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DRAFT REGULATORY GUIDE

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DRAFT REGULATORY GUIDE DG-1157

(Proposed Revision 1 of Regulatory Guide 1.61, dated October 1973)

DAMPING VALUES FOR SEISMIC DESIGN OF NUCLEAR POWER PLANTS

A. INTRODUCTION

This regulatory guide is being revised to update the guidance to applicants and licensees on the damping values that staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in the seismic response analysis of Seismic Category I[1] nuclear power plant structures, systems, and components (SSCs) in accordance with Title 10, Part 50, of the *Code of Federal Regulations* (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities."

Specifically, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 requires that SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquakes without losing the ability to perform their safety functions. Such SSCs must also be designed to accommodate the effects of and be compatible with the environmental conditions associated with normal operation and postulated accidents. Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50 specifies the requirements for the implementation of General Design Criterion 2 with respect to earthquakes.[2]

[1] Structures, systems, and components of a nuclear power plant that are designated as Seismic Category I are designed to withstand the effects of the safe shutdown earthquake (SSE) and remain functional, see Regulatory Guide 1.29, "Seismic Design Classification."

[2] Appendix S to 10 CFR Part 50 applies to applicants for a design certification or combined license pursuant to 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," or a construction permit or operating license pursuant to 10 CFR Part 50 after January 10, 1997. However, for either an operating license applicant or holder whose construction permit was issued before January 10, 1997, the earthquake engineering criteria in Section VI of Appendix A to 10 CFR Part 100 continue to apply.

This draft regulatory guide specifies the damping values that the NRC staff considers acceptable for complying with the agency's regulations and guidance for seismic analysis. The specified damping values are intended for elastic modal dynamic seismic analysis where energy dissipation is accounted for by viscous damping (i.e., the damping force is proportional to the velocity).

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required. The NRC issues regulatory guides in draft form to solicit public comment and involve the public in developing the agency's regulatory positions. Draft regulatory guides have not received complete staff review and, therefore, they do not represent official NRC staff positions.

This regulatory guide contains information collections that are covered by the requirements of 10 CFR Part 50 which the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Background

Damping is a measure of the energy dissipation of a material or structural system as it responds to dynamic excitation. It is a term used to assist in mathematically modeling and solving dynamic equations of motion for a vibratory system in which energy is dissipated. When performing an elastic dynamic seismic analysis, one can account for the energy dissipated by specifying the amount of viscous damping (i.e., damping force proportional to the velocity) in the analytical model as equal to the expected viscous damping resulting from the material of the actual structure.

Current NRC guidance on damping values to be used in the elastic design of nuclear power plants is presented in Regulatory Guide 1.61, which the NRC first issued in October 1973 [Ref. 1]. That guide specifies equivalent viscous modal damping values as a percentage of critical damping for Seismic Category I SSCs. However, the staff based the damping values in Regulatory Guide 1.61 on limited data, expert opinion, and other information available at that time. Since 1973, the NRC and industry have been involved in various studies, research work, and testing to predict and estimate damping values of SSCs. In view of the available data, the damping values provided in the original Regulatory Guide 1.61 may not reflect realistic damping values for SSCs. Also, it is recognized that additional guidance is needed to address issues, such as correlation between damping and structures stress level, and damping values for materials not originally included in Regulatory Guide 1.61 (e.g., electrical distribution systems and reinforced masonry structures).

Over the past three decades, the nuclear industry has proposed damping values and discussed these values during various meetings and reviews of licensing issues. Nuclear industry groups and licensees have suggested that the NRC ought to accept more realistic damping values for seismic design and analysis of SSCs, in place of the damping values provided in the original Regulatory Guide 1.61.

Structural Damping

In 1993, the NRC completed an investigation of the adequacy of original Regulatory Guide 1.61 structure damping values and other recommendations, and reported the results in NUREG/CR-6011 [Ref. 2]. Data were analyzed to identify the parameters that significantly influenced structure damping. Based on that study, the NRC determined that the original Regulatory Guide 1.61 damping values for structure design were adequate but required one significant revision. Specifically, Regulatory Guide 1.61 should distinguish between "friction-bolted" and "bearing-bolted" connections for steel structures. Regulatory Position 1 in Section C of this revised guide provides the updated structural damping values.

