October 22, 1996

The Honorable Shirley Ann Jackson
Chairman
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Jackson:

SUBJECT: CAPABILITY OF THE NRC SCDAP/RELAP5 CODE TO PREDICT TEMPERATURES AND FLOWS IN STEAM GENERATORS UNDER SEVERE-ACCIDENT CONDITIONS

During the 434th and 435th meetings of the Advisory Committee on Reactor Safeguards, September 12-13 and October 9-12, 1996, respectively, we held discussions with representatives of the NRC staff concerning the capability of the SCDAP/RELAP5 code to predict steam generator tube temperatures and flows under certain severe-accident conditions. An ACRS member attended a meeting on August 19-20, 1996, of the NRC-sponsored experts panel, which reviewed the adequacy of SCDAP/RELAP5 for the above conditions. We also had the benefit of the documents referenced.

Under some severe-accident conditions, natural convection carries hot steam and gases from the core through the hot leg and into the steam generator inlet plenum. Some fraction of the flow then goes from the inlet plenum through some of the steam generator tubes to the exit plenum and returns via the remaining tubes to the inlet plenum where it mixes with the flow from the hot leg. Countercurrent stratified flow occurs in portions of the core, in the hot leg, and in the steam generator inlet plenum. Either the hot-leg piping, the inlet-surge line, or the steam generator tubes are projected to eventually fail by high-temperature creep rupture. A failure of any one of these components will lead to depressurization of the reactor and probably preclude additional failures. The risk significance of such failure depends on which component fails first. If the steam generator tubes fail first, a containment bypass path could be created for radionuclide release directly to the environment. Such a scenario could be a significant contributor to risk.

In support of the steam generator integrity rulemaking, the NRC staff is using the SCDAP/RELAP5 code to examine steam generator tube integrity for severe-accident scenarios. Steam generator tube temperatures under these conditions are strongly dependent on the extent of mixing of the hot fluid entering the inlet plenum of the steam generator with the cold return fluid and the fraction of steam generator tubes that carry the hot fluid to the exit plenum of the steam generator. These phenomena cannot be

predicted mechanistically by a one-dimensional (1-D) lumped parameter code such as SCDAP/RELAP5, because they depend on the details of the countercurrent flow in the hot leg, the hot plume flow pattern in the

steam generator inlet plenum, and the characteristics of the entire recirculating flow.

If a 1-D lumped parameter code is to be used to analyze the above conditions, the key phenomena must be determined either by suitable supporting analyses or from experiments and then provided as input to the code. The NRC staff and its contractor have used the results of the 1/7-scale tests conducted by Westinghouse to "tune" the SCDAP/RELAP5 code and they have demonstrated that the code can adequately reproduce a limited subset of the test results. These 1/7-scale tests appear to be reasonably well designed and conducted. A panel of experts was convened by the NRC staff to review the adequacy of SCDAP/RELAP5 and the scaling analyses of the tests. Although the panel raised some questions that have not been addressed, it determined that SCDAP/RELAP5 is appropriate for predicting steam generator tube temperatures under severe-accident conditions.

However, we did not find the scaling analyses of the 1/7-scale tests to be completely satisfactory. The tests lack geometric similitude, i.e., the steam generator tubes are a factor of three too large and there are too few tubes. Additionally, the appropriateness of the dimensionless parameters used to scale the tests is questionable. Furthermore, fully developed forced-flow heat transfer correlations were used to represent conditions of mixed convection and developing forced flow, and radiative heat transfer was neglected.

The staff noted that the timing of tube failure is very sensitive to the tube temperatures. Such sensitivity suggests that the uncertainties in the temperature calculations need to be explicitly identified and their impact on this timing assessed. We believe that present NRC codes can be used for assessing uncertainties in the timing of component failures, if proper judgment is exercised by analysts to evaluate code results. We recommend that an appropriate uncertainty analysis addressing the above concerns, including the effects of radionuclide transport, be performed.

In our June 28, 1996 report, we stated that the present NRC codes were not capable of assessing steam generator tube ruptures under severe-accident conditions. Having had the opportunity to review the reports of the panel members and having had more detailed presentations on the use of the 1/7-scale tests to "tune" the SCDAP/RELAP5 code, we now believe that it can be used for the analyses required to support the development of the steam generator integrity rule.

We commend the staff for its competent and timely response to our earlier concerns and look forward to additional interactions on this important topic.

Dr. William J. Shack did not participate in the Committee's deliberations regarding this matter.

Sincerely,

/s/

T. S. Kress
Chairman

References:

1. Report dated June 28, 1996, from T. S. Kress, ACRS Chairman, to Shirley Ann Jackson, NRC Chairman, Subject: Severe Accident Research
2. Memorandum dated September 7, 1996, from I. Catton, ACRS Member, to ACRS Members, Subject: Conditional Probability of a Steam Generator Tube Rupture Following a Core Damage Accident
3. Memorandum dated August 27, 1996, from P. Griffith, Member of NRC-Sponsored Experts Panel, Massachusetts Institute of Technology, to Khatib-Rahbar, Energy Research, Inc., regarding Capability of NRC SCDAP/RELAP5 Code
4. Memorandum dated August 30, 1996, from M. Ishii, Member of NRC-Sponsored Experts Panel, Purdue University, to Richard Lee, Office of Nuclear Regulatory Research, NRC, regarding Capability of NRC SCDAP/RELAP5 Code
5. Letter dated September 11, 1996, from R. Viskanta, Member of NRC-Sponsored Experts Panel, Purdue University, to Khatib-Rahbar, Energy Research, Inc., Subject: SCDAP/RELAP5 Code Modeling of Natural Circulation Under Severe Accident Conditions, Fauske & Associates, Inc., Burr Ridge, Illinois, August 19-20, 1996

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