U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

3.7.4 SEISMIC INSTRUMENTATION

Primary - ~~Structural Engineering Branch (SEB)~~ Civil Engineering and Geosciences Branch (ECGB)[1]

Secondary - None

I. AREAS OF REVIEW

The following areas related to the seismic instrumentation program are reviewed:

1. Comparison with Regulatory Guide 1.12

   A comparison of the proposed seismic instrumentation with the seismic instrumentation guidelines of Regulatory Guide 1.12 ~~(Ref. 4)~~[2] is made. In addition, the bases for elements of the program that differ from Regulatory Guide 1.12 are reviewed.

2. Location and Description of Instrumentation

   The locations for the installation of seismic instrumentation such as triaxial peak accelerographs, triaxial time history accelerographs, and triaxial response spectrum recorders that will be installed in selected Category I structures and components are reviewed. The bases for selection of the instrumentation and the locations and a discussion of the extent to which the seismic instrumentation will be employed to verify the seismic analyses following an earthquake are reviewed.

3. Control Room Operator Notification

   The procedures that will be followed to inform the control room operator of the peak acceleration level and the input response spectra values shortly after occurrence of an earthquake are reviewed. Also reviewed are the bases for establishing predetermined

values for activating the readout of the seismic instrumentation to the control room operator.

4. Comparison of Measured and Predicted Responses

The criteria and procedures that will be used to compare measured responses of Category I structures and selected components in the event of an earthquake with the results of the seismic system and subsystem analyses are reviewed.

5. ~~Inservice~~Instrument Surveillance[3]

The requirements for ~~inservice inspection~~instrument surveillance[4] testing and calibration as pertaining to operability and reliability are reviewed.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in subsection I of this SRP section are given below. Any other seismic instrumentation program which can be justified to be equivalent to the acceptance criteria may be used. ~~SEB~~ The ECGB[5] accepts the seismic instrumentation system if the relevant requirements of General Design Criterion 2 ~~(Ref. 2)~~, Appendix A to 10 CFR Part 100~~, Appendix A~~[6] ~~(Ref. 3)~~, and 10 CFR Part 50, 50.55a ~~(Ref. 1)~~[7], as they relate to the capabilities and performance of the instruments to adequately measure the effects of earthquakes are met. Specific criteria necessary to meet the requirements of GDC 2, Appendix A to 10 CFR Part 100~~, Appendix A~~[8], and 10 CFR Part 50, 50.55a, are as follows:

The instrumentation used for the measurements should be capable of recording the effects produced by the most severe earthquakes that have been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity and period of time in which historical data has been accumulated.

It is required in 10 CFR Part 100, Appendix A, that suitable instrumentation shall be provided so that the seismic response of nuclear plant features important to safety can be determined promptly to permit comparison of such response with that used as the design basis.

The type, locations, operability, characteristics, installation, actuation, remote indication, and maintenance of seismic instrumentation should meet the guidance discussed below. Where an applicant proposes specific details different from these, acceptability should be based upon meeting applicable regulations, as stated above, consistent with current proven technologies and intended use of the recorded information.[9]

1. Comparison with Regulatory Guide 1.12

The seismic instrumentation program is considered to be acceptable if it is in accordance with Regulatory Guide 1.12[10] (see also Table 3.7.4-1). This guide recommends provision of a triaxial time history accelerograph and a triaxial response spectrum recorder to measure the input time history and response spectra directly. Additional time history accelerographs, response spectrum recorders, peak accelerographs, and seismic switches are recommended to measure the responses of structures, equipment, and components at selected locations. The bases for elements of the proposed seismic instrumentation program that differ from Regulatory Guide 1.12 must be provided.

2. Location and Description of Instrumentation

For the construction permit review,[11] there should be a commitment by the applicant to provide the following instruments at the given locations:

a. A triaxial time history accelerograph in the free field or at the containment foundation, with readout in the control room.

b. A seismic switch on the containment foundation, with readout in the control room.

c. A triaxial response spectrum recorder on the containment foundation, with readout in the control room.

In addition, a commitment to provide the recommended additional instrumentation at the various response locations should be made without providing details of actual locations.

For the operating license review, a detailed seismic instrumentation plan including details of the locations, mounting and descriptions of the instrumentation should be provided. To be acceptable, the remaining instrumentation locations are related to the locations of the output vibratory motions used in the seismic design. Typical general locations are:

a. Containment structure or reactor building.

b. Reactor piping.

c. Reactor equipment.

d. Other Category I structures, equipment, and piping.