Piping Damping

In 1986, the American Society of Mechanical Engineers (ASME) established Code Case N-411, "Alternative Damping Values for Response Spectra Analysis of Class 1, 2, and 3 Piping," in Section III, Division 1, of the ASME Boiler and Pressure Vessel Code [Ref. 3]. The NRC staff used Code Case N-411, with certain limitations specified in Regulatory Guide 1.84 [Ref. 4], to review operating reactor issues until Code Case N-411 expired in 2000. The staff also approved the use of alternate damping values for the General Electric Advanced Boiling Water Reactor Design in 1994 [Ref. 5], Combustion Engineering System 80+ Design in 1992 [Ref. 6], and Westinghouse AP600 Design in 1998 [Ref. 7]. Regulatory Position 2 in Section C of this revised guide provides the piping damping values that resulted from the staff's experience with ASME Code Case N–411 and application reviews of new reactor designs.

Electrical Distribution System Damping

Regulatory Guide 1.61 did not originally provide damping values for cable tray or conduit systems. Historically, the nuclear power industry used the damping values for bolted steel structures for seismic design of cable tray and conduit systems. In the late 1980s, however, the NRC staff reviewed the results of the cable tray test at the Comanche Peak Steam Electrical Station [Ref. 8]. Regulatory Position 3 in Section C of this revised guide provides the damping values that resulted from the staff's review of data from the Comanche Peak test [Ref. 9] and two safety evaluation reports [Refs. 8, 10].

Heating Ventilation and Air Conditioning Duct Damping

The proposed damping values for heating ventilation and air conditioning (HVAC) systems are consistent with the guidance provided for steel structures. Because no tests of welded duct construction have been identified, the damping values are the same as for welded steel structures, and Regulatory Position 4 in Section C of this revised guide provides these same damping values. In addition, the NRC provides related information on HVAC duct damping in NUREG/CR-6919, "Recommendations for Revision of Seismic Damping Values in Regulatory Guide 1.61" [Ref. 11].

Mechanical and Electrical Component Damping

NUREG/CR-6919 [Ref. 11] considers guidance in American Society of Civil Engineers (ASCE) Standard 43-05, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities" [Ref. 12], and Non-Mandatory Appendix N, "Dynamic Analysis Methods," to Section III, Division 1, of the ASME Boiler & Pressure Vessels Code [Ref. 13]. In addition, NUREG/CR-6919 [Ref. 11] provides recommendations and commentary on damping values for (1) containment structures, containment internal structures, and other Seismic Category I structures; (2) piping; (3) electrical distribution systems (i.e., cable tray or conduit systems); (4) HVAC; and (5) mechanical and electrical components. Regulatory Position 5 in Section C of this revised guide provides the damping values that resulted from the staff's review of this industry guidance.

C. REGULATORY POSITION

The following regulatory positions provide damping values to be used in the elastic dynamic seismic analysis and design of SSCs, where energy dissipation is approximated by viscous damping unless otherwise specified. Damping values higher than those provided may be used if documented test data support the higher values. Damping values associated with soil-structure interaction analysis are not within the scope of this regulatory guide.

1. Structural Damping

Table 1 provides the damping values to be used in the analysis of containment structures, containment internal structures, and other Seismic Category I structures.

Table 1. Proposed Structural Damping Values for a Safe Shutdown Earthquake (SSE)

Structure	Proposed Damping Value
Reinforced Concrete	7%
Reinforced Masonry	7%
Prestressed Concrete	5%
Welded Steel or Bolted Steel with Friction Connections	4%
Bolted Steel with Bearing Connections	7%
Note: For steel structures with a combination of different connection types, one should use the lowest specified damping value or, as an alternative, a "weighted average" damping value based on the number of each type present in the structure.	

