonably be associated with seismic sources, any part of which is within a radius of 320 km (200 miles) of the site (the site region). The earthquake descriptions should include the date of occurrence and measured or estimated data on the highest intensity, magnitude, epicenter, depth, focal mechanism, and stress drop. Historical seismicity includes both historically reported and instrumentally recorded data. For pre-instrumentally recorded data, intensity should be converted to magnitude, the procedure used to convert it to magnitude should be clearly documented, and epicenters should be determined based on intensity distributions. Methods to convert intensity values to magnitudes in the CEUS are described in References D.1, D.19, D.20, and D.21.

D.2.3.2.2. Seismic monitoring in the site area should be established as soon as possible after site selection. For sites in both the CEUS and WUS, a single large dynamic range, broad-band seismograph, and a network of short period instruments to locate events should be deployed around the site area. ~~may be adequate. For sites in the Western Uni' d States~~WUS~~, a network of at least five such seismographs would be deployed within 25 km (15 mi) surrounding the site.~~

~~The primary purposes of seismic monitoring are to obtain data from distant earthquakes, to determine site response,~~ The data obtained by monitoring current seismicity will be used, along with the much larger data base acquired from site investigations, to evaluate site response and to provide information about whether there are~~assurance that there are no~~ significant sources of earthquakes within the site vicinity, or to provide data by which an existing source can be characterized. ~~For sites in the Western United States seismic monitoring could help locate any ongoing seismicity that may indicate capable faulting within the site vicinity.~~

Monitoring should be initiated as soon as practicable at the site, preferably at least ~~up to~~ five years prior to construction of a nuclear unit at a site, and should continue ~~for at least five years following initiation of plant operation~~at least until the free field seismic monitoring strong ground motion instrumentation described in Regulatory Guide 1.12 is operational.

D.2.3.3 Subsurface Investigations

Ref. D.6 describes geological, geotechnical, and geophysical investigation techniques that can be applied to explore the subsurface beneath the site and in the region around the site. Subsurface investigations in the site area and within the site vicinity to identify and define seismogenic sources and capable tectonic sources may include the following investigations.

D.2.3.3.1. Geophysical investigation~~s~~ that have been useful in the past include, but are not limited to: ~~such as air~~ magnetic and gravity surveys, seismic reflection and seismic refraction surveys, borehole geophysics, electrical surveys, and ground-penetrating radar surveys.

D.2.3.3.2. Core borings to map subsurface geology and obtain samples for testing such as ~~examining~~determining the properties of the subsurface soils and rocks and geochronological analysis.

D.2.3.3.3. Excavating and logging of trenches across geological features as part of the neotectonic investigation and to obtain samples for the geochronological analysis of those features.

At some sites, deep 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 (Refs. D.12 and D.22).

D.2.4 Geochronology

An important part of the geologic investigations to identify and define potential seismic sources is the geochronology of geologic materials. ~~The NRC is currently supporting a research project to develop a data base on which to base a future regulatory guide on geochronological methods. This guide will contain an up to date bibliography of state of the art documents on geochronology. The availability of this guide will be published in the Federal Register.~~ An acceptable classification of dating methods is based on the rationale described in Reference D.23. The following techniques, which are presented according to that classification, are useful in dating Quaternary deposits.

D.2.4.1 Sidereal Dating Methods

- Dendrochronology - tree-ring analysis - age range is from modern times to several thousand years (Refs. D.24 and D.25).
- Varve chronology - 0 to 10,000 years (Ref. D.26).

D.2.4.2 Isotopic Dating Methods

- Radiocarbon for dating organic materials - 100 to 40,000 (up to 100,000 years using AMS) (Refs. D.27 and D.28).

- Potassium argon for dating volcanic rocks ranging in age from about 100,000 to 10 million years (Refs. D.27 and D.29).
- Argon 39 - Argon 40, for dating relatively unweathered igneous and metamorphic rocks - 100,000 to unlimited upper limit (Ref. D.30)
- Uranium series uses the relative properties of various decay products of ^{238}U or ^{235}U. Ages range from 10,000 to 350,000 years (Ref. D.27). $^{235}U/^{238}U$ can yield between 40,000 and 1,000,000 years (Ref. D.31).
- Uranium Trend - for relatively undisturbed soils ranging in age from 100,000 to 900,000 years (Ref. D.32).

D.2.4.3 <u>Cosmogenic Isotopes</u> - for dating surficial rocks and soils. Nuclides ^{36}Cl, ^{10}Be, ^{21}Pb, and ^{26}Al - age range varies within the Quaternary according to isotope tested (Refs. D.33 and D.34).

D.2.4.4 <u>Radiogenic Dating Methods</u>

- Thermoluminescence (TL) - for dating fine-grained eolian and lacustrine, and possibly alluvium and colluvium as well - age range is from 1,000 to 1,000,000 years (Refs. D.27 and D 35).
- Electron spin resonance (ESR) is used for sediments, shells, carbonates, bones, and possibly to date quartz that formed in fault gouge during the fault event - age range is from 50,000 to 500,000 years (Ref. D.36).
- Fission Track - for dating minerals such as zircon and apatite, with fissionable uranium in volcanic rocks - 100 to several million years (Refs. D.27 and D.37).

D.2.4.5 <u>Chemical and Biological Dating Methods</u>

- Obsidian and Tephra Hydration - age range is from 200 to several million years (Ref. D.38).
- Amino Acid Racemization - for fossils, shells, and bones - age range is from 100 to 1,000,000 years (Refs. D.39 and D.40).
- Rock varnish chemistry - cation ratio of manganese, iron, and clay coatings on desert stones - age range is 1,000 to 40,000 years

(Ref. D.41). The results of this method are controversial and its use is not recommended pending further validation.

D.2.4.6 Geomorphic Dating Methods

- Soil profile development - for analysis of the upper few meters of stable soils - age range is from 1,000 to 1,000,000 years (Refs. D.27, D.42 through D.47).
- Rock and mineral weathering - for measuring the progression of weathering, such as thickness of weathering rind development on the margins of clasts, hornblende etching, limestone solutioning, etc. - age range, depending on material - 10 to 1,000,000 (Ref. D.27).
- Geomorphic position - fluvial and marine terraces, and glacial moraines - 1,000 to 1,000,000 years (Ref. D.48).
- Rate of deposition - lacustrine, playa, and sometimes alluvial deposits - tens to millions of years (Ref. D.26)
- Scarp degradation - works best in coarse unconsolidated alluvium - age range is from 2,000 to 20,000 years (Refs. D.15 and D.49).

D.2.4.7 Correlation Dating Methods

- Lithostratigraphy - correlation of distinctive geologic units between sites - age range is from 0 to 4.5 billion years (Ref. D.50)
- Tephrochronology - volcanic ash layers interbedded with sedimentary deposits - age range is from zero to several million years (Refs. D.51 and D.38).
- Paleomagnetism - most igneous and sedimentary rocks containing hematite and magnetite - age range is from 0 to 5,000,000 years (Ref. D.27).
- Archeology - deposits associated with archeological materials (Ref. D.52).
- Paleontology (marine and terrestial) - fossil-bearing rocks or soils - age range is from 0 to 1 billion years (Ref. D.53).

- Lichenometry - used to estimate ages from sizes of lichens growing on gravel or boulders (such as glacial deposits) (Ref. D.54).

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-can normally can be used effectively onshore. However, it is often useful to investigate similar features onshore to learn more about the significant offshore features.

D.2.5 Distinction Between Tectonic and Nontectonic Deformation

At a site, both Nnontectonic deformation, like and tectonic deformation, at a site can pose a substantial hazard to nuclear power plants, but there are likely to be differences in the approaches used to resolve the issues raised by the two types of phenomena. Therefore, nontectonic 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 features include faults on which the last displacement was induced by glaciation or deglaciation; collapse structures, such as found in karst terrain; and growth faulting, such as occurs in the Gulf Coastal Plain or in other deep soil regions subject to 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 ~~earthquakes~~, can often be identified and avoided in siting, and their displacements can be monitored. Some growth faults and antithetic faults related to growth faults are not easily identified; therefore, investigations described above with respect to capable 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.

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<u>APPENDIX E</u>

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

E.1 <u>INTRODUCTION</u>

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

Regulatory Position 4 in this guide describes acceptable PSHAs ~~analyses~~ that were developed by Lawrence Livermore National Laboratories (LLNL) and the Electric Power Research Institute (EPRI) to characterize the seismic hazard for nuclear power plants ~~estimate the controlling earthquakes~~ and to develop the Safe Shutdown Earthquake ground motion (SSE). The procedure to determine the SSE outlined in ~~this Draft~~ Regulatory Guide 1.165 ~~DG-1032~~ 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 ~~sig~~[illegible] information ~~are~~ identified by the site-specific ~~betw~~[illegible] ~~ultsthat are validated by a strong technical basis~~ [illegible] ~~are identified and these differences~~ would result in a significant increase in the hazard estimate for a site, and this new information is validated by a strong technical basis, the PSHA may have to be modified to incorporate the new technical information. Using sensitivity studies, it may also be possible to justify a lower hazard estimate with and exceptionally strong technical basis. However, it is expected that large uncertainties in estimating seismic hazard in the CEUS will continue to exist in the future, and substantial delays in the licensing process will result in trying to address them with respect to a specific site.

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

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

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

E.2.1 Seismic Sources

There are several possible sources of new information from the site-specific investigations that could ~~e~~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. ~~Future~~ ~~g~~Geophysical studies (aeromagnetic, gravity, and seismic reflection/refraction) ~~will probably~~ 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 ~~historical~~

earthquakes that were large and ~~close to~~ 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 ~~localize~~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.

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

E.2.2 Earthquake Recurrence Models

There are three elements of the source zone's recurrence models that could be affected by new site-specific data: (1) the rate of occurrence of earthquakes, (2) their maximum magnitude, and (3) the form of the recurrence model, for example, 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~~would ensue~~ 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 paleoseismic 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 ~~place~~ 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 dat[illegible]y be developed that were not considered or given high weight in the EPRI or LLNL PSHA. Any of these cases could have an impact on the estimated maximum earthquake if the result is larger than the values provided by LLNL and EPRI.

E.2.3 Ground Motion Attenuation Models

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

E.3 PROCEDURE AND EVALUATION

The EPRI and LLNL studies provided 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 median seismic hazard.

An example is an additional nuclear unit sited 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 median of the range of the input parameters. Such new information may indicate the addition of a new seismic source, a change in the rate of activity, a change in the spatial patterns of seismicity, an increase in the rate of deformation, or the observation of a relationship between tectonic structures and current seismicity. The new findings should be assessed by comparing them with the specific input of each expert or team that participated in the PSHA. Regarding a new source, for example, the specific seismic source characterizations for each expert or team (such as tectonic feature being modeled, source geometry, probability of being active, maximum earthquake magnitude, or occurrence rates) should be assessed in the context of the significant new data and interpretations.

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

An example is a consideration of the seismic hazard near the Wabash River Valley (Ref. E.1). Geological evidence found recently within the Wabash River Valley and several of its tributaries indicated that an earthquake much larger than any historic event had occurred several thousand years ago in the vicinity of Vincennes, Indiana. A review of the inputs by the experts and teams involved in the LLNL and EPRI PSHA's 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 5 historic earthquakes that have occurred, and thus had assumed the larger event. This analysis of the source characterizations of the experts and teams resulted in the conclusion by the analysts that a new PSHA would not be necessary for this region because an event similar to the prehistoric earthquake had been considered in the existing PSHAs.

A third step would be required if the site-specific geosciences investigations revealed significant new information that would substantially affect the estimated hazard. Modification of the seismic sources would more than likely be required if the results of the detailed local and regional site investigations indicate that a previously unknown seismic source is identified in the vicinity of the site. A hypothetical example would be the recognition of geological evidence of recent activity on a fault near a nuclear power plant site in the stable continental region (SCR) similar to the evidence found on the Meers Fault in Oklahoma (Ref. E.2). If such a source is identified, the same approach used in the active tectonic regions of the 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 may require determining the appropriate reference probability in accordance with the procedure described in Appendix B.

REFERENCES

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

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

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[1]Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343.

[2]Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343. Copies may be purchased at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-2249); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161.

APPENDIX F

PROCEDURE TO DETERMINE THE SAFE SHUTDOWN EARTHQUAKE GROUND MOTION

F.1 INTRODUCTION

This appendix elaborates on Step 4 of Regulatory Position 4 of ~~Draft Regulatory Guide DG-1032~~this guide, which describes an acceptable procedure to determine the Safe Shutdown Earthquake Ground Motion (SSE). The SSE 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 SSE response spectrum ~~is~~ 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~~to~~ the average of the ground motion levels for 5 and 10 Hz ($S_{a,5-10}$), and 1 and 2.5 Hz ($S_{a,1-2.5}$) as determined in Step C.2 of Appendix C to this guide.

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

F.2 DISCUSSION

For engineering purposes, it is essential that the design ground motion response spectrum be a broad-band smooth response spectrum with adequate energy in the frequencies of interest. In the past, it was general practice to select a standard broad-band spectrum, such as the spectrum in Regulatory Guide 1.60 (Ref. F.2), and ~~anchor~~ scale it ~~to~~ by a peak ground motion parameter (usually peak ground acceleration (PGA)), which is derived based on the size of the controlling earthquake. During the licensing review this spectrum was checked against site-specific spectral estimates derived using Standard Review Plan 2.5.2 procedures to be sure that the SSE design spectrum adequately enveloped the site-specific spectrum. These past practices to define the SSE are still valid and, based on this consideration, the following three possible situations are depicted in Figures F.1 to F.3.

Figure F.1 depicts a situation in which a site is to be used for a certified design with an established SSE (for instance, an Advanced Light Water Reactor with 0.3g PGA SSE). In this example, the certified design SSE spectrum compares favorably with the site-specific response spectra determined in Step 2 or 3 of Regulatory Position 4.

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

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

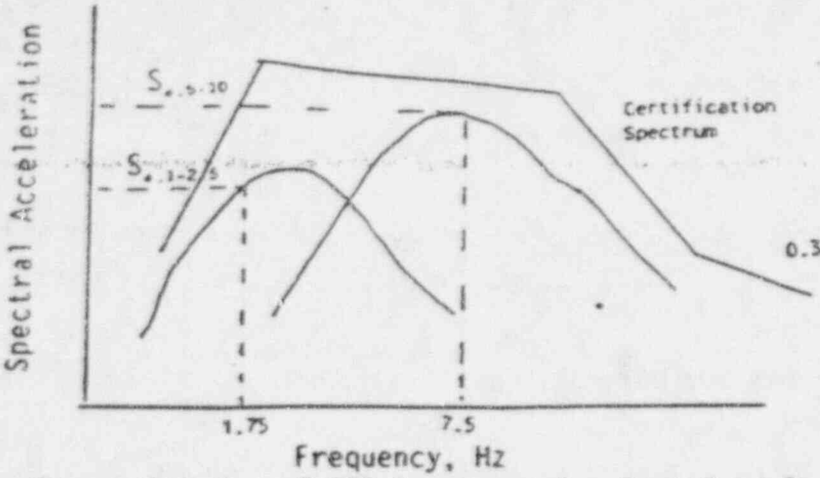

Figure F.1 Use of SSE Spectrum of a Certified Design

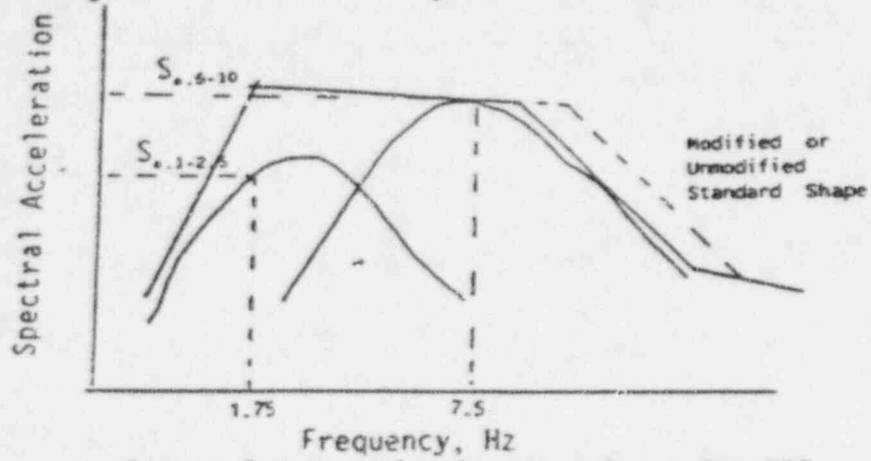

Figure F.2 Use of a Standard Shape for SSE

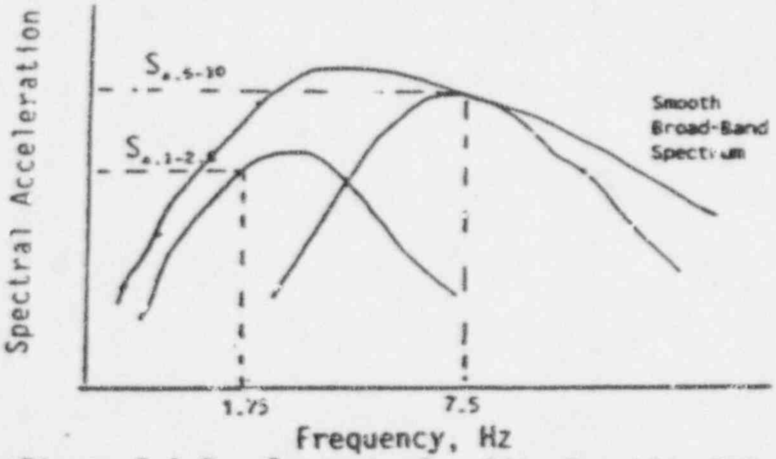

Figure F.3 Development of a Site-Specific SSE Spectrum

(Note: The above figures illustrate situations for a rock site.~~,~~ ~~f~~For other site conditions the SSE spectra are compared at free-field after performing site amplification studies as discussed in Step 4 of Regulatory Position 4.)

<u>REFERENCES</u>

F.1 Electric Power Research Institute, "Guidelines for Determining Design Basis Ground Motions," EPRI Report TR-102293, Volumes 1-4, May 1993.

F.2 USNRC, "Design Response Spectra for Seismic Design of Nuclear Power Plants," Regulatory Guide 1.60.[1]

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[1]Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343. Copies may be purchased at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-2249); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The ~~draft~~ regulatory analysis, "~~Proposed~~ Revision of 10 CFR Part 100 and 10 CFR Part 50," was prepared for the ~~proposed~~ 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 ~~draft~~ regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW. (Lower Level), Washington, DC, as ~~Enclosure 2 to Secy 94-194~~ LATER.

ATTACHMENT 11

SRP SECTION 2.5.1, REVISION 3

(BASIC GEOLOGIC AND SEISMIC INFORMATION)

U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN 2.5.1
BASIC GEOLOGIC AND SEISMIC INFORMATION
~~PROPOSED~~ REVISION 3

~~February 1995~~
~~Contact: A.J. Murphy~~
~~(301)415-6010~~

REVIEW RESPONSIBILITIES

Primary - Civil Engineering and Geosciences Branch (ECGB)

Secondary - None

I. AREAS OF REVIEW

ECGB reviews the geological, seismological, and geophysical information submitted in the applicant's early site evaluation report (ESR) or safety analysis report (SAR), Sections 2.5.1, 2.5.2 and 2.5.3. The technical information presented in these sections of the SAR or ESR results largely from surface and subsurface geological, seismological, geophysical, and geotechnical investigations performed in progressively greater detail toward the site, within each of the areas described by radii of 320 km (200 mi), 40 km (25 mi), 8 km (5 mi), and in the site area 1 km (0.6 mi) around the site. The following specific subjects are addressed: 1. tectonic and seismic information, nontectonic deformation information, and conditions caused by human activities, with respect to Regional Geology (Subsection 2.5.1.1), and Site Geology (Subsection 2.5.1.2).

~~This standard review plan is being issued in draft form to involve the public in the early stages of its development. It has not received complete staff review and does not represent an official NRC staff position.~~

~~Public comments are being solicited on this draft standard review plan, which is part of a group of drafts of regulatory guides and standard review plan sections on meeting proposed amendments to the regulations on siting nuclear power plants (59 FR 52255). Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules Review and Directives Branch, DFIPS, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Copies of comments received may be examined at the NRC Public Document Room, 2120 L Street NW., Washington, DC. Comments will be most helpful if received by May 12, 1995.~~

~~Requests for single copies of this standard review plan (which may be reproduced) will be filled while supplies last. Requests should be in writing to the U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Office of Administration, Distribution and Mail Services Section.~~

Because there is a strong overlap among these areas of review and those of geotechnical engineering and geohydrology, the reviewers of these sections of the SARs should also carefully review SRP Section 2.5.4 and Section 2.4.12, and closely coordinate their reviews and findings with those of the geotechnical engineering and the geohydrology reviewers. For example, coordination with geotechnical engineers is required when verification of geological processes affecting the site, such as the preloading history of the plant's soil foundations by means of glacial and other geologic processes, can be determined through various geotechnical testing methodologies.

References 1 through 8 (regulations and regulatory guides) provide guidance to the ECGB reviewers in evaluating potential nuclear facility sites. The principal regulation that will be used by ECGB in the future to determine the scope and adequacy of the submitted geological, seismological, and geophysical information for new nuclear facility sites is 10 CFR Part 100, ~~Proposed~~ Section 100.23, "Seismic and Geologic Siting Factors" (Ref. 2). Specific guidance for implementing this regulation can be found in ~~Draft~~ Regulatory Guide ~~DG-1032~~1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motions" (Ref. 3). Guidance regarding the geotechnical engineering aspects is found in Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" (Ref. 4). Additional guidance is provided to the ECGB reviewers through information published in the scientific literature. As the state of the art in the geosciences is advancing rapidly, it is the responsibility of the reviewers to stay abreast of changes by reviewing the current scientific literature on a regular basis, attending professional meetings, etc.

~~This standard review plan is being issued in draft form to involve the public in the early stages of its development. It has not received complete staff review and does not represent an official NRC staff position.~~

~~Public comments are being solicited on this draft standard review plan, which is part of a group of drafts of regulatory guides and standard review plan sections on meeting proposed amendments to the regulations on siting nuclear power plants (59 FR 52255). Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules Review and Directives Branch, DFIPS, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Copies of comments received may be examined at the NRC Public Document Room, 2120 L Street NW., Washington, DC. Comments will be most helpful if received by May 12, 1995.~~

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Using the knowledge derived from these activities and the geosciences reviewers' own aggregate academic backgrounds and experience, ECGB judges the adequacy of the geological, seismological, and geophysical information cited in support of the applicant's conclusions concerning the suitability of the plant site.

The geological, seismological, and geophysical information that must be provided by applicants for the site review to proceed is divided into the following three basic categories:

1. Tectonic or seismic information. Information regarding tectonics, (particularly Quaternary tectonics), seismicity, correlation of seismicity with tectonic structure, characterization of seismic sources, and ground motion. Seismicity and vibratory ground motions are primary review responsibilities addressed in SRP Section 2.5.2. However, the review and acceptance of the applicant's basic data-gathering processes and findings that are presented in support of these topics, and their completeness, are also integral parts of the review responsibilities covered in this section. There must be close coordination among geologists, geophysicists, and seismologists in reviewing these sections.

   Sufficient information must be provided to estimate the potential for strong earthquake ground motions or surface deformation at the site, such as the proximity and nature of potential seismic sources, Quaternary geological evidence for faulting, folding, prehistoric earthquakes (i.e., paleoliquefaction features), and other seismically induced features. A complete presentation, including supporting basic data, of the characteristics of the subsurface materials beneath the site must be provided (or cross-referenced with Standard Review Plan (SRP) Section 2.5.4) and reviewed by the staff so that an assessment of the potential for amplification of vibratory ground motion or ground failure under dynamic loading can be made. Potential ground failure modes may include liquefaction, excessive settlement, differential settlement, and those caused by high tectonic stresses. Additionally, for sites adjacent to large bodies of water, information pertinent to estimating tsunami and seiche hazards must be provided, or cross-referenced to SRP Section 2.4.12.

2. Nontectonic deformation information. Adequate information must be provided for an assessment of other nontectonic geological hazards, such as landsliding and other mass-wasting phenomena, subsidence (including differential subsidence), growth faulting, glacially induced deformation, chemical weathering, the potential for collapse or subsidence in areas underlain by carbonate rocks, evidence of preconsolidation, etc.

3. Conditions caused by human activities. Information on changes in groundwater conditions caused by the withdrawal or injection of fluids, subsidence or collapse caused by withdrawal of fluids, mineral extraction, induced seismicity and fault movement caused by reservoir impoundment, fluid injection or withdrawal must be included in the SAR or ESR and evaluated by the ECGB staff.

Acceptance Criteria related to the above conditions are presented in SAR Subsections 2.5.1.1 (Regional Geology) and 2.5.1.2 (Site Geology). This information should be reviewed in terms of the regional and site tectonics, with emphasis on the Quaternary period, structural geology, physiography, geomorphology, stratigraphy, and lithology. In addition, with specific reference to site geology, the following subjects should be reviewed as they relate to the above-mentioned conditions: topography, slope stability, fluid injection or withdrawal, mineral extraction, faulting, solutioning, jointing, seismicity, and fracturing.

The information provided should be documented by appropriate references to all relevant published and unpublished materials. Illustrations such as maps and cross sections should include but should not be limited to structural, tectonic, physiographic, topographic, geologic, gravity, and magnetic maps; structural and stratigraphic sections; boring logs; and aerial photographs. Some sites may require maps of subsidence, irregular weathering conditions, landslide potential, hydrocarbon extraction (oil or gas wells), faults, joints, and karst features. Some site characteristics must be documented by reference to seismic reflection or refraction profiles or to maps produced by various remote sensing techniques.

Maps should include superimposed plot plans of the plant facilities. Other documentation should show the relationship of all Seismic Category I facilities (clearly identified) to subsurface geology. Core boring logs, logs and maps of trenches, aerial photographs, satellite imagery, and geophysical data should be presented for evaluation. In addition, plot plans showing the locations of all plant structures, borings, trenches, profiles, etc., should be included.

The review can be brought to an earlier conclusion if the ESR or SAR contains sufficient data to allow the reviewers to make an independent assessment of the applicant's conclusions. The reviewers should be led in a logical manner from the data and premises given to the conclusions that are drawn without having to make an extensive independent literature search. A literature search will be conducted by the staff at the appropriate level of detail, depending on the completeness of the SAR or ESR. All pertinent data, including that which is controversial, should be presented and evaluated. The geologic terminology used should conform to standard reference works (Refs. 9 and 10).

The primary purposes for conducting the site and regional investigations are to determine the geological and seismological suitability of the site and to provide the bases for the design of the plant. A secondary goal is to determine whether there is significant new tectonic or ground motion information that could impact the seismic design bases as determined by a probabilistic seismic hazard analysis (PSHA) (Refs. 11, 12, and 13). The objective of Section 2.5.1 of the SAR is to present the results of these investigations and to describe geologic and seismic features as they affect the site under review; all data, information, discussions, interpretations, and conclusions should be directed to this objective.

II. ACCEPTANCE CRITERIA

The applicable rules and basic acceptance criteria pertinent to the areas of this section of the SRP are given below:

1. 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena," - The criterion requires that safety-related portions of the structures, systems, and components important to safety be designed to withstand the effects of earthquakes, tsunami, and seiche without loss of capability to perform their safety functions (Ref. 1).

2. 10 CFR Part 100, ~~Proposed~~ Section 100.23, "Geologic and Seismic Siting Factors" ~~(59 FR 52255)~~ - This ~~proposed~~ section of Part 100 ~~would~~ requires that the geological, seismological, geophysical, and geotechnical engineering characteristics of a site and its environs 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 Safe Shutdown Earthquake ground motion (SSE), to preclude sites with potential surface or near-surface tectonic deformation, and to permit adequate engineering solutions to actual or assumed geologic and seismic effects at the proposed site. It ~~would~~ requires the determination of the SSE, the potential for surface tectonic and nontectonic deformations, the design bases for seismically induced floods and water waves, and other design conditions (Ref. 2).

The following regulatory guides provide information, recommendations, and guidance, and in general, describe a basis acceptable to the staff for implementing the requirements of GDC 2, Part ~~100~~ 50, and Section 100.23 of Part 100.

a. ~~Draft~~ Regulatory Guide ~~DG-1032~~1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motions" (Ref.3) - This ~~proposed~~ guide describes acceptable methods to: (1) conduct geological, seismological, and geophysical investigations of the site and region around the site, (2) identify and characterize seismic sources, (3) perform probabilistic seismic hazard analyses (PSHA), and (4) determine the SSE for the site (see SRP Section 2.5.2.6 and Ref. 14).

b. <u>Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants"</u> - This guide describes ~~programs of~~ site investigations related to geotechnical aspects that would normally meet the needs for evaluating the safety of the site from the standpoint of the performance of foundations under anticipated loading conditions, including earthquakes. It provides general guidance and recommendations for developing site-specific investigation programs as well as specific guidance for conducting subsurface investigations, including borings, sampling, and geophysical explorations (Ref. 4).

c. <u>Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations"</u> - This guide discusses the major site characteristics related to public health and safety that the NRC staff considers in determining the suitability of sites for nuclear power stations (Ref. 5).

The information in the SAR or ESR must be complete and thoroughly documented, and it must be consistent with the requirements of Reference 2 and should conform to the format suggested in Reference 6. Information from varied sources, including the United States Geological Survey (USGS) and other Federal or State agencies' published and open file papers, maps, aerial photographs, geophysical data, and similar data from nongovernmental sources covering the region in which the site is located, are used to establish the staff's conclusions as to the completeness and acceptability of the SAR or ESR.

The ECGB reviewers must ensure that investigations, as described in ~~Draft~~ Regulatory Guide ~~DG-1032~~1.165 and Regulatory Guide 1.132, are conducted with the appropriate level of thoroughness within the 4 areas designated in ~~Draft~~ Regulatory Guide 1.165 ~~DG-1032~~, based on distances from the site: 320 km (200 mi), 40 km (25 mi), 8 km (5 mi), and 1 km (0.6 mi). There must be sufficient information presented in the ESR or SAR on which to base a comparison between the new data derived from the regional and site investigations and that used in the tectonic and ground motion models of the probabilistic seismic hazard analysis (Ref. 3).

Specific criteria necessary to meet the relevant requirements of General Design Criterion 2, of Part 100, ~~Appendix A,~~ and ~~Proposed~~ Section 100.23 are as follows:

<u>Subsection 2.5.1.1</u>, "Regional Geology." In meeting the requirements of References 1 and 2, the subsection will be considered acceptable if a complete and documented discussion is presented of all geological, seismological, and geophysical features, as well as conditions caused by human activities. This subsection should contain a review of the regional tectonics, with emphasis on the Quaternary period, structural geology, seismology, paleoseismology, physiography, geomorphology, stratigraphy, and geologic history within a distance of 320 km (200 mi) (site region) from the site, to provide a framework within which the safety significance can be evaluated of the geology, seismology, and conditions brought about by human activities.

<u>Subsection 2.5.1.2</u>, "Site Geology." In meeting the requirements of References 1 and 2, and the regulatory positions of References 4 and 5 and certain recommendations of Reference 7, the subsection will be judged acceptable if it contains a description and evaluation of site-related geologic features, seismic conditions, and conditions caused by human activities, at appropriate levels of detail (defined by the distances of 40 km (25 mi) (site subregion), 8 km (5 mi) (site vicinity), and 1 km (site area) of the site). This subsection should contain the following general site information:

1. The structural geology of the site, specifically the identification and characterization of local seismic sources and their relationship to the regional structural geology and seismic sources.

2. The seismicity of the site, including historical and instrumentally recorded earthquakes, and whether there is a relationship to tectonic structure.

3. The geological history, particularly the Quaternary period, of the site and its relationship to the regional history.

4. Evidence of paleoseismicity or lack of it.

5. The site stratigraphy and lithology and their relationship to those of the region.

6. The engineering significance of geological features underlying the site as they relate to:

   a. Dynamic behavior during prior earthquakes.

   b. Zones of alteration, irregular weathering, or zones of structural weakness.

   c. Unrelieved residual stresses in bedrock.

   d. Materials that could be unstable because of their mineralogy or unstable physical properties.

   e. Effects of human activities in the area.

7. The site groundwater conditions.

III. REVIEW PROCEDURES

The staff review is conducted in three phases. The first phase is the acceptance review, a brief review of the SAR or ESR to evaluate its completeness and to identify obvious safety issues that could result in delays at subsequent stages of the review. The judgments on acceptance or rejection of the SAR or ESR for review are governed by two criteria: (1) adherence to the Standard Format (Ref. 6) in identifying and describing the geological, seismological, and geophysical features and the conditions resulting from human activities that affect safety of the site, and (2) provision of adequate information and documentation as described in ~~Draft~~ Regulatory Guide 1.165 ~~DG-1032~~ to allow for an independent staff review of the conclusions made therein.

After an SAR or ESR is docketed, the staff conducts a thorough review of the material. In this second phase of the review an effort is made to identify all safety issues. The reviewer carefully examines the SAR or ESR to see that all interpretations are founded on sound geological and seismological practice and do not exceed the limits of validity of the applicant's data or of other data, such as that published in the scientific literature.

At the beginning of this phase of the review, the staff usually seeks assistance from the U.S. Geological Survey (USGS) and decides to what extent consultants should be involved. The necessary information is then made available to the USGS advisors and consultants. Advisors from the USGS and consultants are asked to perform such varied tasks as reviewing the tectonic setting of plants in regions of complex geology, evaluating the potential for surface displacement, verifying an applicant's mineral identifications and geochronology, or providing advice on the proper level of earthquake ground motion in the seismic evaluation of selected sites.

A review of relevant references is conducted by the staff, USGS advisors, and consultants. Pertinent references, such as published geological reports, professional papers, open-file material, university theses, physiographic and geological maps, and aeromagnetic and gravity maps, are ordered from the appropriate sources and reviewed. Several basic general references used in the past by the staff are References 9, 15, and 16. GeoRef database (Ref. 17) and other databases, such as References 18 and 19, are used to identify specific references.

As publication usually lags behind the completion of research or construction investigation projects by months or years, the reviewers should not rely entirely on information submitted by the applicant or in the published literature. The reviewers should make an effort to identify any pertinent studies that may be under way in the site region and any preliminary findings of these studies. This may be accomplished by contacting the U.S. Geological Survey or other Federal agencies, State geological surveys, universities, and industry, to obtain current information about the site. Some pertinent information may be of a proprietary nature, and special provisions may be required to examine the data.

The staff members will conduct a geological reconnaissance of the site and region around the site as part of the second phase of the review to examine geological features, soil and rock samples from core borings or test pits, trenches excavated across the site, and actual excavations for the plant facilities, if present at this stage. This site reconnaissance is especially important in view of the revised requirement of 10 CFR Part 52 (Ref. 8), which allows for a combined license as an alternative to the previous two-step requirement of a construction permit followed by an operating license. In the previous procedure, many geologic features, such as faults (as at North Anna, Summer, Byron, Catawba, Seabrook, Watts Bar, etc.) that had the potential to impact the safety of the plant were not identified until the actual construction excavations for the plant were made. Additionally, unanticipated engineering problems have occurred during and after construction (as at North Anna, WNP-2, Nine Mile Point-2). For example, larger-than-expected settlements have frequently occurred in engineered backfill, even though the design had been approved by the staff during the construction permit review. Under 10 CFR Part 52 ~~it is possible that~~ the construction excavations for a plant will not be made until after the staff has prepared~~s~~ the site SER.

During the second phase of the review, questions and comments are developed from items that have not been adequately addressed by the applicant, those which become apparent during the detailed review, or those which develop from the additional information provided as a result of the acceptance review. These first round questions usually require the applicant to conduct additional investigations or to supply clarifying information. Questions may result from the reviewer's discovery of references not cited by the applicant that contain conclusions that are in conflict with those made by the applicant. When the applicant provides insufficient data to support its interpretations and conclusions and there are reasonable, technically supported, ~~and~~ more conservative alternative interpretations in the literature, the staff will request additional investigations, or require that the applicant adopt the more conservative interpretation. This phase of the review will usually involve public meetings with the applicant to clarify questions and allow the applicant to present new data to justify its position. The applicant's response to questions are reviewed and any remaining issues are settled either by a second round of questions or by staff positions.

The third review phase is the staff evaluation of the applicant's responses to questions raised in the second phase. At the end of the third phase, the staff takes positions on all safety-related issues, either concurring with the applicant's positions or taking more conservative positions as may be necessary in the staff's view to assure the required degree of safety.

A staff position is usually in the form of a requirement to provide confirmatory information or to design for a specific condition in a way that the staff considers to be sufficiently conservative and consistent with the requisites of Reference 2. When all safety issues have been resolved, the staff provides its input to the safety evaluation report (SER).

A staff position that has characterized licensing during the past two decades is that all Category I excavations are required to be geologically mapped by the applicant and examined by the staff before backfill is placed or concrete poured. These activities were usually accomplished before the SER was made final. This procedure should continue in the future regarding sites that are licensed under the 10 CFR Part 50 two-phase, Construction Permit and Operating Licensing, procedure.

