



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
WASHINGTON, D. C. 20555

January 11, 1983

The Honorable Nunzio J. Palladino  
Chairman  
U. S. Nuclear Regulatory Commission  
Washington, DC 20555

Dear Dr. Palladino:

SUBJECT: QUANTIFICATION OF SEISMIC DESIGN MARGINS

In its reports on several different nuclear power plants during the past few years, the ACRS has asked that aspects of the adequacy of the seismic design be examined. These plants include the North Anna, Davis Besse, Summer, Clinton, Sequoyah, Wolf Creek, Fermi 2, Clinch River, Midland, and Perry projects. Most of these cases introduced some site-specific or design-specific topics into the overall consideration of seismic safety. However, the general aim of the ACRS in this regard was that the seismic design be adequate. In its report on Perry, the ACRS stated its belief that it was important that there be considerable assurance that the combination of the seismic design basis and the procedures used to establish the design margin be such that the seismic risk represents an acceptably low contribution to the overall risk.

The issue of seismic safety is generic to all nuclear power plants. The seismic initiator has been included in some recent probabilistic risk assessments (PRA) and, although the uncertainties are considerable, earthquakes have been estimated to represent a significant contribution to risk. It appears possible to draw some tentative conclusions, including the following:

1. The NRC has seismic design criteria. However, the effectiveness of these criteria in controlling risk is not well quantified.
2. Current determination of the seismic contribution to risk involves considerable uncertainty; furthermore, there are several important contributors to this uncertainty.
3. The available evidence indicates that the seismic contribution to risk may be large enough that a careful evaluation of the matter is warranted.
4. There are some aspects of nuclear power design where considerable seismic safety margins have been identified. There are other parts of the nuclear power plant for which margins may exist, but they have not been identified with any certainty. There are also some areas of plant design that have not yet been examined for margins. Data on equipment fragility based on tests vary in quality, completeness, and usefulness.

The general issue of seismic safety margins was discussed with representatives of the NRC Staff at ACRS Subcommittee meetings on August 11 and October 21-22, 1982.

We believe that a possible approach to this issue would be for the Nuclear Regulatory Commission, as part of its evaluation of proposed safety goals, to include a probabilistic evaluation of the seismic risk to light water reactor (LWR) safety. This might include the following programs to be conducted during the next two to four years.

(a) Continued Research on Sources and Likelihood of Severe Earthquakes

The ongoing U.S. research program on geology, seismicity and geophysics should continue to receive strong support from the NRC. The recent reevaluation by the U.S. Geologic Survey of the possible causes and potential of a Charleston-like earthquake in the Eastern United States results in large part from such studies and gives strong support to the likely importance of a probabilistic examination of seismic design. The NRC research program in this area should attempt to develop an improved capability for estimating the severity of earthquake-induced ground motion which may have a return frequency in the range of  $10^{-4}$  to  $10^{-5}$  per year at reactor sites.

(b) Generic Studies of Seismic Risk (NRC and Industry)

These studies would involve analyses intended to better ascertain the likely margins beyond the design basis, as well as those design criteria and practices that tend to enhance or diminish such margins. This would be done for all representative systems, components, or structures whose integrity of function is required in order to achieve safe shutdown, given a severe earthquake.

In addition to assessing specific components, etc., a limited seismic PRA should be performed with particular attention to identifying potentially significant failure modes and to examining in detail the uncertainties and their susceptibility to quantification and reduction. Such a program should be carried out with as much cooperation as practical between the industry and the NRC and its contractors. As in the case of severe accident rulemaking, the industry should establish an appropriate generic studies group. We believe that significant industry involvement is essential if this effort is to be successful.

(c) Seismic Reviews of Specific Plants (Licensees)

Plant-specific seismic reviews would involve limited PRAs performed to gain more insight into the relative seismic contribution to risk and the uncertainties therein, to evaluate the seismic adequacy of the specific plants involved, and to benefit from review of plant-specific details not available from generic studies. For example, seismically induced systems interactions can best be examined in terms of the detailed design of individual plants. Similarly, the seismic behavior of small lines or other components, which are not currently evaluated systematically, would best be examined for actual plants. A few plants might be chosen for a limited seismic PRA partly based on special considerations such as population density and partly based on their potential for providing a reasonable representation of the design and construction approaches used by the vendors and architect-engineers.

(d) Seismic Safety Research (NRC and Industry) .

This program would be intended primarily to provide improved methodology for evaluating seismic risk and to obtain improved data on the seismic resistance capability of components (fragility). A beginning has been made on these matters in the Seismic Safety Margins Research Program (SSMRP) and the seismic risk studies included in the recent industry-sponsored PRAs for Zion and Indian Point. Since the fragility cannot be evaluated adequately for many components by analysis, a suitable experimental program should be undertaken. We believe that such a program should take advantage, to the extent possible, of assessment of damage in industrial facilities which have experienced severe earthquakes, of the Japanese program, and of qualification tests performed for other purposes. A systematic examination of the state of current knowledge should be made for all components of interest and a test program developed to provide generic information, if possible, for components that appear to lead to a greater vulnerability, separately or in combination. The experimental program should be given the benefit of insight from system studies and PRA studies undertaken in other sectors of the overall effort.

The proposed use of seismic probabilistic risk analysis would clearly be subject to large uncertainties in results, as well as to large differences of opinion among experts. Nevertheless, such studies, if performed carefully, can provide significant insight. Furthermore, if a probabilistic approach were used in design, some of the seismically induced failure modes predicted in recent PRAs, such as building-building interaction, could be avoided.

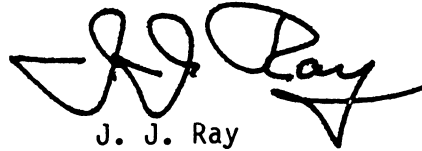
Honorable Nunzio J. Palladino

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The ACRS believes it likely that the NRC will have need for a probabilistic evaluation of the seismic contribution to risk. If the NRC chooses to give sufficient priority to study of the matter and sets up a suitable schedule for decision making in this regard, the ACRS believes that such a generic approach could provide an appropriate substitute for examining certain seismic safety questions case by case.

Sincerely,

A handwritten signature in black ink, appearing to read "J. J. Ray". The signature is stylized with large, sweeping loops and a prominent "R".

J. J. Ray  
Chairman