The SSE-equivalent viscous damping ratios specified in Table 1, for the linear dynamic analysis of structures, were selected because the structural response attributable to load combinations that include SSE will be close to the applicable code stress limits, as defined in Section 3.8 of NUREG-0800 [Ref. 14]. However, there may be cases where the predicted structural response to load combinations that include SSE is significantly below the applicable code stress limits. Because equivalent viscous damping ratios have been shown to be dependent on the structural response level, the possibility exists that the SSE damping values specified in Table 1 may be inconsistent with the predicted structural response, and lower damping values may be more appropriate. Consequently, the staff offers the following guidelines for use in assessing the appropriateness of using the SSE damping values specified in Table 1 and, if necessary, to perform a re-analysis using reduced damping values:

(1) If the significant stresses attributable to load combinations that include SSE are at least 80% of the applicable code stress limits, the NRC finds it appropriate and acceptable to use SSE damping levels for the seismic analysis.

(2) If the significant stresses attributable to load combinations that include SSE are less than 80% of the applicable code stress limits, the NRC cautions against using SSE damping levels, as those levels may underpredict the structure's response to seismic loads. In this case, structural evaluation and development of the in-structure response spectra should be based on a seismic analysis using the operating-basis earthquake (OBE) damping values specified in Table 2.

(3) As an alternative to guideline 2 (above), an applicant or licensee may submit a plant-specific justification for using damping values higher than the OBE damping values specified in Table 2, but less than the SSE damping values used initially.

If the design-basis OBE ground acceleration is greater than one-third of the design-basis SSE ground acceleration, the NRC requires a separate OBE analysis, for which the damping values presented in Table 2 are applicable.

Table 2. Proposed Structural Damping Values for an Operating-Basis Earthquake (OBE)

Structure	Proposed Damping Value
Reinforced Concrete	4%
Reinforced Masonry	4%
Prestressed Concrete	3%
Welded Steel or Bolted Steel with Friction Connections	3%
Bolted Steel with Bearing Connections	5%

2. Piping Damping

Table 3 presents the constant damping values specified for SSE and OBE (where required) analyses of piping systems. These values are applicable to time-history, response spectra, and equivalent static analysis procedures for structural qualification.

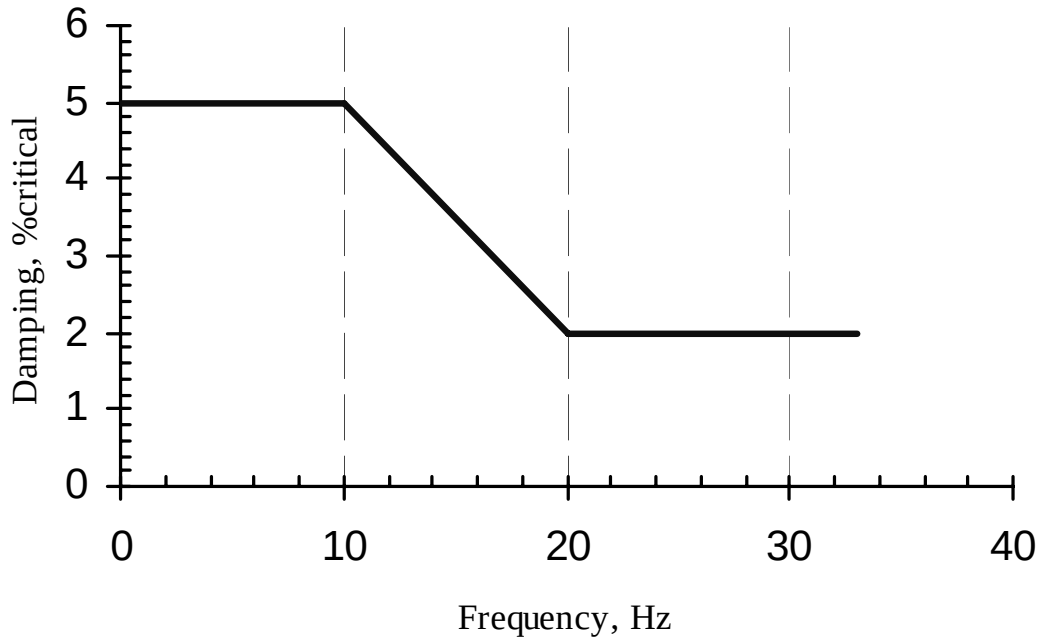
Table 3. Damping Values for Piping Systems

