NRC-00-004

Wisconsin Public Service Corporation
(a subsidiary of WPS Resources Corporation)
Kewaunee Nuclear Power Plant
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920-388-2560

January 17, 2000

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Ladies/Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Additional Information for Proposed Amendment 164 to the Kewaunee Nuclear Power Plant Technical Specifications: Extension of Use Through Cycle 24 of the Length Based Pressure Boundary Definition for Westinghouse Steam Generator Hybrid Expansion Joint Sleeved Tubes

References:
1) Letter from M.L. Marchi (WPSC) to Document Control Desk (NRC), dated June 22, 1999
2) Letter from M.L. Marchi (WPSC) to Document Control Desk (NRC), dated December 2, 1999

In reference 1 Wisconsin Public Service Corporation submitted a proposed Technical Specification (TS) amendment. The amendment extends the use of the length based pressure boundary definition for Westinghouse steam generator hybrid expansion joint (HEJ) sleeved tubes through Cycle 24. During their review the NRC staff requested additional information regarding the submittal. Reference 2 transmitted the requested information. The attachment to this letter provides additional information relative to the capability of a Westinghouse Hybrid Expansion Joint (HEJ) sleeve with a Parent Tube Indication (PTI) to meet the structural recommendations of Regulatory Guide 1.121.

WPSC continues to express its appreciation to the NRC staff for their timely review of this proposed TS amendment. We will continue to support this review effort by providing any needed additional information. Please contact Mr. Tim Olson of my staff at (920) 388-8443 if you have any questions or require additional information.

Sincerely,

Mark L. Marchi
Vice President–Nuclear

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TPO
Attachment
cc - US NRC, Region III
US NRC Senior Resident Inspector
Electric Division, PSCW

ATTACHMENT

Letter from Mark L. Marchi (WPSC)

To

Document Control Desk (NRC)

Dated

January 17, 2000

Additional Information for Proposed Amendment 164 to the Kewaunee Nuclear Power Plant Technical Specifications: Extension of Use Through Cycle 24 Of the Length Based Pressure Boundary Definition for Westinghouse Steam Generator Hybrid Expansion Joint Sleeved Tubes

Background

By letter dated June 22, 1999 (reference 1), Wisconsin Public Service Corporation (WPSC) submitted a proposed Technical Specification (TS) amendment to extend the use of the length based pressure boundary definition for Westinghouse steam generator (SG) hybrid expansion joint (HEJ) sleeved tubes through Cycle 24. During their review the NRC staff requested additional information regarding the submittal. By letter dated December 2, 1999 (reference 2), WPSC provided the requested information.

The reference 2 letter discussed the influence of both ligamentation and an interference lip in providing additional HEJ joint strength relative to the test configuration. Taking this into account, the combined probability of any parent tube indication (PTI) not meeting Regulatory Guide (RG) 1.121 structural margins at the end of cycle (EOC) 24 was reported to be 6.5×10^{-4}. Upon further examination, WPSC feels that the reference 2 letter underpredicted the influence of ligamentation on HEJ joint strength.

Provided below is a re-evaluation of the effect of ligamentation on HEJ joint strength and a revised combined probability of any PTI not meeting RG 1.121 structural margins at the end of cycle 24.

Evaluation of the Effect of Ligamentation on HEJ Joint Strength

In the reference 2 submittal, an EOC arc length up to 240 degrees was justified as providing additional HEJ joint strength by the presence of at least a 120 degree ligament. This was based on testing performed in 1994 (as reported in reference 3 of WCAP-15050) which demonstrated that a 120 degree ligament will withstand axial loads in excess of 3 times normal operating differential pressure ($3\Delta P$) end cap load without suffering plastic overload failure in the ligament region.

This was an extremely conservative assumption in light of tube pull results. For the two tubes destructively examined in 1995, field arc length measurements indicated 300 to 360 degree degradation while parent tube ligament failure loads exceeded 10,000 lbf (the end cap load corresponding to $3\Delta P$ for the Kewaunee SGs is approximately 2450 lbf).

An alternative approach in predicting the influence of ligamentation on HEJ joint strength is to define the amount of ligamentation necessary for a PTI to satisfy RG 1.121 structural margins. This is provided below.

