



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

February 1995
Division 1
Task DG-1034

DRAFT REGULATORY GUIDE

Contact: R.M. Kenneally (301)415-6303

DRAFT REGULATORY GUIDE DG-1034
(Previously Issued as Draft DG-1017)

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 require that suitable instrumentation¹ 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 require 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 not be available after occurrence of the OBE, the licensee would be required to consult with the NRC and 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 of nuclear power plants that have adopted the earthquake engineering criteria in Proposed Appendix S to 10 CFR Part 50 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 provide guidance acceptable to the NRC staff for a timely evaluation after an earthquake of the recorded instrumentation data and for

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

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.

1 determining whether plant shutdown would be required by the proposed
2 amendments to 10 CFR Part 50.

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

13 Any information collection activities mentioned in this draft regulatory
14 guide are contained as requirements in the proposed amendments to 10 CFR Part
15 50 that would provide the regulatory basis for this guide. The proposed
16 amendments have been submitted to the Office of Management and Budget for
17 clearance that may be appropriate under the Paperwork Reduction Act. Such
18 clearance, if obtained, would also apply to any information collection
19 activities mentioned in this guide.

20 B. DISCUSSION

21 When an earthquake occurs, ground motion data are recorded by the
22 seismic instrumentation.¹ These data are used to make a rapid determination
23 of the degree of severity of the seismic event. The data from the seismic
24 instrumentation, coupled with information obtained from a plant walkdown, are
25 used to make the initial determination of whether the plant must be shut down,
26 if it has not already been shut down by operational perturbations resulting
27 from the seismic event. If on the basis of these initial evaluations
28 (instrumentation data and walkdown) it is concluded that the plant shutdown
29 criteria have not been exceeded, it is presumed that the plant will not be
30 shut down. Guidance is being developed on postshutdown inspections and plant
31 restart; see Draft Regulatory Guide DG-1035, "Restart of a Nuclear Power Plant
32 Shut Down by a Seismic Event."

33 The Electric Power Research Institute has developed guidelines that will
34 enable licensees to quickly identify and assess earthquake effects on nuclear

1 power plants. These guidelines are in EPRI NP-5930, "A Criterion for Deter-
2 mining Exceedance of the Operating Basis Earthquake," July 1988²;
3 EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake,"
4 December 1989²; and EPRI TR-100082, "Standardization of Cumulative Absolute
5 Velocity," December 1991.²

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

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

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

34 ²EPRI reports may be obtained from the Electric Power Research Institute, Research
35 Reports Center, P.O. Box 50490, Palo Alto, CA 94303

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

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

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

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

19 C. REGULATORY POSITION

20 1. BASE-LINE DATA

21 1.1 Information Related to Seismic Instrumentation

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

24 1. Information on each instrument type such as make, model, and
25 serial number; manufacturers' data sheet; list of special features or options;
26 performance characteristics; examples of typical instrumentation readings and
27 interpretations; operations and maintenance manuals; repair procedures (manu-
28 facturers' recommendations for repairing common problems); and a list of any
29 special requirements, e.g., maintenance, operational, 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).

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 Position 4). The response spectrum and CAV should be calculated after the initial installation and each servicing of the free-field instrumentation.

1.2 Planning for Postearthquake Inspections

The selection of 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," 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

The guidelines for immediate postearthquake actions 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.

1 3. EVALUATION OF GROUND MOTION RECORDS

2 3.1 Data Identification

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

- 5 1. The date and time of collection,
- 6 2. The make, model, serial number, location, and orientation of the
7 instrument (sensor) from which the record was collected.

8 3.2 Data Collection

9 3.2.1 Only personnel trained in the operation of the instrument should
10 collect the data.

11 3.2.2 The steps for removing and storing records from each seismic
12 instrument should be planned and performed in accordance with established
13 procedures.

14 3.2.3 Extreme caution should be exercised to prevent accidental damage
15 to the recording media and instruments during data collection and subsequent
16 handling.