Category	Damping Value	
	SSE	OBE > SSE/3
Piping Systems	4%	3%

As an alternative for response spectra analyses using an envelope of the SSE response spectra at all support points (uniform support motion), frequency-dependent damping values shown in Figure 1 may be used, subject to the following restrictions:

- Frequency-dependent damping should be used completely and consistently, if at all. (For equipment other than piping, damping values specified in Regulatory Guide 1.61 are to be used.)
- The specified damping values may be used only in those analyses in which current seismic spectra and procedures have been employed. Such use is to be limited to response spectral analyses. The acceptance of the use in other types of dynamic analyses (e.g., time-history analyses or independent support motion method) is pending further justification.
- When used for reconciliation work or support optimization of existing designs, the effects of increased motion on existing clearances and online mounted equipment should be checked.
- Frequency-dependent damping is not appropriate for analyzing the dynamic response of piping systems using supports designed to dissipate energy by yielding.
- Frequency-dependent damping is not applicable to piping in which stress corrosion cracking has occurred, unless a case-specific evaluation is provided and reviewed by the NRC staff.

Figure 1 Frequency-dependent damping



3. Electrical Distribution System Damping

Table 4 presents the constant damping values specified for SSE and OBE (where required) analyses of cable tray and conduit systems. These values are applicable to response spectra and equivalent static analysis procedures for structural qualification. The damping values specified in Table 4 are applicable to all types of supports, including welded supports. The use of higher damping values for cable trays with flexible support systems (e.g., rod-hung trapeze systems, strut-hung trapeze systems, and strut-type cantilever and braced cantilever support systems) is permissible, but may be subject to staff review on a case-by-case basis.

The analysis methodology should consider the flexibility of supports in determining the system response to seismic excitation.

Table 4. Damping Values for Electrical Distribution Systems

Category	Damping Value	
	SSE	OBE > SSE/3
Cable Tray System[4]		
Maximum Cable Loading[1]	10%	7%
Empty[2]	7%	5%
Sprayed-on Fire Retardant or other cable-restraining mechanism[3]	7%	5%
Conduit Systems[4]		
Maximum Cable fill[1]	7%	5%
Empty[2]	5%	3%

Notes:
1. Maximum cable loadings, in accordance with the plant design specification, must be utilized in conjunction with these damping values.
2. Spare cable tray and conduit, initially empty, may be analyzed with zero cable load and these damping values. (Note: Re-analysis is required when put into service.)
3. Restraint of the free relative movement of the cables inside a tray reduces the system damping.
4. When cable loadings of less-than maximum are specified for design calculations, the applicant or licensee must justify the selected damping values, and the NRC reviewed for acceptance on a case-by-case basis.

4. Heating, Ventilation, and Air Conditioning Duct Damping

Table 5 presents the constant damping values specified for SSE and OBE (when required) analyses of HVAC duct systems. These values are applicable to response spectra and equivalent static analysis procedures for structural qualification.

The analysis methodology must consider the flexibility of supports in determining system response to seismic excitation.

Table 5. Damping Values for HVAC Duct Systems

Type of Duct Construction	Damping Value	
	SSE	OBE > SSE/3
Pocket Lock	10%	7%
Companion Angle	7%	5%
Welded	4%	3%

5. Mechanical and Electrical Component Damping

Table 6 presents the damping values for mechanical and electrical components, which are applicable to passive subcomponents that can be seismically qualified by analysis. Active subcomponents do not readily lend themselves to seismic qualification by analysis, and require qualification by test, as described in Section 3.10 of NUREG-0800 [Ref. 14].

Table 6. Damping Values for Mechanical and Electrical Components

Component Type	Damping Value	
	SSE	OBE > SSE/3
Motor, Fan, and Compressor Housings (protection, structural support)	3%	2%
Pressure Vessels, Heat Exchangers, and Pump and Valve Bodies (pressure boundary)	3%	2%
Welded Instrument Racks (structural support)	3%	2%
Electrical Cabinets, Panels, and Motor Control Centers (MCCs) (protection, structural support)	3%	2%
Metal Atmospheric Storage Tanks (containment, protection) — Impulsive Mode — Sloshing Mode	 3% 0.5%	 2% 0.5%

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this draft regulatory guide. No backfitting is intended or approved in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. Except in those cases in which an applicant or licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the methods to be described in the active guide will reflect public comments and will be used in evaluating (1) submittals in connection with applications for construction permits, standard plant design certifications, operating licenses, early site permits, and combined licenses; and (2) submittals from operating reactor licensees who voluntarily propose to initiate system modifications if there is a clear nexus between the proposed modifications and the subject for which guidance is provided herein.

