UNITED STATES
NUCLEAR REGULATORY COMMISSION
Nuclear Safety Research Review Committee
Washington, D.C. 20555

January 14, 1993

Dr. David Morrison
Chairman, NSRRC
The MITRE Corporation
7525 Colshire Drive, MC W766
McLean, VA 22102

SUBJECT: NSRRC Advanced Reactors Subcommittee Meeting of December 2 and 3, 1992

Dear Dr. Morrison:

This is a report of the subject meeting. The Subcommittee members participating in this meeting were T. Boulette, S. Burstein, S. Bush, N. Todreas (Chair) and D. Turcotte. Additionally, the Subcommittee was assisted in its deliberation by H. Isbin and E. Kintner who attended the entire meeting and R. Vogel and yourself who attended a moderate portion of the meeting. Advanced reactor activities in Instrumentation and Control and in Severe Accidents are being covered in parallel by separate subcommittees under Messers Kintner and Isbin, respectively, so that their attendance here assured effective coordination of ongoing NSRRC oversight reviews.

The agenda of the meeting was designed so that when taken together with the coverage of our July 1 and 2 meeting it would expose the Subcommittee to the remaining key Research Office activities involving Advanced Reactors. Consequently, a diverse but important number of topics was reviewed. The meeting agenda is appended. The Subcommittee appreciates the continuation at this meeting of the commitment the RES management has made to participate in and gain counsel from NSRRC deliberations.

1. Thermal-Hydraulic Systems Activities

- ROSA Facility Preparation for AP-600 Confirmatory Tests

  RES presented an update on the negotiations for the ROSA facility, and referenced an INEL report (NUREG/CR-5833) which completes the evaluation of the use of the modified ROSA facility. The results of this report were discussed. The Subcommittee requests that in the future, topical report such as this one should be made available to NSRRC in a timely manner. Further, the Subcommittee emphasizes that the expertise and experience of INEL and RES on instrumentation and data evaluations be used to the fullest extent in carrying out the ROSA tests. In response to questions, we were informed INEL had already participated in the instrumentation planning for this facility and that INEL is to have a resident engineer at the site. The most effective means should be selected to reflect the NRC's input on instrumentation, selection and performance as well as control of the data evaluation process. Information pertaining to this activity should be communicated to the NSRRC over the life of this program.

  RES chose not to have a cooperative testing program with Westinghouse using the ROSA/OSU (Oregon)/SPES (Italy) facilities. In this way, NRC maintains its regulatory independence from the vendor tests that are to be used for design certification. While most members of the Subcommittee agreed with this position, at

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least one member considered this approach to be yet another element in the persisting NRC/industry confrontational pattern and voiced strong objections.

- SBWR Thermal-Hydraulic Assessment Activity

1) GE's Test Program –

A fairly detailed presentation was made describing the GE testing program in support of the SBWR. The four major test areas being reviewed by GE include stability, full pressure passive heat removal, passive core flooding and passive containment heat removal. The presentation described the tests facilities and requirements, as well as RES' dependence on the GE results for the design certification effort, RELAP assessment and validation support. Subtasks were identified and a schedule of requirements presented.

The overall presentation was thorough; however, interdependencies among RES, NRR and GE were not adequately addressed. In particular, the Subcommittee is quite concerned with the communication aspects of this endeavor. Communication between RES and GE requires routing through NRR, which has apparently slowed the exchange process. Control of information is clearly required, but it should not significantly hamper timely information flow. We are concerned that several subtasks identified by RES regarding this effort are awaiting receipt and review of data from GE. Also, GE is awaiting NRC comments on certain of their test configurations that they indicated would be useful if received by GE in a timely manner.

2) NRC's Proposed SBWR Integral Test Facility –

RES with NRR's concurrence has determined that there is a need for a reduced-height, low pressure integral facility modeling the SBWR reactor and containment. The vendor's GIST facility simulating an earlier SBWR design does not contain the features added in the current design.

