Schmidt

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

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MEMORANDUM FOR: William F. Anderson, Chief
Mechanical Structural Engineering Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

FROM: Zoltan R. Rosztoczy, Chief
Research and Standards Coordination Branch
Division of Safety Technology
Office of Nuclear Reactor Regulation

SUBJECT: SEISMIC ANALYSIS RESEARCH PLAN

In G. A. Arlotto's memorandum to me of January 25, 1983 comments and corrections were requested on the draft seismic analysis research plan, especially those on how the various planned research results and objectives will resolve current and expected regulatory issues. The enclosures to this memorandum provide our detailed comments. Enclosure I combines the comments of the Research and Standards Coordination Branch, the Reliability and Risk Assessment Branch and the Division of Licensing. Enclosure II contains the comments of the Division of Engineering which includes comments from the Structural and Geotechnical Engineering Branch, the Geosciences Branch and the Equipment Qualification Branch. Most of these comments have been available to your staff in draft form for several weeks. The principal exception is that the DST Comments have been revised to reflect the comments from the Geosciences Branch. We have met with your staff following issuance of both the December and January drafts of the seismic analysis research plan to discuss many of these comments and NRR's regulatory needs.

In addition to the comments provided in the enclosures the following discussion responds to how the research will resolve current and expected regulatory issues. The regulatory needs in the seismic research area fall into three broad categories: seismotectonic research, collection of fragility data, and the evaluation of current requirements and practices with respect to low probability, high consequence earthquakes. The goal of the seismotectonic research should be to provide the methodology and data for the establishment of ground acceleration requirements for nuclear power plants sited anywhere in the U.S. This part of the program should address the location frequency and intensity of earthquakes in various regions of the U.S. It should provide verified methods to predict the attenuation between the epicenter of the quake and the plant site and predict the transmittal of the motion to the plant structure in terms of soil-structure interactions.

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Priority should be given to the eastern seaboard area of the U.S. in order to be able to evaluate, in a timely manner, the recent U.S. Geological Survey position which indicates that seismic events of the magnitude of the Charleston earthquake ought to be considered everywhere on the eastern seaboard. Special attention should also be given to the frequency of low probability, high intensity earthquakes which might play a significant role in the assessment of the overall seismic risk.

The current seismic design approach is based on a specified safe shutdown earthquake (SSE). It also requires the use of design margines. These margins are different for equipment, components (like tanks, vessels, heat exchangers), piping systems and structures. The actual conditions that would result in inoperability of the equipment or failure of the components, piping or structures are often not known. It should be one of the goals of the program to collect together and assemble fragility data for essential equipment, components and structures to facilitate the evaluation of current regulatory requirements. The presently available data are probably limited and some of it might have large uncertainties. It should be the purpose of the program to bring attention to the shortcommings of the data base and to recommend appropriate resolutions. Industry or NRC supported test programs could be part of the resolution.

Low probability, high consequence earthquakes, those beyond the SSE, might be significant contributors to the overal seismic risk. The program should evaluate the inherent protection provided by the current regulatory requirements with respect to these low probability events. If the outcome of the evaluation indicates a need for additional requirements, the program should evaluate various means of assuring sufficient protection, for example: requiring larger design margins; establishing new design criteria for selected equipment, components or structure or imposing an additional probabilistic criterion on seismic risk. The cost associated with each of the approaches considered should be estimated and should play a role in the selection of a recommended approach for NRC management consideration.

The seismic research program should be organized and executed in a manner that will meet these goals. The ongoing programs are expected to provide valuable information toward these goals; however, from the present draft of the program plan it is not clear whether these programs in their present form will fullfill all regulatory needs. The program could be organized

along the lines of these main goals and then broken down to subtasks. Some of the current programs might need redirection to satisfy all requirements of a given subtask and some of the needed subtasks might not have an equivalent ongoing program. The program plan should indicate how these gaps are going to be filled. At the same time the program plan should recognize the limitations of NRC's responsibility relative to other government organizations like the U.S. Geological Survey and relative to the nuclear industry. You should take full advantage of the information available from these sources and should also rely, to the extent possible, on the resources of these organizations for developing needed new information.