REGULATORY ANALYSIS

1. Statement of the Problem

The U.S. Nuclear Regulatory Commission (NRC) originally issued Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants," in October 1973. That original version provided the damping values that the staff considered acceptable for use in reviewing elastic modal (dynamic) seismic analysis of Seismic Category I structures, systems, and components (SSCs). Over the past 30 years, however, the NRC and industry have been involved in various studies, research, and testing to predict and estimate damping values of SSCs of nuclear power plants. In view of the data now available, the damping values originally provided in Regulatory Guide 1.61 may not reflect realistic damping values for SSCs in nuclear power plants. There have been many occasions in which proposed damping values were the subject of discussion during the review of licensing issues. Nuclear industry groups and licensees have suggested the need for more realistic damping values for seismic design and analysis of SSCs, in place of the damping values originally provided in Regulatory Guide 1.61. Therefore, a revision to this regulatory guidance is necessary to include updated information.

2. Objective

The objective of this regulatory action is to update the NRC's guidance with respect to the damping values that the staff considers acceptable for use in reviewing elastic modal (dynamic) seismic analysis of Seismic Category I SSCs. This will give applicants and licensees more realistic and, thus, accurate damping values, which should lead to increased safety and regulatory effectiveness with more accurate seismic models.

3. Alternative Approaches

The NRC staff considered the following alternative approaches to the problem of realistic damping values for seismic design of nuclear power plants:

(1) Do not revise Regulatory Guide 1.61.
(2) Update Regulatory Guide 1.61.

3.1 Alternative 1: Do Not Revise Regulatory Guide 1.61

Under this alternative, the NRC would not revise this guidance, and licensees would continue to use the original version of this regulatory guide. This alternative is considered the baseline or "no action" alternative and, as such, involves no value/impact considerations.

3.2 Alternative 2: Update Regulatory Guide 1.61

Under this alternative, the NRC would update Regulatory Guide 1.61 with damping values based on the latest research results that predict and estimate damping values for seismic design of SSCs in nuclear power plants.

The benefit of an updated Regulatory Guide 1.61 would be cost savings to both the NRC and the industry, with the latter realizing the predominant savings.

The costs to the NRC would be the one-time cost of issuing the revised regulatory guide (that is, relatively small), and applicants and licensees would incur little or no cost. However, the NRC would also realize cost savings associated with standardizing the seismic review of licensee submittals. In the staff's view, the continual and ongoing cost savings associated with these reviews should more than offset this one-time cost.

On balance, the industry would realize a net savings, as the one-time incremental cost to review and comment on a revised regulatory guide would be more than compensated by the efficiencies (e.g., elimination of unnecessary conservatism, reduced followup questions and revisions) associated with each licensee submission.

4. Conclusion

Based on this regulatory analysis, the staff recommends that the NRC should revise Regulatory Guide 1.61. The staff concludes that the proposed action will incorporate the latest data and information in the updated regulatory guide, and reduce unnecessary conservatism in specification of damping values for seismic design and analysis of SSCs in nuclear power plants.

BACKFIT ANALYSIS

This draft regulatory guide provides licensees and applicants with new guidance that the NRC staff considers acceptable for use in selecting damping values for seismic design of structures, systems and components in nuclear power plants. The application of this guide is voluntary. Licensees may continue to use the original version of this regulatory guide if they so choose. No backfit, as defined in 10 CFR 50.109, is either intended or implied.