17 3.2.4 As data are collected and the instrumentation is inspected, notes
18 should be made regarding the condition of the instrument and its installation,
19 for example, instrument flooded, mounting surface tilted, fallen objects that
20 struck the instrument or the instrument mounting surface.

21 3.2.5 For validation of the collected data, the information described
22 in Regulatory Position 1.1(4) should be added to the record without affecting
23 the previously recorded data.

24 3.2.6 If the instrument's operation appears to have been normal, the
25 instrument should remain in service without readjustment or change that would
26 defeat attempts to obtain postevent calibration.

1 3.3 Record Evaluation

2 Records should be analyzed according to the manufacturer's specifica-
3 tions and the results of the analysis should be evaluated. Any record
4 anomalies, invalid data, and nonpertinent signals should be noted, along with
5 any known causes.

6 4. DETERMINING OBE EXCEEDANCE

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

16 4.1 Response Spectrum Check

17 4.1.1

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

- 19 1. The spectrum used in the certified standard design, or
- 20 2. A spectrum other than (1) used in the design of any Seismic
21 Category I structure.

22 4.1.2

23 The OBE response spectrum is exceeded if any one of the three components
24 (two horizontal and one vertical) of the 5 percent damped free-field ground
25 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

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 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 calibration standard (see Regulatory Position 1.1(4)) to demonstrate that the time-history analysis hardware and software were functioning properly.

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.

1 5. CRITERIA FOR PLANT SHUTDOWN

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

5 5.1 OBE Exceedance

6 If the response spectrum check and the CAV limit (performed or
7 calculated in accordance with Regulatory Positions 4.1 and 4.2) were exceeded,
8 the OBE was exceeded and plant shutdown is required. If either limit does not
9 exceed the criterion, the earthquake motion did not exceed the OBE. If only
10 one limit can be checked, the other limit is assumed to be exceeded. The
11 determination of whether or not the OBE has been exceeded should be performed
12 even if the plant automatically trips off-line as a result of the earthquake.

13 5.2 Damage

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

17 5.3 Continued Operation

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

22 6. PRE-SHUTDOWN INSPECTIONS

23 The pre-shutdown inspections described in Section 4.3.4 (including all
24 subsections) of EPRI NP-6695, "Guidelines for Nuclear Plant Response to an
25 Earthquake," with the exceptions specified below are acceptable to the NRC
26 staff for satisfying the requirements proposed in Paragraph IV(a)(3) of
27 Proposed Appendix S to 10 CFR Part 50 for ensuring the safety of nuclear power
28 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 guide reflecting public comments will be used in the evaluation of applications for construction permits, operating licenses, combined

1 licenses, or design certification submitted after the implementation date to
2 be specified in the active guide. This guide would not be used in the
3 evaluation of an application for an operating license submitted after the
4 implementation date to be specified in the active guide if the construction
5 permit was issued prior to that date.

1 3. The earthquake was of magnitude 5.0 or greater and occurred within
2 200 km of the plant.

3 A postearthquake plant walkdown should be conducted (see Regulatory
4 Position 2 of this guide).

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

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

1 APPENDIX B
2 DEFINITIONS

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

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

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

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

13 Spectral Velocity. The velocity response of a linear oscillator with pre-
14 scribed frequency and damping.

1 REGULATORY ANALYSIS

2 A separate regulatory analysis was not prepared for this regulatory
3 guide. The draft regulatory analysis, "Proposed Revisions of 10 CFR Part 100
4 and 10 CFR Part 50," was prepared for the proposed amendments, and it provides
5 the regulatory basis for this guide and examines the costs and benefits of the
6 rule as implemented by the guide. A copy of the draft regulatory analysis is
7 available for inspection and copying for a fee at the NRC Public Document
8 Room, 2120 L Street NW. (Lower Level), Washington, DC, as Enclosure 2 to
9 Secy 94-194.

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

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, \$300

FIRST CLASS MAIL
POSTAGE AND FEES PAID
USNRC
PERMIT NO. G-67