However, ~~Under~~ the new 10 CFR Part 52 combined licensing procedure (COL), as described above, geological features such as faults that ~~were~~ are not discovered until after the construction excavations are made, and therefore after the ~~SER~~ has been ~~prepared~~ issued, ~~would~~ will not have been assessed by the staff. Likewise, unanticipated engineering problems such as the presence of liquefiable materials, excessive settlement, heave, or groundwater flow that occur~~red~~ during or following construction ~~would~~ will not have been evaluated by the staff. For these reasons, there must be a commitment in the site specific portion of the SAR for a facility: (1) notify the staff immediately if previously unknown geologic features that could represent a hazard to the plant are encountered during excavation; (2) geologically map all excavations for Category 1 structures, as a minimum; and (3) notify the staff when the excavations are open for its examination and evaluation. ~~conditions should be included in the SER that t~~The staff should conduct a followup site review when the excavations for the Seismic Category I ~~facilities~~ structures are open to confirm ~~tentative~~ the conclusions that the site parameters are within the envelope of the certified design. ~~presented in the SER., and that final conclusions by the staff are pending the results of this site review unless there is reasonable certainty that such occurrences are unlikely.~~

IV. EVALUATION FINDINGS

If the evaluation by the staff, on completion of the review of the geological and seismological aspects of the plant site and region, confirms that the applicant has met the requirements of applicable portions of References 1 and 2, and the guidance contained in References 3, 4, 5, and 6, the conclusion in the SER states that the information provided and investigations performed support the applicant's conclusions regarding the geological and seismological integrity of the proposed nuclear power plant site. Licensing conditions instituted by the staff to resolve ~~Staff reservations about~~ any significant deficiency ~~presented~~ identified in the applicant's SAR or ESR are stated in sufficient detail to make clear the precise nature of concern and required resolution.

The evaluation determinations with respect to the geological and seismological suitability of the site are made by the staff after the early site, construction permit, or operating license reviews. A conclusion regarding an Operating License will include an evaluation of the excavations for Category 1 structures. A ~~similar~~ conclusion regarding the geological and seismological suitability of a site following a combined license review will be made when the applicant has committed to mapping excavations for Category 1 facilities and notifying the staff of their availability for examination. ~~should not be tentative finalized until after t~~The staff will conduct this examination at the appropriate time after licensing ~~as the excavations for the seismic category 1 facilities and~~ to confirm ~~determines~~ that there are no previously unknown features, such as potentially active faults, evidence for strong ground motions such as late Quaternary seismically induced paleoliquefaction features, unsuitable soil zones, or cavities in the excavations. ~~There may be additional questions that arise because of this examination. However, documentation of the staff's final conclusions should be made as soon after the excavation examination as possible.~~

This final staff visit, in addition to determining whether there is any new information since the combined licensing review, ensures that the staff recommendations or ~~positions~~ conditions formulated by the staff during the combined licensing review have been implemented.

A typical staff finding at the conclusion of the ~~combined~~ licensing review follows:

> In its review of the geological and seismological aspects of the plant, the staff has considered pertinent information gathered in support of the application for a ~~combined~~ license. The information reviewed includes data from site and near-site investigations, as well as a geological reconnaissance of the site and region, an independent review of recently published literature, and discussions with knowledgeable scientists with the USGS and other Federal agencies, the State Geological Survey, local universities, consulting firms, etc.
>
> Based on its review, the staff concludes that:
>
> (1) The results of ~~G~~geological, geophysical and seismological investigations~~,~~ and other information provided by the applicant and required by ~~the Proposed~~ Section 100.23 ~~to~~ of 10 CFR Part 100~~;~~, the staff's independent review of the data and other sources of information, ~~and~~ including a geological reconnaissance of the site and region and examination of excavations for Seismic Category I structures at the site ~~by the staff~~, provide an adequate basis to establish that no capable tectonic sources or seismogenic sources exist in the plant site area that have the potential of causing near-surface displacement or earthquakes to be centered there.
>
> (2) Based on the results of the applicant's regional and site geological, seismological, and geophysical investigations, and the staff's independent evaluation ~~(which is conducted primarily by the reviewer of Section 2.5.2 but supported by the reviewer of this section)~~, the staff concludes that all seismic sources significant to determining the SSE for the site have been identified and appropriately characterized by the applicant in accordance with ~~Draft~~ Regulatory Guide ~~DG-1032~~1.165 and SRP Section 2.5.2.

(3) Based on the applicant's geological, geophysical, and geotechnical investigations of the site vicinity and site area, the staff concludes that the site lithology, stratigraphy, geological history, structural geology, and characteristics of the subsurface soils and rocks have been properly characterized.

(4) There is no potential for the occurrence of other geological events (such as landsliding, collapse or subsidence caused by carbonate solutioning, differential settlement) that could compromise the safety of the site; or the applicant has mitigated such occurrences and has adequately supported the engineering solutions in the SAR.

(5) There is no potential for the effects of human activity, such as subsidence caused by withdrawal or injection of fluids or collapse due to mineral extraction, that compromises the safety of the site; or the applicant has taken steps to prevent such occurrences and has adequately supported these actions in the SAR.

(6) If this is a combined license review, the staff states that the conclusions stated under (1) above ~~are pending until~~ will be confirmed ~~ation by the staff, after~~ based on a detailed examination of the walls and floors of the excavations for the seismic category 1 facilities and the applicant's geological map of these exposures; and an examination by the staff of the applicant's engineering solutions to mitigate any nontectonic geological hazard.

The information reviewed for the proposed nuclear power plant is discussed in Sections 2.5.1, 2.5.2, and 2.5.3.

The staff concluded that the site is acceptable from a geological and seismological standpoint and meets the requirements of (1) 10 CFR Part 50, Appendix A (General Design Criterion 2) and (2) 10 CFR Part 100, ~~Proposed~~ Section 100.23. This conclusion is based on the following:

1. The applicant has met the requirements of:

a. Appendix A (General Design Criterion 2) of 10 CFR Part 50 with respect to protection against natural phenomena such as earthquakes, faulting, and collapse.

b. ~~Proposed~~ Section 100.23 (Geologic and Seismic Siting Factors) to 10 CFR Part 100, with respect to obtaining the geologic and seismic information necessary to determine (1) site suitability and (2) the appropriate design of the plant. In complying with this regulation the applicant also meets the staff's guidance described in ~~Draft~~ Regulatory Guide ~~DG-1032~~1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion"; Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants"; and Regulatory Guide 4.7, "General Site Suability Criteria for Nuclear Power Stations."

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

The provisions of this SRP section apply to reviews of construction permits (CP), operating licenses (OL), early site permits, and combined license (CP/OL) applications docketed pursuant to ~~the proposed~~ Section 100.23 ~~to~~ of 10 CFR Part 100.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 100, ~~Proposed~~ Section 100.23, "Geologic and Seismic Siting Factors" ~~(59 FR 52255)~~.

3. US NRC, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motions," ~~Draft~~ Regulatory Guide ~~DG-1032~~1.165.

4. US NRC, Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants."

5. US NRC, "General Site Suitability Criteria for Nuclear Power Stations," Regulatory Guide 4.7 ~~(Proposed Revision 2, DG-4004)~~.

6. US NRC, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," Regulatory Guide 1.70.

7. US NRC, "Report of Siting Policy Task Force," NUREG-0625, August 1979.

8. 10 CFR Part 52, "Early Site Permits, Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

9. R.L. Bates and J. Jackson, editors, "Glossary of Geology," Second Edition, American Geological Institute, Falls Church, Virginia, 1980.

10. S.M. Colman, K. L. Pierce, and P. W. Birkeland, "Suggested Terminology for Quaternary Dating Methods," Quaternary Research, Volume 288, pp. 314-319, 1987.

11. J.B. Savy et al., "Eastern Seismic Hazard Characterization Update," Lawrence Livermore National Laboratory, UCRL-ID-115111, June 1993.

12. US NRC, "Revised Livermore Seismic Hazard Estimates for Sixty-Nine Nuclear Power Plant Sites East of the Rocky Mountains," NUREG-1488, April 1994.

13. Electric Power Research Institute, "Probabilistic Seismic Hazard Evaluation of Nuclear Power Plant Sites in the Central and Eastern United States," Volumes I through 10, NP-4726A, 1989.

14. Electric Power Research Institute, "Guidelines for Determining Design Basis Ground Motions," EPRI Report TR-102293, Vols. 1-4, May 1993.

15. A.L. Odom and R. D. Hatcher, Jr., "A Characterization of Faults in the Appalachian Foldbelt," U.S. Nuclear Regulatory Commission, NUREG/CR-1621, 1980.

16. G.V. Cohee (Chairman) et al., "Tectonic Map of the United States," U.S. Geological Survey and American Association of Petroleum Geologists 1962.

17. GeoRef Data Base, American Geological Institute, Falls Church, Virginia.

18. American Petroleum Institute data base, accessible through RECON system.

19. RECON/Energy Data base, Department of Energy.

ATTACHMENT 12

SRP SECTION 2.5.2, REVISION 3

(VIBRATORY GROUND MOTION)

U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN 2.5.2
VIBRATORY GROUND MOTION
~~SECOND PROPOSED~~ REVISION 3

~~February 1995~~
~~Contact: A.J. Murphy~~
~~(301)415-6010~~

REVIEW RESPONSIBILITIES

Primary - Civil Engineering and Geosciences Branch (ECGB)

Secondary - None

AREAS OF REVIEW

The Civil Engineering and Geosciences Branch review covers the seismological, ~~and~~ geological, geophysical, and geotechnical investigations carried out to ~~establish~~ determine ~~the acceleration for~~ the safe shutdown earthquake ground motion (SSE) ~~and the operating basis earthquake (OBE)~~ for the site. ~~The safe shutdown earthquake is that earthquake that is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake that produces the maximum vibratory ground motion for which safety related structures, systems, and components are designed to remain functional. The operating basis earthquake is that earthquake that, considering the regional and local geology, seismology, and specific characteristics of local subsurface material, could reasonably be expected to affect the plant site during the operating life of the plant; it is that earthquake~~

~~This standard review plan is being issued in draft form to involve the public in the early stages of its development. It has not received complete staff review and does not represent an official NRC staff position.~~

~~Public comments are being solicited on this draft standard review plan, which is part of a group of drafts of regulatory guides and standard review plan sections on meeting proposed amendments to the regulations on siting nuclear power plants (59 FR 52255). Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules Review and Directives Branch, DFIPS, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Copies of comments received may be examined at the NRC Public Document Room, 2120 L Street NW., Washington, DC. Comments will be most helpful if received by May 12, 1995.~~

~~Requests for single copies of this standard review plan (which may be reproduced) will be filled while supplies last. Requests should be in writing to the U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Office of Administration, Distribution and Mail Services Section.~~

~~that produces the vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public are designed to remain functional.~~ The SSE represents the ~~potential for~~ design earthquake ground motion at the site and is the vibratory ground motion for which certain structures, systems, and components are designed to remain functional. The SSE is based upon a detailed evaluation of earthquake potential, taking into account regional and local geology, Quaternary tectonics, seismicity, and specific geotechnical characteristics of the site's subsurface material. The SSE is defined as the free-field horizontal and vertical ground response spectra at the plant site.

The principal regulation used by the staff in determining the scope and adequacy of the submitted seismologic and geologic information and attendant procedures and analyses is Section 100.23 of 10 CFR Part 100 (Ref. 1). Additional ~~guidance~~ information (regulations, regulatory guides, and reports) is provided to the staff through References 2 through ~~8~~ 9.

Guidance on seismological and geological investigations is ~~being developed~~ provided in ~~Draft~~ Regulatory Guide ~~DG-1032~~ 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion." These investigations describe the seismicity of the site region and the correlation of earthquake activity with seismic sources. Seismic sources are identified and characterized, including the rates of occurrence of earthquakes associated with each seismic source. ~~All~~ Seismic sources that have any part within 320 km (200 miles) of the site must be identified. More distant sources that have a potential for earthquakes large enough to affect the site must also be identified. Seismic sources can be capable tectonic sources or seismogenic sources; a seismotectonic province is a type of seismogenic source.

Specific areas of review include seismicity (Subsection 2.5.2.1), geologic and tectonic characteristics of the site and region (Subsection 2.5.2.2), correlation of earthquake activity with ~~geologic structure or tectonic provinces~~ seismic sources (Subsection 2.5.2.3), ~~maximum earthquake potential~~ probabilistic seismic hazard analysis (PSHA) and controlling earthquakes (Subsection 2.5.2.4), seismic wave transmission characteristics of the site (Subsection 2.5.2.5), and safe shutdown earthquake ground motion (Subsection

2.5.2.6)~~, and operating basis earthquake (Subsection 2.5.2.7)~~.

The geotechnical engineering aspects of the site and the models and methods employed in the analysis of soil and foundation response to the ground motion environment are reviewed under SRP Section 2.5.4. The results of the geosciences review are used in SRP Sections 3.7.1 and 3.7.2.

II. ACCEPTANCE CRITERIA

The applicable regulations (Refs. 1, 2, and 3) and regulatory guides (Refs. 4, 5, 6, and 9) and basic acceptance criteria pertinent to the areas of this section of the Standard Review Plan are:

1. 10 CFR Part 100, "Reactor Site Criteria" (Ref. 3). This part describes general criteria that guide the evaluation of the suitability of proposed sites for nuclear power and testing reactors.

   ~~Proposed~~ Section 100.23 ~~10 CFR Part 100~~, "Geologic and Seismic Siting Factors," ~~Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants." These criteria~~ describes the ~~kinds of~~ geologic and seismic information needed to determine site suitability and identify geologic and seismic factors required to be taken into account in the siting and design of nuclear power plants (Ref. 1).

2. 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants"; General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena" (Ref. 2). This criterion requires that safety-related portions of the structures, systems, and components important to safety ~~shall~~ be designed to withstand the effects of earthquakes, tsunamis, and seiches without loss of capability to perform their safety functions.

~~3. 10 CFR Part 100, "Reactor Site Criteria" (Ref. 3). This part describes criteria that guide the evaluation of the suitability of proposed sites for nuclear power and testing reactors.~~

4 3. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants." This guide describes programs of site investigations related to geotechnical aspects that would normally meet the needs for evaluating the safety of the site from the standpoint of the performance of foundations under anticipated loading conditions, including earthquakes. It provides general guidance and recommendations for developing site-specific investigation programs as well as specific guidance for conducting subsurface investigations, including the spacing and depth of borings as well as sampling intervals (Ref. 4).

5 4. Regulatory Guide 4.7 ~~(Proposed Revision 2, DG-4004)~~, "General Site Suitability Criteria for Nuclear Power Stations." This guide discusses the major site characteristics related to public health and safety ~~which~~ that the NRC staff considers in determining the suitability of sites for nuclear power stations (Ref. 5).

6 5. Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants." ~~This guide gives one method acceptable to the NRC staff for defining the response spectra corresponding to the expected maximum ground acceleration (Ref. 6). See also~~ Smoothed response spectra are generally used for design purposes - for example, a standard spectral shape that has been used in the past is presented in Regulatory Guide 1.60 (Ref. 6). These smoothed spectra are still acceptable when the smoothed design spectra compare favorably with site-specific response spectra derived from the ground motion estimation procedures discussed in Subsection 2.5.2.6.

6. ~~Draft~~ Regulatory Guide ~~DG-1032 (Ref. 9)~~1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," describes acceptable methodologies for determining the controlling earthquakes and SSE ground motion for nuclear power plant sites. (Ref. 9)

The principal geologic and seismic consideration for site suitability and geologic and ~~primary required investigations are described in 10 CFR Part 100, in Section IV(a) of Appendix A (Ref. 1) The acceptable procedures for determining the~~ seismic design bases are given ~~in Sections V(a) and Section~~

~~VI(a) of the appendix.~~ in ~~the proposed~~ Section 100.23 of 10 CFR Part 100. ~~Draft~~ Regulatory Guide ~~DG-1032~~ 1.165 (Ref. 9) ~~is being developed to~~ provides more detailed guidance on investigations. The seismic design bases are predicated on a reasonable, conservative determination of the SSE ~~and the OBE~~. ~~As defined in Section III of Appendix A (Ref. 1) to 10 CFR Part 100, the~~ The SSE ~~and OBE are~~ is based on consideration of the regional and local geology and seismology and on the characteristics of the subsurface materials at the site. ~~and are described in terms of the vibratory ground motion that they would produce at the site.~~ No comprehensive definitive rules can be promulgated regarding the investigations needed to establish the seismic design bases; the requirements vary from site to site.

2.5.2.1 Seismicity. ~~In~~ To meet~~ing~~ the requirements ~~of~~ ~~proposed~~ in Reference 1, this subsection is accepted when the complete historical record of earthquakes in the region is listed and when all available parameters are given for each earthquake in the historical record. The listing should include all earthquakes having Modified Mercalli Intensity (MMI) greater than or equal to IV or magnitude greater than or equal to 3.0 that have been reported ~~in all tectonic provinces~~ ~~for all seismic sources~~, any parts of which are within 320 km (200 miles) of the site. Other large earthquakes outside of this area, but which would impact the SSE, should be reported. A regional-scale map should be presented showing all listed earthquake epicenters and should be supplemented by a larger-scale map showing earthquake epicenters of ~~all known~~ events within 80 km (50 miles) of the site. The following information concerning each earthquake is required whenever it is available: epicenter coordinates, depth of focus, date, origin time, highest intensity, magnitude, seismic moment, source mechanism, source dimensions, distance from the site, and any strong-motion recordings (sources from which the information was obtained should be identified). All magnitude designations such as m_b, M_L, M_s, M_w should be identified. In the Central and Eastern United States, relatively little information is available on magnitudes for the larger historic earthquakes; hence, it may be appropriate to rely on intensity observations (descriptions of earthquake effects) or the dimensions of the area in which the event was felt to estimate magnitudes of historic events (e.g., Refs. ~~34 and 35~~ 10 and 11). In addition, any reported earthquake-induced geologic failure, such as liquefaction (including paleoseismic evidence of large prehistoric earthquakes), landsliding, landspreading, and lurching should be described completely, including the estimated level of strong motion that induced failure and the physical properties of the materials. The completeness of the earthquake history of the region is determined by comparison to published sources of information ~~(e.g., Refs. 9 through 13)~~. When conflicting descriptions of individual earthquakes are found in the published references, the staff should determine which is appropriate for licensing decisions.

2.5.2.2 Geologic and Tectonic Characteristics of Site and Region. ~~In meeting the requirements of References 1, 2, and 3, this subsection is accepted when all geologic structures within the region and tectonic activity seismic sources that are significant in determining the earthquake potential of the region are identified, or when an adequate investigation has been carried out to provide reasonable assurance that all significant tectonic structures seismic sources have been identified.~~ For the CEUS sites, when the SSE is determined using the results of the LLNL or EPRI PSHA methodology and Regulatory Guide 1.165 (Ref.9), in meeting the requirements of References 1, 2, and 3, this subsection is acceptable when adequate information is provided to demonstrate: (1) that a thorough investigation has been conducted to identify seismic sources that could be significant in estimating the seismic hazard of the region if they exist; and (2) that existing sources (in the PSHA) are consistent with the results of site and regional investigations, or the sources have been updated in accordance with Appendix E of Regulatory Guide 1.165.

For sites where LLNL or EPRI methods and database have not been used, and it is necessary to identify and characterize seismic sources in meeting the requirements of References 1, 2,and 3, this subsection is acceptable when adequate information is provided to demonstrate that all seismic sources that are significant in determining the earthquake potential of the region are identified, or that an adequate investigation has been carried out to provide reasonable assurance that there are no unidentified significant seismic sources.

Information presented in Section 2.5.1 of the applicant's safety analysis report (SAR) and information from other sources ~~(e.g., Refs. 9 and 14 through 18)~~ dealing with the current tectonic regime should be developed into a coherent, well-documented discussion to be used as the basis for characterizing the earthquake-generating potential of seismic sources. ~~the identified geologic structures~~ Specifically, each ~~tectonic province~~ seismic source, any part of which is within 320 km (200 miles) of the site, must be identified. In the CEUS the seismic sources will most likely be seismogenic sources with large regions of diffuse seismicity, each characterized by the same recurrence model (more specifically referred to as seismotectonic provinces). The staff interprets seismotectonic provinces to be regions of assumed uniform ~~earthquake potential (seismotectonic provinces)~~ seismicity (same frequency of occurrence) distinct from the seismicity of the surrounding area. The proposed seismotectonic provinces may be based on seismicity studies, differences in geologic history, differences in the current tectonic regime, or other tectonic considerations ~~etc~~.

The staff considers that the most important factors for the determination of seismic sources ~~tectonic provinces~~ include both (1) development and characteristics of the current tectonic regime of the region that is most likely reflected ~~in the neotectonics (Post Miocene or about 5~~ in the Quaternary period (approximately the last 2 million years and younger geologic history) and (2) the pattern and level of historical seismicity. Those characteristics of geologic structure, tectonic history, present and past stress regimes, and seismicity that distinguish the various seismic sources ~~tectonic provinces~~ and the particular areas within those sources ~~provinces~~ where historical earthquakes have occurred should be described. Alternative regional tectonic models derived from available literature ~~sources, including previous SARs and NRC staff Safety Evaluation Reports (SERs),~~ should be discussed. The model that best conforms to the observed data is accepted. In addition, in those areas where there are capable ~~faults~~ tectonic sources, the results of the additional investigative requirements described in ~~10 CFR Part 100, Appendix A, Section IV(a)(8) (Ref. 1),~~ SRP Section 2.5.1 must be presented. The discussion should be augmented by a regional-scale map showing the ~~tectonic provinces~~ seismic sources, earthquake epicenters, locations of geologic structures and other features that characterize the seismic sources. ~~, and the locations of any capable faults.~~

2.5.2.3 Correlation of Earthquake Activity with Seismic Sources ~~Geologic Structure or Tectonic Provinces~~. ~~In meeting~~ To meet the requirements proposed in ~~of~~ Reference 1, acceptance of this subsection is based on the development of the relationship between the history of earthquake activity and ~~the geologic structures or tectonic provinces~~ seismic sources of a region. For the CEUS sites, when the SSE is determined using LLNL or EPRI PSHA methodology and Regulatory Guide 1.165, in meeting the requirements of Reference 1, this subsection is acceptable when adequate information is provided to demonstrate: (1) that a thorough investigation has been conducted to assess the seismicity and identify seismic sources that could be significant in estimating the seismic hazard of the region if they exist; and (2) that existing sources (in the PSHA) are consistent with the results of site and regional investigations, or the sources have been updated in accordance with the Appendix E of Regulatory Guide 1.165.

For sites where LLNL or EPRI methods are not used, and it is necessary to identify and characterize seismic sources in meeting the requirements of Reference 1, this subsection is acceptable when adequate information is provided to demonstrate that all seismic sources that are significant in determining the earthquake potential of the region are identified, or that an adequate investigation has been carried out to provide reasonable assurance that there are no unidentified significant seismic sources.

The applicant's presentation is accepted when the earthquakes discussed in Subsection 2.5.2.1 of the SAR are shown to be associated with ~~either geologic structure or tectonic province~~ seismic sources. Whenever an earthquake hypocenter or concentration of earthquake hypocenters can be reasonably correlated with geologic structures, the rationale for the association should be developed considering the characteristics of the geologic structure (including geologic and geophysical data, seismicity, and the tectonic history) and the regional tectonic model. The discussion should include identification of the methods used to locate the earthquake hypocenters, an estimation of their accuracy, and a detailed account that compares and contrasts the geologic structure involved in the earthquake activity with other areas within the ~~tectonic province~~ seismotectonic province. Particular attention should be given to determining the ~~capability~~ recency and level of activity of faults with which instrumentally located earthquake hypocenters ~~are~~ may be associated. ~~The presentation should be augmented by regional maps, all of the same scale, showing the tectonic provinces, the earthquake~~

~~epicenters, and the locations of geologic structures and measurements used to define provinces.~~ Acceptance of the proposed ~~tectonic provinces~~ seismic sources (those identified by the investigations) is based on the staff's independent review of the geologic and seismic information presented by the applicant and available in the scientific literature.

<u>2.5.2.4 ~~Maximum Earthquake Potential~~ Probabilistic Seismic Hazard Analysis (PSHA) and Controlling Earthquakes (CE)</u>. ~~In meeting the requirements of Reference 1, this subsection is accepted when the vibratory ground motion due to the maximum credible earthquake associated with each geologic structure or the maximum historic earthquake associated with each tectonic province has been assessed and when the earthquake that would produce the maximum vibratory ground motion at the site has been determined. The maximum credible earthquake is the largest earthquake that can reasonably be expected to occur on a geologic structure in the current tectonic regime. Geologic or seismological evidence may warrant a maximum earthquake larger than the maximum historic earthquake. Earthquakes associated with each geologic structure or tectonic province must be identified. Where an earthquake is associated with a geologic structure, the maximum credible earthquake that could occur on that structure should be evaluated, taking into account significant factors, for example, the type of the faulting, fault length, fault slip rate, rupture length, rupture area, moment, and earthquake history (e.g., Refs. 19 through 22).~~

~~In order to determine the maximum credible earthquake that could occur on those faults that are shown or assumed to be capable, the staff accepts conservative values based on historic experience in the region and specific considerations of the earthquake history and geologic history of movement on the faults. Where the earthquakes are associated with a tectonic province, the largest historic earthquake within the province should be identified. Isoseismal maps should also be presented for the most significant earthquakes. The ground motion at the site should be evaluated assuming appropriate seismic energy transmission effects and assuming that the maximum earthquake associated with each geologic structure or with each tectonic province occurs at the point of closest approach of the structure or province to the site. (Further description is provided in Subsection 2.5.2.6.)~~

~~The earthquake(s) that would produce the most severe vibratory ground motion at the site should be defined. If different potential earthquakes would produce the most severe ground motion in different frequency bands, these earthquakes should be specified. The description of the potential earthquake(s) is to include the maximum intensity or magnitude and the distance from the assumed location of the potential earthquake(s) to the site. The staff independently evaluates the site ground motion produced by the largest earthquake associated with each geologic structure or tectonic province.~~

~~Acceptance of the description of the potential that would produce the largest ground motion at the site is based on the staff's independent analysis.~~

For the CEUS sites relying on LLNL or EPRI methods and databases, the staff will review the applicant's probabilistic seismic hazard analysis, including the underlying assumptions and how the results of the site investigations ~~and findings of Sections 2.5.2.2 and 2.5.2.3~~ are used to update the existing sources in the probabilistic seismic hazard analysis, how they are used to develop additional sources, or how they are used to develop a new data base.

The staff will review the controlling earthquakes and associated ground motions at the site derived from the applicant's probabilistic hazard analysis to be sure that they are either consistent with the controlling earthquakes/ground motions used in licensing of (a) other licensed facilities at the site, (b) nearby plants, or (c) plants licensed in similar seismogenic regions, or the reasons they are not consistent are understood. For the CEUS, a comparison of the PSHA results can be made with the information included as Table 1, which is a very general representation based on technical information developed over the past two decades of licensing nuclear power plants.

The applicant's probabilistic analysis, including the derivation of controlling earthquakes, is considered acceptable if it follows the procedures ~~proposed~~ in ~~DG-1032~~ Regulatory Guide 1.165 and its Appendix C (Ref. 9) . The incorporation of results of site investigations into the probabilistic analysis is considered acceptable if it follows the procedure outlined in Appendix E of ~~DG-1032~~ Regulatory Guide 1.165 and is consistent with the review findings of Sections 2.5.2.2 and 2.5.2.3.

For the sites not using LLNL or EPRI methods and databases, the staff will review the applicant's PSHA or other methods used to derive controlling earthquakes. The staff will particularly review the approaches used to address uncertainties. The staff will perform an independent evaluation of the earthquake potential associated with each seismic source that could affect the site. The staff will evaluate the applicant's controlling earthquakes based on historical and paleo-seismicity. In this evaluation, the controlling earthquakes for each source are at least as large as the maximum historic earthquake associated with the source.

TABLE 1

Controlling Earthquakes

SEISMIC SOURCE	LLNL Magnitude	LLNL Distance (KM)	EPRI Magnitude	EPRI Distance (KM)
Northern New England	5.6 - 5.7	15	5.7 - 5.8	18
Piedmont - New England	5.5 - 5.7	14	5.7	19
Southern Valley and Ridge	5.6 - 5.7	14	5.4 - 5.7	18, 19
Atlantic Coastal Plain	5.5 - 5.6	15-16	5.4 - 5.5	19, 21
Gulf Coast	5.3	16-18	5.3	23, 39
Central Stable Region	5.4 - 5.5	15-20	5.3 - 5.5	19, 20 21, 30
Charleston	7.5 Ms	Site-Specific		
New Madrid	8.5 Ms	Site-Specific		

2.5.2.5 Seismic Wave Transmission Characteristics of the Site. In the PSHA procedure described in ~~DG-1032~~ Regulatory Guide 1.165 (Ref. 9), the controlling earthquakes are determined for actual or hypothetical rock conditions. The site amplification studies are performed in a distinct separate step as a part of the determination of the SSE. In this section the applicant's site amplification studies are reviewed in conjunction with the geotechnical and structural engineering reviews.

~~In meeting the requirements of Reference 1, this subsection is accepted when~~ To be acceptable, the seismic wave transmission characteristics (amplification or deamplification) of the materials overlying bedrock at the site are described as a function of the significant frequencies (Ref.12). The following material properties should be determined for each stratum under the site: thickness, seismic compressional and shear wave velocities, bulk densities, soil index properties and classification, shear modulus and damping variations with strain level, and water table elevation and its variation (Ref. 13). In each case, methods used to determine the properties should be described in Subsection 2.5.4 of the SAR and cross-referenced in this subsection. ~~For the maximum earthquake determined in Subsection 2.5.2.4, the free field ground motion (including significant frequencies) must be determined, and an analysis should be performed to determine the site effects on different seismic wave types in the significant frequency bands. If appropriate, the analysis should consider the effects of site conditions and material property variations upon wave propagation and frequency content.~~

~~The free field ground motion (also referred to as control motion) should be defined to be on a ground surface and should be based on data obtained in the free field. Two cases are identified, depending on the soil characteristics at the site and subject to availability of appropriate recorded ground motion data. When data are available, for example, for relatively uniform sites of soil or rock with smooth variation of properties with depth, the control point (location at which the control motion is applied) should be specified on the soil surface at the top of the finished grade. The free field ground motion or control motion should be consistent with the properties of the soil profile. For sites composed of one or more thin soil layers overlying a competent material, or in case of insufficient recorded ground motion data, the control point is specified on an outcrop or a hypothetical outcrop at a location on the top of the competent material. The control motion specified should be consistent with the properties of the competent material.~~

Where vertically propagating shear waves may produce the maximum ground motion, a one-dimensional equivalent-linear analysis (e.g., Ref. ~~23 or 24~~ 14 or 15) or nonlinear analysis (e.g., Refs. ~~25, 26, and 27~~ 16, 17, or 18) may be appropriate and is reviewed in conjunction with geotechnical and structural engineering. Where horizontally propagating shear waves, compressional waves, or surface waves may produce the maximum ground motion, other methods of analysis (e.g., Refs. ~~28 and 29~~ 19 and 20) may be more appropriate. However, since some of the variables are not well defined and the techniques are still in the developmental stage, no generally agreed-upon procedures can be promulgated 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 available.

2.5.2.6 Safe Shutdown Earthquake Ground Motion. ~~In meeting the requirements of Reference 1, this subsection is accepted when the vibratory ground motion specified for the SSE is described in terms of the free field response spectrum and is at least as conservative as that which would result at the site from the maximum earthquake determined in Subsection 2.5.2.4, considering the site transmission effects determined in Subsection 2.5.2.5. If several different maximum potential earthquakes produce the largest ground motions in different frequency bands (as noted in Subsection 2.5.2.4), the vibratory ground motion specified for the SSE must be as conservative in each frequency band as that for each earthquake.~~

In this subsection, the staff reviews the applicant's procedure to determine the SSE, including the procedure used to derive spectral shape from the controlling earthquakes as described in Reference 9.

As a part of the review to judge the adequacy of the SSE proposed by the applicant, the staff performs an independent evaluation of ground motion estimates, as required. ~~In these independent estimates, the staff may consider effects on ground motion from the controlling earthquakes discussed in Subsection 2.5.2.4 by assuming the controlling earthquake for each seismic source (geological structures or seismotectonic provinces) to be at its closest approach to the site.~~

~~The staff reviews the free field response spectra of engineering significance (at appropriate damping values). Ground motion may vary for different founda-~~

~~tion conditions at the site. When the site effects are significant, this review is made in conjunction with the review of the design response spectra in Section 3.7.1 to ensure consistency with the free field motion. The staff normally evaluates response spectra on a case by case basis. The staff considers compliance with the following conditions acceptable in the evaluation of the SSE. In all these procedures, the proposed free field response spectra shall be considered acceptable if they equal or exceed the estimated 84th percentile ground motion spectra from the maximum or controlling earthquake described in Subsection 2.5.2.4.~~

The following procedures (in descending order of preference) should be used to develop the site-specific spectral shapes for controlling earthquakes. ~~The staff will also use t~~These procedures are also used to make ~~its independent~~ ground motion estimates when the probabilistic methods are not used. In the following procedures, 84th percentile response spectra are used for both spectral shape as well as ground motion estimates.

~~The following steps summarize the staff review of the SSE.~~

1. Both horizontal and vertical component site-specific response spectra should be developed statistically from response spectra of recorded strong motion records that are selected to have similar source, propagation path, and recording site properties as the controlling earthquakes. It must be ensured that the recorded motions represent free-field conditions and are free of or corrected for any soil-structure interaction effects that may be present because of locations ~~and/~~or housing of recording instruments. Important source properties include magnitude and, if possible, fault type~~,~~ and tectonic environment. Propagation path properties include distance, depth, and attenuation. Relevant site properties include shear velocity profile and other factors that affect the amplitude of waves at different frequencies. A sufficiently large number of site-specific time-histories or response spectra or both should be used to obtain an adequate~~ly~~ broadband spectrum to encompass the uncertainties in these parameters. An 84th percentile response spectrum for the records should be presented for each damping value of interest. ~~and compared to the SSE free field and design response spectrum~~ (e.g., Refs. ~~30, 31, 32, and 33~~

21, 22, 23, and 24). The staff considers direct estimates of spectral ordinates preferable to scaling of spectra to peak accelerations. ~~In the Eastern United States, relatively little information is available on magnitudes for the larger historic earthquakes; hence, it may be appropriate to rely on intensity observations (descriptions of earthquake effects) to estimate magnitudes of historic events (e.g., Refs. 34 and 35).~~ If the data for site-specific response spectra were not obtained under geologic conditions similar to those at the site, corrections for site effects should be included in the development of the site-specific spectra.

2. Where a large enough ensemble of strong-motion records is not available, response spectra may be approximated by scaling that ensemble of strong-motion data that represent the best estimate of source, propagation path, and site properties (e.g., Ref. ~~36~~ 25). Sensitivity studies should show the effects of scaling.

3. If strong-motion records are not available, site-specific peak ground acceleration, velocity, and displacement (if necessary) should be determined for appropriate magnitude, distance, and foundation conditions. Then response spectra may be determined by scaling the acceleration, velocity, and displacement values by appropriate amplification factors (e.g., Ref. ~~37~~ 26). ~~Where only estimates of peak ground acceleration are available, it is acceptable to select a peak acceleration and use this peak acceleration as the high frequency asymptote to standardized response spectra such as described in Regulatory Guide 1.60 (Ref. 6) for both the horizontal and vertical components of motion with the appropriate amplification factors.~~ For each controlling earthquake, the peak ground motions should be determined using current relations between acceleration, velocity, and, if necessary, displacement, earthquake size (magnitude or intensity), and source distance. Peak ground motion should be determined from state-of-the-art relationships. Relationships between magnitude and ground motion are found, for example, in References 12 and 27. ~~Due to~~ Because of the limited data for high intensities greater than Modified Mercalli Intensity (MMI) VIII, the available empirical relationships between intensity and peak ground motion may not be suitable for determining the appropriate reference

acceleration for seismic design.

4. ~~Response~~ Spectra developed by theoretical-empirical modeling of ground motion may be used to supplement site-specific spectra if the input parameters and the appropriateness of the model are thoroughly documented (e.g., Refs. ~~19, 44, 45, and 46~~ 12, 27, and 28). Modeling is particularly useful for sites near ~~capable faults~~ ~~tectonic~~ seismic sources ~~or for deeper structures~~ that may experience ground motion that is different in terms of frequency content and wave type from ground motion caused by more distant earthquakes.

~~5. Probabilistic estimates of seismic hazard should be calculated (e.g., Refs. 41 and 47) and the underlying assumptions and associated uncertainties should be documented to assist in the staff's overall deterministic approach. The probabilistic studies should highlight which seismic sources are significant to the site. Uniform hazard spectra (spectra that have a uniform probability of exceedance over the frequency range of interest) showing uncertainty should be calculated for 0.01, 0.001, and 0.0001 annual probabilities of exceedance at the site. The probability of exceeding the SSE response spectra should also be estimated and comparison of results made with other probabilistic studies.~~

The SSE ground motion response spectra proposed by the applicant are considered acceptable if they meet Regulatory Position 4 and Appendix F of Reference 9. If the independent staff estimates of ground motion are significantly different than those proposed by the applicant, the staff will review the reasons for differences and resolve them as appropriate.

The time duration and number of cycles of strong ground motion are required for analysis ~~of site foundation liquefaction potential~~ and ~~for~~ design of many plant components. The adequacy of the time history for structural analysis is reviewed under SRP Section 3.7.1. The time history is reviewed in this SRP section to confirm that it is compatible with the seismological and geological conditions in the site vicinity and with the accepted SSE model. At present, models for ~~deterministically~~ computing the time history of strong ground motion from a given source-site configuration ~~may be~~ are limited. ~~It is~~

~~therefore acceptable to use an ensemble of ground motion time histories from earthquakes with similar size, site source characteristics, and spectral characteristics or results of a statistical analysis of such an ensemble.~~ Total duration of the motion is acceptable when it is as conservative as values determined using current studies such as References ~~48, 49, 50, and 51~~ 29, 30, 31, and 32.

For evaluation of the liquefaction potential at the site, the time duration and number of cycles of strong ground motion are ~~more~~ critical parameters and require additional consideration. If the controlling earthquakes for the site have magnitudes of less than 6, the time history selected for the evaluation of liquefaction potential must have duration and number of strong motion cycles corresponding to at least an event of magnitude 6.

