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

June 14, 1983

Mr. William J. Dircks
Executive Director for Operations
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Dircks:

SUBJECT: FRACTURE MECHANICS APPROACH TO PIPE FAILURE

During its 278th meeting, June 9-11, 1983, the ACRS heard a report from its Subcommittee on Metal Components and presentations from the NRC Staff and its consultants regarding a proposed criterion for replacing the double-ended guillotine break (DEGB) with a leak-before-break (LBB) concept when justified by an application of fracture mechanics to pipe failure.

The NRC has been a leader in supporting research to validate the application of both elastic and elastic-plastic fracture mechanics to nuclear systems and components. Over the last decade this has led to a sound basis for predicting the conditions under which cracks in the primary pressure boundary will be stable. In particular, this work has provided confidence in predicting the range of crack sizes that will be stable and grow slowly. That is, crack sizes that will leak but not break.

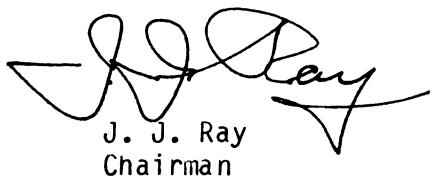
We believe it is now appropriate and fitting to apply this to the analysis of Task Action Plan A-2 dealing with the treatment of Asymmetric Blowdown Loads on Reactor Primary Coolant Systems. The central question here is whether the crack grows slowly to sizes well beyond those which will give detectable leaks, or if a pipe containing a crack too small to produce a detectable leak will suddenly and catastrophically break, and impose substantial asymmetric blowdown loads. Here, the fracture mechanics analysis clearly indicates that in PWR primary piping a substantial range of stable crack sizes exists between those which give detectable leaks, and the much larger size that results in a sudden failure. That is, there is no known mechanism in PWR primary piping material for developing a large break without going through an extended period during which the crack would leak copiously.

A related application of fracture mechanics concepts deals with predicting the growth of cracks by fatigue. These procedures were originally developed for the analysis of aircraft structures, but are now used in the ASME Boiler and Pressure Vessel Code. The Office of Nuclear Regulatory Research funded program at Lawrence Livermore National Laboratory has combined the fatigue crack growth and crack stability formalisms to estimate the probability of a safe shutdown earthquake causing the DEGB. This has shown that the

principal risk comes not from the direct growth of cracks to a size that would be ruptured by an earthquake, but from failure due to indirect causes such as the earthquake-induced failure of the supports of heavy components, e.g., the steam generators and pumps. We find this procedure to be an acceptable and proper approach to the problem, and the decoupling of the loss of coolant accident and seismic loads to be appropriate. However, any relaxation of requirements to cope with DEGB should be preceded by rigorous reexamination of the integrity of heavy component supports under all design conditions.

The exact changes in the regulations that will flow from these applications of fracture mechanics were not available at the time of our meeting with the NRC Staff. Thus, although we approve of the approach for considering stable crack sizes, we would like to have the opportunity to consider the implementation plans after these have been developed by the NRC Staff. When the Staff prepares these changes, we recommend that they document the positions of foreign regulatory bodies for various similar applications. Also, before these changes are extended to the oldest nuclear plants there should be clear assurance that the design and construction of the system involved is of the quality required.

Sincerely,



J. J. Ray
Chairman