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

October 12, 1966

Honorable Glenn T. Seaborg
Chairman
U. S. Atomic Energy Commission
Washington, D. C. 20545

Subject: REPORT ON REACTOR SAFETY RESEARCH PROGRAM

Dear Dr. Seaborg:

For the past several years the Advisory Committee on Reactor Safeguards, at the request of the Division of Reactor Development and Technology, has reviewed and commented on the Commission's reactor safety research program. This activity gives the Committee an opportunity to keep currently informed of the content and status of the research program and to suggest modifications and additions on the basis of recent Committee experience in the course of reactor licensing reviews.

The following comments, therefore, are intended to emphasize the Committee's interest in the present program, and to suggest certain areas in which the Committee believes more research results are now or will soon be needed.

A. The Committee attaches special importance to the following areas.

1. A vigorous research program should be initiated promptly on the potential modes of interaction between sizeable masses of molten mixtures of fuel, clad and other materials with water and steam, particularly with respect to steam explosions, hydrogen generation, and possible explosive atmospheres. Work should be directed toward understanding the mechanisms of heat transfer connected with such molten masses of material, the kinds of layers formed at cooled surfaces, the nature and consequence of any boiling of the fuel, and the manner and forms in which fission products escape from bulk molten fuel mixtures. Further, studies should be initiated by industry to develop nuclear reactor design concepts with additional inherent safety features or new safeguards to deal with low-probability accidents involving primary system rupture followed by a functional failure of the emergency core cooling system.

2. Because of the importance of emergency core cooling as an engineered safeguard, studies on core cooling processes already underway within the AEC and industry should receive continued attention. Coolant distribution and heat transfer phenomena which could influence emergency cooling significantly should be examined to remove existing uncertainties, including those related to an assumed course of events where cooling is marginal or inadequate in sections of the core. Tests of actual spray cooling and core flooding systems under accident conditions warrant careful consideration.

3. Development of practical, effective methods for extensive periodic inspection of pressure vessels is of great importance. The current program in AEC and industry should be augmented, as necessary, to assure this. One or more practical systems for such inspection should be developed as soon as possible.

4. A strong program on the properties, homogeneity, and behavior of thick steel pressure vessel sections, including research areas described in the recently proposed program of the Pressure Vessel Research Committee, should be implemented by industry and the AEC. The work on thick-walled vessels should include a thorough study of potential failure modes under pneumatic loading for various flaw sizes and types, and the significance of the reduction in the energy absorption shelf as a function of neutron irradiation.

5. Because the Commission may be called upon to consider proposals to construct reactors utilizing prestressed concrete pressure vessels, the nuclear industry and the AEC should promptly institute a very active safety research program into such vessels, including their design for seismic effects. This program should include research into anomalous failure modes of such vessels, particularly under pneumatic loading. This work should encompass effects of potential structural defects or overloads and problems associated with closures, penetrations, and anchors.

6. The further development of advanced methods of calculating destructive reactivity transients in water-cooled reactors, including predictions of damage to the primary system, is recommended. Important phenomena, such as the mode, time-sequence, and effect of fuel element failure, should be identified and studied so that the phenomena are dealt with adequately in the over-all analyses. Also, the role of space-dependent kinetic effects should be fully identified.

When it reaches the operational stage, the planned PBF program should play an important part in identifying fuel failure modes. The large transient experiments in the Spert program have already been very useful. Further experiments with low-enrichment-fuel water reactors should be considered as a means of providing additional calibration points with which to test improved theoretical methods of predicting large reactivity transients. Such experiments may also uncover new or overlooked phenomena.

B. The following areas are, in the Committee's view, also of current and increasing significance.

1. The trend toward higher reactor powers may require larger pressure vessels, thus favoring steels stronger than modified A-302-B. Preliminary AEC and industrial irradiation effects programs on some higher strength steels have revealed a limited NDT shift at relatively high neutron exposures. Work on potential new pressure vessel steels should be augmented so that adequate information is available on radiation effects, fabrication and joining processes, fatigue effects, etc., prior to their application to reactor pressure vessels.

2. The complex interrelationships between flaw size, shape and orientation, flaw growth, and neutron exposure in pressure vessels are still incompletely established. The Committee suggests a continuation and expansion of existing programs in fracture mechanics and irradiation damage, including their relation to fabrication, welding, and heat treatment parameters. Potential for propagation into the base metal of cracks that initiate in cladding should be further examined.

3. A review and evaluation of nonnuclear industrial experience on pressure vessels, steam generators, valves, and other components of reactor primary systems, similar to the recent study of piping, should contribute to the safety of power reactors by providing recommendations for changes in their current design, fabrication, inspection, or operational practice. A thorough review should be instituted and information obtained from insurance companies, state regulatory groups, and industry associations.

4. In connection with the review of power reactors for construction permits and operating licenses by regulatory bodies, standard methods of calculating various important events, ranging from reactivity excursions to reactor blowdown following a postulated coolant system rupture, usually do not exist. Applicants use a variety of methods employing a range of parameters. It would be helpful if a series of calculational methods could be developed and placed into use, against which the methods and parameters used by individual applicants could be compared.

Alternatively, a series of reference problems (and solutions) might be established which the applicant could calculate by his particular methods, and the results studied to help judge their degree of conservatism.

Some computational methods are already being developed in connection with various safety research programs. Others could be developed. In expanding this program, the Division of Reactor Development and Technology should work closely with the Regulatory Staff to establish an appropriate series of standard methods or reference problems.

5. In view of the large amounts of recycled plutonium fuel that will probably be used in thermal reactors in the future, potential safety problems arising from the use of such fuel should be identified and appropriate information developed in timely fashion.

6. Since early detection of small leaks in primary coolant systems of reactors can provide considerable protection against more serious difficulties, existing leak detection methods should be evaluated from the safety standpoint and new techniques developed, if appropriate.

7. The dilution, dispersion, and transport of liquid radioactive wastes in surface waters (rivers, lakes, estuaries, bays and open ocean) are important factors in the siting of nuclear reactors. In addition to these phenomena, attention frequently needs to be directed toward biological concentration of radionuclides in aquatic life. It may be desirable to review previous work on this subject, including related reaearch on discharge of municipal and industrial liquid wastes. Preparation of a state of the art review of current knowledge, and delineation of areas where further research is needed, would be useful. A special evaluation of the impact of siting many reactors on the shores of the Great Lakes, in relation to retention and flushing characteristics and to accumulation of radionuclides in aquatic organisms, may also be desirable.

It should be noted that information developed in connection with several items listed above would not only help to enhance public safety, but would also contribute toward a more expeditious review of the large number of reactor projects anticipated for the future.

Sincerely yours,

Original signed by
David Okrent

Chairman