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

June 12, 1975

Mr. Ralph V. Carlone
Assistant Director
Resources and Economic Development Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Carlone:

This letter is in response to your letters of May 7, 1975 and June 3, 1975 which transmitted certain questions on which you sought the views of the Advisory Committee on Reactor Safeguards. The Committee completed its response to your questions at its 182nd Meeting, June 5-7, 1975. The Committee had the benefit of a Subcommittee Meeting in Los Angeles on May 30, 1975, at which representatives of the NRC Staff and of Aerojet Nuclear Corporation (ANC), the contractor responsible for LOFT construction, experiments and analysis, discussed the status of LOFT and other aspects of light water reactor safety research. Representatives of ERDA, EPRI, Westinghouse and Holifield National Laboratory were also present at the Subcommittee Meeting.

The Committee response to your questions is attached.

Sincerely,

/s/ William Kerr

William Kerr
Chairman

Attachment:
ACRS Response to Questions

cc: Honorable William A. Anders,
Chairman, NRC

Question 1

"In its November 20, 1974, letter report on Water Reactor Safety Research, the Committee recommended core work on emergency core cooling systems, including conceptual design work, analytical studies, investigations of ways ECCS performance might be optimized, and assessments of the overall reliability of ECCS. Within the same report, the Committee reiterated previous recommendations for research into phenomena involved in core meltdown, including the mechanisms, rate and magnitude of radioactive releases, ways to retain molten cores, or ameliorating their consequences, and the possibility and extent of steam explosions in the presence of large quantities of molten fuel and steel.

"What was the basis of the Committee's recommendation in its November 20, 1974, report as to the importance of conducting research into the phenomena involved in a core meltdown?

"Which of these two areas, ECCS and core meltdown, is more important, and why? Should LOFT be used for research on the core meltdown phenomena described above?"

Answer

In its August 16, 1966, reports on the Indian Point 2 and Dresden 3 reactors, the ACRS first recommended major improvements in emergency core cooling systems, and strong measures to reduce the probability of loss-of-coolant accidents including improved primary system quality, expanded inservice inspection, and improved leak detection. In its October 12, 1966, report on the reactor safety research program the ACRS first recommended a vigorous research program on potential modes of interaction between sizeable masses of molten mixtures of fuel, clad and other materials with water and steam, on the mechanisms of heat transfer connected with such molten masses, and other related mechanisms and phenomena. The ACRS also recommended that studies be initiated to develop reactor concepts with new safeguards to deal with low probability accidents involving primary system rupture followed by a functional failure of the emergency core cooling system.

The second major recommendation of the October 12, 1966, report related to the need for improved understanding of the loss-of-coolant accident (LOCA) and the phenomena important to a proper functioning of ECCS. The third and fourth recommendations related to methods of better assuring pressure vessel integrity.

The ACRS has reiterated its recommendations for safety research in these areas on many occasions, most recently in its November 20, 1974, report on Water Reactor Safety Research.

In effect, these actions by the ACRS represented an effort 1) to reduce the probability of occurrence of an accident 2) to assure the presence of reliable, conservatively designed ECCS to keep core temperatures within acceptable limits, should a LOCA occur and 3) to obtain knowledge concerning core meltdown and possible design steps to cope with or ameliorate the consequences of this unlikely event as a possible means of providing still greater protection of the public health and safety. The ACRS believes that the importance of the items is in the order stated; that is, first in importance is the prevention of accidents, and second in importance is the mitigation of consequences, should an accident occur.

Core meltdown can arise from a variety of initiating events; hence, if measures could be developed to cope with core melt, accidents other than LOCA might also be mitigated.

The ACRS view has been that the ECCS must be designed to cope with a complete spectrum of postulated pipe breaks, including sudden gross rupture of the largest pipe. To attain assurance in this regard, the Committee has persistently given the matter much attention, both in licensing reviews and in recommendations for safety research. The expected performance of currently designed systems satisfies existing criteria; the ACRS, nevertheless, has urged that still more reliable and capable ECCS be developed (see ACRS reports on Interim Acceptance Criteria of January 7, 1972, and on Acceptance Criteria of September 10, 1973).

With regard to safety research on core meltdown for LWR's, very little has been done in the ensuing years since 1966. The absence of adequate knowledge of relevant phenomena and of any serious design efforts on plant changes to cope with or mitigate core meltdown has handicapped evaluation of the true potential for enhancing protection of the public health and safety in this regard.

The ACRS has been advised that the Reactor Safety Research Division (RSR) of NRC will initiate a new program on core meltdown phenomena at a funding level of $500,000 in FY-76. The ACRS believes that research on both ECCS and core meltdown is important, and that the effort on the latter should be expanded.

The ACRS believes that LOFT would best be utilized in the next several years for experiments related to the performance of existing ECCS and for experiments intended to explore possible improvements in ECCS. Considerable study would be required before the usefulness of LOFT for core meltdown research could be ascertained. If it were to be useful in this regard, it would probably require major modification of the facility; any such experimental program should be preceded by out-of-pile and small-scale in-pile experimentation.