Please note that each of the three regulatory needs outlined above are general in nature, and that they are not limited to a probabilistic risk assessment approach. Deterministic approaches relying on general design criteria, design basis accident evaluation, system assurance analysis, or additional regulatory guidance (Reg. Guides or NUREGs) should be considered as regulatory options together with the probabilistic approach. One section of the program plan should specifically address the interfaces between the seismic program and other NRC programs; for example, the PRA methodology development program. It should clearly identify information needed for the execution of this task from other programs. It should also list deliverables generated in the seismic program in support of other programs together with their schedule.

While we have commented extensively on the January draft we would like to assure you that this draft is a substantial improvement over the earlier draft. Our comments are intended to be constructive and to facilitate your development of a document for division and office level review and concurrence by Mr. Denton. Such a review will require a minimum of four weeks.

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ENCLOSURE I
DST AND DL COMMENTS ON THE RES SEISMIC ANALYSIS
RESEARCH PLAN OF JANUARY 25, 1983

1. An acronym for Seismic Analysis Research Plan is SARP, which can be confused with the Severe Accident Research Plan. Consequently, we will use in this document the title Seismic Plan or simply "the plan" for the Seismic Analysis Research Plan. RES may wish to consider retitling the Seismic Plan to yield an acronym that differs from SARP.

2. While the RES seismic plan generally reflects NRR needs as expressed in the Denton to Minogue memorandum of April 8, 1982, "NRR Research Needs in Seismic Analysis Methodology" and in subsequent communications and meetings, we find that the plan is not complete and will require substantial revision. Our major comments in this regard are summarized below and expanded elsewhere in this document:

   a. The plan should explicitly discuss how each of the proposed program elements will contribute to the resolution of specific licensing issues. Further the interrelationship between the various programs should be identified to clarify how the goals of the plan will be achieved.

   b. More specific information such as schedules for providing program end-products, product descriptions and the associated costs should be provided in the plan for each program element. This should include milestone information on intermediate research progress and for research deliverables and how various lines of research will be integrated together to meet various overall goals.

   c. Information on costs is presented in a confusing manner or not presented at all. In this regard, the list of Research Products to Meet Objectives (given on pages 20 and 21) should be fully correlated with the costs given in Section VII, Resource Requirements (page 22). For example, the reader should be able to gather cost of the program to produce "seismic hazard curves and site specific spectra for eastern U.S. sites (1984)" and see what are the FINS and intermediate milestones involved in this job.

   d. The plan should prioritize the degree of emphasis to be placed on each type of product and indicate the conditions under which generic products can be applied to plant specific cases. In this regard, it should better distinguish between the research products being developed as generic tools and research products that can cope with plant and site specific characteristics.

3. The Seismic Plan does not appear to be well coordinated with the three other program plans now in various stages of development. These plans are in (1) Improved PRA Methodology, (2) Severe Accidents (NUREG-0900) and (3) Human Factors (SECY-82-462). Our comments pertaining to each of these plans follow.

a. The extent to which the draft plan has been coordinated with the RES plan on PRA development activities is not evident. The latter RES plan is in the early stages and the opportunity for complete coordination of the two plans exists. Coordinaton is particularly important with regard to the selection of a plant or plants for study. In the Denton to Minogue memorandum of November 30, 1982, "NRR Research Needs in PRA Methodology," we recommended that Browns Ferry 1 be used for both plants. We have not changed our recommendation in this matter and believe the question of plant selection should be promptly resolved by RES. We further note that the discussion of seismic PRAs (p.4) and planning assumptions (p.7) includes the statement that SSMRP and PRA studies show "that seismic risk is a major contributor to overall plant risk." We are not aware of the basis for such a generalization. More appropriately, some PRA studies have indicated that seismic risk may be a major risk contributor.

b. The short-term objective of the Severe Accident Research Program (NUREG-0900) is to make certain decisions in early 1984 pertaining to the Commissions Policy Statement on Severe Accidents (SECY-82-18). One of these decisions will relate knowledge of seismic hazards and the adequacy of current plant seismic designs to the causes and consequences of severe accidents. For this reason, the Seismic Plan should provide an assessment of the kind and quality of the deliverables available by January 1984 that can contribute to severe accident decision making. Some specific suggestions we have for the acceleration of deliverables that would aid the early 1984 decisions are:

   i. Accelerate the ongoing negotiations with Japan so that more of the benefits from Japanese seismic knowledge will be available to us prior to January 1984.

   ii. Accelerate the documentation of available fragility data to the end of FY83 from the end of FY84. This program should continue in FY84 if necessary, but it is hoped that the major available information can be collected as soon as possible. The data base for defining fragilities for structures and equipment, components, piping systems and structures is a very important element of the program.

