U.S. ATOMIC ENERGY COMMISSION

October 1973

REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 1.61

DAMPING VALUES FOR SEISMIC DESIGN OF NUCLEAR POWER PLANTS

A. INTRODUCTION

Criterion 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires, in part, that nuclear power plant structures, systems, and components important to safety be designed to withstand the effects of earthquakes. Proposed Appendix A, "Seismic and Geologic Siting Criteria," to 10 CFR Part 100, "Reactor Site Criteria," would require, in part, that suitable seismic dynamic analysis, such as a time-history or spectral response analysis, be performed to demonstrate that the structures, systems, and components important to safety will remain functional in the event of a Safe Shutdown Earthquake (SSE). This guide delineates damping values acceptable to the AEC Regulatory staff to be used in the elastic modal dynamic seismic analysis of Seismic Category I[1] structures, systems, and components. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

The energy dissipation within a structure due to material and structural damping while it is responding to an earthquake depends on a number of factors such as types of joints or connections within the structure, the structural material, and the magnitude of deformations experienced. In a dynamic elastic analysis, this energy dissipation usually is accounted for by specifying an amount of viscous damping that would result in energy dissipation in the analytical model equivalent to that expected to occur as a result of material and structural damping in the real structure.

After reviewing a number of applications for construction permits and operating licenses and after reviewing pertinent literature including Reference 1, the AEC Regulatory staff has determined as acceptable, for interim use, the modal damping values shown in Table 1 of this guide. These modal damping values should be used for all modes considered in elastic spectral or time-history dynamic analyses. Values are tabulated for the two earthquakes, the Safe Shutdown Earthquake and the Operating Basis Earthquake (or ½ the Safe Shutdown Earthquake), for which nuclear power plants are required to be designed as specified in proposed Appendix A to 10 CFR Part 100, "Seismic and Geologic Siting Criteria."

C. REGULATORY POSITION

1. The modal damping values expressed as a percentage of critical damping shown in Table 1 of this guide should be used for viscous modal damping for all modes considered in an elastic spectral or time-history dynamic seismic analysis of the Seismic Category I structures or components specified in the table. The modal damping values specified in Table 1 are for use in the dynamic analyses associated with two different magnitudes of earthquakes, the Safe Shutdown Earthquake and the Operating Basis Earthquake (or ½ the Safe Shutdown Earthquake). These analyses would be required by proposed Appendix A to 10 CFR Part 100, "Seismic and Geologic Siting Criteria."

2. Damping values higher than the ones delineated in Table 1 of this guide may be used in a dynamic seismic analysis if documented test data are provided to support higher values.

[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").

USAEC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the AEC Regulatory staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

Published guides will be revised periodically, as appropriate, to accommodate comments and to reflect new information or experience.

Copies of published guides may be obtained by request indicating the divisions desired to the U.S. Atomic Energy Commission, Washington, D.C. 20545, Attention: Director of Regulatory Standards. Comments and suggestions for improvements in these guides are encouraged and should be sent to the Secretary of the Commission, U.S. Atomic Energy Commission, Washington, D.C. 20545, Attention: Chief, Public Proceedings Staff.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust Review
10. General

3. If the maximum combined stresses due to static, seismic, and other dynamic loading are significantly lower than the yield stress and ½ yield stress for SSE and ½ SSE, respectively, in any structure or component, damping values lower than those specified in Table 1 of this guide should be used for that structure or component to avoid underestimating the amplitude of vibrations or dynamic stresses.

TABLE 1

DAMPING VALUES[1]

(Percent of Critical Damping)

Structure or Component	Operating Basis Earthquake or ½ Safe Shutdown Earthquake[2]	Safe Shutdown Earthquake
Equipment and large-diameter piping systems[3], pipe diameter greater than 12 in.	2	3
Small-diameter piping systems, diameter equal to or less than 12 in.	1	2
Welded steel structures	2	4
Bolted steel structures	4	7
Prestressed concrete structures	2	5
Reinforced concrete structures	4	7

[1] Table 1 is derived from the recommendations given in Reference 1.

[2] In the dynamic analysis of active components as defined in Regulatory Guide 1.48, these values should also be used for SSE.

[3] Includes both material and structural damping. If the piping system consists of only one or two spans with little structural damping, use values for small-diameter piping.

REFERENCE

1. Newmark, N. M., John A. Blume, and Kanwar K. Kapur, "Design Response Spectra for Nuclear Power Plants," ASCE Structural Engineering Meeting, San Francisco, April 1973.