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J. D. Woodard
Vice President
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July 1, 1992

Docket No. 50-348

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

J. M. Farley Nuclear Plant - Unit 1
Steam Generator Tube Leakage Technical Specification

Gentlemen:

By letter dated June 3, 1992, the NRC requested additional information on the technical specification amendment reducing allowable steam generator primary-to-secondary leakage from 500 gpd to 140 gpd. Responses to the NRC request are provided in the attachment to this letter.

Respectfully submitted,

J. D. Woodard

JDW/REM:map 2460

Attachment

cc: Mr. S. D. Ebneter
Mr. S. T. Hoffman
Mr. G. F. Maxwell

SWORN TO AND SUBSCRIBED BEFORE ME

THIS 1st DAY OF July, 1992

(Notary Public)

9-14-94

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Attachment

Response to NRC Request for Additional Information

Dated June 3, 1992

1. Reference is made to the discovery of circumferential cracks which resulted in implementing an administratively reduced steam generator primary-to-secondary leakage limit. The reduced leakage limit was implemented in order to justify continued operation of Joseph M. Farley Nuclear Plant (Farley), Unit 1. Please provide the technical basis for why these cracks require the reduced primary-to-secondary leak rate limit.

   SNC Response

   During inspections of the Unit 1 steam generators (SG) at Farley Nuclear Plant, circumferentially oriented indications were discovered in the WEXTEX expansion transition in tubes within the sludge pile region and in the U-bend region of Row 1 tubes in SGs A, B, and C. These indications were discovered while conducting a 100% bobbin coil inspection of the tubes and a supplemental inspection of 100% of the hot leg WEXTEX expansion transitions in each SG using rotating pancake coil (RPC) probes. The U-bend region of the row 1 and 2 tubes was also inspected in each SG using RPC probes. The circumferential indications in the WEXTEX expansion transition were located in the central, sludge pile region of the SGs. This location agrees with previous industry experience. The U-bend region cracking occurred at the tangent point and the apex locations of the tubes.

   This inspection was the first 100% of the hot leg expansion transition region using RPC probes. A review of past bobbin inspections at the same locations revealed distorted bobbin indications as early as 1985. Therefore, it is reasonable to expect that the existing circumferential indications developed over a number of cycles and not just the previous cycle. However, no growth rate can be obtained based on the previous inspections since this is the first RPC probe inspection.

   All tubes identified with circumferential indications were removed from service by plugging. A total of 41 tubes with circumferential indications were plugged; 36 tubes with indications at the top of the tubesheet; 5 row 1 tubes with indications in the U-bend region.

   For the row 1 U-bend region circumferential cracks, the application of the U-bend heat treatment process during the last outage is expected to minimize any residual tensile stresses in the tubing and minimize crack growth in subsequent plant operation. Although crack growth may still occur, removal of the residual tensile stresses that are much higher than the normal pressure stress is expected to significantly reduce the normal slow crack growth rate of PWSCC.

   Relative to the tube burst strength considerations for the Farley Unit 1 7/8 inch diameter and 0.050 inch wall thickness SG tubing, the maximum allowable single, through-wall, circumferentially oriented crack extent for tubes within the SG tube bundle is 220°. This angle of involvement meets all the requirements of normal, upset, and accident loading conditions. The controlling factor is the 3 times normal operating differential pressure requirement.

The detection of circumferential cracks is more likely accomplished using an RPC probe than using the bobbin probe. The industry accepted detection threshold for determining the presence of a circumferential crack using an RPC probe for 50% through-wall penetration is approximately 40°. The detection threshold for through-wall circumferential cracks is approximately 25° of circumferential arc. Eddy current uncertainty using the RPC in determining crack arc length for through-wall cracks is approximately 22°. The average crack growth rate expected for the progression of a crack around the circumference of a tube is 45° per fuel cycle, based on growth rates estimated for another plant and corrected for Farley operating temperatures.

Therefore, the maximum end of cycle circumferential crack existing at the RPC detection threshold at the beginning of the cycle for Farley would be approximately 107°, i.e., 40° initial crack + 22° uncertainty + 45° growth. Based on the 220° critical crack length, an available safety margin of at least 113° arc is available for tubes in the sludge pile region.

Should cracking continue at Farley Unit 1, the most likely pattern would be the eventual development of a segmented crack morphology having through-wall cracks of 35° arc on the average at several locations. If a series of cracks with typical aspect ratios develops, as many as eight 35° cracks with 20 mil ligaments separating the individual cracks would be expected to leak at 140 gallons per day. A single, through-wall crack such as might occur due to the loss of a ligament between two 35° cracks would similarly leak at 140 gallons per day.

