ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
UNITED STATES ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

January 14, 1975

Honorable Dixy Lee Ray
Chairman
U. S. Atomic Energy Commission
Washington, D. C. 20545

Subject: SAFETY RESEARCH FOR LIQUID-METAL-COOLED FAST BREEDER REACTORS

Dear Dr. Ray:

At its 177th meeting, held on January 9-11, 1975, the ACRS completed a report on safety research for liquid-metal-cooled fast breeder reactors (LMFBR). The Committee had the benefit of a Subcommittee meeting on July 24-25, 1974, as well as Subcommittee and full Committee meetings dealing with the Fast Flux Test Facility (FFTF) and the Clinch River Breeder Reactor. The Committee last reported on LMFBR safety research in its report of December 17, 1970.

The Committee believes that substantial advances in our knowledge of fast reactor safety have resulted from the Commission's research program. In addition, LMFBR safety research is being pursued on a substantive scale in several other countries, and the interchange of information is relatively prompt, to the benefit of all concerned. The Committee wishes to emphasize the importance of early dissemination of new experimental results and analytical techniques, as well as relevant operating experience as it becomes available.

Since 1970, the AEC program on LMFBR safety research under the Reactor Research and Development Division (RRD) has grown appreciably. In addition, the Reactor Safety Research Division (RSR) is establishing a program to provide an independent confirmatory ability and source of consultants to the Regulatory Staff and ACRS. Furthermore, the Regulatory Staff has established its own Technical Assistance Program on LMFBR safety.

In its letter of December 17, 1970, the ACRS concentrated on four major aspects of LMFBR safety, (1) fuel failure propagation, (2) design basis accidents, (3) mechanical effects of nuclear accidents, and (4) post-accident heat removal. Since then, significant progress has been made in all four areas.

Fuel Failure Propagation

The experimental and analytical work on fuel failure propagation indicates that rapid failure propagation from pin to pin at normal operating conditions is unlikely. Gross propagation resulting from gradual blockage appears to be unlikely for oxide-fuel elements of current design. A considerably improved understanding of sodium boiling and voiding exists. Although progress has been made with regard to fuel-coolant interaction, this phenomenon may arise under a variety of situations, some of which remain to be properly explored.

As work on advanced fuels for LMFBR's is undertaken, it is important to recognize that new safety-related problems may arise with the new fuels. It is, therefore, desirable that the safety research program include investigations of these problems in a timely manner.

Progress has been made on the development of in-reactor instrumentation intended to detect and locate incipient or on-going fuel failure propagation; however, experiments to test and qualify various methods to perform such a function in the protection system of a reactor remain to be conducted.

Design Basis Accidents

Considerably more comprehensive accident analysis codes have been developed, with major application thus far to FFTF. It has become clear that if certain postulated accidents are to be pursued mechanistically to the end of the event (which could be a demonstrably subcritical and stable state), further analytical tools and experiments will be needed to follow the events subsequent to a situation which overheats much of the core but leaves it essentially in place. This so-called transition period involves complex geometry and a wide range of possible boundary conditions which may render unique solutions impractical. With increased understanding, however, it may be possible to make best estimates and bounding estimates with an acceptable degree of uncertainty. Sizeable theoretical efforts have been initiated on this aspect.

Some progress has been made on behavior of fuel elements in transients and accidents. However, definitive knowledge remains to be garnered in this area which is vital to many aspects of LMFBR accident analyses.

Mechanical Effects of Nuclear Accidents

Considerable experimental and theoretical progress has been made in this area, particularly on codes to calculate potential mechanical effects within the reactor vessel. The Committee recommends an active program to examine the potential for various feasible designs of primary system and primary containment to withstand a wide range of postulated energy releases in order to provide background knowledge for use in both safety design and evaluation.

Post-Accident Heat Removal

Some progress has been made with regard to the containment of molten fuel but at a slower pace than in the three areas discussed previously. This area is, however, now benefitting from significant augmentation, and from the focus provided from an intensive effort to prepare detailed engineering designs of an effective system to contain and cool a molten core.

An in pile experimental program should be developed to examine those problems and phenomena which require the use of actual materials and uniform internal heat generation in the fuel for their examination.

Other Topics

At the Subcommittee meeting on July 24-25, 1974, various other research programs relating to topics such as sodium fires, aerosol behavior, and means of primary system inspection were described by the AEC representatives. The Committee agrees both with the needs and the general plans outlined. In addition, the Committee encourages studies of the possible effects on aerosol behavior of radioactive species associated with recycle mixed oxide fuel.

The Committee wishes to emphasize the importance of obtaining a definitive characterization of the effects on people of exposures to plutonium and other transuranics. Associated research should consider recycled fuels, including the full range of fuel composition which can be anticipated throughout core life. Specific studies should be conducted to define the chemical nature and biological behavior of transuranic aerosols that may result from LMFBR accidents.

The Committee supports the initiation of probabilistic studies of the course of design basis accidents for specific conceptual designs. The Committee also suggests that studies be made of the course and consequences of various Class Nine accidents, similar (but in less depth) to that recently performed for light-water reactors.

The purposes and needs for new LMFBR safety research in pile test facilities were also discussed at the July 1974 ACRS Subcommittee meeting. This matter is quite properly under active investigation by both RRD and RSR. The categories of possible new facilities, their complexity, and their potential varied widely, and no definite recommendations were presented. It is likely that any new in pile safety research facility will be expensive and take a considerable time to obtain. The Committee believes it important to initiate steps to provide such facilities and to expedite decisions regarding their specific nature and capability. In this regard, the Committee offers several comments:

1) The longer range safety research needs for future, large commercial LMFBRs should be directly factored into the planning of new test facilities.

2) It may be desirable to consider several facilities, each with a specific major orientation or function, rather than a larger, more complex and expensive multi-purpose facility. For example, one facility might be intended primarily to meet the needs for testing instrumentation for rapidly detecting local overheating, fuel failure propagation, etc. A second facility might be intended primarily to examine performance characteristics and phenomena important to ex-vessel post-accident heat removal. And a third might be intended primarily to give improved information on the behavior of fuel elements during transients.

3) The Committee recognizes the importance of fuel and clad motion on the anticipated course of events during postulated accidents. It also recognizes the difficulty of performing experiments on a scale much larger than that currently possible and the difficulty of obtaining quantitative, definitive or even readily interpretable results from such experiments. Hence, the Committee recommends that rather explici definition of the expected experimental program be prepared and evaluated in connection with a potential new facility of this nature.

4) The Committee suggests that consideration be given to a few, well-instrumented, relatively well-defined "benchmark" disassembly experiments to provide confirmation of some of the significant input parameters and calculational techniques employed in analyses of postulated disassembly situations. If performed, such experiments would probably involve small systems, some of whose properties were designed to be similar to those of large reactors. In any case the capability to transfer knowledge gained from small experiments should be demonstrated prior to any such tests.

5) It may be desirable to explore the efficacy of a cooperative international facility in an instance where an important need is identified but the anticipated capital cost is too high for any single country to undertake alone.

In conclusion, the Committee again states its general approval of the current program in LMFBR safety research and emphasizes the need for expediting decisions on new programs and facilities to meet the safety research requirements of commercial LMFBRs.

W. R. Stratton did not participate in the preparation of this report.

Sincerely yours,

W Kerr

W. Kerr
Chairman