~~2.5.2. Operating Basis Earthquake. In meeting the requirements of Reference 1, this subsection is acceptable when the vibratory ground motion for the OBE is described and the response spectrum (at appropriate damping values) at the site specified. Probability calculations (e.g., Refs. 41, 47, and 52) should be used to estimate the probability of exceeding the OBE during the operating life of the plant. The maximum vibratory ground motion of the OBE should be at least one half the maximum vibratory ground motion of the SSE unless a lower OBE can be justified on the basis of probability calculations. It has been staff practice to accept the OBE if the return period is on the order of hundreds of years (e.g., Ref. 31).~~

III. REVIEW PROCEDURES

Upon receiving the applicant's SAR, an acceptance review is conducted to determine compliance with the ~~proposed~~ investigative requirements of 10 CFR Part 100, Section 100.23 ~~Appendix A~~ (Ref. 1). The reviewer also identifies any site-specific problems, the resolution of which could result in extended delays in completing the review.

After SAR acceptance and docketing, ~~those areas are identified where~~ the reviewer identifies areas that need additional information ~~is required~~ to support the review of the applicant's seismic design ~~determine the earthquake hazard~~. These are transmitted to the applicant as ~~draft~~ requests for additional information.

A site visit may be conducted, during which the reviewer inspects the geologic conditions at the site and the region around the site as shown in outcrops, borings, geophysical data, trenches, and those geologic conditions exposed during construction ~~if the review is for an operating license~~. The reviewer also discusses the questions with the applicant and his consultants so that it is clearly understood what additional information is required by the staff to continue the review. ~~Following the site visit, a revised set of requests for additional information, including any additional questions that may have been developed during the site visit, is formally transmitted to the applicant.~~

The reviewer evaluates the applicant's response to the questions, prepares requests for any additional ~~clarifying~~ information, and formulates positions that may agree or disagree with those of the applicant. These are formally transmitted to the applicant.

The Safety Analysis Report and amendments responding to the requests for additional information are reviewed to determine that the information presented by the applicant is acceptable according to the criteria described in Section II (Acceptance Criteria) above. Based on information supplied by the applicant and information obtained from site visits, ~~or from~~ staff consultants, or literature sources, the reviewer independently identifies and evaluates the relevant ~~seismotectonic provinces~~ seismic sources, including their ~~evaluates the~~ capability ~~of faults in the region~~, and determines the earthquake potential for each ~~province and each capable fault or tectonic structure~~ using procedures noted in Section II (Acceptance Criteria) above. The reviewer evaluates the vibratory ground motion that the ~~potential earthquakes~~ controlling earthquakes could produce at the site and ~~defines~~ compares that ground motion to the SSE used for design. ~~safe shutdown earthquake and operating basis earthquake~~.

IV. <u>EVALUATION FINDINGS</u>

~~If the evaluation by the staff,~~ On completion of the review of the geologic and seismologic aspects of the plant site, if the evaluation by the staff confirms that the applicant has met the requirements or guidance of applicable portions of References 1 through 6 and 9, the conclusion in the SER states that the information provided and investigations performed support the applicant's conclusions regarding the seismic ~~integrity~~ characterization of the subject nuclear power plant site. In addition to the conclusion, this section of the SER includes an evaluation of (1) ~~definitions of tectonic provinces~~ seismic sources, (2) ~~evaluations of~~ the capability of geologic structures in the region, (3) ~~determinations of the SSE earthquake(s) and~~ controlling earthquakes and associated free-field response spectra ~~based on evaluation of the potential earthquakes~~, (4) the SSE, and (~~5~~ 4) the time history of strong ground motion~~, and (5) determinations of the OBE free field response spectra~~. Staff reservations about any significant deficiency presented in the applicant's SAR are stated in sufficient detail to make clear the precise nature of the concern. In addition, the staff will also note the results of its independent analyses, if performed, and discuss how these results were used in the safety evaluation. The above evaluations ~~determinations or redeterminations~~ are made by the staff during ~~both~~ the construction permit (CP), ~~and~~ operating license (OL), combined license (COL), or early site permit phases of review as appropriate.

OL and combined license applications are reviewed for any new information developed subsequent to the CP ~~safety evaluation report~~ SER or the early site evaluation. The review will also determine whether the ~~CP~~ recommendations made following the CP or early site review have been implemented.

A typical combined license or OL-stage summary finding for this section of the SER follows:

> In our review of the seismologic aspects of the plant site, we have considered pertinent information gathered since our initial seismologic review ~~which~~ that was made in conjunction with an early site review or the issuance of the Construction Permit. This new information includes data gained from both site and near-site investigations as well as from a review of recently published literature.

As a result of our recent review of the seismologic information, we have determined that our earlier conclusion regarding the safety of the plant from a seismological standpoint remains valid. These conclusions can be summarized as follows:

1. Seismologic information provided by the applicant and required by ~~Appendix A~~ Section 100.23 ~~to~~ of 10 CFR Part 100 provides an adequate basis to establish that no ~~capable faults~~ seismic sources exist in the plant site area ~~which~~ that would cause earthquakes to be centered there.

2. The response spectrum proposed for the safe shutdown earthquake is the appropriate free-field response spectrum in conformance with ~~Appendix A~~ Section 100.23 of ~~to~~ 10 CFR Part 100.

The new information reviewed for the proposed nuclear power plant is discussed in Safety Evaluation Report Section 2.5.2.

The staff concludes that the site is acceptable from a seismologic standpoint and meets the requirements of (1) 10 CFR Part 50, Appendix A (General Design Criterion 2), (2) 10 CFR Part 100, and (3) 10 CFR Part 100, ~~Appendix A~~ Section 100.23. This conclusion is based on the following:

1. The applicant has met the requirements of:

   a. 10 CFR Part 50, Appendix A, General Design Criterion 2 with respect to protection against natural phenomena such as faulting.

   b. 10 CFR Part 100, Reactor Site Criteria, with respect to the identification of geologic and seismic information used in determining the suitability of the site.

   c. 10 CFR Part 100, ~~Appendix A (Seismic and Geologic Siting Criteria for Nuclear Power Plants)~~ Section 100.23 (Ref. 1) with respect to obtaining the geologic and seismic information necessary to determine (1) site suitability and (2) the appropriate design of the plant. Guidance for complying with this regulation is contained in Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" (Ref. 4); ~~Draft~~ Regulatory Guide ~~DG-1032~~ 1.165, "Identification and Characterization of Seismic Sources and Safe Shutdown Earthquake Ground Motion" (Ref. 9); and Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations" ~~(Proposed Revision 2)~~ (Ref. 5)~~; and Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants" (Ref. 6)~~.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant or licensee proposes an acceptable alternative method for complying with specific portions of the Commission's regulations, the methods described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREGs (Refs. 4 through ~~8~~ 9).

The provisions of this SRP section apply to reviews of construction permits (CP), operating licenses (OL), early site permits, ~~preliminary design approval (PDA), final design approval (FDA),~~ and combined license (CP/OL) applications docketed pursuant to ~~the proposed~~ Section 100.23 to 10 CFR Part 100. ~~after the date of issuance of this SRP section.~~

VI. REFERENCES

1. 10 CFR Part 100, ~~Proposed~~ Section 100.23, "Geologic and Seismic Siting Factors," ~~Appendix A, "Seismic and Geologic Siting Criteria~~

~~for Nuclear Power Plants."~~

2. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

3. 10 CFR Part 100, "Reactor Site Criteria."

4. USNRC, "Site Investigations for Foundations of Nuclear Power Plants," Regulatory Guide 1.132.

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ATTACHMENT 13

SRP SECTION 2.5.3, REVISION 3

(SURFACE FAULTING)

U.S.NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN 2.5.3 ~~February 1995~~
SURFACE FAULTING ~~Contact: A.J. Murphy~~
~~PROPOSED~~ REVISION 3 ~~(301)415-6010~~

REVIEW RESPONSIBILITIES

Primary - Civil Engineering and Geosciences Branch (ECGB)

Secondary - None

I. AREAS OF REVIEW

ECGB reviews information in the applicant's Safety Analysis Report (SAR) or Early Site Evaluation Report (ESR) that addresses the existence of a potential for surface deformation that could affect the site. The technical information presented in this section of the SAR or ESR results largely from detailed surface and subsurface geological, seismological, and geophysical investigations performed in progressively greater detail within each of the areas described ny radii of ~~the site subregion ([~~40 km ~~or~~ (25 mi), ~~from the site)]~~, ~~site vicinity ([~~8 km ~~or~~(5 mi), and ~~in the site area ([within~~ 1 km ~~or~~(0.6 mi) ~~of~~ around the site~~)]~~. The following specific subjects are addressed: the geological, seismological, and geophysical investigations~~structural and stratigraphic conditions of the site subregion, site vicinity, and site area~~ (subsection 2.5.3.1), geological evidence, or absence of evidence for surface deformation~~any evidence of fault offset, including near surface folding, uplift, or subsidence that reflects faulting~~

~~at depth, or evidence demonstrating the absence of faulting within these areas~~ (subsection 2.5.3.2), correlation of earthquakes with capable tectonic sources ~~earthquakes associated with tectonic structures within these areas~~ (subsection 2.5.3.3), areas of most recent deformations~~determination of the age of most recent movement on faults or other near surface tectonic deformation~~ (subsection 2.5.3.4), relationship of tectonic structures in the site area to regional tectonic structures~~determination of structural relationships of site area faults to regional faults~~ (subsection 2.5.3.5), ~~identification and~~ characterization of capable tectonic sources (subsection 2.5.3.6), designations of zones of Quaternary deformation in the site region~~that require detailed fault investigations~~ (subsection 2.5.3.7), and ~~results of studies in zones requiring~~ the potential for surface tectonic deformation at the site ~~identified during the detailed Quaternary faulting investigations~~ (subsection 2.5.3.8).

References 1 through ~~8~~7 (regulations and regulatory guides) provide guidance to the ECGB reviewers in evaluating potential nuclear power plant sites. The principal regulation that will be used by ECGB ~~in the future~~ to determine the scope and adequacy of the submitted geological, seismological, and geophysical information is ~~Proposed~~ Section 100.23, "Geologic and Seismic Siting Factors," 10 CFR Part 100 (Ref. 2). Specific guidance for implementing this ~~proposed~~ regulation can be found in ~~Draft~~ Regulatory Guide ~~DG-1032~~ 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion" (Ref. 3). Guidance regarding the geotechnical engineering aspects is found in Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" (Ref. 4). Additional guidance is provided to the ECGB reviewers through information published in the scientific literature. As the state of the art regarding the geosciences

~~This standard review plan is being issued in draft form to involve the public in the early stages of its development. It has not received complete staff review and does not represent an official NRC staff position.~~

~~Public comments are being solicited on this draft standard review plan, which is part of a group of drafts of regulatory guides and standard review plan sections on meeting proposed amendments to the regulations on siting nuclear power plants (59 FR 52255). Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules Review and Directives Branch, DFIPS, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Copies of comments received may be examined at the NRC Public Document Room, 2120 L Street NW., Washington, DC. Comments will be most helpful if received by May 12, 1995.~~

~~Requests for single copies of this standard review plan (which may be reproduced) will be filled while supplies last. Requests should be in writing to the U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Office of Administration, Distribution and Mail Services Section.~~

is advancing rapidly, it is the responsibility of the reviewers to stay abreast of changes by reviewing the current scientific literature on a regular basis and attending professional meetings.

II. ACCEPTANCE CRITERIA

ECGB acceptance criteria are based on meeting the requirements of the following regulations:

1. Appendix A, "General Design Criteria for Nuclear Power Plants", General Design Criterion 2 - "Design Bases for Protection Against Natural Phenomena, 10 CFR Part 50." This criterion requires that safety-related portions of the structures, systems, and components important to safety be designed to withstand the effects of earthquakes, tsunami, and seiches without loss of capability to perform their safety functions (Ref. 1).

2. 10 CFR Part 100 ~~Proposed~~ Section 100.23, "Geologic and Seismic Siting Factors." These ~~proposed~~ requirements describe the general nature of the geological, seismological, and geophysical data necessary to determine the site suitability (Ref. 2).

   The following regulatory guides provide information, recommendations, and guidance and in general describe bases acceptable to the staff for implementing the requirements of General Design Criterion 2, Part 100, and ~~Proposed~~ Section 100.23 of Part 100.

   a. ~~Draft~~ Regulatory Guide ~~DG-1032~~1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion." This ~~draft~~ guide and its appendices ~~are being developed to~~ describe geological, seismological, and geophysical investigations to determine site suitability; methods to identify and characterize potential seismic sources; acceptable methods to conduct probability seismic hazard analyses; and methods to determine the Safe Shutdown Earthquake ground motion (SSE) (Ref. 3).

b. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants." This guide describes programs of site investigations related to geotechnical aspects that would normally meet the needs for evaluating the safety of the site from the standpoint of the performance of foundations and earthworks under anticipated loading conditions, including earthquakes. It provides general guidance and recommendations for developing site-specific investigation programs as well as specific guidance for conducting subsurface investigations such as borings, sampling, and geophysical explorations (Ref. 4).

c. Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations." This guide discusses the major site characteristics related to public health and safety that the NRC staff considers in determining the suitability of sites for nuclear power stations (Ref. 5, also see Ref. 6).

The data and analyses presented in the SAR or ESR are acceptable if, as a minimum, they describe and document the information proposed to be required by Reference 2, show that the methods described in Reference 3 or comparable methods were employed, and conform to the format suggested in Reference 7. References 8 and 9 have been used by the staff in past licensing activities as relevant guides to judge whether or not all of the current pertinent references have been consulted. References 10 through 17 are also used by the staff.

Specific criteria necessary to meet the relevant requirements of the Commission regulations identified above are described in the following paragraphs. If the information that satisfies these criteria is presented in other sections of Chapter 2.5, it may be cross-referenced and not repeated in this section.

Subsection 2.5.3.1 Geological, Seismological, and Geophysical Investigations. In meeting the requirements of References 1 and 2 and the positions of References 3 and 4, this subsection is considered acceptable if the discussions of the Quaternary tectonics, structural geology, stratigraphy, geochronological methods used, paleoseismology, and geological history of the site are complete, compare well with studies conducted by others in the same area, and are supported by detailed investigations performed by the applicant. For coastal and inland sites near large bodies of water, similar detailed investigations are to be conducted, and the information is to be provided in the SAR or ESR regarding offshore geology and seismology as well as onshore. In some instances it may be possible to identify an onshore projection of the offshore fault or fold of concern, or a tectonic structure that is analogous to it at an onshore location. It is acceptable to the staff, along with other investigations of the specific feature, to investigate the more remote, accessible exposure to learn the nature of the potentially hazardous offshore or buried fault and apply it to the local structure (Refs. 3 and 18). Site and regional maps (Ref. 3) and profiles constructed at scales adequate to illustrate clearly the surficial and bedrock geology, structural geology, topography, and the relationship of the safety-related foundations of the nuclear power plant to these features should have been included in the SAR or ESR.

Subsection 2.5.3.2 Geological Evidence, or Absence of Evidence for Surface Deformation. In meeting the requirements of References 1, 2, and 3, this subsection is acceptable if sufficient surface and subsurface information is provided and supported by detailed investigations, either to confirm the absence of surface tectonic deformation (i.e., faulting) or, if present, to demonstrate the age of its most recent displacement and ages of previous displacements. If tectonic deformation is present in the site vicinity, it must be defined as to geometry, amount and sense of displacement, recurrence rate, and age of latest movement. In addition to geological evidence that may indicate faulting, linear features interpreted from topographic maps, low and high altitude aerial photographs, satellite imagery, and other imagery should be documented and investigated. In order to expedite the review process, an identification list, index, and duplicates of the remote sensing data used in the linear features study should be provided to and reviewed by the staff. Evidence for the absence of tectonic deformation is obtained by the applicant conducting site surface (geological reconnaissance and mapping, etc.) and subsurface investigations (geophysical, core borings, trenching and logging, etc.) in such detail and areal extent to ensure that undetected offsets or other deformations are not likely to exist.

In the Central and Eastern United States (CEUS), except for the New Madrid Seismic Zone, the Meers fault, ~~and possibly the Harlan County fault of Nebraska~~ and the Cheraw fault of the Colorado piedmont, earthquake generating faults either do not extend to ground surface or there is insufficient overlying soil or rock of known or of a sufficient age to date those that do.

In tectonically active regions such as the Western United States (WUS), many capable tectonic sources are exposed at ground surface and can be characterized as to their seismic potential. However, in these regions many other capable tectonic sources are buried (blind faults), and may be expressed at the surface or near surface by folding, uplift, or subsidence (including faults related to subduction zones). Investigations in these regions should take these phenomena into account. The nature of geological, seismological, and geophysical investigations will vary in detail and extent according to the geological complexity of the specific site.

Subsection 2.5.3.3 Correlation of Earthquakes with Capable Tectonic Sources. In meeting the requirements of References 1 and 2, this subsection is acceptable if all historically reported earthquakes within 40 km (25 mi) of the site are evaluated with respect to hypocenter accuracy and source origin, and if all capable tectonic sources that could, based on their orientations, extend to ~~that trend~~ within 8 km (5 mi) of the site are evaluated with respect to their potential for causing surface deformation. In conjunction with these discussions, a plot of the earthquake epicenters superimposed on a map showing the local capable tectonic sources should have been ~~shown~~ provided.

Subsection 2.5.3.4 Ages of Most Recent Deformations. In meeting the requirements of References 1 and 2, this subsection is acceptable when every fault, or fold associated with a blind fault, any part of which is within 8 km (5 mi) of the site, is investigated in sufficient detail using geological and geophysical techniques of sufficient sensitivity to demonstrate, or allow relatively accurate estimates of the age of most recent movement and identify geological evidence for previous displacements if it exists (Ref. 3). An evaluation of the sensitivity and resolution of the exploratory techniques used should be given.

Subsection 2.5.3.5 Relationship of Tectonic Structures in the Site Area to Regional Tectonic Structures. In meeting the requirements of References 1 and 2, this subsection is satisfied by a discussion of the structural and genetic relationship between site area faulting or other tectonic deformation and the regional tectonic framework. In regions of active tectonism it may be necessary to conduct detailed geological and geophysical investigations to assess possible structural relationships of site area faults to regional faults known to be seismically active.

Subsection 2.5.3.6 Characterization of Capable Tectonic Sources. In meeting the requirements of References 1 and 2, this subsection is acceptable when it has been demonstrated that the investigative techniques used have sufficient sensitivity to identify all potential capable tectonic sources such as faults, or folds associated with blind faults, within 8 km (5 mi) of the site and when the geometry, length, sense of movement, amount of total offset, amount of offset per event, age of latest and any previous displacements, and limits of the zone are given for each capable tectonic source. Investigations are to extend at least 8 km (5 mi) beyond all plant sites boundaries, including those adjacent to large bodies of water such as oceans, rivers, and lakes.

Subsection 2.5.3.7 Designation of Zones of Quaternary Deformation in the Site Region. In meeting the requirements of Reference 2, this subsection is judged acceptable if the zone designated by the applicant as requiring detailed faulting investigation is of sufficient length and breadth to include all Quaternary deformation significant to the site (Ref. 3).

Subsection 2.5.3.8 Potential for Surface Tectonic Deformation at the Site. In meeting the requirements of References 1 and 2, this subsection must be presented by the applicant if the aforementioned investigations reveal that surface displacement must be taken into account. If there is a potential for tectonically induced surface displacement at the site, it would be prudent of the applicant to abandon the site. No commercial nuclear power plant has been constructed on a known capable fault (capable tectonic source) and it is an open question as to whether it is feasible to design for tectonic surface or near-surface displacement with confidence that the integrity of the safety-related features of the plant would remain intact should displacement occur. It is, therefore, staff policy to recommend relocation of plant sites found to be located on capable faults (capable tectonic sources) as determined by the detailed faulting investigations. If in the future it becomes feasible to design for surface faulting, it will be necessary to present the design basis for surface faulting and supporting data in considerable detail.

III. REVIEW PROCEDURES

The three-phase review procedure described in Section 2.5.1 should be applied to assessing the potential for surface faulting. The first phase consists of an acceptance review to determine the completeness of the ESR or SAR by comparing the contents with the Criteria described in Part II, Acceptance Criteria, of this section. The second phase consists of a detailed review of the applicant's data and other independently derived information, which may result in requests for additional information. The third phase is a final review to resolve open issues and prepare a Safety Evaluation Report (SER).

The staff review procedure involves an evaluation to determine that the applicant has performed adequate investigations to fulfill the general requirements of Reference 2. Acceptable methods are described in Reference 3. Consultants or advisors may be called on to assist the staff in reviewing this section of the ESR or SAR on a case-by-case basis. On request, the advisor or consultant provides expertise in numerous earth science disciplines and occasionally is able to provide first-hand knowledge of the site. A literature search is conducted independently by the staff concerning the regional and local geology and seismology. The staff also utilizes the expertise of the U.S. Geological Survey and other Federal agencies, State geological surveys, universities, and private industry to obtain additional, up-to-date geosciences information regarding Quaternary tectonics at the site.

~~The Proposed~~ Section 100.23 of 10 CFR Part 100 ~~would~~ requires that applicants investigate the potential for near-surface deformation, both tectonically induced and that induced by other phenomena (Ref. 2). The steps that applicants may follow in determining the presence and extent of deformation and whether near-surface deformation (if present) represents a hazard are in ~~Draft~~ Regulatory Guide ~~DG-1032~~ 1.165, Appendix D (Ref 3). The site vicinity ~~(~~[8 km ~~-~~(5 mi) from the site~~)~~] and site area ~~(~~[1 km ~~-~~(0.6 mi) from the site~~)~~] must be investigated by a combination of exploratory methods that should include borings, trenching, seismic profiling and other geophysical methods, geological mapping, and seismic instrumentation. The results of these explorations are cross-compared with other available data and evaluated by the staff. An important part of the staff's review effort is to compare the new information derived from these investigations or other sources with the specific data base used in the probabilistic seismic hazard analysis (PSHA) for the site (Ref. 3).

It has been the policy of the staff to encourage applicants to avoid areas that have a possibility for near-surface tectonic deformation. As the question of whether or not a surface tectonic deformation condition exists is ~~so~~ critical in determining site suitability, this consideration is usually addressed very early in the review. The exceptions are cases in which a previously unknown fault is revealed in excavations during construction or is discovered during the course of other investigations in the area. The staff should require early ~~on~~ in the review that it be notified by the applicant when the excavations for Seismic Category I structures are available for NRC inspection and when the detailed geological maps to be used by the staff while examining the excavations will be available. In addition, the staff should require that it be contacted immediately if a fault, not previously identified in the SAR or ESR, is found within 8 km (5 mi) of the plant.

10 CFR Part 52 describes an alternative licensing approach that may be used in lieu of ~~T~~the ~~previous~~ current two-step procedure of requiring applicants to obtain a Construction Permit, followed several years later after the plant design bases have been approved by the staff, by application for an Operating License.~~, has been provided with an alternative method, a combined licensing procedure, by 10 CFR Part 52.~~ This procedure, called combined licensing, could create a problem for the staff in that the Safety Evaluation Report (SER) will already have been written and the applicant ~~could~~ will ~~already~~ have a license before excavations are started.~~, and~~ Therefore, faults discovered for the first time in the excavations ~~that fall in the category described in the previous paragraph~~ will not have been evaluated by the staff ~~before time for the preparation of the Safety Evaluation Report (SER)~~ . ~~Therefore, It is imperative that~~ To alleviate this potential problem, ~~Section 2.5.3 of the SER be~~ there must be a commitment in the site specific portion of the SAR for a facility to: (1) notify the staff immediately if

previously unknown geologic features that could represent a hazard to the plant are encountered in the excavation; (2) geologically map all excavations for Category 1 structures, as a minimum; and (3) notify the staff when the excavations are open for examination and evaluation. ~~staff has carefully examined the walls and floors of the excavations for the plant and determined that there are no previously unidentified potentially hazardous faults or other features beneath the proposed plant. When the staff is satisfied regarding this issue, the SER should be finalized as soon as possible. made conditional on the demonstrated absence of previously unknown potentially hazardous faults beneath the plant as determined by careful examination of the excavations by the staff as described in the previous paragraph.~~

When faults are identified in the site vicinity or site area, it must be demonstrated that the faults do not have the potential to ~~generate earthquakes at the site (seismogenic source) or~~ cause near-surface ground displacement (capable tectonic source) at the site. This is accomplished by determining the ages of the latest displacement on the faults, preferably by stratigraphic methods, that is, identifying strata or a stratum of datable soil or rock overlying the fault that is undeformed by the fault. Other methods include correlating the last faulting event with regional tectonic activity of known ancient age, geomorphic evidence of age, and determining the relationship between the time of the fault rupture event and the ages of marine or fluvial terraces. Geochronological methods are discussed in References 3 and 17. ~~Draft~~ Regulatory Guide ~~DG-1032~~ 1.165 (Ref. 3) provides brief descriptions and a list of references of state-of-the-art methods and their applications, which can be used to estimate the geochronological history of geological materials associated with faults or other features.

In cases such as are described in the ~~last~~ previous paragraph, the staff will carry out limited site observations and investigations of its own such as examinations of excavations. In some cases, the staff may select samples from shear zones or other materials for subsequent dating and analysis. In past investigations ~~activities~~ ~~Applicants~~ ~~usually~~ applicants have often excavated trenches in the areas where major facilities are to be located for in situ testing ~~and~~ to reduce the chance for surprises when the construction excavations are made.

Subsection 2.5.3.1 Geological, Seismological, and Geophysical Investigations. This subsection is evaluated by conducting an independent literature search and cross-comparing the results with the information submitted in the SAR or ESR. The comparison should show that the conclusions presented by the applicant are based on sound data, are consistent with the published reports of experts who have worked in the area, and are consistent with the conclusions of the staff and its advisors or consultants. If the applicant's conclusions and assumptions conflict with the literature, and the staff disagrees with the applicant's analysis and assumptions, additional investigative results to support those conclusions must be submitted to the staff for review.

Subsection 2.5.3.2 Geological Evidence, or Absence of Evidence for Surface Deformation. This subsection is evaluated by first determining through a literature search and comparison with the applicant's data, that all ~~known~~ evidences of tectonic deformation such as fault offset identified in the literature have been considered in the investigation. The results of the applicant's site investigations are studied and cross-compared in detail to see if there is evidence of existing or possible displacements. If such evidence is found, additional investigations such as field mapping, geophysical investigations, borings, or trenching must be carried out to demonstrate that there is no offset or to define the characteristics of the fault if it does exist. It is important to distinguish between tectonically induced near-surface deformation and deformation caused by nontectonic phenomena such as growth faulting, collapse caused by the development of karst terrane, etc. (Ref. 3).

Subsection 2.5.3.3 Correlation of Earthquakes with Capable Tectonic Sources This subsection is reviewed in conjunction with the consideration of SRP Section 2.5.2. Historical earthquake data derived from the review of SRP Section 2.5.2 are compared with known local tectonic features and a determination is made as to whether any of these earthquakes can reasonably be associated with the local tectonic structures. This determination includes an evaluation of the hypocentral error estimates of the earthquakes. When available, the earthquake source mechanisms should be evaluated with respect to fault geometry. In addition, applicants and licensees are encouraged to evaluate the relationship of fault parameters to earthquake magnitude. These parameters may include, but are not limited to, slip rate, recurrence intervals, length, rupture area, and fault type (Ref. 18).

Subsection 2.5.3.4 Ages of Most Recent Deformation This subsection is evaluated to determine whether the geochronological methodologies used by the applicant are based on accepted ~~geological~~ procedures. In some cases unusual or untested age-dating techniques may have been used. When such methods are employed, the staff will require documentation of the technique. The ~~resolution~~ precision of all age dating techniques used in the applicant's analysis should be carefully documented. The staff may require the services of one or more ~~a~~ consultants who haves expertise in the methods used.

Subsection 2.5.3.5 Relationship of Tectonic Structures in the Site Area to Regional Tectonic Structures This Subsection is evaluated by determining through a literature search that the applicant's evaluation of the regional tectonic framework is consistent with that of recognized experts whose reports appear in the peer reviewed published literature. The conclusions reached by the applicant should be based on sound geological principles and should explain the available geological and geophysical data. When special investigations are made to determine the structural relationship between faults that pass within 8 km (5 mi) of the site and regional faults, the resolution accuracy of the investigative techniques should be given.

Subsection 2.5.3.6 Characterization of Capable Tectonic Sources This Subsection is evaluated to determine whether a sufficiently detailed investigation has been made by the applicant to define the specific characteristics of all potential capable tectonic sources any part of which is located within 8 km (5 mi) of the site. The ~~fault~~ structural ~~e's~~ characteristics that must be defined include length, orientation, geometry, and relationship of the fault or fold to regional structures; the nature, amount, and geological history of displacements along the fault; and the outer limits of the zone established by mapping the extent of Quaternary deformation in all directions. The staff must be satisfied that the investigations cover a large enough area and are in sufficient detail to demonstrate that there is little likelihood of near-surface deformation hazards associated with capable tectonic sources existing undetected near the site.

Subsection 2.5.3.7 Designation of Zones of Quaternary Deformation in the Site Region. The zone that needs requires detailed investigations is defined by the area characterized by Quaternary deformation in the site subregion (within a distance of 40 km or 25 miles of the site). The staff reviews the results of the applicant's investigation together with a review of the published literature. The investigative techniques employed by the applicant are evaluated to ascertain that they are consistent with the state of the art. As part of this phase, experts in specific disciplines may be asked to review certain aspects of the investigative program. The results of the investigations are analyzed to determine whether the outer limits of the zone of Quaternary deformation investigation are appropriately conservative.

Subsection 2.5.3.8 Potential for Surface Tectonic Deformation of the Site. If the detailed faulting investigations for the proposed commercial nuclear power plant reveal that there is a potential for surface deformation at the site, the staff recommends that an alternative location for the proposed plant be considered. It is not expected that nuclear power plants could be successfully designed for displacement in its foundation at the present time. However, Iin the future, when if it may becomes feasible to design a commercial nuclear power plant for to accommodate displacements, substantial information would be required to support the design basis for surface faulting deformation.

While fulfilling the tasks of Subsections 2.5.3.1 through 2.5.3.8, it is important for the staff SAR or ESR reviewer to identify all significant new information, such as a seismic source or a new tectonic model that was not included in the site PSHA, and coordinate that information with the staff PSHA reviewer.

IV. EVALUATION FINDINGS

If the evaluation by the staff, on completion of the review of the geological and seismological aspects of the plant site, confirms that the applicant has met the requirements of applicable portions of General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A to 10 CFR Part 50; and Proposed 10 CFR Part 100, Section 100.23, "Geologic and Seismic Siting Factors," the conclusion in the SER would state that the investigations performed, and the information and analyses provided, support the applicant's conclusions regarding the geologic and seismic suitability of the subject nuclear power plant site with respect to surface deformation potential. Staff reservations about any significant deficiency, either presented in the applicant's ESR or SAR, and identified by the staff, should be stated in sufficient detail to make clear the precise nature of the concern. The above determinations are made by the staff during the early site, construction permit, operating license, or combined license reviews.

The ESR or SAR is also reviewed for any significant new information derived by the site-specific geological, seismological, and geophysical investigations that had not been applied to the tectonic and ground motion models used in the PSHA. Appendix E of ~~Draft~~ Regulatory Guide ~~DG-1032~~ 1.165 (Ref. 3) discusses an acceptable method to address significant new information in the PSHA.

A typical finding for this section of the SER follows:

> In its review of the geological and seismological aspects of the plant site, the staff considered pertinent information gathered during the regional and site-specific geological, seismological, and geophysical investigations. The information includes data gathered from both site and near-site investigations and from an independent review of state-of-the-art, published literature and other sources by the staff.
>
> As a result of this review, the staff concludes that the geological, seismological, and geophysical investigations and information provided by the applicant in accordance with ~~the Proposed~~ Section 100.23 of 10 CFR Part 100 and ~~Draft~~ Regulatory Guide ~~DG-1032~~ 1.165 provide an adequate basis to establish that no capable tectonic sources exist in the plant site vicinity that would cause surface deformation or localize earthquakes there.

The information reviewed for the proposed nuclear power plant concerning the potential for near-surface tectonic deformation is summarized in Safety Evaluation Report Section 2.5.3.

The staff concludes that the site is suitable from the perspective of tectonic surface deformation and meets the requirements of: (1) 10 CFR Part 50, Appendix A (General Design Criterion 2), and (2) ~~the Proposed~~ Section 100.23 of 10 CFR Part 100. This conclusion is based on the following:

1. The applicant has met the requirements of:

   a. <u>10 CFR Part 50, Appendix A (General Design Criterion 2)</u> with respect to protection against natural phenomena such as faulting.

   b. ~~The Proposed~~ <u>Section 100.23 of 10 CFR Part 100 (Geologic and Seismic Siting Factors)</u> with respect to obtaining the geological and seismological information necessary (1) to determine site suitability, (2) to determine the appropriate design of the plant, and (3) to ascertain that any new information derived from the site-specific investigations does not impact the SSE ground motions derived by a PSHA. In complying with this regulation, the applicant also meets the staff's guidance proposed in ~~Draft~~ Regulatory Guide ~~1032~~ 1.165, ~~"Geologic and Seismic Siting Factors~~ "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion"; Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants;" and Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Plants."

V. <u>IMPLEMENTATION</u>

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant/licensee proposes an acceptable alternative method for complying with specific portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides (Refs. 4, 5, 6, 7, and 8).

The provisions of this SRP section apply to reviews of construction permits (CP), operating licenses (OL), early site permits, and combined license (CP/OL) applications docketed pursuant to the ~~proposed~~ Section 100.23 to 10 CFR Part 100.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

2. CFR Part 100, ~~Proposed~~ Section 100.23, "Geologic and Seismic Siting Factors," Federal Register, Volume 59, page 52255, October 17, 1994 (59 FR 52255)

3. US NRC, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motions," ~~Draft~~ Regulatory Guide ~~DG-1032~~1.165.

4. US NRC, "Site Investigations for Foundations of Nuclear Power Plants." Regulatory Guide 1.132.

5. US NRC, "General Site Suitability Criteria for Nuclear Power Stations." Regulatory Guide 4.7 ~~(Proposed Revision 2, DG-4004)~~.

6. US NRC, "Report of Siting Policy Task Force," NUREG-0625, August 1979.

7. US NRC, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Regulatory Guide 1.70.

8. American Petroleum Institute data base, accessible through RECON system,

9. GeoRef data base, American Geological Institute, Falls Church, Virginia.

10. R.L. Bates and J.A. Jacksons, editors, "Glossary of Geology," American Geological Institute, Falls Church, Virginia, 1980.

11. G.V. Cohee (Chairman) et al., "Tectonic Map of the United States," U.S. Geological Survey and American Association of Petroleum Geologists, 1962.

12. RECON/Energy data base, Department of Energy.

13. State geological maps and accompanying texts.

14. U.S. Geological Survey 7.5 and 15 minute topographic and geologic quadrangle maps.

15. Aerial photographs from Federal agencies such as the National Aeronautics and Space Administration, the U.S. Department of Agriculture, the U.S. Geological Survey, and the U.S. Forest Service.

16. Satellite imagery such as Landsat and Skylab.

17. P.J. Murphy, J. Briedis, and J. H. Pfeck, "Dating Techniques in Fault Investigations," pp. 153-168, in <u>Geology in the Siting of Nuclear Power Plants</u>, A.W. Hatheway and C.R. McClure, Jr., editors, "Reviews in Engineering Geology," Volume 4, Geological Society of America, 1979.

18. US NRC, "Safety Evaluation Report Related to the Operation of Diablo Canyon Nuclear Power Plant, Units 1 and 2," NUREG-0675, Supplement No. 34, June, 1991.

ATTACHMENT 14

REGULATORY GUIDE 1.12, REVISION 2
DRAFT WAS DG-1033

(SEISMIC INSTRUMENTATION)

REGULATORY GUIDE 1.12
(Draft was DG-1033)

NUCLEAR POWER PLANT INSTRUMENTATION FOR EARTHQUAKES

A. INTRODUCTION

In 10 CFR Part 20, "Standards for Protection Against Radiation," licensees are required to make every reasonable effort to maintain radiation exposures as low as is reasonably achievable. Paragraph IV(a)(4) of ~~Proposed~~ Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," ~~would~~ requires that suitable instrumentation must be provided so that the seismic response of nuclear power plant features important to safety can be evaluated promptly after an earthquake. Paragraph IV(a)(3) of ~~Proposed~~ Appendix S to 10 CFR Part 50 ~~would~~ requires shutdown of the nuclear power plant if vibratory ground motion exceeding that of the operating basis earthquake ground motion (OBE) occurs.[1]

This guide ~~is being developed to~~ describes seismic instrumentation that is acceptable to the NRC staff for satisfying the requirements of Parts 20 and ~~50 and the Proposed~~ Appendix S to Part 50.

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

[1] ~~Guidance is being developed in Draft~~ Regulatory Guide ~~DG-1034~~ 1.1[illegible], "Pre- Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions," ~~on~~ provides criteria for plant shutdown.

Any information collection activities mentioned in this ~~draft~~ regulatory guide are contained as requirements in ~~the proposed amendments to~~ 10 CFR Part 50, which provides ~~that would provide~~ the regulatory basis for this guide. The ~~proposed amendments have been submitted to~~ information collection requirements in 10 CFR Part 50 have been approved by the Office of Management and Budget ~~for clearance that may be appropriate under the Paperwork Reduction Act. Such clearance, if obtained, would also apply to any information collection activities mentioned in this guide~~, Approval No. 3150-0011

B. DISCUSSION

When an earthquake occurs, it is important to take prompt action to assess the effects of the earthquake at the nuclear power plant. This assessment includes both an evaluation of the seismic instrumentation data and a plant walkdown. Solid-state digital time-history accelerographs installed at appropriate locations will provide time-history data on the seismic response of the free-field, containment structure, and other Seismic Category I structures. The instrumentation should be located so that ~~a comparison and evaluation of such~~ the response may be ~~made~~ compared and evaluated with the design basis and so that occupational radiation exposures associated with their location, installation, and maintenance are maintained as low as reasonably achievable (ALARA).

