LETTERS TO THE EDITOR

COMMENTS ON "FAILURE PROBABILITY OF AXIALLY CRACKED STEAM GENERATOR TUBES: A PROBABILISTIC FRACTURE MECHANICS MODEL"

In Ref. 1, Mavko and Cizelj proposed a strategy for operating pressurized water reactor plants with certain sizes of cracks in the steam generator tubes. The purpose of this letter is to indicate that the proposed method of screening tubes for removal from service may not be sufficiently conservative.

Using a fracture mechanics model, Mavko and Cizelj calculated tube failure probability as a function of the critical crack length following a loss-of-feedwater accident. These results, together with measured crack length distributions, were then used to determine the maximum size of through-wall cracks that may remain in service.

The underlying assumption in this approach is that an actual tube rupture is required to fail a steam generator. It is shown below, however, that if the number of cracks is sufficiently large, significant primary-to-secondary leakage may result from cracks that are smaller than the critical size. Since the leakage rate and the location of the feed line or steamline break will determine how quickly the operator is able to isolate the faulted steam generator, a tube rupture alone is not a sufficient safety criterion for plugging tubes.

Fracture and fluid mechanics considerations[2] indicate that the flow through cracks increases when the pressure differential across the crack is increased. For the 10-mm-long crack discussed by Mavko and Cizelj in connection with plugging limits, an increase from normal operating pressures to design pressures causes the leakage per crack to increase from 0.13 to 0.40 gal/min. Since the flow through 1500 such cracks roughly equals a flow from one ruptured tube, it is apparent that significant flow can be attained through cracks that are smaller than the critical size without actually rupturing a single tube. Thus, a transient may initiate multiple leakages from small through- and partially through-wall cracks.

If one could reliably predict the total leakage increase following a transient, leakage limits during normal operation could reduce the possibility of a sudden increase in leakage during an accident. In the absence of data on flow through cracks under prototypical conditions, however, predictions of flow through thousands of cracks with varying morphology may not be a realistic basis for a "leak before break" strategy.

Even though the frequency of events that can cause a significant primary-to-secondary leak is low (e.g., 10^{-4}/reactor-yr), the frequency of a core melt with containment bypass may be close to the event frequency if the primary- and second-side pressures cannot be equalized promptly. This risk may not justify continuous operation with tubes containing through-wall cracks, even if such cracks are much smaller than the critical size.

[This comment contains information that does not necessarily represent an agreed-upon U.S. Nuclear Regulatory Commission (NRC) staff position. The NRC has neither approved nor disapproved its technical content.]

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REFERENCES

1. B. MAVKO and L. CIZELJ, "Failure Probability of Axially Cracked Steam Generator Tubes: A Probabilistic Fracture Mechanics Model," *Nucl. Technol.*, **98**, 171 (1992).

2. J. R. KURTZ et al., "Steam Generator Tube Integrity Program," NUREG/CR-2336, U.S. Nuclear Regulatory Commission (Aug. 1988).

RESPONSE TO "COMMENTS ON 'FAILURE PROBABILITY OF AXIALLY CRACKED STEAM GENERATOR TUBES: A PROBABILISTIC FRACTURE MECHANICS MODEL'"

In Ref. 1, a methodology to estimate the failure probability of axially cracked steam generator tubes was proposed to cope with degradation processes that are increasingly affecting steam generator tubes in the transition zone. The method makes the assumption, among others, that the length and number of cracks in the steam generator tubing has been reliably determined.