REFERENCES

1. Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC, October 1973, available in ADAMS under Accession #ML003740213.[3]

2. NUREG/CR-6011, "Review of Structure Damping Values for Elastic Seismic Analysis of Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC, March 1993.[4]

3. "ASME Boiler and Pressure Vessel Code, Code Case N-411-1, Alternative Damping Values for Response Spectra Analysis of Class 1, 2 and 3 Piping," Section III, Division 1, American Society of Mechanical Engineers, New York, New York, February 20, 1986.[5]

4. Regulatory Guide 1.84, "Design, Fabrication, and Materials Code Case Acceptability — ASME Section III," U.S. Nuclear Regulatory Commission, Washington, DC, October 1994, available in ADAMS under Accession #ML052130562.[3]

5. NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling-Water Reactor," U.S. Nuclear Regulatory Commission, Washington, DC, July 1994.[4]

6. NUREG-1462, "Draft Safety Evaluation Report related to the Design Certification of the System 80+ Design," U.S. Nuclear Regulatory Commission, Washington, DC, September 1992.[4]

7. NUREG-1512, "Final Safety Evaluation Report related to Certification of the AP600 Standard Design," U.S. Nuclear Regulatory Commission, Washington, DC, September 1998.[4]

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[3] All regulatory guides listed herein were published by the U.S. Nuclear Regulatory Commission. Where an ADAMS accession number is identified, the specified regulatory guide is available electronically through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. All other regulatory guides are available electronically through the Public Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/. Single copies of regulatory guides may also be obtained free of charge by writing the Reproduction and Distribution Services Section, ADM, USNRC, Washington, DC 20555-0001, or by fax to (301) 415-2289, or by email to DISTRIBUTION@nrc.gov. Active guides may also be purchased from the National Technical Information Service (NTIS)on a standing order basis. Details on this service may be obtained by contacting NTIS at 5285 Port Royal Road, Springfield, Virginia 22161, online at http://www.ntis.gov, or by telephone at (703) 487-4650. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville, Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555-0001. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4205, by fax at (301) 415-3548, and by email to PDR@nrc.gov.

[4] Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone 202-512-1800); or from the National Technical Information Service (NTIS) by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161; http://www.ntis.gov; telephone 703-487-4650. Copies are available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555 (telephone: 301-415-4737 or 800-397-4209; fax: 301-415-3548; email: PDR@nrc.gov). NUREG-0800 is also available electronically through the NRC's public Web site at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/.

[5] Copies may be obtained from the American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990. Phone (212)591-8500; fax (212)591-8501; www.asme.org.

8. NUREG-0797, "Safety Evaluation Report Related to the Operation of Comanche Peak Steam Electric Station, Units 1 and 2," Supplement No. 16, U.S. Nuclear Regulatory Commission, Washington, DC, July 1988.[4]

9. Slaughterbeck, C.B., and A.G. Ware, "A Survey of Cable Tray and Conduit Damping Research," Idaho National Engineering Laboratory, Report No. EGG-EA-7346, Rev. 1, prepared for the U.S. Nuclear Regulatory Commission, Washington, DC, August 1986.[6]

10. NUREG-0847, "Safety Evaluation Report for Watts Bar Nuclear Plant, Units 1 and 2," Supplement No. 8, U.S. Nuclear Regulatory Commission, Washington, DC, January 1992.[4]

11. NUREG/CR-6919, "Recommendations for Revision of Seismic Damping Values for the Seismic Damping Values in Regulatory Guide 1.61," U.S. Nuclear Regulatory Commission, Washington, DC, October 2006.[4]

12. American Society of Civil Engineers, ASCE Standard 43-05, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities," Reston, VA, 2005.[7]

13. American Society of Mechanical Engineers, "Boiler and Pressure Vessel Code," Section III, Division 1, Non-Mandatory Appendix N, "Dynamic Analysis Methods," New York, New York, 2004.[5]

14. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC.[4]

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[6] Copies may be obtained from Idaho National Laboratory, P.O. Box 1625, Idaho Falls, ID 83415 [phone: (208) 526-0111)]. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555 (telephone: 301-415-4737 or 800-397-4209; fax: 301-415-3548; email: PDR@nrc.gov).

[7] Copies may be purchased from the American Society for Civil Engineers (ASCE), 1801 Alexander Bell Drive, Reston, VA 20190 [phone: (800) 548-ASCE (2723)]. Purchase information is available through the ASCE Web site at http://www.pubs.asce.org.