Instrumentation is provided in the free-field and at foundation level and at elevation in Seismic Category I structures. Free-field instrumentation data ~~would~~ will be used to compare measured response to the engineering evaluations used to determine the design input motion to the structures and to determine whether the OBE has been exceeded (see ~~Draft~~ Regulatory Guide ~~DG-1034~~ 1.166). ~~Foundation level instrumentation would provide data on the actual seismic input to the containment and other buildings and would quantify differences between the vibratory ground motion at the free field and at the foundation level.~~ The instruments located at the foundation level and at elevation in the structures measure responses that are the input to the equipment or piping and ~~would~~ will be used in long-term evaluations (see ~~Draft~~ Regulatory Guide ~~DG-1035~~ 1.167, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event"). Foundation-level instrumentation will provide data on the actual seismic input to the containment and other Seismic Category I structures and will be used to quantify differences between the vibratory ground motion at the free-field and at the foundation level. Instrumentation is not located on equipment, piping, or supports since experience has shown that data obtained at these locations are obscured by vibratory motion associated with normal plant operation.

The guidance ~~being developed~~ in ~~Draft~~ Regulatory Guide ~~DG-1034~~ 1.166 is based on the assumption that the nuclear power plant has operable seismic instrumentation, including the equipment and software needed to process the data within 4 hours after an earthquake. This is necessary to determine whether plant shut down is required. This determination will be made by comparing the recorded data against OBE exceedance criteria and the results of the plant walkdown inspections that take place within 8 hours of the event.

It may not be necessary for identical nuclear power units on a given site to each be provided with seismic instrumentation if essentially the same seismic response at each of the units is expected from a given earthquake.

An evaluation of seismic instrumentation noted that instruments have been out of service during plant shutdown and sometimes during plant operation. The instrumentation system should be operable and operated at all times. If the seismic instrumentation or data processing hardware and software necessary to determine whether the OBE has been exceeded is inoperable, the guidelines in Appendix A to ~~Draft~~ Regulatory Guide ~~DG-1034~~ 1.166 ~~would~~ should be used.

The characteristics, installation, activation, remote indication, and maintenance of the seismic instrumentation are described in this guide to help ensure (1) that the data provided are comparable with the data used in the design of the nuclear power plant, (2) that exceedance of the OBE can be determined, and (3) that the equipment will perform as required.

It is important that all of the significant ground motion associated with an earthquake is recorded. This is accomplished by specifying how long before and after the actuation of the seismic trigger the data should be recorded. Settings for the instrumentations pre-event memory should be correlated with the maximum distance to any potential epicenter that could affect a specific site. The "P" wave may not be recorded at a 3-second setting. Also, when an event occurs at some distance and the trigger threshold limit is not exceeded until 15 or 20 seconds into the event, a part of the record, albeit for a low event, is lost. A 30-second value may be more appropriate and is within the capabilities of current digital time-history accelerographs at no aditional cost.

The appendix to this guide provides definitions to be used with this guidance.

~~Holders of an operating license or construction permit issued prior to the implementation date to be specified in the active guide may voluntarily implement the methods to be described in the active guide and the methods being developed in Draft Regulatory Guides DG 1034, "Pre Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions," and DG 1035, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event."~~

C. REGULATORY POSITION

The type, locations, operability, characteristics, installation, actuation, remote indication, and maintenance of seismic instrumentation described below are acceptable to the NRC staff for satisfying the requirements in 10 CFR Part 20~~, 10 CFR 50.65(b)(2),~~ and Paragraph IV(a)(4) of ~~Proposed~~ Appendix S to 10 CFR Part 50 for ensuring the safety of nuclear power plants.

1. SEISMIC INSTRUMENTATION TYPE AND LOCATION

1.1 Solid-state digital instrumentation that will enable the processing of data at the plant site within 4 hours of the seismic event should be used.

1.2 A triaxial time-history accelerograph should be provided at ~~each of~~ the following locations:

1. Free-field.

2. Containment foundation.

3. Two elevations (excluding the foundation) on a structure internal to the containment.

4. An independent Seismic Category I structure foundation where the response is different from that of the containment structure.

5. An elevation (excluding the foundation) on the independent Seismic Category I structures selected in 4 above.

6. If seismic isolators are used, instrumentation should be placed on both the rigid and isolated portions of the same or an adjacent structure, as appropriate, at approximately the same elevations.

1.3 The specific locations for instrumentation should be determined by the nuclear plant designer to obtain the most pertinent information consistent with maintaining occupational radiation exposures ALARA for the location, installation, and maintenance of seismic instrumentation. In general:

1.3.1 The free-field sensors should be located and installed so that they record the motion of the ground surface and that the effects that are associated with ~~certain~~ surface features, buildings, and components ~~will be absent from~~ on the recorded ground motion will be insignificant.

1.3.2 The in-structure instrumentation should be placed at locations that have been modeled as mass points in the building dynamic analysis so that the measured motion can be directly compared with the design spectra. The instrumentation should not be located on a secondary structural frame member that is not modeled as a mass point in the building dynamic model.

1.3.3 A design review of the location, installation, and maintenance of proposed instrumentation for maintaining exposures ALARA should be performed by the facility in the planning stage in accordance with Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

1.3.4 Instrumentation should be placed in a location with as low a dose rate as is practical, consistent with other requirements.

1.3.5 Instruments should be selected to require minimal maintenance and in-service inspection, as well as minimal time and numbers of personnel to conduct installation and maintenance.

2. INSTRUMENTATION AT MULTI-UNIT SITES

Instrumentation in addition to that installed for a single unit will not be required if essentially the same seismic response is expected at the other units based on the seismic analysis used in the seismic design of the plant. However, if there are separate control rooms, annunciation should be provided to both control rooms as specified in Regulatory Position 7.1

3. SEISMIC INSTRUMENTATION OPERABILITY

The seismic instrumentation should operate during all modes of plant operation, including periods of plant shutdown. The maintenance and repair procedures should provide for keeping the maximum number of instruments in service during plant operation and shutdown.

4. INSTRUMENTATION CHARACTERISTICS

4.1 The design should include provisions for in-service testing. The instruments should be capable of periodic channel checks during normal plant operation.

4.2 The instruments should have the capability for in-place functional testing.

4.3 Instrumentation that has sensors located in inaccessible areas should contain provisions for data recording in an accessible location, and the instrumentation should provide an external remote alarm to indicate actuation.

4.4 ~~After actuation, the~~ The instrumentation should record, at a minimum, ~~the~~ 3 seconds of low-amplitude motion prior to seismic trigger actuation, continue to record the motion during the period in which the earthquake motion exceeds the seismic trigger threshold, and continue to record low-amplitude motion for a minimum of 5 seconds beyond the last exceedance of the seismic trigger threshold.

<u>4.5</u> The instrumentation should be capable of recording 25 minutes of sensed motion.

<u>4.6</u> The battery should be of sufficient capacity to power the instrumentation ~~and~~ to sense and record (see Regulatory Position 4.5) 25 minutes of motion~~, with no battery charger,~~ over a period of not less than the channel check test interval (Regulatory Position 8.2). This can be accomplished by providing enough battery capacity for a minimum of 25 minutes of system operation at any time over a 24-hour period, without recharging, in combination with a battery charger whose line power is connected to an uninterruptable power supply or a line source with an alarm that is checked at least every 24 hours. Other combinations of larger battery capacity and alarm intervals may be used.

<u>4.7</u> Acceleration Sensors

<u>4.7.1</u> The dynamic range should be 1000:1 zero to peak, or greater; for example, 0.001g to 1.0g.

<u>4.7.2</u> The frequency range should be 0.20 Hz to 50 Hz or an equivalent demonstrated to be adequate by computational techniques applied to the resultant accelerogram.

<u>4.8</u> Recorder

<u>4.8.1</u> The sample rate should be at least 200 samples per second in each of the three directions.

<u>4.8.2</u> The bandwidth should be at least from 0.20 Hz to 50 Hz.

<u>4.8.3</u> The dynamic range should be 1000:1 or greater, and the instrumentation should be able to record at least 1.0g ~~0~~ zero to peak.

4.9 Seismic Trigger. The actuating level should be adjustable and within the range of 0.001g to 0.02g.

5. INSTRUMENTATION INSTALLATION

5.1 The instrumentation should be designed and installed so that the mounting is rigid.

5.2 The instrumentation should be oriented so that the horizontal axes are parallel to the orthogonal horizontal axes assumed in the seismic analysis.

5.3 Protection against accidental impacts should be provided.

6. INSTRUMENTATION ACTUATION

6.1 Both vertical and horizontal input vibratory ground motion should actuate the same time-history accelerograph. One or more seismic triggers may be used to accomplish this.

6.2 Spurious triggering should be avoided.

6.3 The seismic trigger mechanisms of the time-history accelerograph should be set for a threshold ground acceleration of not more than 0.02g.

7. REMOTE INDICATION

~~Activation~~ Triggering of the free-field or any foundation-level time-history accelerograph should be annunciated in the control room. If there is more than one control room at the site, annunciation should be provided to each control room.

8. MAINTENANCE

8.1 The purpose of the maintenance program is to ensure that the equipment will perform as required. As stated in Regulatory Position 3, the maintenance and repair procedures should provide for keeping the maximum number of instruments in service during plant operation and shutdown.

8.2 Systems are to be given channel checks every 2 weeks for the first 3 months of service after startup. Failures of devices normally occur during initial operation. After the initial 3-month period and 3 consecutive successful checks, monthly channel checks are sufficient. The monthly channel check is to include checking the batteries. The channel functional test should be performed every 6 months. Channel calibration should be performed during each refueling outage at a minimum.

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.

~~This proposed revision has been released to encourage public participation in its development.~~ Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, ~~the method to be described in the active~~ this guide ~~reflecting public comments~~ will be used in the evaluation of applications for construction permits, operating licenses, combined licenses, or design certification submitted after ~~the implementation date to be specified in the active guide~~ EFFECTIVE DATE OF THE FINAL RULE. This guide ~~would~~ will not be used in the evaluation of an application for an operating license submitted after ~~the implementation date to be specified in the active guide~~ EFFECTIVE DATE OF THE FINAL RULE if the construction permit was issued prior to that date.

Holders of an operating license or construction permit issued prior to EFFECTIVE DATE OF THE FINAL RULE may voluntarily implement the methods described in this guide in combination with the methods in Regulatory Guides 1.166, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions," and 1.167, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event." Other implementation strategies, such as a voluntary implementation of portions of the cited regulatory guides, will be evaluated by the NRC staff on a case-by-case basis.

APPENDIX

DEFINITIONS

<u>Acceleration Sensor</u>. An instrument capable of sensing absolute acceleration and transmitting the data to a recorder.

<u>Accessible Instruments</u>. Instruments or sensors whose locations permit ready access during plant operation without violation of applicable safety regulations, such as those of the Occupational Safety and Health Administration (OSHA), or regulations dealing with plant security or radiation protection safety.

<u>Channel Calibration</u> (Primary Calibration). The determination and, if required, adjustment of an instrument, sensor, or system such that it responds within a specific range and accuracy to an acceleration, velocity, or displacement input, as applicable, or responds to an acceptable physical constant.

<u>Channel Check</u>. The qualitative verification of the functional status of the instrument sensor. This check is an "in-situ" test and may be the same as a channel functional test.

<u>Channel Functional Test</u> (Secondary Calibration). The determination without adjustment that an instrument, sensor, or system responds to a known input of such character that it will verify the instrument, sensor, or system is functioning in a manner that can be calibrated.

<u>Containment</u> - See Primary Containment and Secondary Containment.

<u>Nonaccessible Instruments</u>. Instruments or sensors in ~~a location~~ locations that ~~does~~ do not permit ready access during plant operation because of a risk of violating applicable plant operating safety regulations, such as OSHA, or regulations dealing with plant security or radiation protection safety.

<u>Operating Basis Earthquake Ground Motion</u> (OBE). The vibratory ground motion for which those features of the nuclear power plant necessary for continued

operation without undue risk to the health and safety of the public will remain functional. The value of the OBE is set by the applicant.

Primary Containment. The principal structure of a unit that acts as the barrier, after the fuel cladding and reactor pressure boundary, to control the release of radioactive material. The primary containment includes (1) the containment structure and its access openings, penetrations, and appurtenances, (2) the valves, pipes, closed systems, and other components used to isolate the containment atmosphere from the environment, and (3) those systems or portions of systems that, by their system functions, extend the containment structure boundary (e.g., the connecting steam and feedwater piping) and provide effective isolation.

Recorder. An instrument capable of simultaneously recording the data versus time from an acceleration sensor or sensors.

Secondary Containment. The structure surrounding the primary containment that acts as a further barrier to control the release of radioactive material.

Seismic Isolator. A device (for instance, laminated elastomer and steel) installed between the structure and its foundation to reduce the acceleration of the isolated structure, as well as the attached equipment and components.

Seismic Trigger. A device that starts the time-history accelerograph.

Time-History Accelerograph. An instrument capable of sensing and permanently recording the absolute acceleration versus time. The components of the time-history accelerograph (acceleration sensor, recorder, seismic trigger) may be assembled in a self-contained unit or may be separately located.

Triaxial. Describes the function of an instrument or group of instruments in three mutually orthogonal directions, one of which is vertical.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The ~~draft~~ regulatory analysis, "~~Proposed~~ Revision of 10 CFR Part 100 and 10 CFR Part 50," was prepared for the ~~proposed~~ 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 ~~draft~~ regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW. (Lower Level), Washington, DC, as ~~Enclosure 2 to Secy 94-194~~ LATER.

ATTACHMENT 15

REGULATORY GUIDE 1.166
DRAFT WAS DG-1034

(PLANT SHUTDOWN)

REGULATORY GUIDE 1.166
(Draft was DG-1034)

PRE-EARTHQUAKE PLANNING AND IMMEDIATE NUCLEAR POWER PLANT OPERATOR POSTEARTHQUAKE ACTIONS

A. INTRODUCTION

Paragraph IV(a)(4) of ~~Proposed~~ Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," ~~would~~ requires that suitable instrumentation[1] be provided so that the seismic response of nuclear power plant features important to safety can be evaluated promptly. Paragraph IV(a)(3) of ~~Proposed~~ Appendix S to 10 CFR Part 50 ~~would~~ requires shutdown of the nuclear power plant if vibratory ground motion exceeding that of the operating basis earthquake ground motion (OBE) or significant plant damage occurs. If systems, structures, or components necessary for the safe shutdown of the nuclear power plant ~~would~~ are not ~~be~~ available after occurrence of the OBE, the licensee ~~would be required to~~ must consult with the NRC and must propose a plan for the timely, safe shutdown of the nuclear power plant. ~~Proposed Paragraph 50.54(ff) to 10 CFR Part 50 would require licensees~~ Licensees of nuclear power plants that have adopted the earthquake engineering criteria in ~~Proposed~~ Appendix S to 10 CFR Part 50 are required by 10 CFR 50.54(ff) to shut down the plant if the criteria in Paragraph IV(a)(3) of ~~Proposed~~ Appendix S are exceeded.

This guide ~~is being developed to~~ provides guidance acceptable to the NRC staff for a timely evaluation after an earthquake of the recorded instrumentation data and for determining whether plant shutdown ~~would be~~ is required by ~~the proposed amendments to~~ 10 CFR Part 50.

~~Regulatory guides are issued to describe and make available to the public such information as methods acceptable to the NRC staff for implementing specific parts of the Commission's regulations, techniques used by the staff in evaluating specific problems or postulated accidents, and guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required. Regulatory guides are~~

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[1]~~Guidance is being developed in Draft Regulatory Guide DG 1033, the Third Proposed Revision 2 to~~ Regulatory Guide 1.12, Revision 2, "Nuclear Power Plant Instrumentation for Earthquakes," ~~to~~ describes seismic instrumentation that is acceptable to the NRC staff.

~~issued in draft form for public comment to involve the public in the early stages of developing the regulatory positions. Draft regulatory guides have not received complete staff review and do not represent official NRC staff positions.~~

Any information collection activities mentioned in this ~~draft~~ regulatory guide are contained as requirements in ~~the proposed amendments to~~ 10 CFR Part 50 ~~that would provide~~, which provides the regulatory basis for this guide. The ~~proposed amendments have been submitted to~~ information collection requirements in 10 CFR Part 50 have been approved by the Office of Management and Budget ~~for clearance that may be appropriate under the Paperwork Reduction Act. Such clearance, if obtained, would also apply to any information collection activities mentioned in this guide~~, Approval No. 3150-0011.

B. DISCUSSION

When an earthquake occurs, ground motion data are recorded by the seismic instrumentation.[1] These data are used to make a rapid determination of the degree of severity of the seismic event. The data from the nuclear power plant's free-field seismic instrumentation, coupled with information obtained from a plant walkdown, are used to make the initial determination of whether the plant must be shut down, if it has not already been shut down by operational perturbations resulting from the seismic event. If on the basis of these initial evaluations (instrumentation data and walkdown) it is concluded that the plant shutdown criteria have not been exceeded, it is presumed that the plant will not be shut down (or could restart following a post-trip review, if it tripped off-line because of the earthquake). Guidance ~~is being developed~~ on postshutdown inspections and plant restart~~;~~ is contained in ~~the Draft~~ Regulatory Guide ~~DG-1035,~~ 1.167, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event." The Electric Power Research Institute has developed guidelines that will enable licensees to quickly identify and assess earthquake effects on nuclear power plants. These guidelines are in EPRI NP-5930, "A Criterion for Determining Exceedance of the Operating Basis Earthquake," July 1988[2]; EPRI NP-6695, "Guidelines for

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[2]EPRI reports may be obtained from the Electric Power Research Institute, ~~Research Reports~~ EPRI Distribution Center, 207 Coggins Dr., P.O. Box ~~50490~~ 23205, ~~Palo Alto, CA 94303~~ Pleasant Hill, CA 94523.

Nuclear Plant Response to an Earthquake," December 1989[2]; and EPRI TR-100082, "Standardization of the Cumulative Absolute Velocity," December 1991.[2]

This regulatory guide is based on the assumption that the nuclear power plant has operable seismic instrumentation, including the computer equipment and software required to process the data within 4 hours after an earthquake. This is necessary because the decision to shut down the plant will be made, in part, by comparing the recorded data against OBE exceedance criteria. The decision to shut down the plant is also based on the results of the plant walkdown inspections that take place within 8 hours of the event. If the seismic instrumentation or data processing equipment is inoperable, the guidelines in Appendix A to this guide would be used to determine whether the OBE has been exceeded.

Because free-field seismic instrumentation data are used in the plant shutdown determination, it is important to ascertain that the time-history analysis hardware and software were functioning properly. Therefore, the response spectrum and cumulative absolute velocity (CAV) should be calculated using a suitable earthquake time-history or manufactures calibration standard after the initial installation and each servicing of the free-field instrumentation. After an earthquake at the plant site, the response spectrum and CAV should be calculated using the time-history or calibration standard that was used during the last servicing (or initial instrumentation installation if no servicing has been performed) and the results compared with the latest data on file at the plant.

Because earthquake-induced vibration of the reactor vessel could lead to changes in neutron fluxes, a prompt check of the neutron flux monitoring sensors would provide an indication that the reactor is stable.

Shutdown of the nuclear power plant ~~would be~~ is required if the vibratory ground motion experienced exceeds that of the OBE. ~~Two criteria~~ A criterion for determining exceedance of the OBE (based on data recorded in the free-field) ~~are~~ is provided in EPRI NP-5930: a threshold response spectrum ordinate ~~criterion~~ check and a ~~cumulative absolute velocity (CAV)~~ CAV ~~criterion~~ check. Seismic Category I structures at ~~the~~ a nuclear power plant site may be designed using different ground motion response spectra; for example, one used for the certified standard design and another for site-specific applications. The spectrum ordinate criterion is based on the lowest spectrum used in the design of the Seismic Category I structures. A procedure to standardize the calculation of the CAV is provided in EPRI TR-100082. A spectral velocity threshold has also been recommended by EPRI since some structures have fundamental frequencies below the range specified in EPRI NP-5930. The NRC staff now recommends 1.0 to 2.0 Hz for the range of the spectral velocity limit since some structures have fundamental frequencies below 1.5 Hz. ~~The former range was~~ This is instead of the 1.5 to 2.0 Hz range proposed by EPRI.

Since the containment isolation valves may have malfunctioned during an earthquake, inspection of the containment isolation system is necessary to ensure continued containment integrity.

The NRC staff does not endorse the philosophy discussed in EPRI NP-6695, Section 4.3.4 (first paragraph, last sentence), pertaining to plant shutdown considerations following an earthquake based on the need for continued power generation in the region. If ~~the~~ a licensee determines that plant shutdown is required by the NRC's regulations, but the licensee does not consider it prudent to do so, the licensee would be required to consult with the NRC and propose a plan for the timely, safe shutdown of the nuclear power plant.

Appendix B to this guide provides definitions to be used with this guidance.

~~Holders of an operating license or construction permit issued prior to the implementation date to be specified in the active guide may voluntarily implement the methods to be described in the active guide and the methods being developed in Draft Regulatory Guides DG-1033, "Nuclear Power Plant Instrumentation for Earthquakes," and DG-1035, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event."~~

C. REGULATORY POSITION

1. BASE-LINE DATA

1.1 Information Related to Seismic Instrumentation

A file containing information on all the seismic instrumentation should be kept at the plant. The file should include:

1. Information on each instrument type such as make, model, and serial number; manufacturers' data sheet; list of special features or options; performance characteristics; examples of typical instrumentation readings and

interpretations; operations and maintenance manuals; repair procedures (manufacturers' recommendations for repairing common problems); and a list of any special requirements, e.g., for maintenance, ~~operational,~~ operation, or installation.

2. Plan views and vertical sections showing the location of each seismic instrument and the orientation of the instrument axis with respect to a plant reference axis.

3. A complete service history of each seismic instrument. The service history should include information such as dates of servicing, description of completed work, and calibration records and data (where applicable). The documentation and retention of these data should be commensurate with the recordkeeping for other plant equipment.

4. A suitable earthquake time-history (e.g., the October 1987 Whittier, California, earthquake) or manufacture's calibration standard and the corresponding response spectrum and cumulative absolute velocity (CAV) (see Regulatory Positions 4.1 and 4.2). ~~The response spectrum and CAV should be calculated after~~ After the initial installation and each servicing of the free-field instrumentation, the response spectrum and CAV should be calculated and filed (see Regulatory Position 4.3).

1.2 Planning for Postearthquake Inspections

Section 5.3.1 of EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," describes actions that are to be taken before an earthquake, such as, ~~The selection of~~ selecting equipment and structures for inspections and the content of the baseline inspections ~~as described in Sections 5.3.1 and 5.3.2.1 of EPRI NP 6695, "Guidelines for Nuclear Plant Response to an Earthquake,"~~ , that are acceptable to the NRC staff for satisfying the ~~proposed~~ requirements in Paragraph IV(a)(3) of ~~Proposed~~ Appendix S to 10 CFR Part 50 for ensuring the safety of nuclear power plants.

2. ~~IMMEDIATE POSTEARTHQUAKE ACTIONS~~ ACTIONS IMMEDIATELY AFTER AN EARTHQUAKE

The guidelines for actions ~~immediate postearthquake actions~~ immediately after an earthquake that are specified in Sections 4.3.1 (with the exception specified below) and 4.3.2 ~~(including Section 5.3.2.1 and items 7 and 8 of Table 5-1)~~ of EPRI NP-6695 are acceptable to the NRC staff for satisfying the requirements ~~proposed~~ in Paragraph IV(a)(3) of ~~Proposed~~ Appendix S to 10 CFR Part 50.

In Section 4.3.1, a check of the neutron flux monitoring sensors for changes should be added to the specific control room board checks.

3. EVALUATION OF GROUND MOTION RECORDS

3.1 Data Identification

A record collection log should be maintained at the plant, and all data should be identifiable and traceable with respect to:

1. The date and time of collection,

2. The make, model, serial number, location, and orientation of the instrument (sensor) from which the record was collected.

3.2 Data Collection

3.2.1 Only personnel trained in the operation of the instrument should collect the data.

3.2.2 The steps for removing and storing records from each seismic instrument should be planned and performed in accordance with established procedures.

3.2.3 Extreme caution should be exercised to prevent accidental damage to the recording media and instruments during data collection and subsequent handling.

3.2.4 As data are collected and the instrumentation is inspected, notes should be made regarding the condition of the instrument and its installation, for example, instrument flooded, mounting surface tilted, ~~fallen or~~ objects that fell and struck the instrument or the instrument mounting surface.

3.2.5 For validation of the collected data, the information described in Regulatory Position 1.1(4) should be ~~added to the record without affecting the previously recorded data~~ provided.

3.2.6 If the instrument's operation appears to have been normal, the instrument should remain in service without readjustment or change that would defeat attempts to obtain postevent calibration.

3.3 Record Evaluation

Records should be analyzed according to the manufacturer's specifications and the results of the analysis should be evaluated. Any record anomalies, invalid data, and nonpertinent signals should be noted, along with any known causes.

4. DETERMINING OBE EXCEEDANCE

The evaluation to determine whether the OBE was exceeded should be performed using data obtained from the three components of the free-field ground motion (i.e., two horizontal and one vertical). The evaluation may be performed on uncorrected earthquake records. It was found in a study of uncorrected versus corrected earthquake records (see EPRI NP-5930) that the use of uncorrected records is conservative. The evaluation should consist of a check of the response spectrum~~,~~ and CAV~~ limit~~, and the operability of the instrumentation. This evaluation should take place within 4 hours of the earthquake.

4.1 Response Spectrum Check

4.1.1

The OBE response spectrum check is performed using the lower of:

1. The spectrum used in the certified standard design, or

2. A spectrum other than (1) used in the design of any Seismic Category I structure.

4.1.2

The OBE response spectrum is exceeded if any one of the three components (two horizontal and one vertical) of the 5 percent damped free-field ground motion response spectra is larger than:

1. The corresponding design response spectral acceleration (OBE spectrum if used, otherwise 1/3 of the safe shutdown earthquake (SSE) spectrum) or 0.2g, whichever is greater, for frequencies between 2 to 10 Hz, or

2. The corresponding design response spectral velocity (OBE spectrum if used, otherwise 1/3 of the SSE spectrum) or a spectral velocity of 6 inches per second (15.24 centimeters per second), whichever is greater, for frequencies between 1 and 2 Hz.

4.2 Cumulative Absolute Velocity ~~(CAV) Limit~~ Check

For each component of the free-field ground motion, the CAV should be calculated as follows: (1) the absolute acceleration (g units) time-history is divided into 1-second intervals, (2) each 1-second interval that has at least 1 exceedance of 0.025g is integrated over time, (3) all the integrated values are summed together to arrive at the CAV. The CAV ~~limit~~ check is exceeded if any CAV calculation is greater than 0.16 g-second. Additional information on how to determine the CAV is provided in EPRI TR-100082.

4.3 Instrument Operability Check

After an earthquake at the plant site, the response spectrum and CAV should be calculated using the same input as that used in ~~the calibration standard (see~~ Regulatory Position 1.1(4)~~)~~ and the results should be compared with the latest filed data to demonstrate that the time-history analysis hardware and software were functioning properly. The results of this comparison should be reported to the NRC.

4.4 Inoperable Instrumentation or Data Processing Hardware or Software

If the response spectrum and the CAV (Regulatory Positions 4.1 and 4.2) can not be obtained because the seismic instrumentation is inoperable, data from the instrumentation are destroyed, or the data processing hardware or software is inoperable, the criteria in Appendix A to this guide should be used to determine whether the OBE has been exceeded.

5. CRITERIA FOR PLANT SHUTDOWN

If the OBE is exceeded or significant plant damage occurs, the plant must be shut down unless a plan for the timely, safe shutdown of the nuclear power plant has been proposed by the licensee and accepted by the NRC staff.

5.1 OBE Exceedance

If the response spectrum check and the CAV ~~limit~~ check (performed or calculated in accordance with Regulatory Positions 4.1 and 4.2) were exceeded, the OBE was exceeded and plant shutdown is required. If either ~~limit~~ check does not exceed the criterion, the earthquake motion did not exceed the OBE. If only one ~~limit~~ check can be ~~checked~~ performed, the other ~~limit~~ check is assumed to be exceeded; if neither check can be performed, see Regulatory Position 4.4. The determination of whether or not the OBE has been exceeded should be performed even if the plant automatically trips off-line as a result of the earthquake.

5.2 Damage

The plant should be shut down if the walkdown inspections performed in accordance with Regulatory Position 2 discover damage. This evaluation should take place within 8 hours of the earthquake occurrence.

5.3 Continued Operation

If the OBE was not exceeded and the walkdown inspection indicates no damage to the nuclear power plant, shutdown of the plant is not required. The plant may continue to operate (or may restart following a post-trip review, if it tripped off-line because of the earthquake).

6. PRE-SHUTDOWN INSPECTIONS

The pre-shutdown inspections described in Section 4.3.4 ~~(including all subsections)~~ of EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," with the exceptions specified below, are acceptable to the NRC staff for satisfying the requirements ~~proposed~~ in Paragraph IV(a)(3) of ~~Proposed~~ Appendix S to 10 CFR Part 50 for ensuring the safety of nuclear power plants.

6.1 Shutdown Timing

Delete the last sentence in the first paragraph of Section 4.3.4.

6.2 Safe Shutdown Equipment

In Section 4.3.4.1, a check of the containment isolation system should be added to the minimum list of equipment to be inspected.

6.3 Orderly Plant Shutdown

The following paragraph in Section 4.3.4 of EPRI NP-6695 is printed here to emphasize that the plant should shut down in an orderly manner.

> "Prior to initiating plant shutdown following an earthquake, visual inspections and control board checks of safe shutdown systems should be performed by plant operations personnel, and the availability of off-site and emergency power sources should be determined. The purpose of these inspections is to determine the effect of the earthquake on essential safe shutdown equipment which is not normally in use during power operation so that any resets or repairs required as a result of the earthquake can be performed, or alternate equipment can be readied, prior to initiating shutdown activities. In order to ascertain possible

fuel and reactor internal damage, the following checks should be made, if possible, before plant shutdown is initiated . . . . "

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.

~~This proposed revision has been released to encourage public participation in its development.~~ Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the method ~~to be~~ described in ~~the active~~ this guide ~~reflecting public comments~~ will be used in the evaluation of applications for construction permits, operating licenses, combined licenses, or design certification submitted after ~~the implementation date to be specified in the active guide~~ EFFECTIVE DATE OF THE FINAL RULE. This guide ~~would~~ will not be used in the evaluation of an application for an operating license submitted after ~~the implementation date to be specified in the active guide~~ EFFECTIVE DATE OF THE FINAL RULE if the construction permit was issued prior to that date.

Holders of an operating license or construction permit issued prior to EFFECTIVE DATE OF THE FINAL RULE may voluntarily implement the methods described in this guide in combination with the methods in Regulatory Guides 1.12, "Nuclear Power Plant Instrumentation for Earthquakes," Revision 2, and 1.167, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event." Other implementation strategies, such as a voluntary implementation of portions of the cited regulatory guides, will be evaluated by the NRC staff on a case-by-case basis.

APPENDIX A

INTERIM OPERATING BASIS EARTHQUAKE EXCEEDANCE GUIDELINES

This regulatory guide is based on the assumption that the nuclear power plant has operable seismic instrumentation and equipment (hardware and software) to process the data. If the seismic instrumentation or data processing equipment is inoperable, the following should be used to determine whether the operating basis earthquake ground motion (OBE) has been exceeded:

1. For plants at which instrumentally determined data are available only from an instrument installed on a foundation, the cumulative absolute velocity (CAV) ~~limit~~-check (see Regulatory Position 4.2 of this guide) is not applicable. In this case, the determination of OBE exceedance is based on a response spectrum check similar to that described in Regulatory Position 4.1 of this regulatory guide. A comparison is made between the foundation-level design response spectra and data obtained from the foundation-level instruments. If the response spectrum check at any foundation is exceeded, the OBE is exceeded and the plant must be shut down. At this instrument location it is inappropriate to use the 0.2g spectral acceleration limit or the 6 inches per second (15.24 centimeters per second) spectral velocity limit stated in Regulatory Position 4.1.2.

2. For plants at which no free-field or foundation-level instrumental data are available, <u>or</u> the data processing equipment is inoperable and the response spectrum check and the CAV ~~limit~~-check can not be determined (Regulatory Positions 4.1 and 4.2), the OBE will be considered to have been exceeded and the plant must be shut down if one of the following applies:

    1. The earthquake resulted in Modified Mercalli Intensity (MMI) VI or greater within 5 km of the plant,

    2. The earthquake was felt within the plant and was of magnitude 6.0 or greater, or

3. The earthquake was of magnitude 5.0 or greater and occurred within 200 km of the plant.

A postearthquake plant walkdown should be conducted after the earthquake (see Regulatory Position 2 of this guide).

If plant shutdown is warranted under the above guidelines, the plant should be shut down in an orderly manner (see Regulatory Position 6 of this guide).

<u>Note</u>: The determinations of epicentral location, magnitude, and intensity by the U.S. Geological Survey, National Earthquake Information Center, will usually take precedence over other estimates; however, regional and local determinations will be used if they are considered to be more accurate. Also, higher quality damage reports or a lack of damage reports from the nuclear power plant site or its immediate vicinity will take precedence over more distant reports.

APPENDIX B

DEFINITIONS

Certified Standard Design. A Commission approval, issued pursuant to Subpart B of 10 CFR Part 52, of a standard design for a nuclear power facility.

Design Response Spectra. Response spectra used to design Seismic Category I structures, systems, and components.

Operating Basis Earthquake Ground Motion (OBE). The vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public will remain functional. The value of the OBE is set by the applicant.

Spectral Acceleration. The acceleration response of a linear oscillator with prescribed frequency and damping.

Spectral Velocity. The velocity response of a linear oscillator with prescribed frequency and damping.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The ~~draft~~ regulatory analysis, "~~Proposed~~ Revisions of 10 CFR Part 100 and 10 CFR Part 50," was prepared for the ~~proposed~~ 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 ~~draft~~ regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW. (Lower Level), Washington, DC, as ~~Enclosure 2 to Secy 94-194~~ LATER.

ATTACHMENT 16

REGULATORY GUIDE 1.167
DRAFT WAS DG-1035

(PLANT RESTART)

REGULATORY GUIDE 1.167
(Draft was DG-1035)

RESTART OF A NUCLEAR POWER PLANT SHUT DOWN BY A SEISMIC EVENT

A. INTRODUCTION

Paragraph IV(a)(3) of ~~Proposed~~ Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," ~~would~~ requires shutdown of the nuclear power plant if vibratory ground motion exceeding that of the operating basis earthquake ground motion (OBE) occurs or if significant plant damage occurs.[1] Prior to resuming operations, the licensee must demonstrate to the NRC that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public.

This guide ~~is being developed to~~ provides guidance acceptable to the NRC staff for performing inspections and tests of nuclear power plant equipment and structures prior to restart of a plant that has been shut down by a seismic event.

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

Any information collection activities mentioned in this ~~draft~~ regulatory guide are contained as requirements in ~~the proposed amendments to~~ 10 CFR Part 50 ~~that would provide~~ , which provides the regulatory basis for this guide. The ~~proposed amendments have been submitted to~~ information collection requirements in 10 CFR Part 50 have been approved by the Office of Management

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[1] ~~Guidance is being developed in Draft~~ Regulatory Guide ~~DG-1034~~ 1.166, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions," ~~to~~ provides criteria for plant shutdown.

and Budget ~~for clearance that may be appropriate under the Paperwork Reduction Act. Such clearance, if obtained, would also apply to any information collection activities mentioned in this guide~~, Approval No. 3150-0011.

B. DISCUSSION

Data from seismic instrumentation[2] and a walkdown of the nuclear power plant are used to make the initial determination of whether the plant must be shut down after an earthquake, if the plant has not already shut down from operational perturbations resulting from the seismic event.[1]

The Electric Power Research Institute has developed guidelines that will enable licensees to quickly identify and assess earthquake effects on nuclear power plants in EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake,"[3] December 1989. This regulatory guide addresses sections of EPRI NP-6695 that relate to postshutdown inspection and tests, inspection criteria, inspection personnel, documentation, and long-term evaluations.

EPRI NP-6695 has been supplemented to add inspections and tests as a basis for acceptance of stresses in excess of Service Level C and to recommend that engineering evaluations of components with calculated stresses in excess of service Level D focus on areas of high stress and include fatigue analyses.

~~Holders of an operating license or construction permit issued prior to the implementation date to be specified in the active guide may voluntarily implement the methods to be described in the active guide and the methods being developed in Draft Regulatory Guides DG-1033, "Nuclear Power Plant Instrumentation for Earthquakes," and DG-1034, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Action."~~

C. REGULATORY POSITION

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[2]~~Guidance is being developed in Draft~~ Regulatory Guide ~~DG-1033-~~1.12, ~~the third Proposed Revision 2 to Regulatory Guide 1.12,~~ Revision 2, "Nuclear Power Plant Instrumentation for Earthquakes," ~~that will~~ describes seismic instrumentation acceptable to the NRC staff.

[3]EPRI reports may be obtained from the Electric Power Research Institute, ~~Research Reports~~ EPRI Distribution Center, 207 Coggins Dr., P.O. Box ~~50490~~ 23205, ~~Palo Alto, CA 94303~~ Pleasant Hill, CA 94523.

After a plant has been shut down by an earthquake, the guidelines for inspections and tests of nuclear power plant equipment and structures that are depicted in EPRI NP-6695 in Figure 3-2 and specified in Sections 5.3.2 ~~(including Tables 2-1, 2-2, and 5-1)~~, 5.3.3 ~~(includes Table 5-1)~~, and 5.3.4; the documentation to be submitted to the NRC specified in Section in 5.3.5; and the long-term evaluations that are specified in Section 6.3 ~~(all sections and subsections)~~, with the exceptions specified below, ~~would be~~ are acceptable to the NRC staff for satisfying the requirements ~~proposed~~ in Paragraph IV(a)(3) of ~~the Proposed~~ Appendix S to 10 CFR Part 50.