Question 2

"Are LOFT experiments likely to provide useful information in the following safety research areas:

"a. Lower plenum refill rates, core reflood rates, and impact of steam binding during a loss-of-coolant accident,

"b. Flow distribution of emergency core cooling water through the core prior to reflooding,

"c. Pressurized water reactor pump overspeed for a postulated downstream break, and

"d. System effects in the blowdown of boiling water reactors.

"Are these areas which LOFT should be emphasizing but is not?"

Answer

The LOFT experiments are expected to provide useful information on lower plenum refill rates, core reflood rates and some facets of steam-binding during a LOCA. However, measurements of these and other parameters in the expected environment are difficult to accomplish and accuracy will be limited. Also, some of the phenomena involved may be of greater or lessor importance in LOFT than in a large PWR. Hence, considerable analytical effort and experimental skill will be required to maximize the utility of the experiments.

The LOFT experiments are expected to provide limited information on the flow distribution of emergency core cooling water through the core prior to reflooding, via indirect measurements which will require considerable interpretation.

The LOFT experiments are not expected to provide useful information on pressurized water reactor pump overspeed for a postulated downstream break.

There are currently no planned experiments in LOFT which relate to systems effects in the blowdown of boiling water reactors.

The ACRS recommends no major redirection of the LOFT program. The possible acceleration of the current schedule for high power nuclear blowdown of LOFT (a small PWR) appears to be desirable, as is an acceleration of experiments intended to help assess the potential for improvement in new ECCS designs.

The LOFT program is properly placing emphasis on the development of an improved measurement capability, since more detailed and accurate measurements of the nature of fluid flow would make the experiments more valuable.

The adequacy of safety research programs other than in LOFT that are intended to study systems effects in LOCA-ECCS for boiling water reactors warrants early reevaluation.

The ACRS wishes to reemphasize a recommendation made in its report of November 20, 1974, concerning the need for a much expanded research program aimed at gaining a detailed understanding of the basic fluid flow phenomena and other mechanisms important to LOCA-ECCS.

Question 3

"In a letter to the AEC Chairman, dated November 12, 1969, the Committee pointed out that there are large differences in scale between LOFT and large water power reactors that will be difficult to account for. The Committee also said vendors have stated they will have to rely primarily and directly on analyses to demonstrate the effectiveness of their ECCS design in large water reactors, even if the LOFT integral series is performed.

"In view of this, is LOFT likely to result in any experimental data which is directly applicable to large commercial reactors? Why or why not?"

Answer

The LOFT program was reoriented to study LOCA-ECCS in 1967 following the emphasis by the AEC Regulatory Staff and the ACRS on the need for improved ECCS and a greater understanding thereof. Since the ACRS report of November 12, 1969, there has been an aggressive program to examine differences in scale between LOFT and large PWR's and to scale the LOFT

tests so that the usefulness of the experimental information obtained will be more nearly optimized. The active participation of the reactor vendors has been sought by ANC in evaluating and modifying the proposed test conditions. The contribution of LOFT will be to provide integral tests of the performance of systems in a small PWR. If successfully consummated with good and sufficient data, these experiments should provide important checkpoints for methods of analyzing LOCA-ECCS. Direct application of the experimental data from LOFT to large commercial reactors is not the objective of LOFT and cannot be done. Rational interpretation of the data, taking into account special geometries and different features of systems, will be necessary for the application of the LOFT results. One example of an important difference is that of core height, which could affect several different phenomena.

It is not clear to the ACRS that an adequate program of pre-prediction of the test results from LOFT actively involving the reactor vendors, now exists. The ACRS believes that this should be accomplished and in a way to minimize the influence of prior LOFT experiments on the pre-predictions.

Question 4

"Is a test reactor larger than LOFT needed for ECCS or core meltdown research?"

Answer

At this time the ACRS does not recommend that a test reactor larger than LOFT be constructed for LOCA-ECCS research. The ACRS expects that consummation of the LOFT experimental program, particularly by taking advantage of improvements in instrumentation, should provide considerable information on the thermal-hydraulic behavior of an integral system. Other programs involving separate effects tests will complement the LOFT program. An example is the Plenum Filling Experiment.

The ACRS understands that Reactor Safety Research (RSR) is contemplating a study of the need for new facilities to investigate LOCA-ECCS, and that these probably would be intended to facilitate the examination of three-dimensional flow effects and various improvements of ECCS. The ACRS favors such a study.

Although the originally planned experimental program for LOFT involved the measurement of the transport of fission products from a core which was caused to melt, this was not a program intended to study core meltdown per se, and core meltdown research is not now considered to be an objective of LOFT.