In general, the NSRRC supports NRR's need for independent expertise and for confirmatory research programs. However, on the basis of the presentation at this meeting, which were essentially technical judgments, NRR and RES were not able to convince the Subcommittee that the proposed facility was justified. The Subcommittee believes that RELAP 5 evaluations of the GIST facility and of the SBWR or of a test facility with the appropriate features would improve the basis for justifying whether the NRC's facility is needed. The Subcommittee would like to be kept informed on this matter.

- Code Selections and Assessment

The Subcommittee believes that the plans for code selection and code assessment need to be established in parallel because the high cost of an effective assessment process will directly influence the number of codes that can be selected. While the selection process appears essentially complete, the planning for the assessment process has large voids. These specifically include:

a) The assessment plans for all AP-600 and SBWR transients except LOCAs by RELAP 5 are not established.

b) The assessment plan for RAMONA is not established.

Further, while the coupled CONTAIN/RELAP 5 strategy for containment analysis was not reviewed, we understand that the detailed assessment plan for this code is also not established. The Subcommittee would like to be informed of the progress being made in this task by the branches involved.

The Subcommittee's interest in an effective coordinated selection and assessment process was detailed in the letter of the Subcommittee to Dr. Morrison dated October 7, 1992, which was provided to RES well in advance of this meeting. From the RES presentations it is obvious considerable progress has been made since our July 1992 review; however, it is disappointing to see that RES has completed the selection process without concurrently completing the assessment plan. This comment should not be read to infer that we believe that a full CSAU type assessment is needed in every case; rather, we ask only that a timely, technically supported and disciplined approach be developed and presented for our review.

The ongoing approach could lead to a repeat of the unfortunate situation RES experienced with the TRAC and MELCOR codes in which RES funded and completed their developments without assuring the conduct of a parallel assessment process. This led to the very late and costly conduct of assessment programs for both codes—in the case of TRAC as part of the development of the CSAU procedure, and in the case of MELCOR by a peer review process that is only currently being concluded.

2. Passive System Reliability

The initial objective of the study at Sandia National Laboratories is to compare reliability of ECCS systems (including decay heat removal systems) of the Surry plant with the reliability estimated for the AP-600, using core damage frequencies from transients and LOCAs assuming that the reactor protection systems function successfully. The study is to determine, in particular, the uncertainties associated with the state of knowledge involving the functioning, for example, of the natural circulation and gravity fed injection systems. Work is underway modifying the MELCOR code, using the CSAU methodology. This project has been underway since October, 1990, and an estimated $800K has been expended to date. The Subcommittee, while recognizing that the study seeks to evaluate the advantage of greater reliability that the advanced passive reactor should have relative to that associated with current reactors, has the following concerns with the conduct of the current program:

- The MELCOR code has been selected for this study and, consequently, this program carries the burden of application of the chosen CSAU methodology for this code's assessment. Perhaps the use of a severe accident code for this project will be inevitable, but it is costly (because of the assessment needed) and, at present, its need is not definite. This is because the reliability questions to be answered could possibly be answered with surrogate parameters, specifically a thermal-hydraulic characterization of failure in functioning of systems. This would allow use of RELAP 5, which already has an ongoing assessment program. Further, it would give some meaningful results much quicker and certainly cheaper than the existing Sandia program. Such initial results could then be used to assess whether core damage frequencies themselves needed to be determined in what then would be a more ambitious program of the type underway.

- The meaning of the concept of "uncertainties in natural processes" and their evaluation in this program is a concept that still eludes the Subcommittee even though this was the second meeting at which RES staff attempted to answer the Subcommittee's questions about it. Could it be that the Subcommittee's surmise, that such uncertainties are to be resolved by experiments underway or planned and do not belong as elements in a reliability program such as this, is correct? At the least, RES management needs to evaluate this facet of this program and ensure that a coherent explanation can be offered on the next attempt to the Subcommittee.

3. Seismic Design

Regulations with respect to relevant Appendices of 10CFR50 and 10CFR100 were discussed.