1. <u>EXCEPTIONS TO SECTION 6.3.4.1 OF EPRI NP-6695</u>

<u>1.1</u> Item (1) should read:

If the calculated stresses from the actual seismic loading conditions are less than the allowables for emergency conditions (e.g., ASME Code Level C Service Limits or equivalent) or original design bases, the item is considered acceptable, provided the results of inspections and tests (Section 5.3.2) show no damage.

<u>1.2</u> The second dashed statement of Item (3) should read:

-- An engineering evaluation of the effects of the calculated stresses on the functionality of the item. This evaluation should address all locations where stresses exceed faulted allowables and should include fatigue analysis for ASME Code Class 1 components and systems.

~~1.3 The last paragraph should read:~~

~~Reanalysis of safety related piping systems is not considered necessary unless there is observed damage to the piping systems. Experience has shown that piping systems designed to the ASME Code are not damaged by inertia loads resulting from an earthquake. If damage occurs, it will most likely occur in the piping supports or as damage to the pipe at fixed supports caused by relative support displacements. These types of damage would be detected by the plant walkdown inspections and post-shutdown inspections described in Sections 4 and 5 of this report. In general, piping reanalysis should be performed on a sampling basis to verify the adequacy of piping and to assess the need for supplemental nondestructive examination of potential high strain areas.~~

2. LONG-TERM EVALUATIONS

Coincident with the long-term evaluations, the plant should be restored to its current licensing basis. Exceptions to this must be approved by the Director, Office of Nuclear Reactor Regulation.

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.

~~This draft guide has been released to encourage public participation in its development.~~ Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the method ~~to be~~ described in ~~the active~~ this guide ~~reflecting public comments~~ will be used in the evaluation of applications for construction permits, operating licenses, combined licenses, or design certification submitted after ~~the implementation date to be specified in the active guide~~ EFFECTIVE DATE OF THE FINAL RULE. This guide ~~would~~ will not be used in the evaluation of an application for an operating license submitted after ~~the implementation date to be specified in the active guide~~ EFFECTIVE DATE OF THE FINAL RULE if the construction permit was issued prior to that date.

Holders of an operating license or construction permit issued prior to EFFECTIVE DATE OF THE FINAL RULE may voluntarily implement the methods described in this guide in combination with the methods in Regulatory Guides 1.12, Revision 2, "Nuclear Power Plant Instrumentation for Earthquakes," and 1.166, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions." Other implementation strategies, such as voluntary implementation of portions of the cited regulatory guides, will be evaluated by the NRC staff on a case-by-case basis.

2

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6″

PHOTOGRAPHIC SCIENCES CORPORATION
770 BASKET ROAD
P.O. BOX 338
WEBSTER, NEW YORK 14580
(716) 265-1600

2

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

PHOTOGRAPHIC SCIENCES CORPORATION
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WEBSTER, NEW YORK 14580
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IMAGE EVALUATION TEST TARGET (MT-3)

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(716) 265-1600

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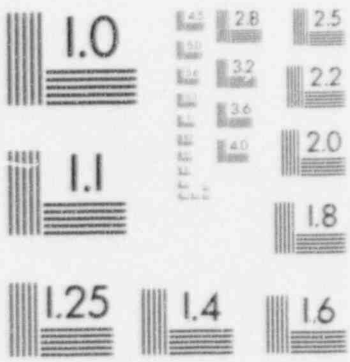
IMAGE EVALUATION TEST TARGET (MT-3)



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REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The ~~draft~~ regulatory analysis, "~~Proposed~~ Revision of 10 CFR Part 100 and 10 CFR Part 50," was prepared for the ~~proposed~~ 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 ~~draft~~ regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW. (Lower Level), Washington, DC, as ~~Secy-94-194~~ LATER.

ATTACHMENT 17

RESOLUTION OF PUBLIC COMMENTS ON DRAFT REGULATORY GUIDES AND STANDARD REVIEW PLAN SECTIONS PERTAINING TO THE PROPOSED SEISMIC AND EARTHQUAKE ENGINEERING CRITERIA FOR NUCLEAR POWER PLANTS

RESOLUTION OF PUBLIC COMMENTS ON DRAFT REGULATORY GUIDES AND STANDARD REVIEW PLAN SECTIONS PERTAINING TO THE PROPOSED SEISMIC AND EARTHQUAKE ENGINEERING CRITERIA FOR NUCLEAR POWER PLANTS

Section	Description
1.	Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Shutdown Earthquake Ground Motions" (Draft was DG-1032)
	Standard Review Plan Section 2.5.1, Revision 3, "Basic Geologic and Seismic Information"
	Standard Review Plan Section 2.5.2, Revision 3 "Vibratory Ground Motion"
	Standard Review Plan Section 2.5.3, Revision 3, "Surface Faulting"
2.	Regulatory Guide 1.12, Revision 2, "Nuclear Power Plant Instrumentation for Earthquakes" (Draft was DG-1033)
3.	Regulatory Guide 1.166, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions" (Draft was DG-10[illegible]4)
4.	Regulatory Guide 1.167, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event" (Draft was DG-1035)

SECTION 1

RESOLUTION OF PUBLIC COMMENTS
REGULATORY GUIDE 1.165 (Draft was DG-1032)
STANDARD REVIEW PLAN SECTIONS 2.5.1, 2.5.2 & 2.5.3

ORGANIZED BY COMMENTOR:

1. American Society of Civil Engineers
2. DOE/OCRWN
3. Morgan, Lewis and Bockius
4. NEI
5. Wais and Associates
6. Westinghouse
7. Yankee Atomic Electric Company

American Society of Civil Engineers (Washington Office)

Comment:

The seismic design and engineering criteria of ASCE Standard 4, "Seismic Analysis of Safety-Related Nuclear Structures and Commentary on Standard for Seismic Analysis of Safety-Related Nuclear Structures," should be incorporated by reference into the regulation.

Response:

We do not agree that ASCE Standard 4 should be referenced in the revised regulation. When a document is referenced in a federal regulation it becomes a part of that regulation. Codifying this standard would be reinstating a prescriptive format into the regulation, which has been cited over the past two decades as being one of the major contributors to difficulties in applying Appendix A to 10 CFR Part 100.

Thus, one of the primary reasons for revising Appendix A is to remove the prescriptive elements. These elements were put into the regulation more than two decades ago and soon became obsolete with respect to the state-of-the-science. Because of the cast-in-concrete nature of a federal regulation, it was extremely difficult to update. Also, the prescriptive list was incomplete, thus allowing the potential for gaps in the site specific investigations and analyses. It also required following procedures that were unnecessary at many sites.

Review Comments by DOE/OCRWM on NRC's Proposed Changes to 10 CFR Parts 50, 52, and 100

General Observations

1. <u>Applicability of Appendix A Seismic Hazard Evaluations to the Mined Geologic Disposal System - MGDS (in "Supplementary Information" - Section III -page 52256)</u>

In the top half of the center column, it is stated that "...The proposed regulatory action would apply to applicants who apply for a construction permit, operating license, preliminary design approval, final design approval, manufacturing license, early site permit, design certification, or combined license...."

COMMENT: This statement does not explicitly indicate whether or not the proposed revisions would apply to the MDGS.

2. Applicability of Appendix A or proposed Subpart B to a Monitored Retrievable Storage (MRS) facility (in "Supplementary Information" - Section III - page 52256)

In the top half of the center column, it is stated that "...The proposed regulatory action would apply to applicants who apply for a construction permit, operating license, preliminary design approval, final design approval, manufacturing license, early site permit design certification, of combined license...."

COMMENT: This statement does not explicitly indicate whether or not the proposed revisions would apply to a MRS.

<u>Responses to Comments 1 and 2:</u>

SECY-94-194, Enclosure 2, page RA-16, paragraph a., under <u>IMPACTS</u>, presents the staff's position on these issues: "The proposed regulation, Section 100.23 to Part 100, is still applicable only to nuclear power plants. The revision of Part 72 and Appendix A to Part 40, subject to the implementation of Section 100.23 to Part 100, should be a separate rulemaking initiative."

3. State of Knowledge about Earthquake Phenomena (in "Supplementary Information" - Section V.B.3. Uncertainties and Probabilistic Methods - page 52261)

In the middle of the third paragraph it is stated that "Because so little is known about earthquake phenomena..."

COMMENT: Use of the expression "so little is known" creates a false impression of the current state of knowledge about earthquake phenomena. Although our understanding of earthquake phenomena remains uncertain, quantum advances in knowledge have been made during the past 25 years. With these very significant advances, geoscientists now have much more confidence than previously in expressions of uncertainty regarding interpretations of inputs to a probabilistic seismic hazard analyses; and these can be fully accounted for in the uncertainty in the seismic hazard results. The language of the regulation should reflect these very positive developments.

Response:

The statement has been revised to put less emphasis on the negative as follows: "Because of uncertainties about earthquake phenomena (especially in the eastern United States), there have often been differences of opinion and differing....."

4. Nature of Geoscience Investigations (in "Supplementary Information" - Section V.B.3. Uncertainty and Probabilistic Methods - page 52262)

The key elements of the NRC's proposed balanced approach are listed in the top third of the left hand column on page 52262.

COMMENT: The wording of the fourth element should be revised to indicate that the geoscience investigations refer to site-specific data, or new regional data, or a combination of the two.

Response:

It refers to both regional and site investigations. The element has been revised to: "Determine if information from the regional and site geoscience investigations....."

DRAFT REGULATORY GUIDE DG - 1032 (now called Regulatory Guide 1.165)

1. Description of Probabilistic Seismic Hazard Analysis (PSHA) (in B. Discussion-Background, page 3, line 29)

COMMENT: Another important aspect of a PSHA, not mentioned, is its explicit estimation of SSE likelihood during the "design lifetime" of a facility.

Suggest adding a sentence after "...seismological parameters." such as: A PSHA also provides an evaluation of the likelihood of SSE recurrence during the design lifetime of a given facility - given the recurrence interval and recurrence pattern on pertinent seismic sources.

Response:

The aspect is implicit in the discussion but is not stated directly. We agree that the statement improves the discussion and have included it as you suggest.

2. Areal Extent for Regional Studies and Seismic Source Identification (in V. Regulatory Position, Section C.1.1., page 7, lines 15-17, and also Appendix D, D..2.1, page D-4, lines 27, 28)

COMMENT: The areal extent of regional seismic source investigations is defined as extending to 320 km (200 miles) from the site.

The requirement to perform investigations within 320 km around a site is excessive, and not generally needed to identify the seismic sources that could contribute to the seismic hazard at a site. Since the EPRI and LLNL seismic sources are accepted (with confirmation) as the basis for evaluating the seismic hazard at potential sites in the Eastern United States (EUS) the potential contributions of all sources in the EUS will be known. In the western United States, the very high rate of attenuation of ground motion precludes seismic sources beyond about 150 km contributing to the seismic hazard at a site. The applicant should be required to develop and justify its rationale for the area considered and the size of seismic sources considered as function of distance from the site.

While Section C.1.1 states that the level of detail for the regional studies is data obtained from a literature survey and geologic reconnaissance, one would assume that all these sources are to be included in a probabilistic seismic hazard assessment (PSHA). This could result in many insignificant seismic sources being characterized and included in the PSHA DG-1032 should be modified to require identification only of sources that may contribute significantly to the seismic hazard at the site.

Response:

The reason for this distance is not only to identify those presently unknown seismic sources close enough to affect the site, but, because CEUS sources are at depth and largely undefined, the area should be as broad as reasonably possible to incorporate any sources identified that could be analogous to sources that may be near to or underlie the site. Within this area, assessment of regional seismological, geological, and geophysical data or other information that could be used to identify or interpret potential seismic sources should be made. It is not expected to be a detailed investigation and may consist of only literature studies (including earthquake catalogs, maps, and geophysical, airphoto, and other remote sensing data) and with limited ground truth reconnaissances.

In the past it has often been necessary to estimate the age of a potential 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. Additionally, because of the relatively aseismic nature that characterizes the CEUS, the broader the area considered, the more earthquake epicenters will be included.

As described in Appendix E of DG-1032 (Regulatory Guide 1.165), a newly identified, potentially significant seismic source, the characteristics of which are supported by a strong technical basis, are identified within 320 km (200 mi) of the site will be assessed by a sensitivity analysis. If the results of that sensitivity test show that source has no impact on the SSE, then no further work will have to be done regarding that source. Most newly identified sources will be small, or ancient, and can be dismissed without sensitivity studies. Only if the sensitivity study indicates that the source could result in a significant change in the hazard will that source have to be included in the PSHA.

In the western U.S., to justify not extending the regional investigation out in all directions to 320 km (200 mi), may be less difficult in that there is usually a large source closer to the site that will be SSE-controlling and dominate more distant sources no matter how large they are. For example, The San Gregorio-Hosgri fault zone, which is approximately 4 km from the Diablo Canyon Nuclear Power Plant, with respect to the San Andreas, which is about 75 km (45 mi) from the site. It would, therefore, not be necessary to search for a seismic source on the other side of the San Andreas, or a source smaller than the San Gregorio-Hosgri between the San Andreas and the site. On the other hand, it may be necessary, as was the case of the San Gregory-Hosgri fault zone, to extend the regional investigations well beyond 320 km (200 mi) along the fault zone in both directions to characterize the seismic hazard of that source.

3. Implied Definition of Seismic Potential (in C. Regulatory Position Section C.2.2, page 9, lines 30, 31)

COMMENT: The term "seismic potential" used in Section C.2.2, page 9. The following parenthetical phrase "magnitude and recurrence rate" implies that this is the definition of seismic potential.

This neglects the possibility that there is uncertainty in whether the source is active at all. The evaluation of the likelihood that a source is active (seismogenic) is necessary, because not all sources have a probability of 1.0 that they are active. Characterization of source's seismic potential should include magnitude, recurrence rate, and probability of activity.

More broadly, there is a general lack of emphasis in this document on the need to characterize the uncertainty in all inputs to the probabilistic seismic hazard analysis.

Response:

We agree and the text has been modified as follows:
"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 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."

4. Use of the word "determined (in C. Regulatory Position, Section C.2.2, page 9, line 32)

COMMENT: The use of the word "determined" in the phrase .....seismic potential should be determined... is too strong and unrealistic, given the lack of precision that can reasonably be expected for this task.

Suggest replacing "determined" with "evaluated".

Response:

The word "determined" has been replaced with "evaluated" as suggested.

5. Steps 1 through 5 in PSHA Procedure (in C. Regulatory Position, Section 3, pages 11 and 12

COMMENT: The applicability of each Step to either "CEUS sites" or "CEUS and/or western USA sites" needs clarification.

Suggest adding the phrase "For any site (CEUS or western USA)," at the beginning of the text of appropriate steps - such as Steps 1, 4, and 5.

Response:

Step 1 concerns regional and site investigations and refers to Appendix D. Appendix D clearly states that these investigations are to be carried out regarding all sites, even for those plants that are to be sited at existing nuclear power plants. The description of Step 2 indicates that these are for CEUS sites. Step 4 refers to Appendix B for guidance, which discusses the procedure in terms of its application to CEUS. Step 5 gives Appendix C as a reference. Appendix C describes how to apply the procedure to CEUS and WUS.

6. Use and definition of the term; "controlling earthquake" (in Appendix A - Definitions, page A - 1, lines 3 - 7

COMMENT: Use of this term is confusing. It is defined on page A - 1 (for the probabilistic seismic hazard analysis) as a mean magnitude and derived from a de-aggregation analysis of the PSHA.

Within this framework, there may be several controlling earthquakes. In Standard Review Plan 2.5.2 (page 2.5.2. - 9) "controlling earthquake" is used in a different (deterministic) sense (e.g., "....controlling earthquakes for each source..."). The definition of controlling earthquake should be expanded in Appendix A of DG-1032 to include its usage within both a probabilistic and deterministic framework.

Response:

At some sites in the CEUS there may be two PSHA controlling earthquakes; a nearby event that dominates the potentially damaging ground motion at higher frequencies, and a more distance large event that dominates the low frequency ground motions (e.g. the Vogtle site).

A deterministic controlling earthquake (or earthquakes) is no longer used in SRP 2.5.2. Therefore, any reference to controlling earthquakes refers to those determined by a PSHA.

7. Rock varnish cation ratio age-dating method (in Appendix D, Section D.2.4.5, page D-11, lines 8,9).

COMMENT: The text states that rock varnish cation ratio dating is controversial, and its use is not recommended pending further validation.

The rock varnish cation ratio method may prove to be no more controversial than many of the other methods discussed in the text. All methods have uncertainties.. The applicant should employ a variety of age-dating techniques to corroborate any given age data, and to address uncertainties.

Additional work on cosmogenic dating, pertinent to an independent potential corroboration of rock varnish ages, is now underway at Los Alamos National Laboratory.. It is recommended that the NRC reconsider the subject statement on page D-11 in light of the above discussion, when results of the in-progress work on cosmogenic dating are available.

Response:

During the past few years, most articles in scientific journals, which have addressed the rock varnish cation ratio method of dating, indicated that the use of this method is becoming progressively less acceptable, based on theoretical, statistical, and practical considerations. Therefore, we feel that the statement is appropriate.

PROPOSED REVISION - STANDARD REVIEW PLAN SECTION 2.5.1

1. Areal Extent for Regional Studies and Seismic Source Identification (in II. Acceptance Criteria Section 2.5.1.1, page 2.5.1-7, lines 20-23)

COMMENT: This section describes the requirement for an applicant to discuss a site's regional geology within a distance of 320 km of the site.

See Comment for DG-1032.

Standard Review Plan Section 2.5.1 (II.. Acceptance Criteria) should be modified to r. uire identification of only those seismic sources that may generate earthquakes which provide strong seismic ground motions at the site.

Response:

See response to Comment 2 on DG-1032 (now called Regulatory Guide 1.165).

PROPOSED REVISION - STANDARD REVIEW PLAN SECTION 2.5.2

1. Areal Extent for Regional Studies and Seismic Source Identification (in I. Areas of Review, page 2.5.2-2, lines 22, 23)

COMMENT: The statement is made that "all seismic sources that have any part within 320 km (200 miles) of the site must be identified."

See Comment 2 for DG-1032.

Standard Review Plan Section 2.5.2 should be modified to require identification only of sources that may contribute significantly to the seismic hazard at the site.

Response:

See responses to Comment 2 for DG - 1032 (Regulatory Guide 1.165).

2. NRC's "Balanced Approach" and It's Deterministic Component (in II. Acceptance Criteria, Section 2.5.2.4, page 2.5.2.9, lines 13, 14)

COMMENT: It would be useful if the NRC provided a flow diagram that clearly indicated how the PSHA procedure would encompass an independent evaluation.

This would be helpful because it would clearly show where independent evaluations will be used as input to the PSHA.

Response:

As stated in a previous comment response, the requirement for the staff to perform a deterministic seismic hazard analysis has been eliminated. "Balanced approach" refers to: (1) deterministic regional and site geological, seismological, geophysical, and geotechnical investigations; and (2) probabilistic seismic hazard analyses.

3. Procedure for Developing Site-Specific Spectral Shapes (in II. Acceptance Criteria, Section 2.5.2.6, pages 2.5.2-11, line 24 through 2.5.2-14, line 10)

COMMENT: This procedure does not take proper advantage of the current state of knowledge in ground motion estimation, and (in general) could be unnecessarily contentious and difficult to implement.

Although the primary preferred procedure (No. 1) would be the most desirable approach, data are rarely (if ever) available to permit this procedure to be properly used. Accordingly, this procedure should be used only in those instances where data are available.

The second preferred (No. 2) procedure should not be used without specific additional procedures for scaling source spectra such as those contained in the random vibration modeling approaches used in Reference 12 of the cited references.

The third of the preferred procedures, the random vibration method, should be emphasized. The random vibration method has been extensively validated against data during the past 10 years and can now be said to be accepted state of practice. Moreover, it is simple to apply now for any region of the United States.

Response:

Procedure No. 1, page 2.5.2-12. It is true that data required for this procedure is rarely available for a specific site, however, the staff is of the opinion that there is usually data available regarding analogous sites (similar sized earthquakes, similar subsurface conditions, etc.) within the worldwide database. If not, greater reliance will have to be placed on one or more of the other procedures.

Regarding your comment on the second procedure, we agree. The staff's intent has always been to use a multi-procedural approach. The results should be confirmed by performing additional procedures for scaling source spectra such as one of those used in Reference 12.

The random vibration method, procedure 3, has been validated to a large extent by data over the past decade, and may be used along with another method or methods. However, the staff prefers the application of Procedure 1.

Comments on Draft Regulatory Guide DG-1032

Draft Regulatory Guide DG-1032 reiterates the provision in Section 100.23(d)(1) of the proposed rule, which states that uncertainties in the Safe Shutdown Earthquake (SSE) must be addressed through appropriate analysis, such as a probabilistic seismic hazard analysis or suitable sensitivity analysis.. However, the draft regulatory guide then goes on to state that a probabilistic seismic hazards analysis should be performed. Additionally, almost all of the draft regulatory guide is devoted to the methodology for performing a probabilistic seismic hazards analysis, and it contains no discussion at all of other methods for addressing uncertainties in the SSE, thereby implying that other methods are not acceptable. However, there is no clear statement that if a probabilistic analysis is performed no further analysis is necessary or if a suitable sensitivity analysis is performed a probabilistic analysis is not necessary.

Furthermore, the draft regulatory guide states that the probability of exceeding the SSE should not exceed the median probability of existing plants exceeding their SSE's. The draft regulatory guide provides no explanation or justification for this provision, and none is apparent.

Response:

The staff prefers that an acceptable probabilistic seismic hazard analysis such as the LLNL or EPRI be performed, but leaves open the option to perform sensitivity studies. In Regulatory Guide 1.165 (formerly DG-1032), Section B. Discussion, Background, the first paragraph reads "A probabilistic seismic hazard analysis (PSHA) has been identified in Section 100.23 as a means to determine the SSE and account for uncertainties in the seismological and geological evaluations. The rule further recognizes that the nature of uncertainty and the appropriate approach to account for it depend on the tectonic regime and parameters such as the knowledge of seismic sources, the existence of historical and recorded data, and the level of understanding of the tectonics. Therefore, methods other than probabilistic methods such as sensitivity analyses may be adequate for some sites to account for uncertainties."

The type of analysis is left up to the applicant. However, in some cases, if an applicant elects to perform a sensitivity study to validate a site, it may also be necessary to conduct a probabilistic analysis, based on the results of the sensitivity analysis. For example, assume that the geological investigations identify paleoseismic evidence for a single large earthquake that occurred near the site several thousand years ago, but there is no evidence of a similar event within the past hundred thousand years. It might be desirable to address that event within the context a probability analysis to determine what percent of the total hazard that earthquake represents before calculating the SSE.

Operating plants have gone through the licensing process and have been subjected to the requirements of Appendix A to 10 CFR Part 100. Furthermore, in the Commission policy statement on severe accidents in nuclear power plants issued on August 2, 1985 (50FR 32138), the Commission concluded, based on available information, that existing plants pose no undue risk to the public health and safety. Based on that decision the staff decided to require that new plants base their SSE on the median probability of exceeding the SSE of the more recently licensed operating plants (those designed to Regulatory Guide 1.60 response spectra or to a similarly conservative response spectra).

This recommendation is discussed in the Statement of Considerations (RIN 3150-AD93), V,B,3, last paragraph, and the procedure itself is described in Appendix B to Regulatory Guide 1.165. In the referenced Statement of Considerations paragraph, the statement is made concerning the staff's review of applicants' SSE databases: "This review takes into account the information base developed in licensing more than 100 plants. Although the basic premise in establishing the target exceedance probability is that the current design levels are adequate, a staff review further assures that there is consistency with previous licensing decisions and that the scientific basis for decisions are clearly understood."

Responses to Comments of NEI Regarding the NRC Siting Documents

Comment No. 3:

Proposed Rule, line 3, 100.23. Section d(1) of this subpart states, "Determination of the Safe Shutdown Earthquake Ground Motion. The Safe Shutdown Earthquake Ground Motion for the site is characterized by both horizontal and vertical free-field ground motion response spectra at the free ground surface. The Safe Shutdown Earthquake Ground Motion for the site is determined considering the results of the investigations required by paragraph (c) of this section. Uncertainties are inherent in such estimates. These uncertainties must be addressed through an appropriate analysis, such as a probabilistic seismic hazard analysis or suitable sensitivity analyses. Paragraph IV (a)(1) of Appendix S to Part 50 of this chapter defines the minimum Safe Shutdown Earthquake Ground Motion for design."

Determination of the SSE is based upon an evaluation that includes investigation of geological and seismological information and the results of a probabilistic seismic hazard analysis. Addressing uncertainties is an inherent part of the process.

Based upon prior licensing decisions and scientific evaluations (Systematic Evaluation Program, Appendix A evaluations, LLNL, and EPRI) it seems reasonable to only perform detailed confirmatory site investigations (Regulatory Guide 1.132) at existing sites. Standardized 0.3g advanced plant designs are sufficiently robust to bound the seismic design attributes of all nuclear power plants at current sites. Inclusion of these simplified requirements for existing sites represents a significant step toward predictable and cost-effective licensing. Revise to read (substitution in italics):

Desired Change:

"Determination of the Safe Shutdown Earthquake Ground Motion. The Safe Shutdown Earthquake Ground Motion for the site is characterized by both horizontal spectra and vertical free-field ground motion response spectra at the free ground surface. *The Safe Shutdown Earthquake Ground Motion for the site is based upon the investigations required by paragraph (c) of this section and the results of a probabilistic seismic hazard analysis. Seismological and geological uncertainties are inherent in these determinations and are captured by the probabilistic analysis. Suitable sensitivity analyses may also be used to evaluate uncertainties.* Paragraph IV (a)(1) of Appendix S to Part 50 of this Chapter defines the minimum Safe Shutdown Earthquake Ground Motion for design. *Based upon prior scientific findings and licensing decisions at existing nuclear power plant sites east of the Rocky Mountain Front (east of approximately 105 west longitude), a 0.3g Standardized design level is acceptable at these sites given confirmatory foundation evaluations.*"(1)DG-1032

Response No. 3:

(1) Determination of the Safe Shutdown Earthquake ground Motion. Your recommended rewording is another way of saying the same thing, but places less

emphasis on site-specific investigations relative to the PSHA than the current wording. We regard the current wording as better reflecting the proper priorities. Site specific investigations (regional and site geological, seismological, geophysical, and geotechnical) are of prime importance in deriving the bases for the SSE. It must not be forgotten that if all of the data that is needed about a site to determine the SSE could be obtained through site-specific investigations, a PSHA would not be necessary. However, because of uncertainties, at the present time, more reliance must be placed on PSHA's than may be necessary in the future when more information is available.

Paragraph IV(a)(1) of Appendix S to Part 50. Investigations at most of the existing sites will more than likely be confirmatory if the initial investigations were thorough, and there has not been too much time past since the initial investigations were accomplished and the results reviewed by the NRC, during which a substantial amount of new information has been developed. However, in many cases it may be necessary to carry out more extensive investigations than are usually considered as "confirmatory" investigations because: (1) the state-of-the-science is rapidly changing as new information is derived from every earthquake that occurs, and from ongoing research; (2) applicants may elect not to use the standard design plant and justify an SSE different than 0.03g; and (3) it will often be necessary, even for standard design sites, to determine a site-specific SSE as the design basis for other, non-standard design, safety-related structures, systems or components such as dams, reservoirs, intake and discharge facilities, etc.

The current wording in the proposed regulation most accurately represents the NRC staff's position on this issue.

Comment No. 4:

DG-1032, page 8, line 8. Item 4 states, " Very detailed geological, geophysical, and geotechnical engineering investigations should be conducted within the site (radius of approximately 1 Km)....."

The guidance language should include English units consistent with NRC staff policy.

Desired Change:

Revise to read:

"Very detailed geological, geophysical, and geotechnical engineering investigations should be performed within the site [1 km (0.5 miles)]..."

Response No. 4:

We agree with this comment and the English units have been added.

Comment No. 5:

DG-1032, pages 7-8, Line 15 on P7 to 10 on P8, Paragraph 3. This Section states:

"1. Regional geological and seismological investigations such as geological reconnaissances and literature reviews should be conducted within a radius of 320 km (200 miles) of the site to identify seismic sources (seismogenic and capable tectonic sources)."

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...

3. Detailed geological, seismological geophysical and geotechnical investigations should be conducted within 8 km (5 miles) of the sites as appropriate...

4. Very detailed geological, geophysical, and geotechnical engineering investigations should be conducted within the site (radius of approximately 1 km) to assess specific soil and rock characteristics..."

The requirements to perform investigations within 320 Km (200 miles) around a site is excessive and not generally needed to determine the seismic sources that could contribute to the seismic hazard at a site. The seismic hazard at a site in the Central and Eastern U.S. (EUS) is dominated by earthquakes that occur at distances less than 100 km in most cases. Nonetheless, seismic sources beyond 100 km are considered in the PSHA if appropriate (e.g., incorporation of the New Madrid seismic zone).

Since the EPRI and LLNL seismic sources are accepted (with confirmation) as the basis for determining the seismic hazard at potential sites in the EUS, the potential contributions of all sources will be known. In the WUS, the very high rate of attenuation of ground motion precludes seismic sources beyond 150 Km contributing to the seismic hazard at a site.

The IAEA Safety Guide No. 50-SG-S1 (Rev. 1), "Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting, 1991" provides the justification for the proposed revisions regarding the distances , i. e, 320 Km to 200 Km and 40 Km to 25 Km.

Desired Change:

Revise Paragraph 1 to read:

"...reviews should be conducted within a radius of 200 Km (125 miles) of the site to identify seismic sources..."

Revise Paragraph 2 to read:

"...carried out within a radius of 25 km (15 miles)..."
Note: This comment also applies to DG-1032, Appendix D, page D-4, line 28; SRP 2.5.2, Page 2.5.2.-5, line 17 and Page 2.5.2.-6, line 17.A.

Response No. 5:

Paragraph 1. The 320 km (200 mi) radius was established by the authors of Appendix A to 10 CFR Part 100 and we see no compelling reason to change that distance at this time. The reason for this distance in the CEUS is not only to provide a broad enough area to allow for the identification of seismic sources close enough to affect the site, but also to allow for the incorporation of more earthquake data, which is diagnostic of seismic sources, into the analysis. It also allows the incorporation of a greater amount of technical information concerning previously identified, more distant potential seismic sources that could be analogous to sources near to, or underlying the site.

In past licensing activities in the CEUS it has often been necessary to estimate the age of a potential capable fault by relating its time of last activity to that of a previously evaluated structure, or a known tectonic episode, the evidence of which may be many tens or hundreds of miles from a site. The converse has also occurred when it became necessary to relate the age of last activity of a distant significant regional source to one investigated in detail near a site.

Because the CEUS is relatively aseismic and earthquake sources are undefined, we believe the area should be as broad as reasonable to expand the database. This database includes regional data such as historic and instrumentally recorded seismicity, paleoseismic evidence, geological evidence, and geophysical anomalies that could be used to identify or interpret potential seismic sources.

In most cases the types of investigations necessary within the 200 mile radius will not be extensive, but consist of a literature search, and the study of existing maps, subsurface data, remote sensing data, and geophysical data, with some ground truth reconnaissances.

In the western U.S. (WUS) it is also 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, the Juan de Fuca Subduction Zone, etc. 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 Zone, it would not be necessary to extend the regional investigations to the east beyond the dominant San Andreas Fault, which is about 75 km (45 mi) from the site; nor to the west beyond the Santa Lucia Banks Fault, which is about 45 km (27 mi) from the site. In other words, in the WUS it is often possible to specifically define and justify closer in (less than 200 mi) limits of regional investigations and focus investigations at greater distances (greater than 200 mi) because the major sources are more often known than in the CEUS.

Paragraph 2. The purpose of the 25 mile (40 km) radius is to ensure that an investigation of sufficient detail will be carried out to demonstrate that there is no potential significant seismic source within the near field of the site, or to provide sufficient information to characterize the hazard of such a source if it exists. The near field is considered to be within about 17 km, however, it is prudent to extend the area of investigations at this level of detail beyond that limit due to the difficulty of defining seismic sources in the CEUS. Detailed investigations within this area will most likely be asymmetric and focussed on limited locations that were identified during the regional investigations.

Comment No. 6:

DG-1032, Page 13, line 23, Item 4. Last paragraph of item 4 states, "To obtain an adequate design SSE based on the site specific response spectrum or spectra, develop a smooth spectrum or spectra...."

As currently stated, this item confuses the design SSE (established by the certified design of the given ALWR) with the site-specific SSE response spectra associated with ensuring a certified design can be placed on that site.

The design SSE is established by the DG-1032 process. Part 100 addresses the determination of the site-specific SSE response spectrum that should be emphasized by the design.

Desired Change:

Revise to read:

"To obtain an adequate comparison of the site-specific SSE response spectrum or spectra with the ground motion spectra used for design, develop...."

Response No. 6:

The paragraph has been revised to address the concern.

Comment No. 7:

DG-1032, Page 10, lines 1 and 21, Sections.2.2.1 & 2.2.2.1. Section 2.2.1 states, "For sites located in the EUS, the seismic sources and data that have been accepted by the NRC staff in past licensing decisions may be used to estimate seismic potential."

Section 2.2.2.1 states, "For sites located in the CEUS, the seismic sources and data that have been accepted by the NRC staff in past licensing decisions may be used to estimate seismic potential."
The actual meaning or value of these statements are not clear in the context of a PSHA and in particular regarding the use of the EPRI and LLNL seismic hazard methodologies. The text should also refer to seismic sources and data used in the LLNL and EPRI seismic hazard studies. Given that past licensing decisions have been made on the basis of deterministic assessments, there is clear method for considering that information.

It would be useful to an applicant if the NRC staff could provide in Appendix D a section that presents a complete description of the "NRC accepted" source zones and their associated controlling earthquakes from past licensing decisions.

Desired Change:

Revise Section 2.2.1 and/or 2.2.2.1 to read:

"For sites located in the EUS and CEUS, the seismic sources and data that have been accepted by the NRC staff in both past licensing decisions and in the

LLNL and EPRI methodologies may be used to estimate seismic potential. Appendix D contains a section that presents a complete description of accepted source zones and their associated controlling earthquakes."

Response No. 7:

Because we are recommending that the LLNL and EPRI PSHA's be used, it is understood that the seismic sources that form the bases of these analyses will be considered. However, the wording has been changed to make the intent of the statement more clear as follows: "For sites located in the CEUS, when the EPRI and LLNL PSHA methodologies are used to determine the SSE, it still may be necessary to investigate and characterize potential seismic sources that were previously unknown or uncharacterized, and perform sensitivity analyses to assess their significance to the seismic hazard estimate. The results of investigations discussed in Regulatory Position 1 are to be used, in accordance with Appendix E, to determine whether updating of the LLNL or EPRI seismic sources and their characterization is needed. The guidance in 2.2 and 2.3 below and Appendix D of this guide may be used if additional seismic sources are to be developed as a result of investigations."

Since the dual deterministic and probabilistic method described in former DG 1015 was abandoned, the intent of Regulatory Guide 1.165 (formerly DG 1032 and before that DG 1015) has been to describe acceptable deterministic investigation procedures and probabilistic seismic hazard methodologies; but not deterministic seismic hazard methodologies. Because your comment is in regard to a deterministic seismic hazard analysis, its resolution more appropriately belongs in SRP 2.5.2. Therefore, a table, Table 1, which is a very general presentation based on technical information developed over the past two decades of licensing nuclear power plants, has been added to Subsection 2.5.2.4, for use by the NRC staff in reviewing the results of the applicants' PSHA.

Comment No. 8:

DG-1032, Page 10, lines 12-14, Sect 2.2.1. This Section states, "These seismic sources and their parameters should be used to judge the adequacy of seismic sources and parameters used in the LLNL or EPRI PSHA."

It is technically inappropriate to establish the seismic sources developed as part of past licensing decisions as a criterion for acceptance of the LLNL and EPRI seismic source characterizations. The determination of seismic sources used in past licensing decisions was made in the context of a deterministic analysis. Consequently, there is no practical way to use these seismic sources and their parameters developed in past licensing decisions as a measure of the adequacy of a probabilistic assessment that considers the uncertainty in the seismic source characterization.

Section 2.2.1 is an apparent attempt to apply a deterministic acceptance criterion (i.e., measure of adequacy) to the PSHA seismic source characterization.

Desired Change:

Delete this entire section.

Response No. 8:

Section 2.21 has been modified as described in the responses to Comments 6 and 7, but the section has been left in. The significance of these modifications is that the staff is no longer required to perform a deterministic check of the applicants' PSHA, which appears to be the objection to the section.

Among the criteria with which the staff will judge the adequacy of the PSHA-determined SSE are: (1) the results of the applicants' deterministic regional and site investigations and other available technical information, (2) the results of its own independent PSHA, and (3) comparison with Table 1 in SRP 2.5.2, which is based to a large extent on consideration of historic seismicity.

Comment No. 9:

DG-1032, Page 2, lines 1-5, Sect A. The text states, "In the proposed section 100.23, paragraph (d)(1)...would require that uncertainty inherent in estimates of the SSE be addressed through an appropriate analysis such as a probabilistic seismic hazard analysis or suitable sensitivity analysis."

The proposed revision makes the draft regulatory guide (DG-1032) consistent with the proposed rule Section 100.23.

See also the rationale provided in Comment Number 3 above.

Desired Change:

Revise to read:

"In the proposed section 100.23, paragraph (d)(1), determination of the safe shutdown earthquake ground motion for the site is based upon the investigations required by paragraph (C) of this section and the results of the probabilistic seismic hazard analysis. Seismological and geological uncertainties are inherent in these evaluations and are captured by the probabilistic analysis."

Response No. 9:

See Response No. 3. Section 100.23, paragraph (d)(1) was not modified in the regulation, so there is no need to alter the present wording for consistency.

Comment No. 10:

DG-1032, page 3, line 5, Sect B. The text states, "A probabilistic seismic hazard analysis (PSHA) has been identified in the proposed Section 100.23 as one of the means to address uncertainties in estimates of the SSE."