Instrumentation should be provided depending upon the plant safe shutdown earthquake acceleration as given in Regulatory Guide 1.12. The specific locations are determined by the plant designer so as to obtain the most pertinent information. A possible approach to the specification of the seismic instrumentation system is given in Regulatory Guide 1.12. Other desirable combinations of instruments which may prove to be as useful as the instrumentation plan outlined in the guide may be utilized.

The criteria for selection of Category I structures, components, and equipment to be instrumented and the location of instrumentation, as well as the extent to which this instrumentation is employed to verify the seismic analyses following an earthquake, should be specified. The criteria will be reviewed on a case-by-case basis.

3. Control Room Operator Notification

To be acceptable, the seismic switch located at the foundation of the containment should be connected to event indicators that are located in the control room, so that a signal is given when the preset threshold level (OBE acceleration level) resulting from the earthquake is exceeded. Also both audio and visual signals should be provided to the control room operators in the event of an earthquake.

In addition, the triaxial time history accelerograph located in the containment foundation or in the free field should be connected to the control room, so that peak acceleration level experienced in the basement of the reactor containment structure or in the free field is indicated to the control room operator. The response spectrum recorder in the reactor containment foundation or in the free field is also connected to the control room to indicate if the design response spectra values for discrete frequencies are exceeded during an earthquake.

4. Comparison of Measured and Predicted Responses

In the event of an earthquake, the control room operator should be immediately informed through the event indicators. If the instrumentation shows that the peak acceleration or the response spectra experienced at the foundation of the containment building or in the free field exceed the OBE acceleration level or response spectra, the plant should be shut down (Ref. 3) pending permission to resume operations. To help predict the capability of the plant for resuming operations, field inspection of safety-related items should be implemented and the measured responses from both the peak-recording and strong motion accelerographs should be compared with those assumed in the design.

The procedures for comparison of measured and predicted responses are acceptable if a commitment is made to provide detailed comparisons, as outlined below, between measured seismic responses of Category I structures and equipment with calculated responses determined from dynamic analysis. First, the time history records are digitized and corrected for time signal variations and baseline variations. The time history records from the triaxial sensors located in the free field or at the foundation of the containment building are used to calculate response spectra at appropriate critical damping values. The response spectra thus obtained, or the response spectra from the response spectrum recorder, are compared with the design response spectra. In addition, the time history records from the free field triaxial sensor are used as input ground motion for the reactor building dynamic model, including soil where applicable. Amplified response spectra are then calculated at the locations of the other sensors in the reactor building for comparison and correlation with the response spectra directly measured. Structural responses and amplified response spectra are calculated using the free field time history records with the dynamic model for comparison with the original design and analysis parameters. This comparison permits evaluation of seismic effects on structures and equipment and forms the basis for remodeling, detailed analyses, and physical inspection.

5. ~~Inservice~~Instrument Surveillance[12]

Each of the seismic instruments shall be demonstrated operable by the performance of the channel check, channel calibration, and channel functional test operations at the intervals specified in Table 3.7.4-2.

Technical Rationale:[13]

The technical rationale for application of the above acceptance criteria to seismic instrumentation is discussed in the following paragraphs.

1. 10 CFR 50.55a requires, in relevant part, that structures, systems and components (SSC) important to safety be tested and inspected to quality standards commensurate with the

importance of the safety function to be performed. Seismic instrumentation is installed to alert the plant operator when a significant seismic event has occurred and to record information critical to evaluation of earthquake effects on plant structures and equipment. Seismic instrumentation is inspected and tested on a periodic basis to assure that it will function as designed. Performing periodic testing to meet 10 CFR 50.55a ensures, in the event of a significant seismic event, that the plant operators are provided with information to assess the need to shut down the reactor and that recorded data are available to allow engineering evaluation of the safety of continued plant operation.

2. General Design Criterion (GDC) 2 requires that SSC important to safety be designed to withstand the effects of natural phenomena such as earthquakes without loss of capability to perform their safety function. The seismic instrumentation records data used to evaluate the effects of earthquakes. Meeting GDC 2 ensures that SSC important to the safety continue to be capable of performing their safety functions if the plant is restarted following a seismic event.

