UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

March 11, 2005

Mr. Luis A. Reyes
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: PRESSURIZED THERMAL SHOCK (PTS) REEVALUATION PROJECT: TECHNICAL BASIS FOR REVISION OF THE PTS SCREENING CRITERION IN THE PTS RULE

Dear Mr. Reyes:

During the 520th meeting of the Advisory Committee on Reactor Safeguards, March 3-5, 2005, we continued our review of the technical basis for revision of the pressurized thermal shock (PTS) screening criterion in the PTS rule (10 CFR 50.61). This matter was also reviewed during a joint meeting of our Thermal-Hydraulic Phenomena, Materials and Metallurgy, and Reliability and Probabilistic Risk Assessment (PRA) Subcommittees on November 30-December 1, 2004, and at our meeting of December 2, 2004. During our review, we had the benefit of discussions with representatives of the NRC staff and the documents referenced.

CONCLUSIONS AND RECOMMENDATIONS

1. The PTS Reevaluation Project has developed a comprehensive technical basis for analyzing the susceptibility of reactor pressure vessels to PTS and to support rulemaking to revise the current PTS Rule (10 CFR 50.61).

2. The external peer review of the technical work was valuable, and the staff response to the criticisms and questions raised by the peer review panel has strengthened the technical basis.

3. The documentation for the project is not yet final, but significant progress has been made. One of the documents, NUREG-1809, "Thermal-Hydraulic Evaluation of Pressurized Thermal Shock," should be substantially revised.

DISCUSSION

The PTS Rule, 10 CFR 50.61, was established in 1985 to ensure the integrity of irradiation-embrittled reactor pressure vessels during overcooling events. Reactor pressure vessel steels undergo a transition from highly ductile behavior at high temperatures to brittle behavior at low temperatures. This change in behavior occurs abruptly over a narrow range of temperatures, and a temperature RT_{NDT} can be defined to characterize the transition in fracture behavior. Under irradiation, the transition temperature RT_{NDT} increases, making the vessel susceptible to brittle fracture at higher temperatures.

Estimation of the frequency of vessel failure requires: (1) identification of sequences that could lead to rapid cooling of the vessel and estimation of their frequencies of occurrence; (2) determination of the pressure, temperature, and heat transfer coefficient adjacent to the embrittled portion of the vessel for each of the event sequences; and (3) probabilistic fracture mechanics analyses to determine the probability of failure under the induced thermal and pressure stresses on the embrittled vessel.

The Reevaluation Project included systematic consideration of uncertainties in (1) the frequency of initiating events for PTS scenarios, (2) the thermal-hydraulic conditions that provide the driving forces for crack initiation and propagation, and (3) the characterization of the fracture toughness of the vessel materials.

A substantial experimental program to establish the thermal-hydraulic parameters was undertaken at the APEX facility at Oregon State University to supplement integral test data from Upper Plenum Test Facility (UPTF), Loss of Fluid Test (LOFT), Multiloop Integral System Test (MIST), and Rig of Safety Assessment (ROSA) facilities.

More realistic distributions for flaw density and geometry were developed based on detailed examination of welds and materials from vessels of cancelled plants and an elicitation of expert opinion. The accuracy and rigor of the probabilistic fracture mechanics code FAVOR, which is used in these analyses, has been improved. Much of this work is directly applicable to other situations involving embrittled pressure vessels such as providing a basis for reducing unnecessary conservatism in current regulation on operational limits on pressure vessel heatup and cooldown (Appendix G to 10 CFR Part 50).

The documentation includes a comprehensive summary report, NUREG-1806, that contains the comments of the peer reviewers and the staff responses to these comments. It also includes six reports on the thermal-hydraulic analyses; eight reports on the PRA studies; and eight reports on the probabilistic fracture mechanics code and analyses, the characterization of the fracture toughness of embrittled pressure vessels, and the characterization of crack distributions in pressure vessel materials and welds.

The focus of the current meeting was on NUREG-1809, "*Thermal Hydraulic Evaluation of Pressurized Thermal Shock,*" which provides a comparison of RELAP5 calculations with results from scaled, integral facility tests and some separate effects tests. The results from the test facilities span a wide range of flow conditions intended to be representative of those that occur in the vessel downcomer during a PTS event. These comparisons were used to develop quantitative estimates of uncertainties in the predicted values of the downcomer pressure and fluid temperature. These uncertainties are small compared to those that arise from the uncertainties in the boundary conditions for the scenarios such as break location, decay heat level, high-pressure injection (HPI) temperature, operator control of HPI, etc. Although the data that can be used to validate a model for the heat transfer coefficient are more limited than those available for validating downcomer pressure and fluid temperature, the results from the integral test facilities suggest that the models used for the heat transfer coefficient in the baseline PTS analyses were reasonably accurate and perhaps slightly conservative.

NUREG-1809 should be substantially revised and we would like to review the final revision. The PTS Reevaluation Project has required a substantial commitment of resources by the Agency. Good documentation is important to preserve the technical basis for revision of the PTS screening criterion.

We commend the staff for outstanding technical work in this multidisciplinary study, which provides a sound technical basis for the development of a revised 10 CFR 50.61.

Sincerely,

/RA/

Graham B. Wallis
Chairman

References:

1. EricksonKirk, M., et al., "Technical Basis for Revision of Pressurized Thermal Shock (PTS) Screening Limit in the PTS Rule (10 CFR 50.61): Summary Report," NUREG-1806, Draft for Peer Review Panel and ACRS Review, November 2, 2004.

2. Bessette, D. E., W. Arcieri, R. Beaton, and D. Fletcher, "Thermal Hydraulic Evaluation of Pressurized Thermal Shock," NUREG-1809, Draft, February 2005.