The proposed revision makes the draft regulatory guide (DG-1032) consistent with the proposed rule § 100.23. Also see the rationale provided in Comment Number 3 above.Revise to read:

"A probabilistic seismic hazard analysis (PSHA) has been identified in the proposed § 100.23 as a means to determine the SSE and account for inherent uncertainties in the seismological and geological evaluations."

Response No. 10:

The text has been changed to include the recommended wording as follows: "A probabilistic seismic hazard analysis (PSHA) has been identified in Section 100.23 as a means to determine the SSE and account for uncertainties in the seismological and geological evaluations."

Comment No. 11:

DG-1032, page 3, line 16, Sect B. The text states, "...incorporate uncertainty in the..."

The proposed revision is more accurate and consistent.

Desired Change:

Revise to read:

"...incorporate uncertainty (i.e., alternative scientific interpretations) in the ...."

Response No. 11:

We agree that the suggested revision says it better, and has been adopted in the following manner: "(including alternative scientific interpretations).

Comment No. 12:

DG-1032, page 4, line 16, Sect B. The text states, "The process to determine the SSE at a site should include:"

The proposed revision makes the draft regulatory guide (DG-1032) consistent with the proposed rule § 100.23. It is understood that regional investigations are not needed at existing sites.

Desired Change:

Revise to read:

"The process to determine the SSE at a site in general include:

Response No. 12:

The phrase "in general" has been inserted to replace "should" in this statement as recommended, however, it will in most cases, be necessary to conduct regional investigations at existing sites. The scope of these regional studies will vary from site to site, however.

Comment No. 13:

DG-1032, page 5, lines 5-9, Sect B. The text states, "Thus, there is greater uncertainty in making judgments about the CEUS than there is for active plate margin regions, and it is important to account for this uncertainty by the use of multiple alternative models."

This sentence should be deleted because it is likely to be incorrect both probabilistically and deterministically. Probabilistic analyses have shown that the uncertainty at a given probability (say 10^{-5} median) for WUS sites is comparable or larger than that found for EUS sites. If a LLNL analysis were performed for an existing WUS site it is likely that the uncertainty would far exceed that shown for a typical EUS site. Furthermore, it would be prudent to exercise the LLNL methodology at a WUS site to confirm the adequacy/suitability of the probabilistic approach for WUS sites. Deterministically, there is great uncertainty concerning blind faults and subduction zone sources. In addition, not only is the process highly uncertain for the WUS, but it has yet to be demonstrated at a hypothetical EUS site.

Desired Change:

Delete this statement.

Response No. 13:

We agree with the comment and have deleted the statement. The last phrase has been made into a sentence that reads " Therefore, it is important to account for this uncertainty by the use of multiple alternative models."

Comment No. 14:

DG-1032, page 10, line 12, Sect B. The text states, "These seismic sources and their parameters should be used to judge the adequacy of the seismic sources and parameters used in the LLNL or EPRI PSHA."

Considering the recommended changes in Comment 8, this statement becomes meaningless. Hence, it is proposed to delete it.

Desired Change:

Delete this statement.

Response No. 14:

This part of the Regulatory Guide has been rewritten and the statement referenced in the comment has been deleted from the document.

Comment No. 15:

DG-1032, page 11, line 31, Sect 3. The text states, "The PSHA should only be updated if it will lead to higher hazard estimates."

More balance and discipline is needed in the process that determines if, a when, the PSHA should be updated to reflect new data than is indicated by this statement. The PSHA should not be updated solely based on new hazard data, rather based on sound technical basis.

Desired Change:

Revise to read: "The PSHA should only be updated if there is a strong technical basis supporting the validity of the new data."

Response No. 15:

The statement has been revised to: "The PSHA should only be updated if the new information indicates that the current version significantly under estimates the hazard and there is a strong technical basis that supports such a revision. It may be possible to justify a lower hazard estimate with an exceptionally strong technical basis. However, it is expected that large uncertainties in estimating seismic hazard in the CEUS will continue to exist in the future, and substantial delays in the licensing process will result in trying to address them with respect to a specific site. For these reasons the staff discourages efforts to justify a lower hazard estimate. In most cases, limited-scope sensitivity studies should be sufficient to demonstrate that the existing data base in the PSHA envelopes the findings from site-specific investigations. In general, significant revisions to the LLNL and EPRI data base are to be undertaken only periodically (every ten years), or when there is an important new finding or occurrence. An overall revision of the data base also require a reexamination of the reference probability discussed in Appendix B and used in Step 4 below. Any significant update should follow the guidance of Reference 9.

Comment No. 16:

DG-1032, App A, page A-1, line 3, para 1. The text states, "In the probabilistic seismic..."

The procedure to determine probabilistic controlling earthquakes is described in detail and is clearly reproducible. On the other hand, deterministic controlling earthquakes are implied (see regulatory Position 4, par (1) of DG-1032), yet there is no parallel definition for the deterministic controlling earthquake. There is a need to clearly define how the staff will determine deterministic earthquakes; also the proposed process should be reproducible.

Desired Change:

Revise to read:

"As a result of the probabilistic seismic..."

Response No. 16:

The suggested wording has been incorporated into the definition. There is no longer a need to define a deterministic controlling earthquake or describe the process for determining its magnitude and distance. The staff is not required to perform an independent deterministic seismic hazard analysis (see the response to Comment 8).

Comment No. 17:

DG-1032, App A, page A-1, line 19, para 5. Safe Shutdown Earthquake Ground Motion is defined as "the vibratory ground motion for which certain structures, systems and components would be designed ...to remain functional."

The ground motion should be noted to be in the free-field.

Desired Change:

Revise to read:

"The safe shutdown earthquake ground motion is the *free-field* vibratory..."

Response No. 17:

We agree. The term "free-field" has been inserted into the sentence.

Comment No. 18:

DG-1032, App A, page A-2, lines 26-29, para 6. Seismogenic Source is defined as "a portion of the earth that has uniform earthquake potential (same expected maximum earthquake and frequency of recurrence) distinct from other regions..."

"Earthquake potential "can have a misleading connotation. The proposed change suggests a more precise definition.

Desired Change:

Revise to read:

"A "seismogenic source" is a portion of the earth that has assumed uniform seismicity (same recurrence frequency) distinct from the seismicity of the surrounding regions..."

Response No. 18:

The sentence has been partially revised to read: "A "seismogenic source" is a portion of the earth that we assume has uniform earthquake potential (same expected maximum earthquake and recurrence frequency) distinct from the seismicity of the surrounding regions."

Comment No. 19:

DG-1032, App B, page B-2, line 18, Sect B.3.2. The text states, "Using an accepted methodology,
calculate..."

The proposed revision should offer applicants the flexibility to use different methodologies, as long as they can be demonstrated to meet the intent of the regulatory guidance.

Desired Change:

Revise to read:

"Using *LLNL, EPRI, or a comparable methodology*, calculate.....".

Response No. 19:

The phrase has been revised to read "Using LLNL, EPRI, or a comparable methodology that is acceptable to the NRC staff, calculate___"

Comment No. 20:

DG-1032, App B, page 2, line 24, Sect B.3.2. The text states, "Calculate the median composite annual probability...".

The word "median" is deleted to be consistent with line 26 of DG-1032, Appendix B, page 2. Also it is prudent to de-emphasize the use of the word median. There is sufficient explanation to show that the composite probability is based upon medians.

Desired Change:

Delete the word "median

Response No. 20:

The term "median" has been deleted.

Comment No. 21:

DG-1032, App C, page 1, line 16, Sect C.1. The text states, "A site specific response spectrum shape is determined..."

Rationale for not determining a site-specific spectrum:
If an ALWR is to be placed at an existing site, then the standardized ALWR spectrum is good enough and no further work should be required.

Desired Change:

Revise to read:

"A site specific response spectrum may be determined...".

Response No. 21:

A site specific response spectrum should be determined, even when a standard design plant is to be placed on a site, for the purposes of: (1) comparing it with the standardized ALWR spectrum, and (2) developing the seismic design basis for other, nonstandardized safety related structures, systems and components.

Comment No. 22:

DG-1032, App C, page 1, line 20, Sect C.2. The text states, "Procedure to determine controlling earthquakes.."

The procedure provided in this section is inconsistent with the example given. In particular, the de-aggregation described in step 1 (page C-2) cannot take place before the de-aggregation ground motion level is determined, which is step 2.

Desired Change:

The example needs further clarification.

Response No. 22:

Steps 1 and 2 have been rewritten to clarify the procedure.

Comment No. 23:

DG-1032, App C, page 2, line 23, Sect C.2. The text states, "Steps 3 to 5 describe the procedure to develop the seismic hazard information base for each ground motion level determined in Step 2. This information base will consist of:

•Fractional contribution of each magnitude-distance pair to the total median seismic hazard.

•Magnitudes and distances of the controlling earthquakes.

•The ground motion levels for the spectral accelerations at 1, 2.5, 5, and 10 Hz defined in Step 2.

•The average of the ground motion levels listed above at the 1 and 2.5 Hz, $S_{a1-2.5}$, and 5 and 10 Hz, S_{a5-10}, spectral accelerations corresponding to the reference probability."

This explanation can be simplified, as indicated in the proposed change.

Desired Change:

Delete this whole paragraph. Replace it with Step 3 as follows:

"Step 3

Perform a complete PSHA, deaggregating in terms of magnitude and distance for each of the bins described in Table C.3."

Response No. 23:

As recommended, the referenced paragraph has been removed. The following statement has been labeled as Step 3 "Perform a complete probabilistic seismic hazard analysis for each of the magnitude-distance bins described in Table C.3."

Comment No. 24:

DG-1032, App C, page 3, lines 13-14, Sect C.2. The text states, "Step 3 Using the de-aggregated median hazard results from Step 1, at the ground motion levels obtained from Step 2 calculate the fractional contribution to the total median hazard of earthquakes in a selected set of magnitude and distance bins... The median annual probability of exceeding the ground motion levels calculated in Step 1 for each magnitude and distance bin and ground motion measure is denoted by H_{mdf}."

The proposed revision, in conjunction with the changed recommended in Comment 23, makes the process sequentially correct.

Desired Change:

Revise to read:

"**Step 4**
Using the de-aggregated median hazard results from **Step 3**, at the ground motion levels obtained from Step 2 calculate the fractional contribution to the total median hazard of earthquakes in a selected set of magnitude and distance bins... The median annual probability of exceeding the ground motion levels calculated in **Step 2** for each magnitude and distance bin and ground motion measure is denoted by H_{mdf}."

Response No. 24:

The sequence is correct by changing Step 1 to Step 3 in the first line of step 4. The suggested modification has been made.

Comment No. 25:

DG-1032, App C, pages 4-5, lines 3 & 17 on Pages 4, 5, and 6, Sect C. The text provides steps 4, 5, and 6 on pages 4 and 5 .

Steps 4, 5, and 6 are unnecessary for the rock sites. The basis for the proposed revision is recent knowledge gained concerning attenuation of ground motion in the EUS. Distant sources are only an issue at soil sites where amplification at low frequencies can be significant.

Desired Change:

Delete steps 4, 5, and 6 for the rock sites.

Response No. 25:

We do not agree with the recommended deletion.

Comment No. 26:

DG-1032, App C, pages 7-8, All, Tables C.3 & C.4. It would be helpful to an applicant to show a table of actual hazard values for each bin and the total hazard. This would help in understanding the overall process and the development of Table C.4.

Desired Change:

Develop table suggested.

Response No. 26:

Tables C.4-C.7, which show the hazard values corresponding to the ground motion levels defined in step 2 for the spectral acceleration at 1, 2.5, 5, and 10 Hz, have been added.

Comment No. 27:

DG-1032, App D, page 8, line 26, Sect. D.2.3.2.1. This item states,".....and provide assurance that there are no significant sources of earthquakes within the site vicinity."

Although it is certainly an objective to demonstrate that there are no significant seismic sources within the site vicinity, the use of seismographic records during a period from site selection to finalization of staff review for combined license is not sufficient time to base conclusions on the results of such records.

Desired Change:

Delete this statement.

Response No. 27:

Your comment is correct. The statement gives more weight to seismic monitoring in accomplishing this objective than is warranted. Instead of deleting the statement we have reworded it to place seismic monitoring in its proper perspective as follows: "The data obtained by monitoring current seismicity will be used, along with the much larger data base acquired from site investigations, to evaluate site response and to provide information about whether there are significant sources of earthquakes within the site vicinity, or to provide data by which an existing source can be characterized."

Comment No. 28:

DG-1032, App D, page 1, line 1, Sect. D. Industry recommended changes to the distance associated with various regional and site studies are defined in earlier comments on the main body of DG-1032. See Comment Number 5.

Desired Change:

As stated in Comment Number 5

Response No. 28:

Based on the reasons described in our response to Comment Number 5, we haven't modified the distances specified for regional and site investigations.

Comment No. 29:

DG-1032, App D, page 8, lines 20-33, Sect D.3.2.2. For sites in the CEUS, a single large dynamic range, broad-band seismograph may be adequate. For sites in the Western United States, a network of at least five such seismographs would be deployed within 25 km (15 mi.) surrounding the site.

The primary purposes of seismic monitoring are to obtain data from distant earthquakes, to determine site response, and provide assurance that there are no significant sources of earthquakes within the site vicinity. For sites in the Western United States seismic monitoring could help locate any ongoing seismicity that may indicate capable faulting within the site vicinity.

Monitoring should be initiated up to five years prior to construction of a nuclear unit at a site and should continue for at least five years following initiation of plant operation.

Comment - to expect data from distant earthquakes or to determine site response for a EUS site based on putting in a seismic network is unlikely.

Desired Change:

Revise to read:
"For sites in the Western United States, a network of at least five such seismographs would be deployed within 25 km (15 mi.) surrounding the site. For sites located in regions containing active seismographic networks, additional monitoring is not required. The primary purpose of seismic monitoring is to provide assurance that there are no significant sources of earthquakes within the site vicinity. For sites in the Western United States seismic monitoring could help locate any ongoing seismicity that may indicate capable faulting within the site vicinity. Monitoring should be initiated as soon as practicable at a site."

Response No. 29:

Relying on existing seismographs is not enough, unless one of these happens to be located at the site. Instrumentation is particularly important if water is to be impounded in a reservoir at the site. An effort should be made by an applicant to monitor seismicity at least five years before construction.

Subsection D.2.3.2.2 has been revised in the following manner: "Seismic monitoring in the site area should be established as soon as possible after site selection. For sites in both the CEUS and WUS, a single large dynamic range, broad-band seismograph, and a network of short period instruments to locate events should be deployed around the site area.

The data obtained by monitoring current seismicity will be used, along with the much larger data base acquired from site investigations, to evaluate site response and to provide information about whether there are significant sources of earthquakes within the site vicinity, or to provide data by which an existing source can be characterized.

Monitoring should be initiated as soon as practicable at the site, preferably at least five years prior to construction of a nuclear unit at a site and should continue at least until the free field seismic monitoring strong ground motion instrumentation described in Regulatory Guide 1.12 is operational."

Comment No. 30:

DG-1032, App E, page 1, lines 1-22, Sect E.1. Updating of the input parameters to the seismic hazard analysis is inherently destabilizing to the licensing process. The reference probability is based upon results obtained from a consistent application of the LLNL methodology at all EUS sites. Application of the reference probability to an analysis that is inconsistent with the basis for the reference probability is inconsistent with the use of relative probabilities. Therefore, all source zones, attenuation models, and upper bound magnitudes should be frozen until they are again determined in a consistent manner. Seismicity parameters should be updated based upon use of a current earthquake catalog. Only if there is consensus within the scientific community supporting the validity of the new data should the data be updated. If the new data only has an impact on the site being evaluated (source zones) then a new reference probability need not be calculated. If the new data has a potential impact on all sites (new attenuation model) then the seismic hazard at all Table B.1 sites needs to be recalculated using the new attenuation model, and a new reference probability be calculated.

Desired Change:

This discussion should be modified to include the admonition that input parameters are only subject to change after thorough review and consensus within the scientific community.

Response No. 30:

We agree that it should be revised if there is a strong technical basis supporting it. The new data will certainly be made available to the scientific community for its opinions. However, obtaining consensus of opinion from the scientific community is usually a very lengthy and tedious process and a decision will more than likely be needed before a consensus is reached (a consensus is not likely anyway). We will rely on discussions with knowledgeable scientists, the applicant and its consultants, the expertise of the staff and its consultants in evaluating the new technical information, and advice from the US Geological Survey in deciding whether the technical bases are strong enough to warrant a modification of the PSHA.

Beginning on line 19 of page E-1, the text has been modified to read: "If new information identified by the site specific investigations would result in a significant increase in the hazard estimate for a site, and this new information is validated by a strong technical basis, the PSHA may have to be modified to incorporate the new technical information.

In general, major recomputations of the LLNL and EPRI data base are planned to be undertaken periodically (approximately every ten years), or when there is an important new finding or occurrence that has, based on sensitivity studies, resulted in a significant change in the hazard estimate."

Comment No. 31:

DG-1032, App F, page 1, line 28, Sect F.2. The text states, "...the following three possible situations...."

The proposed revision provides consistency throughout DG-1032.

Desired Change:

Revise to read:
"...the following acceptable situations...."

Response No. 31:

We see no reason to revise this statement.

Comment No. 32:

DG-1032, App F, page 2, line 4, Sect F.2. The text states, "....site specific spectra."

The proposed addition provides consistency and coherency.

Desired Change:
Revise to add the following sentence at the end of the statement.
"In this case a site specific SSE is determined."

Response No. 32:

We see no reason to revise this statement.

Comment No. 33:

DG-1032, page 4, line 16, Sect B. The text states, "...that site should include:"
This proposed revision provides consistency.

Desired Change:

Revise to read:...at a site in general include:"

Response No. 33:

As suggested, "in general" has been inserted to replace "should" in this statement.

Comment No. 34:

DG-1032, App D, page 8, line 32, Item D.2.3.2.2. This item states,"....and should continue for at least five years following initiation of the plant operation."

The staff assessment of information on which to base a final conclusion of site suitability would have been completed before major plant construction is advanced and certainly before the start of plant operation. Furthermore, the free field seismic monitoring instrumentation required by DG-1034 would be operational by the time of plant operation.

Desired Change:

Delete the last phrase in this statement.

Response No. 34:

The last phrase has been deleted and replaced with "until the free field seismic monitoring strong ground motion instrumentation described in Regulatory Guide 1.12 is operational."

Comment No. 53:

SRP 2.5.1, page 12, lines 8-9, Item IV. This item states, 'The evaluation determinations are made by the staff after the early site, construction permit, or operating license reviews. A similar conclusion...."

In the first sentence, it is unclear whether the phrase *evaluation determinations* refers to . If separate staff reviews are performed at construction permit and operating license stages, the staff evaluation based upon inspection of excavations would be performed during construction and prior to the operating license review, not after it. The phrase *similar conclusion* at line 9 is unclear in as much as a clear description of a conclusion does not precede this sentence.

Desired Changes:

These statements need clarify that a final staff determination is essential to establish a regulatory position on site suitability and relieve the applicant's exposure to regulatory uncertainty. The timely documentation of the staff's final conclusions after their inspection of site excavation for a combined license should be stressed.

Response No. 53:

Evaluation determinations refer to decisions by the staff regarding the geological and seismological suitability of the site. The subject paragraph has been revised to read: "The evaluation determinations with respect to the geological and seismological suitability of the site are made by the staff after the early site and construction permit reviews, and during the operating license reviews. A conclusion regarding an Operating License will include an evaluation of the excavations for Category 1 structures. A conclusion regarding the geological and seismological suitability of a site following a combined license review will be made when the applicant has committed to mapping excavations for Category 1 facilities and notifying the staff of their availability for examination. The staff will conduct this examination at the appropriate time after licensing to confirm that there are no previously unknown features, such as potentially active faults, evidence for strong ground motions such as late Quaternary seismically induced paleoliquefaction features, unsuitable soil zones, or cavities in the excavations."

Comment No 54:

SRP 2.5.2, All pages, lines 7-23 of Pages 8-9, Sect 2.5.2.4. General Comment: This SRP is the staff basis for a deterministic evaluation of controlling earthquakes. It is unclear how the source zone model based upon seismology and geology is to be used, e.g., controlling earthquakes based upon the probabilistic analysis or controlling earthquakes based upon a staff deterministic evaluation. Historically, determination of controlling earthquakes using deterministic methods has been extremely controversial. Also, the basis for determining the controlling earthquake is interpretive and non-quantitative.
More specifically, Section 2.5.2.4 states, "The staff will review the applicant's probabilistic seismic hazard analysis, including the underlying assumptions and how the results of the site investigations and findings of Sections 2.5.2.2 and 2.5.2.3 are used to update the existing sources in the probabilistic seismic hazard analysis. The staff will perform an independent evaluation of the earthquake potential associated with each seismic source that could affect the site. The staff will evaluate the applicant's controlling earthquakes based on historical and paleo-seismicity. In this evaluation, the controlling earthquakes for each source are at least as large as the maximum historic earthquake. The staff will review the controlling earthquakes and associated ground motions at the site derived from the applicant's probabilistic hazard analysis to be sure that they are either consistent with the controlling earthquakes/ground motions used in licensing of (a) other licensed facilities at the site, (b) nearby plants or (C) plants licensed in similar seismogenic regions, or the reasons they are not consistent are understood."

This paragraph describes the independent review the staff will conduct with respect to the seismic sources that are used in the PSHA and SSE determination. The review will look at the controlling earthquake for each seismic source, yet once the controlling earthquake for each seismic source is reviewed, it is not clear how this section will be used. The DG-1032 process does not require, nor should it require, an applicant to determine a controlling earthquake for individual seismic sources.

The controlling earthquake for each seismic source will be compared to the maximum historical event to see if it is at least as large. This acceptance criterion for the source specific controlling earthquake is inappropriate, because it is a criterion that has no relationship to the probabilistic assessment and the manner in which the controlling earthquake is determined. Furthermore, it is an unnecessary conservatism that as a matter of routine NRC staff practice should not be added to the seismic siting process.

This paragraph concludes by saying that the controlling earthquake and the SSE determined from the PSHA will be compared to the SSE and controlling earthquakes for units that have already been licensed at or near the site being considered. The reasons for any inconsistencies will be considered. It is important to recognize, if the SSE were to be evaluated using the procedure described in DG-1032 at each existing plant site, a comparison would conclude that at approximately one-third of the sites the existing SSEs are higher than the value determined using the proposed procedure. This is inherent to the process.

The above being the case, the reason for comparison and the action that might be taken by the staff (e.g., reject the DG-1032 result) is not clear. The net result of this paragraph is open ended flexibility in the NRC staff review with a process that is foreign to the PSHA approach recommend in DG-1032.

Conversely, the SRP provides no guidance relative to reviewing the PSHA performed by the applicant in order to assess its adequacy.

Desired Change:

Suggest clarification of this Section such that the review process can be efficient and reproducible. For example, (1) when NRC staff performs an independent evaluation of the earthquake potential associated with each seismic source, it is not clear if these are the probabilistic sources or the sources based upon the model, (2) can the staff provide examples or description of how this evaluation is performed, and (3) can the staff define what a deterministic controlling earthquake is and how it is determined.

Response No. 54:

The following text now comprises Subsection 2.5.2.4:

For the CEUS sites relying on LLNL or EPRI methods, the staff will review the applicant's probabilistic seismic hazard analysis, including the underlying assumptions and how the results of the site investigations are used to update the existing sources in the probabilistic seismic hazard analysis, how they are used to develop additional sources, or how they are used to develop a new data base.

The staff will review the controlling earthquakes and associated ground motions at the site derived from the applicant's probabilistic hazard analysis to be sure that they are either consistent with the controlling earthquakes/ground motions used in licensing of (a) other licensed facilities at the site, (b) nearby plants, or (c) plants licensed in similar seismogenic regions, or the reasons they are not consistent are understood. For the CEUS, a comparison of the PSHA results can be made with the information included as Table 1, which is a very general presentation based on technical information developed over the past two decades of licensing nuclear power plants.

The applicant's probabilistic analysis, including the derivation of controlling earthquakes, is considered acceptable if it follows the procedures in Regulatory Guide 1.165 and its Appendix C (Ref. 9). The incorporation of results of site investigations into the probabilistic analysis is considered acceptable if it follows the procedure outlined in Appendix E of Regulatory Guide 1.165 and is consistent with the review findings of Sections 2.5.2.2 and 2.5.2.3.

For the sites not using LLNL or EPRI methods, the staff will review the applicant's PSHA or other methods used to derive controlling earthquakes. The staff will particularly review the approaches used to address uncertainties. The staff will perform an independent evaluation of the earthquake potential associated with each seismic source that could affect the site. The staff will evaluate the applicant's controlling earthquakes based on historical and paleo-seismicity. In this evaluation, the controlling earthquakes for each source are at least as large as the maximum historic earthquake.

Comment No. 55:

SRP 2.5.2, Page 7, line 14, Sect 2.5.2.3. The text states, "The applicant's presentation is accepted when the earthquakes discussed in Subsection 2.5.2.1 of the SAR are shown to be associated with ~~either geologic structure or tectonic province~~ seismic sources."

It is not clear how an applicant knows that an earthquake is associated with a seismic source other than the fact that the earthquake occurred within the source.

Desired Change:

Delete the statement.

Response No. 55:

The statement has not been deleted because this activity is still considered an important aspect of the site evaluation procedure.

Comment No. 56:

SRP 2.5.2, page 6, lines 6 & 9, Sect 2.5.2.2. The text states, "...This subsection is accepted when all seismic sources that are significant..."

Also the text on line 9 states "..reasonable assurance that all significant..."

It is impossible to know all seismic sources.

Desired Change:

Replace the word "all" with "known". It would be helpful to clarify the difference between a "seismic source" and a "seismotectonic province", if any.

Response No. 56:

The entire paragraph has been replaced, therefore "all" and "reasonable assurance" are no longer in the text. The definition of seismogenic source, which is a seismic source that is not expected to cause surface faulting, is given in Regulatory Guide 1.165, Appendix A, on page A-2. Seismotectonic province is defined as a seismogenic source that is a large region of diffuse seismicity thought to be characterized by the same earthquake recurrence model.

Comment No. 57:

SRP 2.5.2, page 10, line 1, Sect 2.5.2.5. The text states, "In the PSHA procedure described in DG-1032 (Ref. 9), the controlling earthquakes are determined for actual or hypothetical rock conditions. The site amplification studies are performed in a distinct separate step as a part of the determination of the SSE."

Desired Change:

Delete the phrase, "in a distinct separate step".

Response No. 57:

In DG 1032 (Regulatory Guide 1.165) and Appendix C the application studies are presented as a distinct step, so the phrase should be left in.

Comment No., 58:

SRP 2.5.2, page 11, lines 27-33, Sect 2.5.2.6. This Section states, "As part of the review to judge the adequacy of the SSE proposed by the applicant, the staff performs an independent evaluation of ground motion estimates, as required. In these independent estimates, the staff may consider effects on ground motion from the controlling earthquakes discussed in Subsection 2.5.2.5 by assuming the controlling earthquakes for each seismic source (geological structures or seismotectonic provinces) to be at its closest approach to the site."

This paragraph continues to overemphasize a deterministic process for assessing the adequacy of the SSE derived from the PSHA procedure described in DG-1032. In our opinion it is inappropriate to make an assessment of the SSE in this manner or to use this procedure as a means to assess *the* adequacy of the SSE determined using the DG-1032 process.

The text does not describe how the procedure will be implemented. For example, for the host seismic source, where is the controlling earthquake (which is at least as big as the maximum historic event) located?

Desired Change:

This Section needs clarification for consistency and reproducability of the process. As a minimum, the text should be expanded to clarify how the procedure will be implemented.

Response No. 58:

All of the text that referred to an independent deterministic seismic hazard analysis has been revised. Also see the response to Comment 54.

Comment No. 59:

SRP 2.5.2, page 16, line 8, Sect III. This item states, "..borings, geophysical data, trenches, and those geologic conditions exposed during construction if the review is for an operating license."

The change as suggested would indicate that staff site visits can be performed to inspect trenches excavated prior to a combined license, or to inspect the geologic conditions exposed during construction (after the COL, at the option of the applicant). With the new combined license process, either approach should be permitted in order for the staff to reach a final conclusion. But, as indicated in the comment on SRP, page 2.5.3-9 lines 29-32, a final staff conclusion should not be deferred until the time of construction excavation if an inspection of trenches is performed during the review preceding a combined license.

Desired Change:

Revise to read:

"...borings, geophysical data, trenches, *or* those geologic conditions exposed..."

Also delete the phrase, "if the review is for an operating license."

Response No.59:

Examination of exploratory trenches by the staff during site investigations does not preclude the necessity for the staff to examine the final excavations for the plant. See Response to Comment 53. The phrase, "if the review is for an operating license." has been deleted.

Comment No. 60:

SRP 2.5.2, page 2, line 4, para 1. The text states, "SSE represents the potential for earthquake ground motion at the site and is the vibratory ground motion for which certain structures, systems, and components are designed to remain functional.

The word *potential* typically is associated with maximum, maximum credible, etc. This can be linked to the probabilistic upper bound. In this context, the word *design* is a better choice.

Desired Change:

Revise to read:
"The SSE represents the ~~potential for~~ *design* earthquake ground motion at the site and is the vibratory ground motion for which certain structures, systems, and components are designed to remain functional.

Response No. 60:

The words "potential for" have been deleted from the statement and "design" added as suggested.

Comment No. 61:

SRP 2.5.2, page 2, lines 16-26, para 3. The text states, "Guidance on seismological and geological investigations is being developed in Draft Regulatory Guide DG-1032, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion." These investigations describe the seismicity of the site region and the correlation of earthquake activity with seismic sources. Seismic sources are identified and characterized, including the rates of occurrence associated with each seismic source. All seismic sources that have any part within 320 km (200 miles) of the site must be identified. More distant sources that have a potential for earthquakes large enough to affect the site must also be identified. Seismic sources can be capable tectonic sources or seismogenic sources; a seismotectonic province is a type of seismogenic source.

The wording implies a rate of occurrence of seismic sources. It is more correct to state the rate of occurrence of earthquakes. It is impossible to know when one has identified all source zones and included all seismic sources have been included.

Desired Change:

Revise to read the following "... including the rates of occurrence of earthquakes associated with each seismic sources that have any part within 200 km (125 miles) ..."

Response No. 61:

The distance of 320 km (200 mi) will not be changed. See response to Comment 5.

The subject paragraph has been modified and appears in the SRP as follows:

"Guidance on seismological and geological investigations is provided in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion." These investigations describe the seismicity of the site region and the correlation of earthquake activity with seismic sources. Seismic sources are identified and characterized, including the rates of occurrence of earthquakes associated with each seismic source. Seismic sources that have any part within 320 km (200 miles) of the site must be identified. More distant sources that have a potential for earthquakes large enough to affect the site must also be identified. Seismic sources can be capable tectonic sources or seismogenic sources; a seismotectonic province is a type of seismogenic source."

Comment No. 62:

SRP 2.5.3, page 9, line 3, Sect III. This item states, " This procedure could create a problem for the staff in that the applicant could already have a license ...."

As written, the statement illustrates the potential difficulty that may arise with a Combined Operating License approach. That is, site excavation occurring preceding the staff's final suitability determination.

Desired Change:

The statement should be reworded to more explicitly state how to disposition the issue, e.g., by inspection of the foundation excavation(s) followed by final determination of site suitability by the staff.

Response No. 62:

In response to this comment and Comment 64, the referenced paragraph now beginning on line 9, page 2.5.3-9 and ending on line 23 has been rewritten as follows:

"The current two-step procedure of requiring applicants to obtain a Construction Permit, followed several years later after the plant design bases have been approved by the staff, by application for an Operating License. This procedure, called combined licensing, could create a problem for the staff in that the Safety Evaluation Report will already have been written and the applicant will have a license before excavations are started. Therefore, faults discovered for the first time in the excavations will not have been evaluated by the staff. To alleviate this potential problem there must be a commitment in the site specific portion of the SAR for a facility to: (1) notify the staff immediately if previously unknown geologic features that could represent a hazard to the plant are encountered in the excavation; (2) geologically map all excavations for Category 1 structures, as a minimum; and (3) notify the staff when the excavations are open for examination.

Comment No. 63:

SRP 2.5.3, page 9, lines 29-32, Sect III. This item states, "applicants usually excavate trenches....when the construction excavations are made."

Unless it is intended that such trenching would precede a COL permit and supplant the need for any later staff inspection of construction excavation to reach a final determination, it is inappropriate to speculate on whether the applicants will or will not excavate trenches in the areas where major facilities are to be located.

Desired Change:

Delete this whole sentence, lines 29 through 32.

Response No. 63:

The main purpose of the SRP is to provide guidance to the regulatory staff in assessing information submitted in support of applications for licenses to construct or operate nuclear power plants. It is appropriate to make the staff aware of the kinds of investigations that will be undertaken to obtain the information that appears in that application, particularly when it may be important for the staff to go to the site for first hand observations. As stated in Response No. 59, examination by the staff of exploratory trenches does not supplant the need for the staff to examination the excavations for the plant.

However, we agree that it is not appropriate to speculate about the techniques that might be used. The sentence has been reworded: "In past investigations applicants have often excavated trenches in the areas where major facilities are to be located for in situ testing to reduce the chance for surprises when the construction excavations are made."

Comment No. 64:

SRP 2.5.3, page 9, line 7, Sect III. This item states, "It is imperative that Section 2.5.3. of the SER..."

It is understood that the SRPs provide guidance to the staff and is generally followed. Therefore, the word 'imperative' adds unnecessary emphasis.

Desired Change:

Delete the word "imperative"

Response No. 64:

We agree. The sentence will be revised (without "imperative") as it appears in the revised paragraph in Response No. 62.

Wais and Associates - Comments on Draft Regulatory Guides, DG-1032, SRP 2.5.1, 2.5.2, and 2.5.3.

1. Page 7, lines 15 to 19. Appendix A of Draft Regulatory Guide DG-1034 (now called Regulatory Guide 1.166) proposes an OBE criteria of a Richter 5 earthquake within 200 km of the site. Rightly so, earthquakes farther than 200 km from the site are not given a high importance. To ensure consistency between DG1034 and DG1032, it is recommended that the outer bound of regional geological and seismic investigations also be limited to 200 km, or 125 miles. This can significantly reduce the cost of the investigation without reducing the level of safety that is achieved.

Response:

It is not appropriate for the OBE distance criteria specified in DG 1034 (Regulatory Guide 1.166) and the radius of the area to be investigated for determining the SSE described in DG 1032 (now called Regulatory Guide 1.165) to be the same. They are for different magnitude earthquakes and levels of ground motions.

The reason for specifying a radius of 320 km (200 mi) for the regional investigations is not only to ensure that the area of study be broad enough to encompass those seismic sources close enough to affect the site, but also, because the CEUS is relatively aseismic and sources are at depth and largely undefined, it is our opinion that the area should be as large as reasonably possible to include a greater number of earthquakes for analysis, and to incorporate any sources identified that could be related to, or analogous to sources that may be near to or underlie the site.

In the past it has often been necessary to estimate the age of a potential seismic source, or potential capable fault 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.

Within this area (320 km), assessment should be made of existing regional seismological, geological, geophysical, remote sensing, physiographic, and other information that could be used to identify or interpret potential seismic sources. It is not expected to be a detailed investigation, and may consist of only literature study with limited, focussed ground truth reconnaissances.

2. Page 11, lines 28 to 29. It is not clear why the PSHA should only be updated if it lead to higher hazard estimate. If there is a sound basis for reducing the PSHA, this should not be precluded by regulation.

Response:

It may be possible to justify a lower hazard estimate with an exceptionally strong technical basis. However, it is expected that large uncertainties in estimating seismic hazard in the CEUS will continue in the future, and substantial delays in the licensing process will result in trying to justify a lower value them with respect to a specific site. On the other hand, lower seismic hazard estimates that are supported by strong technical bases can be incorporated into the PSHA during the periodic updating which will occur about every ten years.

The referenced statement in DG 1032 (Regulatory Guide 1.165) has been modified as follows: "The PSHA should only be updated if the new information indicates that the current version significantly under estimates the hazard and there is a strong technical basis that supports such a revision. For 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, the significant revisions to the LLNL and EPRI data base is to be only undertaken periodically (every ten years), or when there is an important new finding or occurrence. The overall revision of the data base will also require a reexamination of the reference probability discussed in Appendix B and used in Step 4 below."

3. Page 13, line 28. A fifth step should be added to this procedure to define and SSE level for which it is not necessary to conduct a seismic design. The process as now written results in an SSE, no matter how small. It is conceivable for sites in the eastern United States that the SSE that results from this process will be very small. There should be some small SSE level for which it is not necessary to design for. Note that in DG 1034, a criteria is provided in the appendix that states that earthquakes of less than MMI VI do not require any shutdown for inspection if there is no apparent damage. If this is the case, does a site with and equivalent to a MMI of VI or less require seismic design?

Response:

Seismic hazard estimates are based to a large extent on historic seismicity, and because of this in certain regions such as Florida and southeastern Texas the calculated Safe Shutdown Earthquake ground motions (SSE) are lower than ground motions expected to be generated by a magnitude 4.5 to 5 (MMI VI) earthquake. This may be because the historical seismic record is not long enough to have experienced larger earthquakes, and it is difficult to identify geological evidence of prehistoric earthquakes in these regions. Additionally, the sources of the earthquakes are undefined. Because of such uncertainties the staff requires a minimum seismic design even in those regions that do not seem to require it based on the seismic hazard analysis.

Appendix A:

1. The definition of the Safe Shutdown Earthquake Ground Motion in this draft Regulatory Guide is almost indistinguishable from the definition of the Operating Basis Earthquake Ground Motion in DG-1033. Given the adoption of PSHA methods, a likelihood should be assigned to the SSE, such as 1 in ten-thousand in any given year; or it should be defined as the largest earthquake that has been felt at the site in the last 50,000 years (see the definition of a capable tectonic source).