- Appendix B

The Subcommittee has serious concerns that the manner in which the deterministic approach is included in the new proposed seismic regulations does not take into account relevant research carried out over the last twenty years. This new regulation, Appendix B, is now released for public comment. The inclusion of probabilistic analysis in the new regulations is certainly a step forward; but using it in parallel with the traditional deterministic approach, with an unclear "comparison," to establish safe shutdown earthquake (SSE) ground motion may represent a step backwards. This is particularly true since one of the principal bases of the deterministic approach, the "capable" fault, has been removed. This has been replaced with the vaguely defined concept of a "capable tectonic source." The deterministic approach is anything but deterministic since no adequate definition of a capable tectonic source is given.

The Subcommittee is concerned that the proposed dual approach makes the new regulation less well defined than the old regulation and provides no real basis for assessing seismic risks. In many parts of the country, a probabilistic approach is fully adequate to demonstrate the seismic safety of a reasonably designed plant. In those areas in which regional tectonic activity can be demonstrated, the more in-depth deterministic approach is certainly justified—but little guidance is provided in the draft regulatory guide as to how this is to be accomplished.

Of particular concern to the Subcommittee is the potentially limited role of the National Research Council Review Panel on Seismic Hazard Evaluation. This is an excellent committee which is capable of considering all aspects of the seismic hazard problem. The purview of the Panel should not be restricted to the intercomparison of the Livermore and EPRI studies. The Panel should also consider the relative merits of the probabilistic and deterministic approaches.

- Appendix S

The NRC proposed changes to establish the operating basis earthquake (OBE) at or less than 1/3 the SSE with no seismic design specification for the OBE appears to allow desired relief to future nuclear plants from unnecessarily burdensome seismic criteria. The concomitant requirements for mandatory shutdown of a plant following exceedance of the OBE set at or less than 1/3 SSE will require more shutdowns than for an OBE set at 1/2 SSE. This may not be inappropriate if the subsequent walkdowns/inspections do not require the reporting and restart procedures currently being proposed. Certainly, there should be a formal approval process when a walkdown after an earthquake discovers damage; however, the formal process of submitting a report to the Director, NRR and the need for his approval prior to startup could result in extensive delays and possible litigation. Hopefully, the wording in Appendix S will clarify how much or how little is required to obtain startup approval.

The use of Cumulative Absolute Velocity as a criterion, apparently modelled after the EPRI approach given in NP-5930, NP-6695 and TR-100082, and the suggested Event Tree for use after earthquakes should lead to sufficient relaxation, assuming that Appendix S finally reflects this approach, so that the probability of extensive shutdowns should be minimal.

4. Analysis and Design of Reactor Internals and Piping Systems

The discussion of reactor internals problems in existing BWRs and PWRs provided an excellent oversight of the spectrum of issues that need to be considered with regard to the advanced reactors such as AP-600 and SBWR. While no specific actions were suggested, the presentation did provide a "snapshot" of the problems that will require corrective action in the advanced reactors.

The past decade has seen substantial and justified relaxations in the conservative seismic and overall design requirements applied to nuclear piping systems. The current activities sponsored by the Advanced Reactor Corporation and by USNRC appear justified in the context of a coordinated assessment of implemented and proposed changes to piping systems. While the suggested review program presented to the Subcommittee is reasonable, caution is needed in how the review is conducted. The application of unduly conservative and cumulative criteria could lead to an unrealistic damage model that might lead to an unnecessary reapplication of requirements that have been removed in the past decade.

5. Reliability of Modular Construction

An interesting program on the subject topic was described. The Subcommittee had no questions on the suitability of the technical topics being pursued, but did question whether the process of placing this work at BNL versus conducting a competitive placement compromised the overall RES objective of having the most competent investigators conduct their research. The staff responded that user time pressures to obtain the needed results led to the selected contracting procedure.