3. Appendix A to 10 CFR 100 requires installation of seismic instrumentation which is capable of providing the seismic response of features important to safety so that the comparisons with that used as the design basis can be appropriately carried out. Regulatory Guide 1.12 describes instrumentation acceptable to the NRC staff for meeting the requirements of 10 CFR 100. Meeting the 10 CFR 100, Appendix A requirement and following the Regulatory Guide 1.12 guidance for seismic instrumentation assures that the appropriate seismic response data are available following a seismic event such that the plant is not operated with structures or equipment in an unsafe condition.

III. REVIEW PROCEDURES

For each area of review, the following review procedure is followed. The reviewer will select and emphasize material from the procedures given below, as may be appropriate for a particular case. The type, locations, operability, characteristics, installation, actuation, remote indication, and maintenance of seismic instrumentation should meet the procedures given below. Where an applicant proposes specific details different from these procedures, acceptability should be based upon meeting applicable regulations, as stated in subsection II, consistent with current proven technologies and intended use of the recorded information.[14]

1. Comparison with Regulatory Guide 1.12

The seismic instrumentation program is checked to assure that the instrumentation is in accordance with the guidelines of Regulatory Guide 1.12. Any differences between the proposed and the regulatory[15] guide seismic instrumentation, which have not been adequately justified, are identified and the applicant is informed of the need for additional technical justification.

2. Location and Description of Instrumentation

At the operating license stage, the locations and descriptions of the seismic instrumentation are reviewed to determine that these are in accordance with the acceptance criteria of subsection II.2 of this SRP section. If the instrumentation provided is judged to be insufficient, the need for additional instrumentation is transmitted to the applicant.

3. Control Room Operator Notification

The seismic instrumentation is checked to verify that the seismic switch located at the foundation of the containment structure or in the free field is connected to event indicators that are located in the control room, so that a signal is given when the preset threshold level is exceeded. If there is no provision for both audio and visual signals in the applicant's seismic instrumentation plan, the applicant is so informed with a request for compliance.

4. Comparison of Measured and Predicted Responses

The criteria and procedures that will be used to compare measured responses of Category I structures and selected components in the event of an earthquake with the results of the seismic system and subsystem analyses are checked to verify that sufficient information as specified in subsection II.4 of this SRP section is included. Any deficiency in the required information is identified and the applicant ~~a~~is[16] requested to provide further information.

5. ~~Inservice~~Instrument Surveillance[17]

The ~~inservice inspection~~instrument surveillance[18] program described by the applicant is reviewed to assure that the acceptance criteria of subsection II.5 of this SRP section are met.

The staff accepted an exemption in both the ABWR and System 80+ design certification FSERs to eliminate the OBE from seismic design considerations. Justification for the exemption was based in part on the licensees' commitment to develop additional seismic related procedural requirements. These additional requirements were primarily concerned with criteria for determining whether or not a reactor would be shutdown following an earthquake, pre-earthquake planning activities, and post-earthquake damage inspections. For the design certifications the Staff also reviewed criteria in EPRI NP-5930 (Reference 5) and documented in the ABWR FSER several exceptions relating to the adequacy of seismic instrumentation. (New rules and regulatory guides are currently being drafted by the Staff to provide additional guidance relating to the elimination of the OBE from design considerations.)[19]

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[20]

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and ~~his~~the[21] review supports conclusions of the following type, to be included in the staff's safety evaluation report:

The staff concludes that the seismic instrumentation system provided for the plant is acceptable and meets the requirements of General Design Criterion 2, Appendix A to 10

CFR Part 100, ~~Appendix A~~[22] and 10 CFR Part 50, 50.55a. This conclusion is based on the following:

The applicant has met the requirements of 10 CFR Part 100, Appendix A by providing the instrumentation that is capable of measuring the effects of an earthquake which meets the requirements of GDC 2. The applicant has met the requirements of 10 CFR Part 50, 50.55a by providing ~~the inservice inspection~~an instrument surveillance[23] program that will verify operability by performing channel checks, calibrations, and functional tests at acceptable intervals. In addition, the installation of the specified seismic instrumentation in the reactor containment structure and at other Category I structures, systems, and components constitutes an acceptable program to record data on seismic ground motion as well as data on the frequency and amplitude relationship of the seismic response of major structures and systems. A prompt readout of pertinent data at the control room can be expected to yield sufficient information to guide the operator on a timely basis for the purpose of evaluating the seismic response in the event of an earthquake. Data obtained from such installed seismic instrumentation will be sufficient to determine that the seismic analysis assumptions and the analytical model used for the design of the plant are adequate and that allowable stresses are not exceeded under conditions where continuity of operation is intended. Provision of such seismic instrumentation complies with Regulatory Guide 1.12.