Response:

The definitions of the SSE and OBE are essentially unchanged in the revised regulations and guides from those in Appendix A to 10 CFR Part 100. The SSE (Safe Shutdown Earthquake ground motion) target probability, which is acceptable to the staff to be used in conjunction with the LLNL and EPRI PSHA, is 1E-5/yr as described in Step 3 of Appendix B to Regulatory Guide 1.165 (formerly DG 1032). It is not appropriate to put that value in the definition of SSE because some applicants may elect to use other acceptable hazard techniques to which that criterion would not apply, including a deterministic seismic hazard analysis. Appendix A to 10 CFR Part 100, Section 100.23 of Part 100, and Appendix S to 10 CFR Part 50 all establish a minimum seismic design level. It has long been a part of the licensing process.

Appendix B

1. The logic for arriving at the reference probability is flawed. Although it is descriptive of how the NRC arrived at a reference probability of 1E-5 for the SSE, it does not add significantly to the Regulatory Guide. It is clear that the NRC has licensed plants in the CEUS with SSE ranging in likelihood from 1E-6 to 1E-4 and that a value of 1E-5 is consistent with past practices. The question that is not answered is whether the use of 1E-5 imposes an unreasonable and imprudent burden on the construction of nuclear plants. Note that many of the plants in the 1E-6 range were forced to assume an SSE of 0.1g by 10 CFR Part 100 Appendix A even though the geology of the region dictated that the value was very conservative. If these plants had selected a lower SSE, their probability would have been higher and the median value would have been greater than 1E-5. Are plants in the Western United States also licensed for an SSE likelihood of 1E-5? Should there be a different standard for eastern US versus the western US?

Average past practice does not appear to be a reasonable basis for selecting a design earthquake. What is reasonable is to select a level of risk that is acceptable to the public and is consistent with other risks the public accepts. If that level of risk is 1E-5 then so be it. However, if we consider that ice ages occur every ten thousand years, then 1E-4 appears to be a more prudent level of risk than 1E-5.

Suggest deleting this appendix once a level of risk is established. The acceptable level of risk should not be revised based on changes individual plants implement, as is stated on page B-1, lines 19 to 20.

Response:

See the response to a similar comment by Morgan, Lewis, and Bockius. The 1E-5 is based on the likelihood of exceedance of the SSE's of operating plants built later on (those designed to RG 1.60 or to a similar spectrum) than those previously designed. We do not regard 1E-5 as being unreasonable or imprudent based on the uncertainties in seismicity, seismic sources and ground motion parameters; nor do we regard that it is placing an unreasonable burden on future builders of nuclear power plants. It is true that several plants had to be designed for an SSE exceedance probability of 1E-6 even though there was no seismic or geologic evidence supporting it. As explained in the response to an earlier comment, the minimum value of 0.1g is a conservatism based on the seismic and geologic uncertainties. Western and eastern U.S. plants are not presently designed to the same likelihood of SSE exceedance because deterministic hazard analyses were done in both regions, and the empirical database is much more extensive in the west than in the east. For this reason an additional layer of conservatism was applied to eastern sites.

Publicly accepted levels of risk vary with the type of hazard. For example, it will accept a much higher risk of an automobile accident or an airplane crash than for a nuclear accident. It isn't reasonable to compare the return of an ice age to earthquake occurrence. To prepare for the resumption of glaciation, one will have hundreds or thousands of years, but for an earthquake there is no lead time.

The NRC staff and the nuclear industry at large are of the opinion that the current PSHA database for LLNL and EPRI will be adequate for the next ten years. When it is time for the first routine update of the PSHA database in about ten years, the acceptable level of risk will be revised based on new geological, seismological, and geophysical information and on changes individual plants implement. This update is considered to be necessary because of the rapid advances that are occurring in the these scientific fields.

Appendix D

1. Page D-8, lines 31 to 33. It is unreasonable to assume that seismic monitoring should be initiated five years prior to construction and should continue for five years following initiation of plant operation. Note that DG1033, DG1034, and DG1035 talk about seismic monitoring over the life of the plant. It is unlikely that a licensee will be interested in updating the seismic design bases following issuance of the construction permit.

Response:

Section D,2.3.2.2 has been modified to: "Seismic monitoring in the site area should be established as soon as possible after site selection. For sites in both the CEUS and WUS, a single large dynamic range, broad-band seismograph, and a network of short period instruments to locate events should be deployed around the site area.

The data obtained by monitoring current seismicity will be used, along with the much larger data base acquired from site investigations, to evaluate site response and to provide information about whether there are significant sources of earthquakes within the vicinity, or to provide data by which an existing source can be characterized.

Monitoring should be initiated as soon as practical at the site, preferably at least five years prior to construction of a nuclear unit at the a site and should continue at least until the free field seismic monitoring strong ground motion instrumentation described in Regulatory Guide 1.12 is operational."

Monitoring seismicity for five years before construction is not considered to be unreasonable by the staff if the site is instrumented shortly after a site is selected. We regard seismic monitoring to be an important part of the site investigations. It is expected to provide information on background seismicity, seismic sources, the characteristics of ground motions from nearby small to moderate earthquakes, more distant large events, and those generated by other mechanisms such as nearby quarry blasts, and provide important data on the ground motion transmission characteristics of site area soils and rocks. Preconstruction monitoring is especially important in the western U.S., where, because of the relatively high seismicity, there is a good chance of recording ground motions from a significant earthquake. It is also important in the central and eastern U.S. where there are numerous uncertainties about ground motion characteristics and little is known about the nature of seismic sources. The analysis of locally recorded earthquakes may help to reduce these uncertainties and provide clues to the nature of seismic sources.

Pre-construction seismic information would have been valuable in past licensing activities (for example: Diablo Canyon, San Onofre, Indian Point, Brunswick, Summer, Oconee, WNP-2, etc.), and is expected to be important in the licensing of future nuclear sites.

These responses also apply to the appropriate SRP Sections.

Westinghouse - Comments on Proposed Rule - 10CFR Parts 50,52, and 100, "Reactor Site Criteria Including Seismic and Earthquake Engineering Criteria for Nuclear Plants"

Seismic

COMMENT No. 1: Westinghouse supports NRC's decision to move guidance material from the proposed rule to the proposed regulatory guides. We also support NRC's decision to eliminate the "dual deterministic and probabilistic analyses from the proposed rule. We, however, are concerned that retaining deterministic evaluations in SRP 2.5.2 will lead to confusion as to whether future licenses will also need to perform a deterministic analysis even though such an analysis is only recommended for NRC to perform as a "sanity" check. This additional deterministic analysis will add to instability in the licensing process and increase a future license applicant's seismic analysis costs (in defending its probabilistic analyses) without any additional benefit to public health and safety. We recommend that references to deterministic analyses be removed from all documentation associated with the proposed rule revision.

Response No. 1:

SRP 2.5.2 has been revised and this concern has been addressed.

COMMENT No. 2: Westinghouse shares NEI's concern with respect to the type of analyses needed to construct a new plant on an existing approved site, using the proposed rule and associated proposed regulatory guides. We also believe that site characterization analysis for existing sites should be confirmatory in nature and of "limited scope," rather than "full scope" as required for new sites.

Response No. 2:

It is possible that site characterization investigations and analyses at some previously validated sites will be confirmatory. Reliance on the previous characterization depends on its thoroughness, the kinds of investigative techniques used as compared to the current state-of-the-art, the geological and seismological complexity of the site and region, and the quantity and quality of new information and hypotheses that have been advanced since the site was last studied. The previous information should be used as part of the database, along with other available technical information, to plan the extent and level of detail of the new investigations for the new plant site. Based on consideration of all available information the new investigations could range from confirmatory to a very extensive investigation.

An example is the Indian Point 1, 2, and 3 site. Indian Point 1 was investigated in the 1960's when investigative methods were far less advanced than in the mid 1970's when units 2 and 3 came in for operating licenses. Because of the complexity of the site and region, the occurrences of several earthquakes, new theories about the tectonics of the region, and new investigative techniques, site characterization with respect to estimating the seismic hazard was similar to that of a new site.

On the other hand, if, within the next year or so a Unit 4 is planned at this site, the regional investigations would likely be minimal because thorough investigations, including monitoring seismicity for a number of years, was accomplished for Units 2 and 3.

COMMENT No. 3: There are several phrases that are used in the proposed rule that should be modified to make the rule more stable from a licensing point of view. Since these phrases are used in several places, only the phrase, and not the location, are identified below. We suggest that these phrases and others that are similar in nature be modified as well.

(1) "certain structures, systems, and components" should read: "certain structures, systems, and components as identified in Regulatory Guides xxx." By referencing the regulatory guides, the vagueness of the statement is eliminated from the rule and the description of the structures, systems, and components can be changed, if necessary. via changes to the regulatory guides.

Response No. 3(1):

Reference to a specific guide in the regulation would raise the guide to the status of a regulation, and its recommendations would be required by law. Therefore, such references cannot be included in the rule.

(2) "without loss of capability to perform their safety functions" should read: "without loss of capability to perform their intended functions." The components perform a function and not a "safety" function -- components may be a part of a safety system or a non-safety system. There are other sentences which have similar phraseology -- for example, item 3 below. These sentences should be similarly modified.

Response No. 3(2):

The structures, systems, and components referred to in these texts are those that have to do with safe shutdown in the event of an accident or potential accident caused by an earthquake or surface deformation. It is therefore correct to have the word "safety" in the statement.

(3) "The required safety functions of structures, systems, and components must be assured" should read: "The required functions of structures, systems, and components must be assured per the guidance provided in Regulatory Guide xxx". The underlined phrase shows that the regulatory guide contains guidance as to how a future license applicant can provide "assurance."

Response No. 3(3):

See response to 3(1). References cannot be included in the proposed rule because the guide referenced would become a requirement.

As stated in the response to 3(2), the word "safety" should remain in the text as is.

Responses to Comments of Yankee Atomic Electric Company Regarding the NRC Proposed Seismic Siting Documents (59FR52255, October 17, 1994)

Attachment 1

YAEC proposes that at existing eastern U.S. sites (rock or soil), or at eastern U.S. rock sites not located in areas of high seismicity (for example, Charleston, South Carolina, New Madrid, Missouri, Attica, New York) a 0.3g standardized ALWR design is acceptable and only evaluations of foundation conditions at the site are required (Regulatory Guide 1.132), but not geologic/geophysical seismological investigations. For other sites a DG-1032 review is required. It proposes that 10CFR Part 100 Section 100.23 be modified to reflect this consideration as follows:

& 100.23 (d) Geologic and seismic siting factors.

> Determination of the Safe Shutdown Earthquake Ground Motion. The Safe Shutdown Earthquake Ground Motion for the site is characterized by both horizontal and vertical free-field ground motion response spectra at the free ground surface. ~~The Safe Shutdown Earthquake Ground Motion for the site is determined considering the results of the investigations required by paragraph (c) of this section. Uncertainties are inherent in such estimates. These uncertainties must be addressed through an appropriate analysis, such as a probabilistic seismic hazard analysis or suitable sensitivity analyses.. Paragraph IV(a) (1) of Appendix S to Part 50 of this chapter defines the minimum Safe Shutdown Earthquake Ground Motion for design.~~
> The Safe shutdown Earthquake Ground Motion for the site is based upon the investigations required by paragraph (c) of this section and the results of a probabilistic seismic hazard analysis. Seismological and geologic uncertainties are inherent in these determinations and are captured by the probabilistic analysis. Suitable sensitivity analyses may also be used to evaluate uncertainties. Paragraph IV(a) (1) of Appendix S to Part 50 of this Chapter defines the minimum Safe Shutdown Earthquake Ground Motion for design. Based upon prior scientific findings and licensing decisions at existing nuclear power plant sites east of the Rocky Mountain Front (east of approximately 105 west longitude) a 0.3g Standardized design level is acceptable at these sites given confirmatory foundation evaluations. For rock sites not in areas of known seismic activity including but not limited to the regions around New Madrid, MO, Charleston, SC, and Attica, New York, a 0.3g Standardized design level is acceptable given confirmatory foundation evaluations at the site.

Response to attachment 1:

Although some of the suggested wording may improve the readability of the text, the staff does not agree with the basic philosophy of the recommended modification for the following reasons:

1. The suggested modification brings back a prescriptive element which we have tried to eliminate in revising the siting document. It is more

appropriate to include such a modification in Regulatory Guide 1.165 (formerly DG 1032). The staff's position regarding the application of the 0.3g ALWR design is addressed in the main body of Regulatory Guide 1.165, and in Appendix D.

2. A standard design of 0.3g does not preclude the need to conduct a thorough regional and site area investigation. The standard plant is designed for 0.3g, but other safety related components aren't part of the standard design plan. Such components include emergency cooling ponds and associated dams levees, spillways, etc., and they will have to be designed to the appropriate level based on regional and site geological, seismological, geophysical, and geotechnical investigations and site specific PSHA.

3. The level of investigations for a standard design plant or any additional unit sited on a previously validated site depends on when that site was previously validated, the complexity of the geology and seismology of the region and site, the advent of new information or hypotheses about regional tectonics, and the kinds of methods used and the thoroughness applied in using those methods in the original investigations and analyses. The investigations can range anywhere between a literature review to a very extensive investigation program.

4. The discovery of the Meers Fault and the paleoseismic evidence for a large prehistoric earthquake in the Wabash Valley are examples in the central and eastern U.S. of the occurrences of events of great significance to the seismic hazard to those regions that were unknown until regional investigations were performed. Thus, we expect that evidence for similar, currently unknown tectonic structures or events is present in the CEUS.

Based on the above factors, the level of investigations could vary considerably, therefore, it would be inappropriate to make the modifications recommended in Attachment 1.

Attachment 2. (DG 1032 and Appendices)

1. Page 1, lines 27-31. YAEC suggests that they be replaced by page 2, lines 1-6 to be consistent with Section 100.23. Since the staff doesn't agree with the recommended change in Section 100.23, there is no need to alter this text.

2. Page 2, lines 15 and 16. YAEC recommends adding the phrase, "level that is acceptable to the staff.", to the first sentence in the paragraph, and replacing the word "information" with "data" in the next sentence. We agree that the first suggested revision improves the text and have made the recommended changes. In regard to the second part of this comment we don't agree. Many times the broader term, information, is more appropriate, such as when it includes reference to interpretations or hypotheses, etc. The word "data" in this case is too restrictive.

3. Page 3, lines 6-9. Recommends changing the text to be consistent with its suggested changes to Section 100.23. The staff has made the suggested changes in the text.

4. Page 3, lines 19 and 20. We did not delete "uncertainty" but added the suggested phrase "(alternative scientific interpretations)" in parentheses.

5. Page 4, lines 14 and 15. The comment has to do with the basic difference in philosophies between the YAEC and the staff. We don't agree with the comment, however, we have modified the text by replacing "should" with "in general includes:".

6. Page 4, lines 37-40 and page 5, lines 1-10. We agree with the comment, and have deleted the sentence beginning with "Thus.....", and have added the statement "Therefore, it is important to account for this uncertainty by the use of multiple alternative models."

7. Page 5, line 24. We regard "information" as being more appropriate than "data." See the response to 2.

8. Page 6, lines 29-41, and page 7, lines 1 and 2. The comment involves the differences in philosophies between the YAEC and the NRC, and the recommended change was not adopted regarding Section 100.23 to 10 CFR Part 100. Therefore, there is no need to make this change.

9. Page 7, lines 16, 17, 20, 24, and 31. The NRC staff does not agree with the radius of investigations for the region and the site area prescribed by the IAEA, and therefore is not obligated to make those specified in Regulatory Guide 1.165 consistent with those of the international organization.

Although recent evidence indicates that a site at distances greater than 200 km from a major earthquake are not likely to experience damaging ground motions, and seismic sources beyond 40 km are not likely to generate near-field ground motions or cause surface deformation at the site, there are other reasons for specifying the greater distances (320 km and 40 km as opposed to 200 km and 25 km of IAEA).

The reasons that we do not plan to reduce the larger radii include:

1. In the CEUS where earthquakes are few, small, and relatively far between, the larger area of consideration allows that more earthquakes be included in the applicant's catalogue for consideration, and thus provides a broader data base with which to study the regional seismicity and to characterize regional and local seismic sources.

2. In past licensing activities, particularly in the CEUS, it has often been impossible to determine the absolute age of most recent displacements on faults identified at sites and thus difficult to show whether those faults met the criteria of being noncapable. To compensate for this lack of evidence, it has been necessary to assess the relationship between the structural geology and tectonics of the site and the regional structural geology and tectonics, often many tens to hundreds of kilometers distant. In these cases, associating the faults identified at the site with documented ancient faults or tectonic events in the region served as a basis for concluding that the site faults were not capable faults.

3. In the WUS it has sometimes been necessary to extend investigations hundreds of kilometers along major tectonic structures that pass near a site to properly characterize the seismic hazard of those structures (i.e. the San Gregorio-Hosgri fault zone relative to the Diablo Canyon Nuclear Power Plant; the Rattlesnake-Wallula Lineament with respect to Washington Nuclear 2; the Cascadia Subduction Zone relative to Washington Nuclear 3; etc.). Conversely, with respect to Diablo Canyon, a case can be made for not extending the regional investigations more than 75 km (45 mi) to the east and 45 km (27 mi) to the west because of the presence of the San Andreas and San Luis Banks faults, respectively.

Most of the regional investigations are expected to be literature searches and the study of existing regional geophysical data, maps, and remote sensing data. The difference in the level of effort in these studies for sites, particularly in the CEUS, between a radius of 200 km and 320 km is not expected to be significant. Most tectonic structures can likely be ruled out as potential seismic sources without going to the field. Ground truth reconnaissances can be made on a very selective basis.

10. Page 9, lines 20-26, and 35-38. The section within which these references are found has been revised. We assume that the main objection to the text was the reference to a deterministic seismic hazard analysis by the staff. The requirement for a deterministic analysis has been removed.

11. Page 10, lines 31-35. We have made the suggested changes in your line 31 as follows: after "PSHA", delete ". The PSHA"; add "and also" before "can be used"; and insert "hazard" between "the" and "sensitivity". The suggested deletion of lines 32 and 33 was not done because its inclusion in Regulatory Guide 1.165 does not make it a requirement for applicants. It is mentioned only as an acceptable methodology.

12. Page 11, lines 11-41. The referenced text has been rewritten as follows: "The PSHA should only be updated if the new information indicates that the current version significantly under estimates the hazard and there is a strong technical basis that supports such a revision. It may be possible to justify a lower hazard estimate with an exceptionally strong technical basis. However, it is expected that large uncertainties in estimating seismic hazard in the CEUS will continue to exist in the future, and substantial delays in the licensing process will result in trying to address them with respect to a specific site. For 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, the significant revisions to the LLNL and EPRI data base is to be only undertaken periodically (every ten years), or when there is an important new finding or occurrence. The overall revision of the data base will also require a reexamination of the reference probability discussed in Appendix B and used in Step 4 below."

"Strong technical basis" is used instead of "consensus of opinion by the scientific community." A decision regarding this issue will more than likely be needed long before consensus among the scientific community can be obtained. The staff will make the decision based on the strength of the available data and advice from the scientific community, including the USGS.

13. Page 12, lines 7-11, and 24. The broader term "information" is preferred in both contexts, so the suggested change has not been made. We do not consider it useful to add the sentence, "For soil sites, the rock hazard results will be amplified based upon site-specific amplification factors" to this paragraph.

14. Page 12, lines, 35-39, and page 13, lines 1-9. The suggested addition to the text was not included because Appendix F discusses options to develop the SSE.

15. Page 13, lines 20-42, page 14, lines 1-7, lines 11-12, and lines 16-18. All of the changes recommended in these references are based on previously recommended changes that were not adopted, or on a basic philosophy that differs from that of the NRC staff, and therefore were not made.

Appendix A

1. Page A-1, line 4, and lines 9-11. As suggested, "In" has been struck and "As a result of" added on line 4. Reference to deterministic controlling earthquakes has been removed from SRP 2.5.2, so there is no need to address the concept here.

2. Page A-1, line 23. "free-field" has been inserted between "the" and "vibratory".

3. Page A-2, lines 22-28. The first sentence in the definition of Seismogenic Source has been revised to read, "A "seismogenic source" is a portion of the earth that we assume has uniform earthquake potential (same expected maximum earthquake and recurrence frequency) distinct from the seismicity of the surrounding regions."

Appendix B

1. Page B-1, lines 17-19. It is inappropriate to refer to the SSHAC program here as "median" as used in that program was for a different intent.

2. Page B-2, lines 17-18. The statement has been modified as suggested to read: "Using LLNL, EPRI, or a comparable methodology that is acceptable to the NRC staff, calculate____"

Appendix C

1. Appendix C has been modified with close consideration of your comments.

2. Change all seismic hazard information base to seismic hazard data base. As stated early, we consider it to be more appropriate to use information because it includes alternate hypotheses as well as data.

3. Page 1, lines 22-24. the phrase "and the results from the PSHA." has been added to the paragraph as recommended.

4. Page 1, lines 26-28, and Page 2, lines 4-24. The procedure described in section C.2 (Steps 1-7) has been modified to put the steps in their proper sequence.

5. Page C-7, lines 29-30. We agree with this comment and Tables C.4-C.7 have been modified to include actual values for each bin and the total hazard.

Appendix D

1. Page D-1, Lines 4 and 5. The staff does not agree with the investigation distance radii recommended by YAEC for the reasons given in the response to DG-1032 (now Regulatory Guide 1.165) Comment No. 9 above.

2. Page D-1, lines 31-35. Regional and site specific investigations are performed and the acquired data are analyzed to evaluate the seismic and geologic conditions of the site and surrounding region, and to determine whether significant seismic sources are present in the region that may not be enveloped by the PSHA database, and to assure that the correct attenuation values have been used. We assume that your concern is related to the way in which this data will be utilized in a deterministic hazard analysis. As stated in an earlier response, the previous requirement in SRP 2.5.2 for the staff to perform a deterministic seismic hazard analysis to compare with the applicant's PSHA results has been removed.

3. Page D-7, lines 22 and 23. The existence of an active seismographic network in the site region may suffice in some cases, but generally not. It is important, particularly in the CEUS, to be able to record small events, including microearthquakes, to obtain data that might provide clues to the nature of the local source. Regional networks, unless they are nearby and are so designed, will not accomplish this. For this reason we did not add the recommended sentence.

4. Page D-7, lines 25-31. The subject paragraph has been revised to read: "The data obtained by monitoring current seismicity will be used, along with the much larger data base acquired from site investigations, to evaluate site response and to provide information about whether there are significant sources of earthquakes within the site vicinity, or to provide data by which an existing source can be characterized."

5. Page D-7, lines 34-38. The paragraph has been reworded as follows: "Monitoring should be initiated as soon as practicable at the site, preferably at least five years prior to construction of a nuclear unit at the site and should continue at least until the free field seismic monitoring strong ground motion instrumentation described in Regulatory Guide 1.12 is operational." Although not pertinent to siting decisions, the presence of a continuously operating free field seismograph could help resolve issues such as occurred at the Perry site following the 1986 Astabula (Ohio) Earthquake. One of the issues arose because there were no free field records to compare with the in-

plant seismograph records. Also, free-field records would have provided clues to the character of the seismic source, which was also a big issue at the time.

Appendix E

1. Page E 1, lines 5-27. Updating the input parameters to the PSHA's could be destabilizing to the licensing process, and it is intended that all source zones, attenuation models, and upper bound magnitudes be frozen until they are again determined in a consistent manner in ten years.

If, however, new data indicate that there is a potential for a significant change in the hazard estimate, such as the discovery of a previously unknown capable tectonic source at the site, then sensitivity studies will be carried out to estimate the impact of the new data on the seismic hazard. If the resulting value is approximately enveloped by the PSHA database, no further analysis is necessary.

Analyses along these lines were performed by NUMARC (now NEI) and EPRI in regard to the effect on the seismic hazard in the Wabash Valley as defined by the LLNL and EPRI PSHA's of the discovery of paleoseismic evidence for a prehistoric earthquake of an estimated magnitude of 7.5. They demonstrated that the occurrence of such an event centered at Vincennes, Indiana, was enveloped by the PSHA input, and a new PSHA was not necessary. It is expected that the results of this analysis of the new information about he Wabash Valley will be typical of most assessments of new data that initially imply that there might be a change in the seismic hazard.

A similar exercise was accomplished regarding new information and its impact on the seismic hazard of a site on the Savannah River Reservation. In this case the seismic design was impacted by the new information because of the significance of new data.

Although advice from the scientific community will be sought, obtaining its consensus regarding the significance of new data is a difficult, if not an impossible task. Licensing activities should not be delayed for a substantial amount of time waiting for this to come about. The staff will make a judgement on the significance of new data based on strong technical evidence, and communication with, but not on a consensus of, the scientific community.

In most cases, if it can be shown that the new data only has an impact on the site being evaluated (source zones only applicable to that site), then a new reference probability need not be calculated. When more than one site is affected, then it may be necessary to recalculate the seismic hazard at all sites ~~and develop a new reference probability~~ An overall revision of the data base would also require a re-examination of the acceptability of the reference probability.

The procedure described in lines 21-23 is similar to the staff's "sanity check" for the PSHA described in DG 1032. The staff is no longer required to perform a deterministic seismic hazard analysis.

2. Page E-2, lines 2-4. These referenced lines have been modified to read; "If new information identified by the site specific investigations would result in a significant increase in the hazard estimate for a site, and this new information is validated by a strong technical basis, the PSHA may have to be modified to incorporate the new technical information.

In general, major recomputations of the LLNL and EPRI data base are planned to be undertaken periodically (approximately every ten years), or when there is an important new finding or occurrence ~~that has, based on sensitivity studies, resulted in a significant increase in the hazard estimate~~."

3. Page E-2, line 13. The word "effect" has been replaced with "affect".

4. Page E-2, line 20. The phrase "will probably" has been replaced with "may".

Appendix F

1. Page F-1, lines 21-27, and page F-2, lines 5-9, 16-21, 24-28, and 33-38. The referenced text has been revised to: "The SSE response spectrum can be determined by scaling a site-specific shape determined for the controlling earthquakes or by scaling a standard broad-band spectral shape to envelop the average of the ground motion levels for 5 and 10 Hz ($S_{a,2-10}$), and 1 and 2.5 ($S_{a,1-2.5}$) as determined in Step C.2 of Appendix C to this guide.

The recommended sentence on lines 18-21 (also page F-2, lines 5-9) were not added.

2. Page F-2, lines 10 and 11. Changing the phrase "three possible" to "acceptable" does not improve the text, therefore this was not done.

3. Page F-3, lines 4-7, and 33-33. We do not agree with the suggested changes of Position 4, therefore the recommended modifications were not made.

SRP 2.5.2

1. Page 2.5.2-1, lines 8-11. The requirement for a deterministic seismic hazard analysis by the staff has been revised.

2. Page 2.5.2-2, line 7. The word "design" has been inserted between "represents the" and "earthquake".

3. Page 2.5.2-2, line 28. The phrase has been revised to: "including rates of occurrence of earthquakes___."

4. Page 2.5.2-2, line 30, and page 2.5.2-3, lines 6 and 7. "All" has been deleted and the "s" in "seismic" has been capitalized.

5. Page 2.5.2-6, line 3 and 7. This part of the text has been rewritten and the word "all" is no longer included.

6. Page 2.5.2-6, lines 16-18. The word "assumed" has been inserted between "regions of" and "uniform" in this statement.

7. Page 2.5.2-6, lines 23 and 24. The relationship between seismic source and seismotectonic province is defined in Regulatory Guide 1.165, Appendix A, Page A-2, in the definition of seismogenic source, which is a seismic source that does not rupture ground surface. Seismotectonic province is defined as a seismogenic source that is a large region of diffused seismicity. The entire paragraph, lines 1-24, has been rewritten and reorganized based on these and other comments.

8. Page 2.5.2-6, lines 38-42, and page 2.5.2-7, lines 1 and 2. The referenced text has been revised. However, in reviewing the results of the applicant's regional and site investigations and assessing the seismic sources identified by those investigations, it still may be necessary to develop realistic models based on this information in order to determine whether those models have been enveloped by the PSHA used in the estimation of the SSE. The evaluation guidance described in the referenced paragraph has ben rewritten with that purpose in mind. Some revision of Sections III, REVIEW PROCEDURES, and Section IV, EVALUATION FINDINGS has also been accomplished to more clearly define the staff's responsibilities.

9. Page 2.5.2-7, lines 15-21. The following statements have been added to the referenced sentence for clarification: "For the CEUS sites, when the SSE is determined using LLNL or EPRI PSHA methodology and Regulatory Guide 1.165, in meeting the requirements of Reference 1, this subsection is acceptable when adequate information is provided to demonstrate: (1) that a thorough investigation has been conducted to assess the seismicity and identify seismic sources that could be significant in estimating the seismic hazard of the region if they exist; (2) that existing sources in the PSHA are consistent with the results of site and regional investigations, or the sources have been updated in accordance with the Appendix E of regulatory Guide 1.165.

For sites where LLNL or EPRI methods have not been used, and it is necessary to identify and characterize seismic sources in meeting the requirements of Reference 1, this subsection is acceptable when adequate information is provided to demonstrate that all seismic sources that are significant in determining the earthquake potential of the region are identified, or that an adequate investigation has been carried out to provide reasonable assurance that there are no unidentified significant seismic sources."

10. Page 2.5.2-7, lines 36-39. The phrase "(those identified by the investigations)" has been inserted between "seismic sources" and "is based on" in parentheses for clarification.

Comments 11. through 16. Page 2.5.2-9, lines 4, 5, 10, 11, 13-15, 16, 17, 24-27, 30-32, 39, and 40. These comments pertain to the deterministic seismic hazard "sanity check" of the applicant's PSHA. This proposed procedure has been abolished. The description of that procedure has been deleted and replaced by the following text:

"For the CEUS sites relying on LLNL or EPRI methods, the staff will review the applicant's probabilistic seismic hazard analysis, including the underlying assumptions and how the results of the site investigations are used to update the existing sources in the probabilistic seismic hazard analysis, how they are used to develop additional sources, or how they are used to develop a new data base.

The staff will review the controlling earthquakes and associated ground motions at the site derived from the applicant's probabilistic hazard analysis to be sure that they are either consistent with the controlling earthquakes/ground motions used in licensing of (a) other licensed facilities at the site, (b) nearby plants, or (c) plants licensed in similar seismogenic regions, or the reasons they are not consistent are understood. For the CEUS, a comparison of the PSHA results can be made with the information included as Table 1, which is a very general presentation based on technical information developed over the past two decades of licensing nuclear power plants.

The applicant's probabilistic analysis, including the derivation of controlling earthquakes, is considered acceptable if it follows the procedure in Regulatory Guide 1.165 and its Appendix C (Ref. 9). The incorporation of results of site investigations into the probabilistic analysis is considered acceptable if it follows the procedure outlined in Appendix E of Regulatory Guide 1.165 and is consistent with the review findings of Sections 2.5.2.2 and 2.5.2.3.

For the sites not using LLNL or EPRI methods, the staff will review the applicant's PSHA or other methods used to derive controlling earthquakes. The staff will particularly review the approaches used to address uncertainties. The staff will perform an independent evaluation of the earthquake potential associated with each seismic source that could affect the site. The staff will evaluate the applicant's controlling earthquakes based on historical and paleoseismicity. In this evaluation, the controlling earthquakes for each source are at least as large as the maximum historic earthquake associated with the source."

17. Page 2.5.2-11, lines 16-18. The sentence is appropriate because, as explained in response to an earlier comment, even at ALWR sites, regional evaluations are still required.

18. Page 2.5.2-11, lines 25-27. The referenced sentence has been deleted from the SRP Subsection.

19. Page 2.5.2-12, lines 1 and 2. The referenced sentence has been modified to: "These procedures are also used to make ground motion estimates when the probabilistic methods are not used. In the following procedures, 84th percentile response spectra are used for both spectral shape as well as ground motion estimates.

SECTION 2

RESOLUTION OF PUBLIC COMMENTS REGULATORY GUIDE 1.12, REVISION 2

COMMENT RESOLUTION

Regulatory Guide 1.12, Revision 2
Seismic Instrumentation for Nuclear Power Plants
(Draft was DG-1033)

BACKGROUND

The first proposed revision of the Reactor Site Criteria Including Seismic and Earthquake Engineering Criteria for Nuclear Power Plants (10 CFR Parts 50, 52 and 100) was published for public comment on October 20, 1992, (57 FR 47802). The availability of the draft regulatory guides and standard review plan section that were developed to provide guidance on meeting the proposed regulations was published on November 25, 1992, (57 FR 55601). Because of the substantive nature of the changes to be made in response to public comments the proposed regulations and draft guidance documents were withdrawn and replaced with the second proposed revision of the regulations published for public comment on October 17, 1994, (FR 59 52255). The availability of the draft guidance documents was published on February 28, 1995, (FR 60 10810).

Nine letters (References 1 through 9) contained comments on Draft Regulatory Guide DG-1016, "Seismic Instrumentation for Nuclear Power Plants," November 1992. Draft Regulatory Guide DG-1C33, "Seismic Instrumentation for Nuclear Power Plants," February 1995 reflects the only documentation pertaining to NRC staff evaluation and implementation of all comments provided in References 1 to 9.

Three letters (References 10-12) contained comments on Draft Regulatory Guide DG-1033, "Seismic Instrumentation for Nuclear Power Plants." A synopsis of the comments and the NRC staff response follows.

A. INTRODUCTION

A1. It is not evident why it is necessary to require (1) that nuclear sites have seismic instrumentation, or (2) that nuclear power plants be shutdown if the Operating Basis Earthquake Ground Motion (OBE) is exceeded, if no damage is apparent. It appears that the USGS has adequate instrumentation for detecting and reporting earthquakes anywhere in the United States. Also, if a plant is designed to withstand an SSE it is more than reasonable that if it survives an OBE (1/2 SSE or an MMI VI) without damage and without tripping, it should be permitted to continue to operate without interruption. (Reference 10)

Response to (1). The USGS may have adequate instrumentation for detecting and reporting earthquakes anywhere in the United States; however, their instrumentation will not satisfy the Commission's requirements that suitable instrumentation must be provided so that the seismic response of nuclear power plant features important to safety can be evaluated promptly. These requirements will be contained in Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," for applications received after the effective date of the final rule. They are currently contained in Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100, "Reactor Site Criteria," for existing plants.

Regulatory guides are issued to describe and make available to the public such information as methods acceptable to the NRC staff for implementing specific parts of the Commission's regulations. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required.

Should an earthquake occur, the instrumentation described in Draft Regulatory Guide DG-1033 satisfies the Commission's regulations by providing information on the vibratory ground motion and resultant vibratory responses of representative Seismic Category I structures. The instrumentation will provide data so that an evaluation can be made as to (1) whether or not the design response spectra have been exceeded, (2) whether or not the calculated vibratory responses used in the design of the representative seismic Category I structures have been exceeded at instrumented locations, and (3) the degree of applicability of the mathematical models used in the seismic analysis of the buildings.

Response to (2). The Commission's regulations cited above also require shut down of the nuclear power plant if vibratory ground motion exceeding that of the Operating Basis Earthquake Ground Motion (OBE) occurs. Appendix S to Part 50 will also require plant shutdown if significant plant damage occurs.

Small, nondamaging earthquakes may exceed the OBE spectrum in the high-frequency range without causing damage. The January 31, 1986 magnitude 5.0 earthquake near the Perry nuclear power plant is a good example. To avoid unnecessary plant shutdowns the Electric Power Research Institute (EPRI) developed guidelines that will enable licensees to quickly identify and assess earthquake effects on nuclear power plants. These guidelines are in EPRI NP-5930, "A Criterion for Determining Exceedance of the Operating Basis Earthquake," EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," and EPRI TR-100082, "Standardization of Cumulative Absolute Velocity." The regulatory position on OBE exceedance in Draft Regulatory Guide DG-1034, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions," is based on EPRI NP-5930 and EPRI TR-100082 reports. The following, extracted from EPRI NP-5930, is a statement about the conservatism deliberately placed in the OBE exceedance criterion:

> "Note that the recommended criterion for determining OBE exceedance is purposely conservative. Based on direct correlation of the criterion parameters with damage data, ground motions which cause damage to buildings of good design and construction (which in general have lesser seismic resistant provisions than nuclear facilities) are a factor of at least 1.5 larger than the recommended threshold values. This means that when the criterion is used in the future, and if the OBE is moderately exceeded, it is very likely that no significant damage will have occurred."

Thus, the criterion stated in DG-1034 is high enough to avoid needless shutdowns yet low enough so that plant safety is not compromised.

The post-shutdown inspections and tests are described in EPRI NP-6695 and endorsed in Draft Regulatory Guide DG-1034. Section 5.3.2(1) addresses the situation where the plant was shut down because of OBE exceedance and the detailed visual inspections of the equipment and structures discover no physical or functional damage.

The guide was not changed.

A2. Guide should be focused on describing the seismic instrumentation a licensee must have in place if it does not wish to follow guideline number 2 of Appendix A of DG-1034. Since the likelihood of an earthquake in the eastern United States is so low, it is more prudent for plants in this region not to install the seismic instrumentation and shutdown for an inspection if the USGS determines that an earthquake that exceeds the guidelines occurs. West Coast or Alaska facilities may find it more prudent to install the instrumentation in order to have an alternative to guideline number 2 of Appendix A to DG-1034. However, it is likely that they too will choose to shutdown and conduct an inspection if the criteria of guideline number 2 in the Appendix are exceeded. If that is the case, the seismic instrumentation is not of benefit too them either. (Reference 10)

Response The regulatory guide describes the type, locations, operability, characteristics, installation, actuation, remote indication, and maintenance of seismic instrumentation that are acceptable to the NRC staff for satisfying the requirements in the Commission's regulations for ensuring the safety of nuclear power plants. The instrumentation system should be operable and operated at all times; however, an evaluation of seismic instrumentation noted that instruments have been out of service during plant shutdown and sometimes during plant operation. Therefore, the staff developed the guidelines in Appendix A to Draft Regulatory Guide DG-1034 to be used if the seismic instrumentation or data processing hardware and software necessary to determine whether the OBE has been exceeded is inoperable. As an incentive to have operable instrumentation, the guidelines on OBE exceedance in Appendix A to DG-1034 are more conservative than those in the regulatory position.