iii. Initiate immediately the planned collection of expert opinion data for use in calculating eastern U.S. seismic hazard curves. Appraise and analyze these data by the end of FY83 to the point where a useful consensus has been developed and the reasons for potential controversies are understood. NRR recognizes that, as in the past, the collection of expert opinion data can lead to more uncertainty than originally envisioned. RES should work closely with its selected experts to determine how their potential differences can be resolved so as to minimize uncertainty.

c. The Human Factors Program Plan (SECY-82-462) is in its final stage of development. This plan states, near the bottom of page 38, that "Research will be continued on the effects of severe stress (e.g., severe seismic events) on human performance with respect to safe operation." For this reason, the element in the Seismic Plan "Human Performance Analysis of Severe Stress Due to Seismic Events," as described on pages 17 and 18, should indicate what portion of the seismic stress issue will be funded and managed separately, if any, from that to be managed and funded under SECY-82-462 or by the Long Range Research Plan (Chapter 9). It should be demonstrated that unnecessary duplication of research has been avoided.

4. The data base for defining fragilities for structures and equipment is a very important element both for understanding seismic risk in PRA studies and for performing deterministic analyses. The confidence on seismic risk estimates and safety margin determination rests largely on the validity of assumptions made on fragilities for structures, systems, and equipment. These data bases are urgently needed in terms of physical test data or validated analysis results. It is recommended that research efforts in this area should be emphasized starting in FY83. However, we offer the following remarks and cautions pertaining to the program.

a. Indirect causes of failures (e.g. roof failures, support failures, etc.) are not discussed in Section F, "Subsystem Response and Fragility Research". The plan should discuss to what extent indirect failures can be accomodated in a generic fragility program and how much fragility information must be based on plant specific data.

b. When establishing fragilities via testing the plan should identify where the tests fit into the data needs. Forinstance, we understand that the HDR experiments are not generally expected to meet data needs for the nonlinear range but will be useful for benchmarking seismic methodology at lower levels. The planned

fragility test programs, including related equipment qualification programs, should be listed in comparison with the data range they will serve.

5. The Seismic Plan does not deal with three recommendations made by NRR in its April 8, 1982, memorandum. These are the Seismic Instrumentation Program, the Handbook for Seismic Data Assemblage, and Regulatory Requirements.

   a. The Seismic Instrumentation Program would provide for a vigorous program of seismic instrumentation and would include agreements with foreign governments for placement of seismic instruments in plants at seismically active locations. In the United States this program would be carried out in coordination with the continued implementation of Regulatory Guide 1.12, "Nuclear Power Plant Instrumentation for Earthquake." In the April 8 memorandum, we stated that we considered this program of good value, although through conversations with staff members, we believe this opinion is not shared by RES. We continue to emphasize our need for this program.

   b. The "Handbook" for the assemblage of seismic data was recommended in the April 8 memorandum for several purposes. It would provide (1) an ordered and diciplined means for collecting and documenting data important to seismic calculations, (2) it would include "validation" and updating procedures to strive toward quality computations, and (3) as a "best available" data source, it could be used by industry for comparing industry developed seismic methodology against those developed by the NRC and for making plant and site-specific seismic analyses using fragility and hazard curve data and other useful data developed by the Seismic Plan.

      We continue to believe that an organized compilation of available data is a valuable but it need not necessarily be compiled in a handbook format.

6. Improvements in seismic methodology must inherently involve credibility of methods and results for both deterministic and PRA applications. The seismic research plan should very clearly, in the introductory part as well as in each description of proposed work, reflect emphasis on the problem of validation of methods, i.e., what will be done to test the methods in terms of an available data base, and to assess the related limitations. In this respect, we don't fully agree with statements on page 16 and believe that the SSMRP should not be considered complete and "applicable for PWR analysis" until the methods have been adequately tested and a good independent consensus on the degree of validation has been obtained. Furthermore, an SSMRP assessment effort should be formulated that would focus on the problems of validation and determine what the limitations of the methodology are.

7. Except for programs currently underway and included in the SSMRP budget through the termination of the program in FY84, the assessment and validation of the methodology developed by SSMRP should be conducted by an independent organization other than the developer. This would include the RES proposed work to perform a comparison between the SSMRP and the PL&G seismic risk analysis of Zion.