In response to Question 1, the ACRS has noted the nearly complete absence of a research program on core meltdown for light water reactors. The ACRS recommends that a study be made of potentially useful facilities for research in this area.

Question 5

"In its November 12, 1969, letter, the Committee said that while the LOFT integral test will provide some confirmatory results for the ECCS, no design-related or operation-related regulatory decisions for large water reactors have been identified that the LOFT integral experiments will resolve.

"In spite of this, should the licensing of commercial reactors be modified in any way pending the result of LOFT experiments or experiments on a larger test reactor?"

Answer

The ACRS believes that the Nuclear Regulatory Commission has continued to take a sufficiently conservative stand with regard to LOCA-ECCS in the licensing of commercial reactors so that no licensing modifications are deemed necessary prior to obtaining results from the LOFT tests. The ACRS, however, intends to pursue its recommendations that improvements for ECCS as outlined in its September 10, 1973, report on Acceptance Criteria for ECCS be sought and incorporated in current and future license applications for commercial power reactors.

Question 6

"The following paragraph concerning LOFT was included near the end of the same letter:

> 'The Committee is unanimous in its belief that, if the integral experiment program is to be implemented, every reasonable effort must be made to accomplish it on an improved time scale (to start high temperature tests before 1975), and at a reduced cost in order to make adequate funding available for other high priority safety research, even though this would require elimi-naton of the less essential elements of the program.'

"LOFT non-nuclear testing is currently scheduled to begin in late 1975 and cumulative total LOFT costs are running in excess of $155 million.

"What is the Committee's assessment of the impact LOFT schedule changes and cost growth have had on nuclear safety research?"

Answer

The ACRS believes now, as it did in 1969, that the large expenditures for the LOFT program, which have continued to increase since that time, have led directly or indirectly to deficiencies in several other aspects of safety research. In its report of November 12, 1969, the ACRS identified specifically several major areas of safety research which, in its opinion were inadequately funded; these continued to be inadequately funded for several years thereafter. However, as noted in its November 20, 1974, report, the ACRS acknowledges that the Commission's reactor safety research program has undergone reorganization and redirection, and has been augmented. Furthermore, a significant industry-sponsored program through the Electric Power Research Institute (EPRI) has been initiated on light water reactor safety. Overall, the ACRS believes that the current implementation efforts are notable improvements over past safety research activities.

The ACRS recommends an augmentation of the current light water reactor safety research funding level.

Question 7

"Does the relationship between NRC and ERDA insure that NRC can independently carry out the confirmatory research it deems necessary? Which of these two agencies should own LOFT? Which should operate LOFT?"

Answer

The ACRS has strongly encouraged the NRC Staff to develop independent evaluation capabilities and to assure itself of sources of independent expert consultants. The ACRS has, in times past, also recommended the establishment of a safety research group independent of development responsibilities and responsive to the needs of licensing bodies.

The ACRS believes it important that NRC can independently carry out confirmatory research which it deems necessary, and that this program be adequate for the needs. The proportion of this work which should be in-house to achieve the necessary independence from vendor and developmental (ERDA) groups has not been determined, although it appears that in the BWR case, more safety research by groups other than the vendor or EPRI should be sought.

The ACRS has not studied whether ERDA or NRC should own and operate LOFT. The ACRS believes that any arrangement must be such that the experimental program is responsive to the needs of NRC.

Question 8

"Did the 'practical value' clause of section 31a(4) of the Atomic Energy Act have any impact on AEC safety research in general or LOFT in particular before it was amended in 1970? Did it have any impact after it was amended?"

Answer

In its November 12, 1969, report the ACRS addressed the projected reduced funding for the water reactor safety research program and discussed the effect that the imposition of such restraints might have on high priority research matters. The Committee urged "that adequate funding be provided to permit timely pursuit of work on all high priority areas." The ACRS did not attempt to specify the mechanism for obtaining reactor safety research funds and did not specifically address the "practical value" clause either before or after it was amended.

The Committee has made similar recommendations concerning the need for reactor safety research, including many of the specific topics discussed above in the answers to Questions 1-7, in its testimony to the Joint Committee on Atomic Energy by Palladino and Okrent in 1966, Bush and Hendrie in 1970, and Mangelsdorf and Siess in 1972.

Question 9

"What mechanism is there for outsiders to bring questions concerning the technical soundness of the LOFT integral test series to the attention of the ACRS?"

Answer

The ACRS attempts to remain informed of outside opinion. In addition, it makes use of a wide spectrum of consultants. ACRS has given its attention to all questions or recommendations received by it.

Meeting of the ACRS and its Subcommittees are, for the most part, open to the public. Notices regarding these meetings are published in the Federal Register and provided to the news media. Written comments from any interested persons are invited, and oral statements or comments may be presented. On occasion the ACRS has invited knowledgeable members of the public to attend meetings and volunteer opinions on reactor safety and safety research.

In general the ACRS welcomes any questions or information which may assist it in trying to exercise its responsibilites.