The Subcommittee understands that special circumstances can justify a limited number of such placements, but that such placements must not be allowed to become the rule. In this case, RES should investigate the benefits of engaging other more competent investigators, should they exist, to assist or direct subsequent phases of this modular construction project.

Sincerely,

Neil E. Todreas
Chairman, Advanced Reactors Subcommittee
NSRRC

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AGENDA
ADVANCED REACTOR SUBCOMMITTEE
NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE
Twinbrook Room, Crowne Plaza, Holiday Inn
Rockville, MA
December 2-3, 1992

Wednesday, December 2, 1992

8:00–8:10	Opening Remarks	N. Todreas Subcommittee Chair
8:10–9:00	Update on AP600 thermal-hydraulic research program	L. Shotkin
9:00–2:00*	SBWR thermal-hydraulic research program:	
	a. Unique features of the SBWR	L. Shotkin
	b. User needs for confirmatory research on SBWR	R. Jones (NRR)
	c. GE testing programs in support of SBWR	D. Bessette
	d. NRC confirmatory testing for SBWR	D. Bessette
	e. RELAP5 analyses of SBWR	M. Modro, INEL
2:00–5:30**	NRC code development program for AP600 and SBWR	
	a. Code selection process	L.Shotkin
	b. Code assessment process	N. Lauben M. Modro, INEL G. Johnsen, INEL

Thursday, December 3, 1992

8:00–8:15	DE introductory remarks on advanced LWR research program	L. Shao
8:15–9:15	Seismic site hazard criteria: revisions to Appendix A to Part 100; status and prospects for resolution of the LLNL and EPRI hazard methodologies	A. Murphy
9:15–9:45	Earthquake engineering criteria: Appendix S to Part 50	R. Kenneally
9:45–10:00	Break	
10:00–10:45	Piping design—lessons learned from today's plants	N. Chokshi, with support from: D. Terao and K. Wichman of NRR
10:45–11:00	Reactor internals—lessons learned from present PWRs & BWRs; corrective action needed for advanced reactors	C. Serpan
11:00–11:15	Modular construction for advanced LWRs	G. Arndt
11:15–11:30	AP600 containment structural integrity	J. O'Brien
11:30–12:30	Executive Session	
12:30–1:30	Lunch	
1:30–3:00	Passive system reliability (including discussion of impact of planned experiments on uncertainty estimation)	M. Cunningham A. Buslik A. Camp
3:00	Adjourn	

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* Break at 9:45–10:00; Lunch at 12:00–1:00
** Break at 3:00–3:15

MEETING REPORT
NSRRC WASTE SUBCOMMITTEE MEETING
December 1, 1992

MEETING OVERVIEW

GENERAL OBSERVATIONS AND COMMENTS

The structure used to manage and coordinate the High Level Waste (HLW) research program is given in Draft NUREG 1406 (February 28, 1992), portions of which have been sent to the Subcommittee. The Phase 2 Iterative Performance Assessment (IPA) Program Plan is dated December 19, 1991, and is noted as Enclosure 4. Enclosure 5, November 1991, is the Project Plan for Performance Assessment Research and provides the general and specific research objectives for the Center for Nuclear Waste Regulatory Analyses (CNWRA). Program management and organizational structure and responsibility are detailed in these documents. The Subcommittee, however, did not focus its meeting on these areas, but chose to confine the agenda to a general overview of IPA and a few selected topics. (See the attached Agenda.)

For the Subcommittee to provide responsible and constructive input to RES, attention needs to be given to providing options for members to request specific reports available in advance of scheduled Subcommittee meetings. Further, the suggestion is offered that at least the Subcommittee Chairman be alerted to special meetings which would provide substantiative accounts of the progress being made in the various HLW research activities. For example, NUREG-1327, "Initial Demonstration of the NRC's Capability to Conduct a Performance Assessment for a High-Level Waste Repository," May 1992, should have been made available to the Subcommittee prior to the meeting so that the agenda would be providing an update of this report.

