NUREG-0800
(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants

Section No. 2.5.2
Revision No. 2

Appendix No. N/A
Revision No. N/A

Branch Tech. Position N/A
Revision No. N/A

Date Issued August 1989

FILING INSTRUCTIONS

PAGES TO BE REMOVED			NEW PAGES TO BE INSERTED		
PAGE NUMBER		DATE	PAGE NUMBER		DATE
2.5.2-1 thru 2.5.2-13	Rev. 1	July 1981	2.5.2-1 thru 2.5.2-15	Rev. 2	August 1989

The U.S. Nuclear Regulatory Commission's Standard Review Plan, NUREG-0800, prepared by the Office of Nuclear Reactor Regulation, is available for sale by the National Technical Information Service, Springfield, VA 22161.

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

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2.5.2 VIBRATORY GROUND MOTION

REVIEW RESPONSIBILITIES

Primary - Structural and Geosciences Branch (ESGB)

Secondary - None

I. AREAS OF REVIEW

The Structural and Geosciences Branch review covers the seismological and geological investigations carried out to establish the acceleration for the safe shutdown earthquake (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 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 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 Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants" to 10 CFR Part 100 (Ref. 1). Additional guidance (regulations, regulatory guides, and reports) is provided to the staff through References 2 through 8.

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 (Subsection 2.5.2.3), maximum earthquake potential (Subsection 2.5.2.4), seismic wave transmission characteristics of the site (Subsection 2.5.2.5), safe shutdown earthquake (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, and 6) and basic acceptance criteria pertinent to the areas of this section of the Standard Review Plan are:

1. 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants." These criteria describe 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." 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, tsunami, and seiches without loss of capability to perform their safety functions (Ref. 2).

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

4. 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 earthquake. 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. 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 which the NRC staff considers in determining the suitability of sites for nuclear power stations (Ref. 5).

6. 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 Subsection 2.5.2.6.

The primary required investigations are described in 10 CFR Part 100, Section IV(a) of Appendix A (Ref. 1). The acceptable procedures for determining the seismic design bases are given in Section V(a) and Section VI(a) of the appendix. The seismic design bases are predicated on a reasonable, conservative determination of the SSE and the OBE. As defined in Section III of 10 CFR Part 100, Appendix A (Ref. 1), the SSE and OBE are 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 meeting the requirement of 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, any parts of which are within 200 miles of the site. 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 50 miles of the site. The following information concerning each earthquake is required whenever it is available: epicenter coordinates, depth of focus, origin time, highest intensity, magnitude, seismic moment, source mechanism, source dimensions, distance from the site, and any strong-motion recordings (references from which the information was obtained should be identified). All magnitude designations such as m_b, M_L, M_s, M_w, etc., should be identified. In addition, any reported earthquake-induced geologic failure, such as liquefaction, landsliding, landspreading, and lurching should be described completely, including the 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 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 have been identified. 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 determining tectonic provinces and the earthquake-generating potential of the identified geologic structures. Specifically, each tectonic province, any part of which is within 200 miles of the site, must be identified. The staff interprets tectonic provinces to be regions of uniform earthquake potential (seismotectonic provinces). The proposed tectonic provinces may

be based on seismicity studies, differences in geologic history, differences in the current tectonic regime, etc. The staff considers that the most important factors for the determination of 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 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 tectonic provinces and the particular areas within those 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, the results of the additional investigative requirements described in 10 CFR Part 100, Appendix A, Section IV(a)(8) (Ref. 1), must be presented. The discussion should be augmented by a regional-scale map showing the tectonic provinces, earthquake epicenters, locations of geologic structures and other features that characterize the provinces, and the locations of any capable faults.

2.5.2.3 Correlation of Earthquake Activity with Geologic Structure or Tectonic Provinces. In meeting the requirements 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 of a region. 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. 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 estimate 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. Particular attention should be given to determining the capability of faults with which instrumentally located earthquake hypocenters are 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 is based on the staff's independent review of the geologic and seismic information.

