R. Denise, DBE

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

May 10, 1979

NOTE TO: Darrell Eisenhut

FROM: Bill Russell

SUBJECT: TESTIMONY BEFORE CONGRESS AND THE COMMISSION CONCERNING PROBABILITY OF EARTHQUAKES AND THE FIVE PLANT SHOW CAUSE ORDERS

1. During the May 3, 1979, Commission briefing on Maine Yankee, the staff identified a 100 year recurrence interval for the design basis earthquake (DBE) at Maine Yankee. This was related to an Intensity V-VI earthquake.

2. During the April 26, 1979, Commission briefing on the five shutdown plants, no discussion of probability or specific recurrence interval occurred. The staff did indicate that the risk associated with the Maine Yankee DBE was a factor of 25 higher than that which would be associated with current requirements.

3. During the March 27, 1979, Hart Authorization Hearing, the five plant shutdown was discussed but the probability of earthquakes was not discussed.

4. During the March 21, 1979, Bevill Hearing extensive discussion occurred on the probability of earthquakes. The 200-400 year recurrence interval for the operating basis earthquake was identified. It appears that about one third of the hearing involved this topic.

5. During the March 19, 1979, Udall Hearing the prepared testimony included a discussion of eastern U.S. seismicity. The formal transcript has not yet been received by the NRC. The prepared testimony, however, relates Maine Yankee to an Intensity VII DBE at the higher end of 10^{-3} to 10^{-4} probability of occurrence.

6. During the March 16, 1979, Hart Hearing a brief mention of overall earthquake probability occurred. A 200-400 year DBE was discussed. The DBE was identified as having 1,000 to 10,000 year recurrence interval. No plant specific earthquake information was discussed.

7. During the closed Commission meeting on March 13, 1979, to discuss the proposed Show Cause Order for five plants, no discussion of earthquake probability occurred.

8. I recommend letters to each congressional committee which identifies the recently revised estimate of the design basis earthquake at Maine Yankee. This should be completed on a priority basis.

9. The Abnormal Occurrence Report on this event which was approved on April 30, 1979, has been revised to delete reference to probability of earthquakes. I have discussed this revision with the Commissioner's Technical Assistants.

Bill Russell

Bill Russell

E. Case, NRR
R. Denise, DSE

Central files

APR 26 1979

MEMORANDUM FOR: Commissioner R. T. Kennedy

THRU: for Lee V. Gossick, Executive Director for Operations

FROM: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

SUBJECT: SEISMIC EVALUATIONS OF FIVE NUCLEAR POWER PLANTS

This is in response to your memorandum of March 14, 1979.

The seismic analysis methods for the five affected plants were reviewed in some detail, especially at the OL stage of review, and found to be acceptable. However, the staff in its review did not explore the spatial (intramodal) method of combination used in the dynamic analysis of system piping. The review was sufficient to disclose that acceptable methods were used in combining modal responses, but we can find no indication in the agency records that the intramodal method of combination was described or questioned on any of the five plants. Records for other plants of Stone and Webster design that we have reviewed in recent years do contain descriptions of acceptable methods for these spatial response combinations. In addition, the enclosed describes the present state of verification of stress analysis methods.

A brief description of how our seismic design methods have evolved follows. In the early years of nuclear regulation, prior to 1967, there were no formal regulations or guidance on seismic design methods. The state of the art of seismic design during this time was perhaps best described in a document entitled "Nuclear Reactors and Earthquakes" (TID-7024) issued in August 1963, by the U.S. Atomic Energy Commission. The report reflected the practices employed in the design of government-owned reactors at that time. Applicants for AEC licenses were made aware of the existence of such documents and instructed to employ them in design of their nuclear power plants. The methods used for seismic design in the period prior to 1967 were the so-called equivalent static methods.

In the equivalent static load method of analysis a single static force is applied at the center of gravity of the structure or component. In using the method, the designers usually took the peak of the calculated dynamic response of the structure, multiplied

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it by some factor between 1.5 and 2, and then calculated an equivalent static force. This single force was intended to represent the forces due to the inertia of the structure and the amplification of those forces due to the dynamic nature of the loading. Although this approach is suitable for systems of simple geometry, it was found to possibly underestimate the seismic response of complex systems in some cases and to overestimate in others.

Starting about 1967, various experts in the field of seismic design, most notably Dr. Nathan Newmark at the University of Illinois, published papers demonstrating that advanced dynamic analysis techniques that were a technological spinoff from the aerospace industry could be applied to the seismic design of structures. The application of these advances in the state of the art to nuclear plant design was encouraged and supported by the AEC regulatory staff because they permitted better characterization of the actual response of nuclear power plant structures and systems to an earthquake. It is also important to note that the use of these more advanced dynamic analysis techniques in design of complex structures like nuclear power plants was feasible by the late 1960s because of the increasing availability of computers with sufficient capacity and calculating speed.

When the staff began to require dynamic analysis in the design of structures and components for seismic loading in about 1967, the methods and practices employed by industry were based on the available technical literature and on what had evolved as accepted engineering practice in the field of dynamic analysis as it was appplied outside the nuclear industry. Inherent in the dynamic analysis techniques was the recognition that actual structures and systems would respond to an earthquake in several simultaneous modes of vibration. This meant that a mathematical method was necessary for combining the spatial (intramodal) components of the seismic response at a given point in a structure or system to determine the total response. However, the regulatory staff guidance on acceptable techniques of dynamic analysis for use in license applications was limited to basic criteria such as earthquake and accident loading combinations, allowable stress and deformation limits and damping values. These criteria were communicated principally through the question and answer process used in the staff review of an application. The NRC records disclose

that no criteria were issued at the detailed level of analysis involving the combination of spatial response components in piping or structures in these early years.

Beginning about 1967, consulting organizations were retained by the AEC regulatory staff to assist in the evaluation of seismic design criteria for most plants, including Maine Yankee, Surry, Fitzpatrick, and Beaver Valley. Expert and nationally recognized consultants were retained under contract with the AEC regulatory staff in lieu of hiring staff members with comparable expertise.

In the period 1970-1974 the staff was enlarged to include personnel with expertise in dynamic analysis, and a number of consultants were employed to assist in defining more specific requirements for seismic analysis. During this same period of time there was a great deal of activity in the engineering community in the development of techniques for dynamic analysis of nuclear power plants. A number of studies were undertaken by engineers in both academic and industrial circles to define the applicability and limitations of the analytical techniques that were coming into use, including the subjects of modal and spatial response combinations. From our regulatory point of view, this period culminated when the essence of these efforts was codified in NRC Regulatory Guide 1.92 "Components of Modes and Spatial Components in Seismic Response Analyses" first published in 1974 and revised in 1976. The guide is now in routine use in the licensing process and treats fully the method of response combinations of concern in the five affected plants.

Original Signed By
Roger S. Boyd

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosure:
"Present State of Verification of Stress Analysis Methods"

cc: Chairman Hendrie
Commissioner Gilinsky
Commissioner Bradford
Commissioner Ahearne
A. Kenneke, OPE
L. Bickwit, OGC
S. Chilk, SECY
C. Kammerer, OCA
J. Fouchard, OPA

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