Therefore, the conservative 140 gallon per day limit provides additional assurance that should a circumferential crack propagate at an unexpectedly high rate or if two individual 35° through-wall cracks should combine, sufficient time will exist to shutdown Farley Unit 1 prior to a postulated SG tube rupture.

2. A 140 gallon-per-day (gpd) leakage limit per steam generator has been proposed for Farley, Unit 1, based on the finding of circumferential cracks during the last inservice inspection. The technical basis to demonstrate that the 140 gpd primary-to-secondary leakage limit is sufficient to meet the guidelines contained within Regulatory Guide 1.121 should be provided.

<u>SNC Response</u>
The NRC Regulatory Guide (RG) 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes", issued for comment, addresses tubes with through-wall cracking. Any through wall crack morphology that is projected to result in a condition such that the limiting crack morphology is exceeded during an operating interval when a corrosion growth allowance for continued degradation and an eddy current uncertainty are considered, is unacceptable for use. By also involving an allowance for continued degradation and for nondestructive examination detection accuracy, its use establishes a reactor coolant pressure boundary that should have an

extremely low probability of abnormal leakage, rapidly propagating failure, and of gross rupture. The required confirmation that the leakage rate limit being used is less than the leakage rate of the largest permissible crack (leak-before-break) completes the "defense in depth" approach of RG 1.121.

Per paragraph C.3.d of RG 1.121, the analytical and loading criteria applicable to tubes with through-wall cracks in thinned and unthinned tubes are:

1. Through-wall cracks in minimum thickness tubes should not propagate and result in tube rupture under accident conditions combined with safe shutdown earthquake.

2. The maximum permissible crack length of the largest single crack should be such that the burst pressure is at least 3.0 times the normal operating pressure differential.

3. The leakage rate limit under normal operation should be less than the leakage limit determined for the largest permissible crack.

The primary stress calculations should also consider all the stresses and tube deformations imposed on the tube bundle during postulated accident condition loadings. Additionally, all major hydrodynamic and flow induced forces (primary and secondary) should be considered in the analysis to determine the limiting crack morphology.

As stated in the response to question 1 above, relative to the tube burst strength considerations for the Farley Unit 1 7/8 inch diameter and 0.050 inch wall thickness SG tubing, the maximum allowable single, through-wall, circumferentially oriented crack extent for tubes within the SG tube bundle is 220°. This angle of involvement meets all the requirements of normal, upset, and accident loading conditions. The controlling factor is the 3 times normal operating differential pressure requirement. The 220° critical angle was determined based on analyses for:

a. Tubes within the sludge pile region with dented (or fixed) support boundary condition at the first tube support plate elevation, the most limiting boundary condition, for flow induced vibration loadings at normal operating conditions and for steam line break. Significantly large circumferential cracks in the peripheral regions of the SG are not expected based on past experience at Farley Unit 1 and at other plants.

b. Loss of Coolant Accident (LOCA)

c. Safe Shutdown Earthquake (SSE)

d. Combination of LOCA + SSE

e. Combination of Steam Line Break (SLB) + SSE

Consequently, criteria 1 and 2 above are satisfied.

Concerning criteria 3, as stated in the response to question 1 above, should cracking continue at Farley Unit 1, the most likely pattern would be the eventual development of a segmented crack morphology having through-wall cracks of 35° arc on the average at several locations. If a series of cracks with typical aspect ratios develops, as many as eight 35° cracks with 20 mil ligaments separating the individual cracks would be expected to leak at 140 gallons per day. A single, through-wall crack such as might occur due to the loss of a ligament between two 35° cracks would similarly leak at 140 gallons per day. Therefore, the 140 gallon per day limit is significantly less than the leak rate expected for a 220° critical crack.

Additional conservatism is added based on the determination of the 220° critical crack. The critical crack is modeled as a single crack of through-wall extent equal to the angle measured by RPC. Destructive examinations of pulled tubes support a segmented crack morphology, which would result in a predicted burst pressure significantly higher than the single crack model for equal circumferential involvement.

Therefore, the 140 gallon per day limit provides additional assurance that should a circumferential crack propagate at an unexpectedly high rate or if the ligaments separating individual cracks should rupture, sufficient time will exist to shutdown Farley Unit 1 prior to a SG tube rupture.