2.5.2.4 Maximum Earthquake Potential. 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 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 earthquake(s) that would produce the largest ground motion at the site is based on the staff's independent analysis.

<u>2.5.2.5 Seismic Wave Transmission Characteristics of the Site</u>. In meeting the requirements of Reference 1, this subsection is accepted when 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. The following material properties should be determined for each stratum under the site: 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. 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) or nonlinear analysis (e.g., Refs. 25, 26, and 27) 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) 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 insure 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. 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.

The staff reviews the free-field response spectra of engineering significance (at appropriate damping values). Ground motion may vary for different foundation 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 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 earthquake(s). 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 sufficently large number of site-specific time histories and/or response spectra should be used to obtain an adequately 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). 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). 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). 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 38, 39, 40, and 41 and relationships between ground motion and intensity are found, for example, in References 41, 42, and 43. Due to 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). Modeling is particularly useful for sites near capable faults 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 time duration and number of cycles of strong ground motion is 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 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.

2.5.2.7 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 investigative requirements of 10 CFR Part 100, 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 additional information is required to 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 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 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, obtained from site visits or from staff consultants or literature sources, the reviewer independently identifies the relevant seismotectonic provinces, 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 could produce at the site and defines the safe shutdown earthquake and operating basis earthquake.

IV. EVALUATION FINDINGS

If the evaluation by the staff, on completion of the review of the geologic and seismologic aspects of the plant site, confirms that the applicant has met the requirements or guidance of applicable portions of References 1 through 6, the conclusion in the SER states that the information provided and investigations performed support the applicant's conclusions regarding the seismic integrity of the subject nuclear power plant site. In addition to the conclusion, this section of the SER includes (1) definitions of tectonic provinces; (2) evaluations of the capability of geologic structures in the region; (3) determinations of the SSE earthquake(s) and free-field

response spectra based on evaluation of the potential earthquakes; (4) 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. The above evaluation determinations or redeterminations are made by the staff during both the construction permit (CP) and operating license (OL) phases of review.

OL applications are reviewed for any new information developed subsequent to the CP safety evaluation report (SER). The review will also determine whether the CP recommendations have been implemented.

A typical 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 was made in conjunction with 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 to 10 CFR Part 100 provides an adequate basis to establish that no capable faults exist in the plant site area which 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 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. 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) 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," Regulatory Guide 4.7, "General Site Suitability for Nuclear Power Stations," and Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants."

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/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).

The provisions of this SRP section apply to reviews of construction permit (CP), operating license (OL), preliminary design approval (PDA), final design approval (FDA), and combined license (CP/OL) applications docketed after the date of issuance of this SRP section.

VI. REFERENCES

1. 10 CFR Part 100, 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. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants."

5. Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations."

6. Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants."

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

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NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER *(Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)*

NUREG-0800
Section 2.5.2
Revision 2

2. TITLE AND SUBTITLE

Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition

Section 2.5.2, Rev. 2, "Vibratory Ground Motion"

3. DATE REPORT PUBLISHED

MONTH	YEAR
November	1989

4. FIN OR GRANT NUMBER

5. AUTHOR(S)

6. TYPE OF REPORT

7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION – NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

9. SPONSORING ORGANIZATION – NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Same as above.

10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

This revision specifies the preferred hierarchy of ground motion specifications as follows:

(1) Site-specific spectra (horizontal and vertical) using records suitable for site conditions
(2) Site-specific spectra (horizontal and vertical) using scaled records
(3) Multiple parameter characterization such as NUREG/CR-0098 Spectra
(4) Regulatory Guide 1.60 Spectra scaled to peak ground acceleration

Additional references have been provided.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

USI A-40
Seismic Design Criteria
Ground Motion

13. AVAILABILITY STATEMENT

Unlimited

14. SECURITY CLASSIFICATION

(This Page) Unclassified

(This Report) Unclassified

15. NUMBER OF PAGES

16. PRICE

NRC FORM 335 (2-89)