The regulatory position was not changed.

B. DISCUSSION

B1. Page 2, lines 27-30. The sentence "Foundation-level instrumentation would provide data on the actual seismic input to the containment and other buildings and would quantify differences between the vibratory ground motion at the free-field and at the foundation level." should be deleted or placed after the next sentence. The current location implies that the differences between the foundation motion and motions in the buildings are used in the determination of OBE exceedance, which is incorrect. (Reference 11)

Response. The sentence was moved.

B2. Page 2, line 28. Foundation level seismic instrumentation should not be required at buildings other than seismic category I structures. Revise to read ".. to the containment and other seismic category I buildings and would quantify ..." (Reference 11)

Response. Agreed.

B3. Page 3, lines 3-6. Revise to state that Draft Regulatory Guide DG-1034 addresses cases when the installed seismic instrumentation is and is not operable. (Reference 11)

Response. Page 3, lines 3-6 discusses a critical assumption about seismic instrumentation operability and data processing capability pertaining to the development of the regulatory positions in DG-1034. Lines 16-19 discusses the NRC staff's position if the seismic instrumentation or data processing hardware and software is inoperable.

The discussion was not changed.

B4. Page 3, lines 10-12. Supports the discussion about instrumentation at multi-unit sites in so far as the same or higher levels of quality are implemented during the construction phase of the follow-on plants. There should be an established means to verify, from a structural perspective, that the reactors are built to the same quality levels. In those cases where this cannot be demonstrated, separate seismic instrumentation should be installed in subsequent units. (Reference 12)

Response. The design and construction methods proposed by an applicant are described in a safety analysis report that is submitted to the NRC staff for review and approval. In its review the NRC staff ensures that the proposed design and construction methods are commensurate with current practices.

C. REGULATORY POSITION

C1. Page 5, lines 1-3. The phrase "certain features" should be defined or more specific language used in its place. (Reference 11)

Response. A portion of the statement provided in References 1 and 2 was inadvertently omitted. The regulatory position was revised.

C2a. Page 5, lines 24-25. Supports the regulatory position about annunciation in separate control rooms, if applicable, for new licensees. Recommends an exemption for licensees of existing plants that may want to voluntarily upgrade their systems and implement the new standards. (Reference 12)

C2b. Page 5, lines 24-25. This implies that annunciation is required in the control room. EPRI TR-104239 allows a minimum system where the data is retrieved by hand and processed at a different site. As long as the determination of OBE exceedance can be performed within 4 hours this should be acceptable to the NRC. Running cables from the instrumentation to the control room is expensive and may not be cost beneficial to some utilities. Note that if the operators in the control have not felt an earthquake then for practical considerations an earthquake has not occurred.

Revise the section not to require control room annunciation. (Reference 11)

Response. Support for the NRC staff's regulatory position for control room annunciation is contained in several peer reviewed national standards, most notably, ANSI N18.5, "Earthquake Instrumentation Criteria for Nuclear Power Plants," (endorsed with exception in Regulatory Guide 1.12, Revision 1), and ANSI/ANS-2.2-1978 and 1988, "Earthquake Instrumentation Criteria for Nuclear Power Plants." The regulatory position because it pertains to new plants was not changed. However, the implementation section of the regulatory guide was revised to include a voluntary implementation by licensees of operating plants. The implementation section states that partial compliance with the regulatory positions will be reviewed on a case-by-case basis recognizing that it may not be cost beneficial for licensees to implement all aspects of the regulatory positions.

C3. Page 6, lines 13-14. State that the instrumentation should record, at minimum, 3 seconds of low amplitude motion prior to seismic trigger actuation. Setting for the pre-event memory should be correlated with the maximum distance to any potential epicenter that can effect a specific site. The "P" wave may not be recorded at a 3 second setting. Also, when an event occurs at some distance and the trigger threshold limit is not exceeded until 15 or 20 seconds into the event, a part of the record, albeit for a low event, is lost. A 30 second value may be more appropriate and is within the capabilities of current digital time-history accelerographs. (Reference 12)

Response. Agreed. The regulatory position was changed. In addition, a new paragraph was added to the Discussion section addressing the pre-event memory setting.

C4. Page 6, lines 21-24. Can not comply with the stated regulatory position. It would require equipment to have the capability to record for 30 days without power. Current capability is for equipment to sense and record for no less than 24 hours in the absence of power. Loss of AC and DC power alarms are optionally available that would notify personnel if there is a problem with the power system. (Reference 12)

Response. The regulatory position was revised to recommend enough battery capacity for a minimum of 25 minutes of system operation at any time over a 24 hour period, without recharging, in combination with a battery charger whose line power is connected to an uninteruptable power supply or a line source with an alarm that is checked, at least every 24 hours. It is also stated that other combinations of larger battery capacity and alarm intervals may be used.

C5. Page 7, lines 10-11. The lower range of the seismic trigger actuation level should be 0.005g (not 0.001g). Our instrumentation is capable of having a trigger actuation level of 0.001g, however, an actuation level of 0.005g would avoid spurious triggering of the system. (Reference 12)

Response. What is stated is a range of seismic trigger operability not a specific setting. If necessary, the actuation level of the seismic trigger could be set to 0.005g to avoid spurious triggering of the system. Therefore, in response to References 1 and 2, and because the stated range is available the regulatory position was not changed.

C6. Page 8, lines 4-7. Supports control room annunciation of the free-field or any foundation level time history accelerograph for new plants. Recommends an exemption for licensees of existing plants that may want to voluntarily upgrade their systems and implement the new standards. (Reference 12)

Response. See response to C2.

C7. Reinstate Regulatory Position 4.3 of DG-1016, "The instrumentation of the foundation and at elevations within the same building or structure should be interconnected for common starting and common timing, and the instrumentation should contain provisions for an external remote alarm to indicate actuation." In the absence of a common time base for instruments in the same building or structure, comprehensive post-earthquake (off-line) dynamic analysis, is not possible. (Reference 12)

Response. The regulatory guide recommends the minimum instrumentation requirements necessary to meet the Commission's regulations. As noted in Reference 5, the proposed instrumentation is not sufficient to identify some of the major vibratory modes of the structure, such as rocking and torsion. However, the instrumentation described in the regulatory guide will provide data so that an evaluation can be made as to (1) whether or not the design response spectra have been exceeded, (2) whether or not the calculated vibratory responses used in the design of the representative seismic Category I structures have been exceeded at instrumented locations, and (3) the degree of applicability of the mathematical models used in the seismic analysis of the buildings.

The regulatory position was not changed.

APPENDIX

AA1. Improve the definition of the Operating Basis Earthquake. First, it is not necessarily true that all features necessary for continued operation of the plant are seismically designed (circulating water system, sewage treatment, turbine, reactor coolant pumps, etc.). Systems necessary for safe shutdown are seismically designed. Second, why require shutdown at the OBE if the plant is designed for it? Third, as written, all earthquakes less than the OBE meet the definition of the OBE. Fourth, DG-1034 page 8 appears to define the OBE as either an OBE spectra, as 1/3 the SSE, or as .2g. Fifth, Appendix A of DG-1034, guideline number 2 appears to define an OBE as an MMI earthquake within 5 km of the plant, a Richter 6 felt at the plant, or a Richter 5 within 200 km of the plant.

A better definition for the OBE is: "An earthquake occurring in the vicinity of a plant after which the plant is shutdown for detailed review and evaluations, even if no damage is apparent. The earthquake must result in an MMI VI or greater within 5 km of the plant. For plants with calibrated, operable and installed seismic instrumentation, the OBE must also exceed 1/2 of the SSE spectrum." (Reference 10)

Response. With regard to the other OBE related statements, the proposed regulations and information pertaining to NRC staff positions on the value of the OBE ground motion, required OBE analysis, and required plant shutdown are contained in the Federal Register notice cited above and briefly summarized below.

The requirement associated with the OBE is that all structures, systems, and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public must remain functional and within applicable stress, strain, and deformation limits when subjected to the effects of the OBE in combination with normal operating loads (Paragraph IV(a)(2) of Appendix S to 10 CFR Part 50). The value of the OBE can be set at (i) one-third or less of the SSE, where OBE requirements are satisfied without an explicit response or design analyses being performed, or (ii) a value greater than one-third of the SSE, where analysis and design are required. In selecting the value of the OBE the applicant should consider two items: first, the regulations require plant shutdown if vibratory ground motion exceeding that of the OBE occurs (Paragraph IV(a)(3) of Appendix S to 10 CFR Part 50), and second, the amount of analyses associated with the OBE. (Refer to Paragraphs V(B)(5) and V(B)(6) of FR 59 52255 for more discussion.)

Since December 1973 (the effective date of Appendix A to 10 CFR Part 100) the Commission's regulations have required that a nuclear power plant shut down if vibratory ground motion exceeding that of the OBE occurred. Exceedance is not clearly defined in the regulation or in any other regulatory guidance. Interim guidelines as to what constitutes an OBE exceedance warranting shutdown were published in Reference 13. The cited pages in DG-1034 contain OBE exceedance guidelines for plants with and without operable seismic instrumentation and data processing equipment, not additional OBE definitions. Note that the OBE exceedance criteria has been developed to reflect damage potential of the earthquake ground motion at a site and, as such, relates to the MMI measures. EPRI NP-5930 and EPRI TR-100082 contain details of the development of the OBE exceedance criteria.

REFERENCES

1. Yankee Atomic Electric Company, D.W. Edwards, March 23, 1993

2. Nuclear Management and Resources Council (now Nuclear Energy Institute), William H. Rasin, March 24, 1993

3. Department of Energy, Dwight E. Shelor, March 24, 1993

4. South Carolina Electric and Gas Company, John L. Skolds, March 24, 1993

5. United States Department of the Interior, Geological Survey, Dallas L. Peck, June 2, 1993

6. Sargent and Lundy Engineers, B.A. Erler, March 23, 1993

7. State of Vermont, Laurence R. Becker, March 23, 1993

8. TU Electric, William J. Cahill, March 30, 1993

9. Northern States Power Company, Roger O. Anderson, April 21, 1993

10. Wais and Associates, Inc., Royce M. Reinecke, April 4, 1995, (Comments on Draft Regulatory Guides DG-1033, DG-1034, and DG-1035)

11. Nuclear Energy Institute, William H. Raisin, May 12, 1995

12. Kinemetrics, Inc., Brian S. Herzog, May 11, 1995

13. Proceedings of the Third Symposium on Current Issues Related to Nuclear Power Plant Structures, Equipment and Piping, December 1990, Paper XII/3

SECTION 3

RESOLUTION OF PUBLIC COMMENTS
REGULATORY GUIDE 1.166

COMMENT RESOLUTION

Regulatory Guide 1.166
Pre-Earthquake Planning and
Immediate Nuclear Power Plant Operator Postearthquake Actions
(Draft was DG-1034)

BACKGROUND

The first proposed revision of the Reactor Site Criteria Including Seismic and Earthquake Engineering Criteria for Nuclear Power Plants (10 CFR Parts 50, 52 and 100) was published for public comment on October 20, 1992, (57 FR 47802). The availability of the draft regulatory guides and standard review plan section that were developed to provide guidance on meeting the proposed regulations was published on November 25, 1992, (57 FR 55601). Because of the substantive nature of the changes to be made in response to public comments the proposed regulations and draft guidance documents were withdrawn and replaced with the second proposed revision of the regulations published for public comment on October 17, 1994, (FR 59 52255). The availability of the draft guidance documents was published on February 28, 1995, (FR 60 10810).

Seven letters (References 1 through 7) contained comments on Draft Regulatory Guide DG-1017, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions," November 1992. Draft Regulatory Guide DG-1034, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions," February 1995 reflects the only documentation pertaining to NRC staff evaluation and implementation of all comments provided in References 1 to 7.

Two letters (References 8-9) contained comments on Draft Regulatory Guide DG-1034, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions." A synopsis of the comments and the NRC staff response follows.

B. DISCUSSION

B1. Page 2, lines 23-27. Clarification is needed. First, only the free-field instrument (or possibly the containment foundation accelerograph, if the utility elects to only use the response spectrum check) are used to determine if the plant must be shut down. Second, shutdown by "operational perturbations" does not necessarily mean that OBE exceedance has occurred and that the plant must go through analytical steps before the plant can be restarted. (Reference 9)

Response. The sentence starting on line 23 was changed to read: "The data from the free-field seismic instrumentation, coupled with ..."

The following was added after the words "shut down" on line 30: "(or could restart following a post-trip review, if it tripped off-line because of the earthquake)."

B2. Page 3, lines 6-15. It is not clear why the seismic instrumentation must process the data within four hours when plant walkdowns need not be completed for eight hours. Suggest changing the data processing requirements to eight hours. It is also not clear why if the plant has operated without problems for eight hours following the earthquake, and no damage is apparent, why the plant is automatically forced to shutdown. (Reference 8)

Response. The recommended times for the processing of data from the seismic instrumentation and the completion of the operator walkdown inspections was extracted from guidelines published by the Electric Power Research Institute (EPRI). These guidelines are contained in EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," Sections 4.3.2, Operator Walkdown Inspections, and 4.3.3, Evaluation of Ground Motion Records. The following is extracted from the Report Summary (Approach Section):

> "The guidelines were developed by a team with expertise in system performance, plant operations, and seismic structural engineering disciplines. Based on the knowledge that operating and emergency procedures to respond to plant systems are already in place at nuclear power plants, the team formulated comprehensive guidelines for utilities to develop plant-specific procedures for response to an earthquake. Throughout guideline development, a panel of utility and industry experts on plant operation and earthquake engineering provided a comprehensive peer review."

The Commission's regulation (Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities") require shut down of the nuclear power plant if vibratory ground motion exceeding that of the Operating Basis Earthquake Ground Motion (OBE) or significant plant damage occurs. If no damage is apparent shutdown would only be required if the OBE were exceeded.

The discussion was not changed.

B3. Page 3, lines 12 to 15. Suggest rewording to "If the seismic instrumentation or data processing equipment is inoperable, or the licensee has chosen not to install seismic monitoring instrumentation, the guidelines in Appendix A to this guide will be used to determine whether the OBE has been exceeded." (Reference 8)

Response. The installation of seismic monitoring instrumentation is not optional it is required by the Commission's regulations (Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"). The discussion was not expanded to include the phrase "or the licensee has chosen not to install seismic monitoring instrumentation."

B4. Page 3, lines 20-23. EPRI NP-5930 refers to a single "criterion" with two checks (i.e., response spectrum and CAV). The NRC should adhere to this convention to avoid misunderstandings. (Reference 9)

Response. Agreed.

B5. Page 4, lines 1-3. Delete this statement. We are not aware of any plants where containment isolation valves have malfunctioned during an earthquake. It is not believed that it is necessary that these valves be checked by the plant operators during a post-earthquake walkdown. This would be an appropriate component to review during the restart phase, if a plant is shutdown due to OBE exceedance or discovery of significant damage. (Reference 9)

Response. The comment on page 4, lines 1-3 discusses why the NRC staff took exception to Section 4.3.4 of EPRI NP-6695 and added Regulatory Position 6.2. Section 4.3.4 of EPRI NP-6695 describes pre-shutdown inspections that are only performed if it has been determined that the plant must shut down because the OBE was exceeded or the operator walkdown inspections discovered damage. For the selected equipment it is important to perform a visual inspection focusing on functional damage that may impair the capability of the damaged item to perform its safety function. Physical damage which does not affect equipment operability is not a major concern in these inspections. Because it is essential to maintain containment integrity a check of the containment isolation system was added to the minimum list of equipment to be checked.

B6. Page 4, lines 4-10. The NRC position that nuclear power plants be automatically shutdown following an OBE, even if the plant is stable and no damage is observed, precludes prudent operators in earthquake prone zones such as the West Coast and Alaska from building nuclear power plants. This decision will limit nuclear power facilities to low seismic zones such as the eastern United States, where the likelihood of an earthquake is so low that shutdown of the power plant for a post OBE inspection is moot anyway. (Reference 8)

Response. The requirement associated with the OBE is that all structures, systems, and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public must remain functional and within applicable stress, strain, and deformation limits when subjected to the effects of the OBE in combination with normal operating loads (Paragraph IV(a)(2) of Appendix S to 10 CFR Part 50). The value of the OBE can be set at (i) one-third or less of the SSE, where OBE requirements are satisfied without an explicit response or design analyses being performed, or (ii) a value greater than one-third of the SSE, where analysis and design are required. In selecting the value of the OBE the applicant should consider two items: first, the regulations require plant shutdown if vibratory ground motion exceeding that of the OBE occurs (Paragraph IV(a)(3) of Appendix S to 10 CFR Part 50), and second, the amount of analyses associated with the OBE. (Refer to Paragraphs V(B)(5) and V(B)(6) of FR 59 52255 for more discussion.) The regulations do not preclude prudent operators in earthquake prone zones such as the West Coast and Alas[illegible] om building nuclear power plants.

Shutdown of the power plant for a post OBE inspection is not a moot point for eastern United States power plants. Small, nondamaging earthquakes have exceeded the OBE spectrum in the high-frequency range without causing damage. In 1978 and 1979 a series of earthquakes occurred near the Virgil C. Summer plant in South Carolina, in 1986 an earthquake occurred near the Perry plant in Ohio, in 1987 an earthquake that occurred in southern Illinois was either felt of triggered instruments at six plants. To avoid unnecessary plant shutdowns the Electric Power Research Institute (EPRI) developed guidelines that will enable licensees to quickly identify and assess earthquake effects on nuclear power plants. These guidelines are in EPRI NP-5930, "A Criterion for Determining Exceedance of the Operating Basis Earthquake," EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," and EPRI TR-100082, "Standardization of Cumulative Absolute Velocity." The regulatory position on OBE exceedance in Draft Regulatory Guide DG-1034, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Actions," is based on EPRI NP-5930 and EPRI TR-100082 reports.

C. REGULATORY POSITION

C1. Page 5, line 4. Add a statement that the requirements for service history of seismic instrumentation should not be more restrictive than requirements for other plant equipment. (Reference 9)

Response. Agreed.

C2. Page 5, lines 8-11. It should be made clear that the same earthquake time-history used for the calibration check should be used for all accelerometers. This will avoid someone thinking that the response of the structure from a dynamic analysis should be used to check accelerometers high up in the building.

The request in lines 11, 12 and 13 (listed above) seems inconsistent. It would be more appropriate if each accelerometer were treated independently. A calibration check should be performed for an instrument after servicing, but there is no need to require a check (of all instruments) after only the free-field instrument is serviced. (Reference 9)

Response. The intent of this Position is to have sufficient information available at the plant so that the licensee can ascertain that the time-history analysis hardware and software were functioning properly.

Regulatory Positions 1.1(4) and 4.3 were modified to clarify this point. The following was added to the Discussion section of the guide:

> "Because free-field seismic instrumentation data are used in the plant shutdown determination, it is important to ascertain that the time-history analysis hardware and software were functioning properly. Therefore, the response spectrum and cumulative absolute velocity (CAV) should be calculated using a suitable earthquake time-history or manufactures calibration standard after the initial installation and each servicing of the free-field instrumentation. After an earthquake at the plant site, the response spectrum and CAV should be calculated using the time-history or calibration standard that was used during the last servicing (or initial instrumentation installation if no servicing has been performed) and the results compared with the latest data on file at the plant."

This Position is not addressing seismic instrumentation maintenance. The maintenance of the accelerometers is described in Regulatory Guide 1.12, "Nuclear Power Plant Instrumentation for Earthquakes," Revision 2 (Draft was DG-1033).

C3. Page 5, lines 15-18. Sections 5.3.1 and 5.3.2.1 of EPRI NP-6695 are for "post-shutdown inspections and tests" assuming that the plant has been shut down due to OBE exceedance or discovery of significant damage during the operator walkdown. This section should be revised to refer to Section 4.3.2 of EPRI NP-6695. This latter section refers to Section 5.3.2.1, but it says: "In performing these inspections, <u>consideration</u> (underline added for emphasis) should be given to the specific list of equipment selected for focused inspections described in Section 5.3.2.1 of this report.

The key word here is "consideration." Section 5.3.2.1 guidance relies on a very major inspection procedure that is beyond the scope of post earthquake inspection guidance of Section 4 of EPRI NP-6695. The post earthquake walkdown is performed by plant operators, while the post-shutdown review in Section 5 is performed by engineers. The operator walkdown after a felt earthquake should be kept simple. (Reference 9)

<u>Response</u>. Regulatory Position 1.2 discusses pre-earthquake actions, that is, the upfront planning that is needed to perform the postearthquake inspections. Section 5 of EPRI NP-6695 is titled,

"Guidel'nes for Post-Shutdown Inspections and Tests," howr.. 'on 5.3.1 is titled, "Pre-Event Actions," and describes the s .n of equipment and structures for inspections and the base line .spections.

Section 5.3.2.1 of EPRI NP-6695 was cited because it is mentioned in Section 5.3.1 and the NRC staff wanted to make it clear that it was also accepted. In retrospect this is not necessary, exceptions to a section, if any, are noted (see Regulatory Position 2). The text was modified to state that the Position pertains to pre-earthquake actions, and the reference to Section 5.3.2.1 was removed.

C4. Page 5, lines 22-24. See comment C3 above. There should not be a direct reference to Section 5 in EPRI NP-6695 since this refers to post-shutdown actions. Revise this Section so it does not refer to Section 5 in EPRI NP-6695, which refers to post-shutdown earthquake actions. (Reference 9)

Response. Agreed, the parenthetical statement was removed. See response to Comment C3 for the rational as to why the parenthetical statement was made.

C5. Page 7, lines 7-10. The option should be permitted to allow the containment basemat location to be used in the same manner as a free-field station for plants founded on rock sites. This is specifically allowed for this in the EPRI NP-5930 report, because flexibility was conservatively included in the OBE exceedance criterion to account for variability between free field and containment basemat responses at rock sites. (Reference 9)

Response. NRC staff approval of an applicants standard design certification submittal pursuant to 10 CFR Part 52 means that the design is usable for a multiple number of units or at a multiple number of sites without reopening or repeating the review. In the design certification applications that have been reviewed and approved by the NRC staff (System 80+, NUREG-1462 and Advanced Boiling Water Reactor, NUREG-1503), the applicant has committed to the location and characteristics of the seismic instrumentation, OBE exceedance criterion (using data from free-field seismic instrumentation), and plant shutdown and restart procedures. Deviations from these commitments can not be made after site selection and still have the design characterized as a certified standard design. In addition, an application for a construction permit or operating license pursuant to Appendix S of Part 50 has the SSE characterized by free-field ground motion response spectra at the free ground surface. Thus, the free-field seismic instrumentation data would be used to compare measured response to the engineering evaluations used to determine the design input motions to the structures.

In a 10 CFR Part 50 application the characteristics of the design and site are reviewed simultaneously. The applicant's commitments to the location and characteristics of the seismic instrumentation, OBE exceedance criterion, and plant shutdown and restart procedures are made with explicit siting conditions known. However, an application for a construction permit or operating license pursuant to Appendix S of Part 50 has the SSE characterized by free-field ground motion response spectra at the free ground surface. The free-field seismic instrumentation data would be used to compare measured response to the engineering evaluations used to determine the design input motions to the structures.

In addition, there is a publication on recent Lucerne Valley, California data (Reference 10) which questions the criteria for classifying a site as rock. Reference 10 concludes that the use of rock outcrop motion to develop base rock motion needs further evaluation. The NRC staff is aware of other unpublished studies with similar conclusions that were conducted after recent California earthquakes. This will be addressed in a new NRC sponsored research program to develop revised regulatory guidance to characterize the vibratory ground motion used for nuclear power plant design. Results will provide the technical basis to support a revision to Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," and associated standard review plan sections.

The final regulatory guide will be used in the evaluation of applications for construction permits, operating licenses, combined licenses, or design certifications submitted after the effective date of Appendix S to 10 CFR Part 50 (the regulatory positions will not be backfit). Therefore, for the reasons cited above a general option that would allow that the containment basemat location could be used in the same manner as a free-field station for plants founded on rock sites will not be included. However, applicants have proposed alternative methods for complying with specific portions of the Commission's regulations that were accepted by the NRC staff. Recognizing the NRC staff's concerns about criteria for classifying a site as rock, an application submitted pursuant to Part 50 could propose the stated option with their submittal.

C6. Page 8, lines 1-8. EPRI NP-5930 recommends a confirmatory check when only a single spike exceeds one of the three earthquake component response spectra. In order to minimize of the likelihood of a spurious signal indicating falsely that the OBE has been exceeded a confirmation check should also be allowed consistent with the provisions in EPRI NP-5930. (Reference 9)

Response. The recommendations in EPRI NP-5930 were developed in part, based on the data that would be available from the seismic instrumentation in the currently operating nuclear power plants. For the response spectrum check EPRI NP-5930 recommends that spectral ordinates, computed at a minimum of 8 frequency points approximately evenly spaced on a logarithmic scale, are compared to the criterion values. The response spectrum check is considered to have been exceeded if one spectral ordinate from any of the three directions exceeds the criterion value and one additional spectral ordinate, from a different frequency of the same direction or any frequency of a different direction, exceeds two-thirds of the criterion value. For instruments such as Engdahl recorders which rely on light indicators (i.e., amber and red) one red light with at least one additional indicator (red or amber) from a different oscillator must light for the response spectrum check to have been exceeded.

The recommendations stated above were intended to minimize the likelihood of a spurious signal (a single narrow frequency spectral acceleration spike) as being interpreted as a damaging earthquake motion. The solid-state digital instrumentation recommended in Regulatory Guide 1.12, "Nuclear Power Plant Instrumentation for Earthquakes," Revision 2 (Draft was DG-1033) will provide spectra data as a continuum, and not be limited to a preselected number of frequencies. All frequencies between 1 and 10 hertz should be used to determine if the response spectrum check was exceeded. Upon evaluation of the data the appearance of a spurious signal would be evident.

The regulatory position was not changed.

C7. Page 8, lines 1-8. Item 4.1.2 in this section provides three criteria for exceeding the OBE spectra: first, the OBE spectra; second, 1/3 of the SSE; and third, .2g or 6 inches per second as appropriate. Historically, the criteria for the OBE is 1/2 the SSE. Why the change? Does the definition of the OBE as 1/3 of the SSE preclude the need for any OBE design analysis? Also, does the .2g or 6 inches per second criteria correlate in any way to an MMI VI within 5 km of the plant? The number of options available in this section is confusing. Why is the criteria not limited to exceeding 1/2 the SSE spectra? From a design perspective, it seems prudent for licensees to design only for the SSE spectra. Then the OBE (either 1/3 or 1/2 the SSE spectra) becomes simply a trigger for a shutdown and inspection. (Reference 8)

Response. Historically, the criteria for the OBE was 1/2 the SSE. Appendix S to 10 CFR Part 50 now states that the value of the OBE can be set at (i) one-third or less of the SSE, where OBE requirements are satisfied without an explicit response or design analyses being performed, or (ii) a value greater than one-third of the SSE, where analysis and design are required.

The 0.2g spectral acceleration was recommended in the EPRI NP-5930, "A Criterion for Determining Exceedance of the Operating Basis Earthquake." The 6 inches per second spectral velocity threshold was also recommended by EPRI since some structures have fundamental frequencies below the range specified in EPRI NP-5930. However, the NRC staff recommends 1.0 to 2.0 Hz for the range of the spectral velocity limit (EPRI recommended 1.5 to 2.0 Hz) since some structures have fundamental frequencies below 1.5 Hz. The 0.2g and 6 inches per second criteria were established from the real earthquakes used to establish the OBE exceedance criteria as discussed in EPRI NP-5930.

C8. Page 9, line 2. Define significant plant damage. Isn't it better defined and actually already addressed by the Plant Technical Specifications action statements? (Reference 8)

Response. Significant damage is defined in EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake."

C9. Page 9, lines 6-8. Regulatory Position 4.4 which addresses inoperable instrumentation should be referenced in this Section. (Reference 9)

Response. Agreed. The sentence that started at the end of line 9 was expanded to: "If only one limit can be checked, the other limit is assumed to be exceeded; if neither limit can be checked see Regulatory Position 4.4."

C10. Page 9, line 14. What triggers the walkdown inspection? The criteria for these inspections should be as explicitly defined as the criteria for OBE exceedance. (Reference 8)

Response. Actions are triggered by a felt earthquake at a nuclear power plant. EPRI NP-6695 defines a felt earthquake as: "An earthquake of sufficient intensity such that: (a) the vibratory ground motion is felt at the nuclear power plant site and is recognized as an earthquake based on a consensus of the control room operators on duty at the time, and (b) for plants with operable seismic instrumentation, the seismic switches installed at the plant are activated. For most plants with seismic instrumentation, the seismic switches are set at an acceleration of about 0.01g.

C11. Page 9, line 15. Define damage. Does this include papers on the floor, overturned coffee cups, easily repairable items? Isn't this better addressed through compliance with Technical Specification action statements? (Reference 8)

Response. Damage (functional, physical, and significant) is defined in EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake."

APPENDIX A

AA1. Page A-1, lines 8-20. For plants on rock sites the OBE exceedance instrumentation should be allowed to be located at either a free-field site or at the top of the containment basemat. The limits of 0.2g or 6 inches per second should not be eliminated from the response spectrum check. Significant additional conservatism is provided by eliminating the CAV check. (Reference 9)

Response. The criteria in the Appendix are used to determine if the OBE has been exceeded because the free-field seismic instrumentation is inoperable, data from the seismic instrumentation are destroyed, or the data processing hardware or software is inoperable. Also, see response to Comment C5.

AA2. Page A-1, lines 29-30. Criteria 2 appears to apply to earthquakes of Richter magnitude 6.0 or greater that occur more than 200 km from the plant and are "felt" at the plant. Define "felt" since it is subjective. Better yet, delete this criteria. Also suggest deleting criteria 3 since it is not directly related to any damage at the plant. (Reference 3)

Response. Refer to the response to Comment C10. The NRC staff would use the "(a)" portion of the definition in EPRI NP-6695; the "(b)" portion is not applicable because the seismic instrumentation is inoperable

Criteria 2 and 3 will be retained, they are based on information that would be readily available to the NRC staff and would require shutdowns when they are consistent with the intent of the regulations, and avoid shutdowns when they are not. Reference 11 has additional information pertaining to these criteria.

AA3. Page A-2, lines 3-4. Delete this paragraph since they are better addressed in DG-1035. (Reference 8)

Response. This postearthquake walkdown is recommended after any felt earthquake ground motion as an added assurance that no damage has occurred.

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1. Yankee Atomic Electric Company, D.W. Edwards, March 23, 1993

2. Nuclear Management and Resources Council, (now Nuclear Energy Institute), William H. Rasin, March 24, 1993

3. South Carolina Electric and Gas Company, John L. Skolds, March 24, 1993

4. Delaware Geological Survey, Thomas E. Pickett, March 10, 1993

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9. Nuclear Energy Institute, William H. Raisin, May 12, 1995

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11. Proceedings of the Third Symposium on Current Issues Related to Nuclear Power Plant Structures, Equipment and Piping, December 1990, Paper XII/3

SECTION 4

RESOLUTION OF PUBLIC COMMENTS
REGULATORY GUIDE 1.167

COMMENT RESOLUTION

Regulatory Guide 1.167
Restart of a Nuclear Power Plant Shut Down by an Earthquake
(Draft was DG-1035)

BACKGROUND

The first proposed revision of the Reactor Site Criteria Including Seismic and Earthquake Engineering Criteria for Nuclear Power Plants (10 CFR Parts 50, 52 and 100) was published for public comment on October 20, 1992, (57 FR 47802). The availability of the draft regulatory guides and standard review plan section that were developed to provide guidance on meeting the proposed regulations was published on November 25, 1992, (57 FR 55601). Because of the substantive nature of the changes to be made in response to public comments the proposed regulations and draft guidance documents were withdrawn and replaced with the second proposed revision of the regulations published for public comment on October 17, 1994, (FR 59 52255). The availability of the draft guidance documents was published on February 28, 1995, (FR 60 10810).

Three letters (References 1 through 3) contained comments on Dra. gulatory Guide DG-1018, "Restart of a Nuclear Power Plant Shut Down by an Earthquake," November 1992. Draft Regulatory Guide DG-1035, "Restart of a Nuclear Power Plant Shut Down by an Earthquake," February 1995 reflects the only documentation pertaining to NRC staff evaluation and implementation of all comments provided in References 1 to 3.

Three letters (References 4-6) contained comments on Draft Regulatory Guide DG-1035, "Restart of a Nuclear Power Plant Shut Down by an Earthquake." A synopsis of the comments and the NRC staff response follows.

A. INTRODUCTION

A1. DG-1034 does not provide guidance on what is significant plant damage. Suggest defining significant plant damage as requiring entry into a Plant Technical Specification action statement. (Reference 4)

Response. Significant damage is defined in EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake."

C. REGULATORY POSITION

C1. The statement in Regulatory Position 1.1 is vague relative to its applicability. The limitation does not apply to piping, because Regulatory Position 1.3 states that reanalysis of safety-related piping is unnecessary. Reanalysis of components designed to ASME Section II [Section III] Class MC or ASME Division II should be unnecessary following an OBE exceedance, because they are designed within ASME stress limitations for an SSE and demonstrated to have functionality at seismic margin levels above the OBE. It appears that the evaluations for potential fatigue considerations should be limited in this paragraph to ASME vessels and components. Revise to clarify to what vessels and components the evaluation of limitations of ASME Code Service Level C apply. (Reference 5)

Response. Regulatory Position 1.3 is withdrawn. The NRC staff does not take exception to the last paragraph in Section 6.3.4.1 of EPRI NP-6695, which states "For piping, seismic reanalysis should be limited to ASME Code Class 1 piping and/or piping which shows evidence of large displacement or distress. Complete seismic reanalysis of all piping is not considered necessary. Experience has shown ...."

C2. Given that the earthquake has occurred and restart deliberations are in progress, a more liberal acceptance criterion in Regulatory Position 1.2 would be appropriate. More specific guidance is needed as to what constitutes an acceptance criterion. (Reference 5)

Response. In general, restart deliberations are not in progress because Regulatory Position 1.2 pertains to the long-term evaluation that are performed after the nuclear power plant has restarted (EPRI Damage Intensity 3 is the exception), see Figure 3-2 of EPRI NP-6695. Also, more liberal acceptance criteria are not warranted because the acceptability consideration noted in the regulatory guide and the others noted in Section 6.3.4.1, Item (3), of EPRI NP-6695 are used only if the calculated stresses are greater than allowables for faulted conditions.

C3. This is in reference to calculated stresses from a seismic event if these exceed the allowables used for the faulted condition (e.g., ASME Code Level D service limits). The draft guide DG-1035 adds a sentence in Regulatory Position 1.2 for functionality: "This evaluation should address all locations where stresses exceed faulted allowables and should include fatigue analysis."

(a) Historically, seismic events have not produced enough strong motion cycles to make fatigue an issue for structures, systems and components. This is especially true for low amplitude, highcycle, fatigue evaluations. The computed peak stress would have to be a significant fraction of the ultimate tensile strain to initiate a high-amplitude, low-cycle, fatigue failure. For engineered systems, structures and components to be susceptible to low-cycle fatigue effects, the recorded seismic event would have to exceed the Safe Shutdown Earthquake Ground Motion (SSE) spectrum by a significant margin.

(b) The ASME Code currently only requires Code Class 1 components to perform fatigue analyses that account for thermal and pressure cycles. The plant computer system is monitoring these systems to more accurately assess the effect of operating cycles on the fatigue life of piping components. To do a fatigue analysis for ASME Code Class 2 and 3 piping systems, it would be necessary to use estimated values for thermal and pressure cycles. The amount of conservatism or error introduced by using estimated operating cycles would be more significant than the computed seismic stresses.

Based on the above discussion, the requirement for fatigue analysis should be limited to ASME Code Class 1 components and systems. (Reference 6)

Response. Agreed.

C4. In Regulatory Position 1.3, if reanalysis of piping systems is not considered necessary unless there is observed damage, then why is reanalysis to be conducted on a sampling basis? A better position is to require reanalysis of damaged piping and a generic implications study to determine if other, non-damaged lines, also need to be evaluated. (Reference 4)

Response. Regulatory Position 1.3 is withdrawn (see response to Comment C1). However, it should be noted that Section 6.3.3, Seismic Re-Evaluations, of EPRI NP-6695, describes considerations that should be used in the selection of items for seismic re-evaluation.

C5. The exception in Regulatory Position 1.3 infers that all piping showing evidence of distress be evaluated, since the draft regulatory guide did not identify that evaluation be limited to only ASME Code Class 1 piping and/or structures that show evidence of large displacements or distress.

The draft regulatory guide suggests that piping should be evaluated based on a sampling program. However, the parameters for the design of a sampling program are not depicted anywhere.

It appears that the draft guideline is requiring also an analytical evaluation of non-nuclear safety related components that exhibit signs of damage. Most non-nuclear safety components do not have deterministic evaluations to the level of detail of nuclear safety related components, which is particularly true for systems in the turbine buildings. As a result, generating analysis for the non-nuclear safety related systems and components would be very time consuming and expensive with no benefit with respect to nuclear safety.

Based on the above, we suggest to clarify in the Regulatory Guide exclusion of the analysis requirement for non-nuclear safety related systems and components. (Reference 6)

Response. Regulatory Position 1.3 is withdrawn. See response to Comments C1, C2 and C4.

REFERENCES

1. Nuclear Management and Resources Council (now Nuclear Energy Institute), William H. Rasin, March 24, 1993

2. Sargent and Lundy Engineers, B.A. Erler, March 23, 1993

3. Letter from G. Slagis to N. Chokshi (NRC), dated October 26, 1993, Subject: Comments on EPRI NP-6695.

4. Wais and Associates, Inc., Royce M. Reinecke, April 4, 1995, (Comments on Draft Regulatory Guides DG-1033, DG-1034, and DG-1035)

5. Nuclear Energy Institute, William H. Raisin, May 12, 1995

6. TU Electric, J.S. Marshall, May 11, 1995