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The Honorable Kenneth M. Carr
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Chairman Carr:

SUBJECT: YANKEE ROWE REACTOR PRESSURE VESSEL INTEGRITY

During the 365th meeting of the Advisory Committee on Reactor Safeguards, September 6-7, 1990, we discussed the degree and consequences of the Yankee Rowe reactor pressure vessel embrittlement due to neutron irradiation. Our Subcommittee on Materials and Metallurgy discussed this matter with representatives of the NRC staff and the Yankee Atomic Electric Company during a meeting on September 5, 1990. We also had the benefit of the documents referenced.

It has recently come to the staff's attention that the reference temperature nil ductility transition (RTNDT) of parts of the Yankee Rowe pressure vessel may substantially exceed the temperature limits for action delineated in the pressurized thermal shock (PTS) rule (10 CFR 50.61). The main reason is that the Yankee Rowe core inlet temperature is about 50°F lower than that of other plants. Another reason is the higher nickel content of the lower vessel plate. These increase the rate of rise in RTNDT with fast neutron irradiation.

The exact value of RTNDT for the vessel is uncertain because of:

- Uncertainty in the copper and nickel content of the circumferential weld near the reactor vessel beltline.

- The absence of surveillance data for areas that appear to have the largest shift in RTNDT, namely the circumferential weld and the lower plate of the vessel.

Assurance of vessel integrity is further hindered by:

- The absence of any inservice inspection for flaws in the reactor vessel beltline region. Such inspection has been infeasible due to the design of the vessel internals.

- Relatively low toughness (low upper shelf energy) of the plate and welds near the core.

Analysis of the various safety issues involved leads to the conclusion that PTS is the issue of most concern. One bright spot in this picture is that several features of the plant's design make it less susceptible to overcooling events than more modern plants.

The licensee and the staff have both arrived at estimates of the shift in RTNDT. Both agree that the circumferential weld and the

lower plate of the pressure vessel have the highest RTNDT. However, in each case their estimates differ by about 150°F. The licensee's representatives argue that due to the particular microstructure of the steel in the vessel, the shift in RTNDT is independent of irradiation temperature and nickel content. We do not believe these arguments are valid, and agree with the staff that temperature and nickel effects must be included in a valid estimate of the shift in RTNDT. An additional difference between the staff and the licensee concerns estimates of the copper content of the circumferential weld. There being no measurements for the composition of the circumferential weld and a large spread in copper values found in other plants, the staff prefers to choose a bounding value. The applicant chose more of an average value. In view of the uncertainty in the value for the Yankee Rowe vessel, we would choose the staff's bounding value.

Given that RTNDT values for parts of the vessel probably exceed those requiring action under the PTS rule, is there significant risk in operating the plant? The low probability of a PTS challenge leads to a low risk, even with a high RTNDT. Thus, we agree with the staff that operation for one more cycle is acceptable, provided the licensee initiate an active program to better characterize the material in the vessel near the reactor vessel beltline. To do this the staff requires determination of the composition of the circumferential weld metal in the beltline by removing samples from the weld and development of an inspection method for the beltline welds and plate to depths of an inch below the inside surface of the vessel. Both of these have been required by the staff for completion before the startup of the 22nd fuel cycle (now scheduled to begin in early 1992). It is not clear that both can be achieved in that time, but certainly they should be accomplished in two fuel cycles.

The staff also requires "tests on typical Yankee Rowe base metal" to determine the effect of irradiation, austenitizing temperature and nickel content on embrittlement. It is doubtful that any tests that the licensee could perform during the next fuel cycle would convince us that the effects of temperature and nickel on embrittlement are substantially different from those established by the much more extensive studies already available. The effects are not well understood, and we believe prudence dictates tending more toward bounding values rather than best estimates based on limited new data that may become available.

However, the above will not adequately address the long-term operation of the plant. This is the lead PWR plant in the industry's Plant Life Extension (PLEX) program, and long-term operation with such large uncertainties in vessel integrity is unacceptable. The extended operation of this plant would be acceptable only if:

A state-of-the-art ultrasonic inspection can be done on essentially all of the radiation affected inner surface of reactor pressure vessel, e.g., one that complies with Appendices VII and VIII of Section XI of the ASME Code. This inspection

should also check for significant thinning in the lower head as a result of loose parts (irradiation capsules). Continued operation would be dependent on the absence of significant flaws.

A reanalysis of the PTS question is made using well established compositions for the material in the beltline region, or using limiting values of copper and nickel. This analysis should also include the fact that the crack arresting ability of such material will be lower than more modern steel because of its low upper shelf energy. Such an analysis must show acceptable risk.

Sincerely,

Carlyle Michelson
Chairman

References:

1. Letter dated July 5, 1990 from John D. Haseltine, Yankee Atomic Electric Company, to Richard Wessman, NRR, transmitting Reactor Pressure Vessel Evaluation, dated July 9, 1990

2. Letter dated August 31, 1990 from Thomas E. Murley, NRR, to Andrew C. Kadak, Yankee Atomic Electric Company, Subject: Yankee Rowe Reactor Vessel, with Enclosure