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.[24]

V. IMPLEMENTATION

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

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[25] 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.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.[26]

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.[27]

VI. REFERENCES

1. 10 CFR Part 50, 50.55a "Codes and Standards."

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."[28]

3. 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."

4. Regulatory Guide 1.12, "Instrumentation for Earthquakes."[29]

5. Electric Power Research Institute, "A Criterion for Determining Exceedance of the Operating Basis Earthquake," EPRI NP-5930, Palo Alto, California, July 1988.[30]

TABLE 3.7.4-1 SEISMIC INSTRUMENTATION REQUIREMENTS

Instrumentation		Triaxial Time-History Accelerograph		Triaxial Response Spectrum Recorder		Triaxial Peak Accelerograph		Seismic Switch	
Location	SSE	2.9 m/s^2 (0.3 g) or less	over 2.9 m/s^2 (0.3 g)	2.9 m/s^2 (0.3 g) or less	over 2.9 m/s^2 (0.3 g)	2.9 m/s^2 (0.3 g) or less	over 2.9 m/s^2 (0.3 g)	2.9 m/s^2 (0.3 g) or less	over 2.9 m/s^2 (0.3 g)[25]
I. Free Field		1*#	1*#						
II. Inside Containment									
Basement		1*	1*	1*	1*	1*		1*	1*
At Elevation		1	1						
Reactor Equip. Sup.				}1	}1				}1*
Reactor Piping Sup.									
Reactor Equipment						1	1		
Reactor Piping						1	1		
III. Outside Containment									
Cat. I Structure			1	1	1				
Cat. I Equip. Sup.					1				
Cat. I Piping Sup.				}1					
Cat. I Equipment							1		
Cat. I Piping						}1	1		

* Control room readout.

\# May be omitted if soil-structure interaction is negligible.

} Denotes either of the two locations.

TABLE 3.7.4-2

SEISMIC MONITORING INSTRUMENTATION SURVEILLANCE REQUIREMENTS

INSTRUMENT	CHANNEL CHECK	CHANNEL CALIBRATION	CHANNEL FUNCTIONAL TEST
1. Triaxial Time-History Accelerographs	M	R	SA
2. Triaxial Peak Accelerographs	NA	R	NA
3. Triaxial Seismic Switches	M	R	SA
4. Triaxial Response-Spectrum Recorders	M	R	SA

Legend:
M = Monthly
R = Refueling
SA = Once per 18 months
NA = Not Applicable

SRP Draft Section 3.7.4
Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	SRP-UDP Format Item, Update PRB names and abbreviations.	Changed PRB name to reflect latest responsibility assignments for SRP section 3.7.4.
2.	SRP-UDP Format Item, Reference Citations.	Removed parenthetical listing of reference number for Regulatory Guide 1.12. Reference numbers are not specified for RGs.
3.	Editorial.	Changed “Inservice Surveillance” to “Instrument Surveillance” consistent with terminology used in other sections.
4.	Editorial.	Changed “inservice inspection” to “instrument surveillance” consistent with terminology used in other sections and to avoid confusion with inservice inspection of piping and mechanical components as specified in the ASME Boiler and Pressure Vessel Code.
5.	SRP-UDP Format Item, Update PRB names, Editorial.	Changed PRB name to reflect latest responsibility assignments for SRP section 3.7.4; added “The” before PRB designator to improve sentence.
6.	Editorial.	Changed “10 CFR Part 100, Appendix A” to “Appendix A to 10 CFR Part 100” to avoid confusion among the list of regulatory citations in this sentence, all separated by commas.
7.	SRP-UDP Format Item, reference citations.	Removed parenthetical reference notations for GDC 2, 10 CFR 100 Appendix A, and 10 CFR 50.55a. Reference notations are not included for 10 CFR citations.
8.	Editorial.	Changed “10 CFR Part 100, Appendix A” to “Appendix A to 10 CFR Part 100” to avoid confusion among the list of regulatory citations in this sentence, all separated by commas.
9.	**Integrated Impact #949**.	Added discussion to Acceptance Criteria, specific criteria, to address review of seismic instrumentation using improved technologies.