The Subcommittee has received the May 1, 1992, report of the Advisory Committee on Nuclear Waste (ACNW), entitled "Review of NRC High-Level Radioactive Waste Research Program Plan (Draft-1406)," but has not been advised of the NRC response.

OVERVIEW OF NRC HLW ITERATIVE PERFORMANCE ASSESSMENT PROGRAM

In approaching an IPA, four disruptive scenarios have been identified and involve volcanism, seismicity, climatic and human intrusion. RES reported that the Phase III development will add the biosphere to the modeling for estimating dose and health effects to people.

The research being carried out is divided almost equally into three groups: the NRC's offices of RES and NMSS, and the CNWRA. The research funnels into the development of the HLW IPA program. This Subcommittee meeting is a first step in reviewing and evaluating specific research programs. The inherent difficulties in projecting milestones is illustrated by the delay in the completion of the IPA Phase II, originally scheduled for 6/92. It was reported that contributions to this delay include changes in staff personnel, and perhaps, more importantly, the overall complexities of the IPA activities. The Subcommittee requests that it be kept informed of any future delays in scheduled publication of major PA and research products should they occur.

An informative briefing was made by the NMSS in describing the general features of the IPA programs, including the auxiliary programs involving models and sensitivity analyses. The IPA provides an evaluation of the HLW repository in terms of a complementary cumulative distribution function (CCDF) of radionuclide releases. The specific releases are weighted by a factor proportional to radiotoxicity and are integrated over a time period of about 10,000 years. The performance calculations remain tied to the current EPA Rule 40 CFR 191 and the NRC Rule 10 CFR 60. The NRC staff noted that they have provided and will continue to provide the EPA technical bases which could be helpful in supporting any reevaluations of the EPA Rule that are now underway.

HLW PERFORMANCE ASSESSMENT RESEARCH PROGRAM

The presentation, made by RES, indicated that the basic SANDIA work on developing IPA has been successfully transferred to CNWRA, and that the Sandia flow model can handle the interaction between fractures and the matrix for the unsaturated tuff.

Since only a brief reference was made to the contents of the consequence models, the Subcommittee needs to plan for additional meetings. The Subcommittee would like to receive briefings on the strengths and limitations for models being used in performance assessments by EPRI, and DOE contractors, as well as by CNWRA. The Subcommittee was briefed on the motivation and general programmatic needs, and how CNWRA research tasks are correspondingly structured. Although it is recognized that IPA's can be used to prioritize research, examples were not presented.

The Subcommittee concurs with the broad features of the research programs designed to provide insight and understanding of the many interacting phenomena, characteristics and properties of the materials and structures involved, model developments, and with the process which seeks validation of the performance of the repository. All participants recognize the difficult assignment pertaining to validation of the models. RES has wisely chosen to call the approach a PROCESS which will involve a combination of efforts on a national and international scale. To be defensible, the PROCESS must be scrutable. The Subcommittee plans to review the PROCESS in a timely manner.

The Subcommittee appreciated receiving an overview on research associated with hydrology, volcanism, tectonics, geochemistry, natural analogs, thermohydrologics, and seismic rock mechanics. The presentations were responsive to the NSRRC request. The Subcommittee strongly endorses the format used in identifying and linking the research objectives to the current regulatory bases, identification of the needed research, and defining the technical approaches being used to guide the research.

SPECIFIC COMMENTS

1) There was essentially universal agreement that field work is very important at this stage of the NRC's IPA work and that natural analog studies, in particular, promise to provide broad and useful information. However, there was some concern that analog information is not being incorporated into IPA in a sufficiently rapid manner. For example, why is a greater emphasis not being given to the OKLO site? Here we can locate the daughter species of long ago decayed fission products and actinides and get a reading on the migration behavior under this one set of circumstances. Some of these data have already been collected.

Field and analog studies can provide a wide variety of observations that can be used to test the validity of codes. Field tests can test flow models under a variety of circumstances but the means of code validation should be carefully considered. Given the results, any code can be treated to get the observed results. Either the calculation should be carried out prior to the observations or some observations should be withheld from the modelers until computations have been completed. The analog studies can test sorption models and contribute to corrosion studies among other contributions.