8. On Page 11, a nonlinear analysis of basemat uplift is planned. The need for this program should be more fully identified together with the scope of the program planned. If no physical validation testing is planned or feasible, will the quality of the results be commenserate with its need?

9. The plan needs to be revised to show in detail how the seismotectonic program will contribute to development of seismic hazard curves at the high consequence, low probability end for various power reactor sites. Furthermore, the seismotectonic program needs to be substantially updated to better incorporate our current approach as described in our new plan for addressing the USGS clarification regarding the eastern seaboard earthquakes. In general the seismotectonic program should show a closer relationship between the seismotechtonic programs and the overall objectives of the plan. Furthermore, the discussion in Appendix 1, "Cost-Sharing Benefits to the NRC Seismology/Geology Research Program" needs substantial expansion, clarification and coordination with the specific topical programs identified on Pages 24 and 25.

10. The RES efforts to expand seismic research cooperation with other government agencies, industry, and other countries are highly commendable. Cooperative research with a high seismic exposure country such as Japan can be expected to be highly productive in helping to resolve the problem of validation of fragility models. Japan's extensive seismic research program (including the shaker table and fragility monitoring programs) and the possibility for early development of a good statistical data base for model testing offers attractive possibilities for highly cost-effective research investments. The program plan makes reference to such possibilities but should be more specific and indicate definite activities in this important area.

11. While it is usually obvious that research expenditures should be prioritized toward reducing areas of highest risk, it is not obvious where the highest seismic risk resides. Research results and opinion of knowledgeable workers have been expressed that estimate high-risk domains ranging from two times the SSE up to five times the SSE. We believe it important that a focus be achieved on how these levels translate to ground motion, stress limits and other factors, so that

the gathering of fragility and structural response data and of planning experiments will be oriented toward risk reduction priorities. More precisely, RES should strive to set upper limits on seismic design parameters that adequately bound seismic risks and yet are in reasonable accord with historial observations of the great earthquakes. We believe there is suitable information available at present to permit RES to develop these upper bounds for both current guidance to related research and to develop criteria for future programs. These upper limits would, not at this time be expected to consider site specific aspects but would be set to be inclusive of all current and potential sites for nuclear power plants in the U.S.

12. The SSMRP program has dropped the task of evaluating seismic margins of current criteria in structures and equipment due to budget cuts and higher priority topics. While this task may no longer be possible under SSMRP funding, this product is of fundemental need to NRR and should be provided for somewhere in the program plan. This task should be undertaken following validation of the SSMRP methodology and performed after corrections to the methodology are made as may be necessary following validation.

13. Design and construction errors (Section D, p.12) can, of course, conceptually impact plant risk, whether seismic or otherwise. The problem of assessing the relative importance of the question in a PRA context and of developing a feasible, but realistic analytical treatment of such possible errors is an appropriate one for the area of PRA development research. In this connection, the SSMRP project referred to on p. 12 may overlap related RES work in the Division of Risk Analysis and should be coordinated to reduce possible unnessary duplication of effort. We also request that the Seismic Plan provide further information on this topic as follows: What is the schedule? How will this program be attacked? What is the level of accomplishment anticipated? Is the output likely to be generic or plant specific? What data are available (e.g., Zimmer task force) and how will they be used?

14. We agree that there is a need for the proposed soil failure research as identified on page 10. The Seismic Plan should be expanded to indicate the scope, objectives, schedules and funding level for this program.

15. Because of the lack of task details, it is not clear whether the following items are included in the short-term objectives:

    a. Seismic Anchor Movement and Inertial Load Combinations for (i) piping and (ii) piping and equipment supports.

    b. Multiple Support Input Piping Analysis.

16. A research product given on page 15 is seen to effect placement of pipe whip restraints and asymetric blowdown analysis by 1984. More discussion should be given on the program to achieve this product.

17. It would appear that the benchmarking of SSMRP's soil structure interaction techniques could be advanced from 1985 since both data and SSMRP computer codes are available.

18. The Category I program (page 12) might be related by scale-up factors to demonstrate actual margin levels of nuclear structures in addition to the stated goal of "better characterize the loads for earthquake levels...". Please discuss this suggestion.

19. An important fallout from the seismic-inclusive PRA studies performed by industry for the Zion and Indian Point plants was the identification of "outliers" or unexpected structural weaknesses. The Seismic Plan should consider a program that would focus on generic outliers. This could be of immerse practical use in improving seismic design margins in existing plants. This comment should be considered in connection with Comment 12.