Item	Source	Description
10.	Potential Impact #24550.	Draft Regulatory Guide DG-1016 was developed as the second proposed revision 2 to Regulatory Guide 1.12. As stated in the proposed rule at 59 FR 52255, the staff is developing the third proposed revision 2 to Regulatory Guide 1.12 as Draft Regulatory Guide DG-1033.
11.	Editorial.	Added comma to improve readability of the sentence.
12.	Editorial.	Changed “Inservice Surveillance” to “Instrument Surveillance” in paragraph subheading to be more consistent with terminology used for instrumentation systems.
13.	SRP-UDP format item, Develop Technical Rationales.	Added Technical Rationales for 10 CFR 50.55a, GDC 2, and 10 CFR 100, Appendix A. Technical Rationale is a new SRP-UDP format item.
14.	**Integrated Impact #949**.	Added discussion to Review Procedures introduction to address review of seismic instrumentation using improved technologies.
15.	Editorial.	Added “regulatory” to clarify the sentence.
16.	Editorial.	Changed "as" to "is" to make the sentence grammatically correct.
17.	Editorial.	Changed “Inservice Surveillance” to “Instrument Surveillance” in paragraph subheading to be more consistent with terminology used for instrumentation systems.
18.	Editorial.	Changed “inservice inspection” to “instrument surveillance” to be consistent with terminology used for instrumentation systems, as opposed to inservice inspection of piping and mechanical components.
19.	**Integrated Impact #1417.**	Provided background information in the Review Procedures relating to the exemption, approved in the evolutionary FSERs, that allowed the designers to eliminate the OBE from their design considerations.
20.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
21.	Editorial.	Changed “his review” to “the review” to make the sentence more generic.

Item	Source	Description
22.	Editorial.	Changed “10 CFR Part 100, Appendix A” to “Appendix A to 10 CFR Part 100” to avoid confusion among the list of regulatory citations in this sentence, all separated by commas.
23.	Editorial.	Changed “inservice inspection” to “instrument surveillance” to be consistent with terminology used for instrumentation systems, as opposed to the inservice inspection of piping and mechanical components required by the ASME Boiler and Pressure Vessel Code.
24.	SRP-UDP Format Item, Implementation of 10 CFR 52.	Added standard paragraph discussing evaluation findings for design certification reviews.
25.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
26.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
27.	Editorial.	Added standard phrase regarding implementation schedules.
28.	Reference Verification.	Added GDC 2 and title to the listing of 10 CFR 50 Appendix A, consistent with the GDC references within the SRP Section.
29.	Potential Impact #24550.	Draft Regulatory Guide DG-1016 was developed as the second proposed revision 2 to Regulatory Guide 1.12. As stated in the proposed rule at 59 FR 52255, the staff is developing the third proposed revision 2 to Regulatory Guide 1.12 as Draft Regulatory Guide DG-1033.
30.	**Integrated Impact #1417.**	Cited EPRI NP-5930 as an appropriate reference to be included in this SRP section.
31.	SRP-UDP format item, Metrication policy implementation.	The existing threshold of 0.3 g (standard acceleration of gravity) for changes in seismic instrumentation requirements was converted to 2.9 m/s^2 using the guidance of Federal Standard 376B. See enclosed conversion documentation.

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SRP Draft Section 3.7.4
Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
524	Consideration should be given to revising RG 1.12 to reflect current staff positions with regards to seismic instrumentation	No change to SRP. Action tracked by IPD-7.0 form #3.7.4-1.
690	Consideration should be given to updating RG 1.12 citation of ANSI N18.5 to ANS 2.2.	No change to SRP or RG 1.12, based upon PIPB comments.
949	Pending issuance of proposed revisions to Appendix A of 10 CFR 100 and Regulatory Guide 1.12, consider revising specific criteria and Review Procedures for seismic instrumentation to accommodate improved technologies.	ACCEPTANCE CRITERIA, subsection II; REVIEW PROCEDURES, subsection III.
950	Consider revising Acceptance Criteria, Review Procedures and Evaluation Findings, applicable to evolutionary plants, for review of seismic instrumentation.	No change to SRP at this time.
951	Consider revising Acceptance Criteria, Review Procedures and Evaluation Findings, applicable to evolutionary plants, for pre-earthquake planning and post-earthquake operator actions, including restart of a plant shutdown by a seismic event.	No change to SRP at this time.
1417	Consider revising the Review Procedures to provide information regarding commitments made in the evolutionary FSERs upon which an exemption was approved to eliminate the OBE from seismic design considerations.	III and VI