2) The committee was concerned that in the IPA process, too much emphasis may be placed on complex computer models. The vast amount of data required to run such codes in a predictive manner is almost never available. Simply fitting models to data (see comment 1) provides only a limited degree of validation. The committee intends to re-evaluate this concern on a regular basis in the future, and it asks the NRC to do likewise.

3) A serious disruptive process, but possibly of low probability, is the potential occurrence of a volcanic eruption through the repository. The subcommittee believes that the current research in this area is a good start towards resolving this problem. However, it must be approached with great care. The occurrence of massive pyroclastic eruptions associated with the Bishop Tuff and elsewhere in the region raises concerns. Volcanism in the Basin and Range environment is poorly understood, and it appears that a statistical approach is required. The distribution of volcanics (size and ages) within a distance of 500 to 1000 Km should be determined in detail and can form the basis of a probabilistic hazard assessment for the site. This approach follows directly from the current work (as presented by Drs. Birchard and Kovach) and should be given a high priority. The association of Prof. Wernicke with this project is considered to be a real asset. He is one of the leading experts on the tectonics and volcanism of the region. The subcommittee also recommends that a probabilistic risk assessment be carried out with regard to seismic hazards. One can use as models the Livermore and EPRI studies. The subcommittee questions whether the integrity of the repository to large volcanic eruptions can be established. Thus the probabilistic hazard assessment must be the basis of defusing attacks on the site based on volcanic disruption.

4) Some but not all subcommittee members were concerned about the recently proposed idea of high temperature storage and the resulting need for high temperature canisters. Although high temperature, in principle, could provide a dry environment, the thermohydrologies in a partially saturated medium with a variety of matrix and fracture porosity may not be understood well enough to assure dryness under a variety of weather and climatic conditions. A high temperature environment may be viewed as a high risk environment, should anything perform in an unexpected way in the future. If in the future it should become desirable to approach the repository, high temperatures could make this difficult or impossible. It seems more sensible that the design of the repository should conform to the natural environment as closely as practical.

5) NRC should continue to maintain a detailed awareness of external high-level waste programs, both nationally and internationally, and how they relate to NRC & DOE work. For this and related purposes it might be a good idea to develop milestone charts of considerable greater detail than has been done in the past. Such milestone charts should identify the customer for the activity, the time the results are needed and the identification of interim results. Furthermore, the charts should cover not only the NRC program but also the DOE and other programs. The discipline of preparing the charts would help the staff and also give the subcommittee confidence

that the interrelationships between the various parts of the program have been thought through. Such charts should be updated perhaps every six months. This would help to avoid duplication and provide positive synergism between different research efforts.

6) A great deal of chemistry is involved in the HLW program. This includes corrosion of containment, speciation of important nuclides and the adsorption-desorption characteristics of the appropriate nuclides. The speciation of the nuclides requires the identification of the pH, the temperature and the oxidation potential in the aqueous transporting media. The extensive report of uranium results was somewhat discomforting. Some uranium results are of course useful but not readily extrapolated to, for example, plutonium. The chemistry base may be in the program but it was not apparent to the subcommittee.

CLOSING COMMENTS

The Subcommittee appreciated the efforts by RES to provide an abbreviated update of the HLW activities. The oral presentations and written handouts were responsive to NSRRC requests. This does not mean, however, that the program does not need further focusing. The problems that must be solved should be identified clearly. Solution approaches should be selected that are practical and understandable. The proper role of the computer in these endeavors is still not clear. RES must continue its efforts to get firmly in control of the situation from a PA viewpoint. As noted in this report, additional Subcommittee meetings need to be planned for substantive agenda items.

One additional thought is that high-level waste problems cross many disciplines, as do most NRC research topics. Therefore, the use of terms specific to, for example, geology should not be done without definition of these terms. In future reviews, a supplementary list of definitions of terms and particularly acronyms would be helpful.