Structural Design
Bases

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APPENDIX 5A
STRUCTURAL DESIGN BASES

AEC Publication TID-7024, "Nuclear Reactors and Earthquake," as amplified herein will be used as the basic design for seismic analysis.

Structural design for normal operating conditions will be governed by the applicable design codes. The design for the loss-of-coolant accident and maximum seismic condition will ensure no loss of functions when related to public safety.

1 CLASSES OF STRUCTURES AND SYSTEM

The plant structures, components, and systems will be classified according to their function and the degree of integrity required to protect the public. The classes are:

1.1 CLASS I

Those structures, components, and systems, including instruments and controls, whose failure might cause or increase the severity of a loss-of-coolant accident or result in an uncontrolled release of excessive amounts of radioactivity and those structures and components which are vital to safe shutdown and isolation of the reactor are classified Class I. When a system as a whole is referred to as Class I, certain less essential portions not associated with loss of function of the system may later be designated under Class II or III as appropriate. Examples of Class I structures, components, and systems are:

a. Reactor Building and its penetrations including plant vent.

b. Reactor Building crane.

c. Reactor vessel and its internals including control rod drive assemblies.

d. Vital cooling water systems.

e. Primary system including vents and drains within Reactor Building.

f. Spent fuel cooling system and shutdown cooling system.

g. Makeup and purification system.

h. Engineered safeguards systems including their electrical power sources and distribution systems.

i. Fuel storage pool.

j. Reactor control room and equipment.

k. Waste disposal system.

l. Post-incident filtration system.

1.2 CLASS II

Those structures, components, and systems which are important to reactor operation but not essential to safe shutdown and isolation of the reactor and whose failure could not result in the release of substantial amounts of radioactivity are classified Class II. Examples of Class II structures, components, and systems are:

a. Secondary coolant system.

b. Electric power system, except emergency systems.

c. Auxiliary building, and waste disposal building, except as included in Class I above.

1.3 CLASS III

Those structures, components, and systems which are not related to reactor operation or containment are classified Class III.

2 CLASS I DESIGN BASES

All structures, components, and systems classified as Class I will be designed in accordance with the following criteria:

a. Primary steady state stresses, when combined with the seismic stress resulting from the response to a ground acceleration of 0.06 g acting horizontally and 0.04 g acting vertically and occurring simultaneously shall be maintained within the allowable working stress limits accepted as good practice and, where applicable, set forth in the appropriate design standards, e.g., ASME Boiler and Pressure Vessel Code, ASA B31.1 Code for Pressure Piping, Building Code Requirements for Reinforced Concrete, ACI 318 and AISC Specifications for the Design and Erection of Structural Steel for Buildings.

b. Primary steady state stress when combined with the seismic stress resulting from the response to a ground acceleration of 0.12 g acting horizontally and 0.08 g acting vertically and occurring simultaneously, shall be limited so that the function of the component, system, or structure shall not be impaired as to prevent a safe and orderly shutdown of the plant. 2

3 CLASS II DESIGN BASES

All structures, components, and systems classified as Class II will be designe for a ground acceleration of 0.06 g in accordance with procedures of the Unifo Building Code.

4 CLASS III DESIGN BASES

All structures, components, and systems classified as Class III will be design in accordance with applicable building code requirements.

5 DAMPING FACTORS

The following gives the damping factors used in the seismic design of componen and structures.

Component Or Structure	Per Cent Of Critical Damping
1. Reactor Building	2.0
2. Concrete Support structures inside the Reactor Building	2.0
3. Assemblies and Structures	
a) Bolted or Riveted	2.5
b) Welded	1.0
4. Vital Piping Systems	0.5
5. Other Concrete Structures above ground	5.0

6 METHOD OF ANALYSIS

The acceleration response spectra included in Appendix 2B will be used for the design of Class I and II structures, components, and systems. The vertica component of ground motion is assumed to be 2/3 of the horizontal component. The vertical and horizontal components are assumed to occur simultaneously an their effects added algebraically.

For Class I structures, components, and systems the method of analysis will either be a modal analysis wherein modal shapes, frequencies, stresses, and proportionality factors are determined or will be performed as follows:

a. The natural period of vibration of the structure, component, or syst will be determined.

b. The response acceleration of the component to the seismic motion wil be taken from the response spectrum curve at the appropriate natural period.

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c. Stresses and deflections resulting from the combined influence of normal loads and the additional load from the 0.06 g earthquake will be calculated and checked against the limits imposed by the design standard or code.

d. Stresses and deflections resulting from the combined influence of the normal loads and the additional loads from the 0.12 g earthquake will be calculated and checked to verify that deflections do not prevent functioning and that stresses do not produce rupture or excessive distortion.

e. The dynamic analysis of critical piping systems (i.e.. Class I systems) will be a modal analysis based upon either a distributed or lumped-mass solution depending upon the complexity of the system. The two approaches are performed as follows:

1. Distributed-Mass Analysis

The system is represented by a number of straight uniform beams with a distributed mass and stiffness. First, the transfer matrix for each of the straight beams is determined and the rotation transfer matrix for each joint calculated. Next the equation of motion is written in matrix form. Previously determined transfer matrices are used. Considering the appropriate boundary conditions, the characteristic determinant is generated. When the natural frequencies are known, the corresponding mode shapes are determined. Then by using the response spectrum for a single-degree-of-freedom system, the maximum displacements are obtained as the root-mean-square sum of the modal maxim a. Finally, after the maximum displac ments are known, forces and moments are calculated at the structural joints.

2. Lumped-Mass Analysis

The system is represented by a series of concentrated masses. First the space coordinates are established for the system and coordinates are established for the system and coordinates of mass points are determined. Using a static analysis, flexibility matrices corresponding to these mass points are computed. Next, the equations of motion are written in matrix form. Force influence coefficients method is used. Natural frequencies and mode shapes are obtained assuming harmonic motion of the system. Finally, using the same tec nique as for the distributed-mass analysis, maximum internal forces and moments are calculated at the structural joints.

In addition to the earthquake response for the pipe system, the moda described above will be used to determine forces and moments with resulting stresses for any transient or permanent displacements whic will be induced at the support points.

REFERENCES

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a. Nuclear Reactors and Earthquakes. AEC Publication TID-7024.

b. Wind Forces on Structures. Task Committee on wind forces. ASCE Paper No. 3269.