A normal distribution can approximate the EOC 24 distribution of PTIs (Figure 6 and Figure 7 of reference 2). For a given test pressure, the probability function of a normal distribution is represented as follows:

$$F(y) = \frac{1}{\sigma\sqrt{2\pi}} \exp^{-\frac{1}{2}[(y-\mu)/\sigma]^2} dy$$

where y = test pressure
μ = mean
σ = standard deviation

Since there are many different normal curves (depending on the parameters σ and μ) there are infinitely many possible normal distributions and it becomes impossible to tabulate areas (probabilities) for all normal curves. However, by specifying the probability that a variable y lies within a certain number of standard deviations of its mean, only one table of probabilities is needed. The number of standard deviations that the variable y lies away from the mean is given by the following formula:

$$z = \frac{y - \mu}{\sigma}$$

Given the above, a differential pressure can be calculated corresponding to a probability of 0.05% that a PTI will have a pressure less than that calculated. Pressure is calculated as follows:

$y = \mu \pm z\sigma$

where μ = 5571 psi (from Table 4 of WCAP-15050)
σ = 486 psi (from Table 4 of WCAP-15050)

The value of z corresponding to a probability of 0.99995 is 3.89 for a one-tailed distribution.

$y = 5571 - (3.89)(486) = 3680$ psi

Therefore, there is a probability of 0.05% that the burst pressure of any PTI at the test specimen configuration (100% throughwall for 360°) will be below 3680 psi when observing a value from a normal distribution with a mean of 5571 psi and a standard deviation of 486 psi. Conversely, there is a probability of 99.95% that the burst pressure of a PTI at the test specimen configuration will be greater than 3680 psi.

In order for an inservice PTI to withstand 3ΔP pressures without burst, it follows that the remaining ligament must be able to with withstand a load corresponding to an 1120 psi pressure load (4800 psi–3680 psi). Testing performed in 1994 (as reported in reference 3 of WCAP-15050) demonstrated that a 120° ligament would withstand axial loads in excess of 3ΔP end cap loads without suffering plastic overload failure in the ligament region. Therefore, the arc length necessary to withstand an internal pressure of 1120 psi is as follows:

$$\frac{1120 psi}{4800 psi} \times 120° = 28°$$

As a result, the limiting EOC 24 arc length for an inservice PTI necessary to satisfy with a high probability the structural margins of RG 1.121 is 332°. Based on the postulated EOC 24 frequency distribution of PTIs, there are 12 tubes (10 in SG A, 2 in SG B) with PTIs greater than or equal to 330° in arc length. As the EOC 24 population of PTIs numbers 712 tubes (570 in SG A, 142 in SG B), the probability of a PTI with ligamentation less than 30° is 0.0169 (12/712).

Conclusions

Table 4 of WCAP-15050 provides the summary of failure pressure test results for the specimens used in the qualification testing of HEJ joint strength. As reported in WCAP-15050, the probability of failure of the HEJ joint test configuration, at a differential pressure of less than 3ΔP is approximately 5%. This is for an HEJ joint with a 360°, 100% throughwall PTI located 0.95 inches from the HRUT, i.e., with no consideration of an interference lip or ligamentation providing additional strength. The PTIs found in the Kewaunee SGs are different than the HEJ test configuration, i.e., a large majority of the PTIs contain both an interference lip and/or ligamentation, which provides additional strength relative to the test configuration.

Taking into account the influence of both ligamentation and an interference lip in providing additional strength relative to the test configuration, the combined probability of any PTI not meeting RG 1.121 structural margins at the end of cycle 24 is as follows:

$P_T = P_A \times P_I \times P_L$

P_T is the combined probability of any inservice PTI not meeting RG 1.121 structural margins. P_A is the probability of a PTI test specimen not meeting RG 1.121 structural margins. As reported in WCAP 15050, this value is approximately 0.05. P_I is the probability of an inservice PTI not exhibiting the required interference lip. As reported in reference 2, this value is 0.07. P_L is the probability of an inservice PTI not exhibiting the required ligamentation and is defined above as 0.0169.
As a result,

$P_T = P_A \times P_I \times P_L$

$= 0.05 \times 0.07 \times 0.0169$

$= 5.9 \times 10^{-5}$

As there are 712 postulated tubes with PTIs at EOC 24, the total number of tubes that may not meet RG 1.121 margins at the end of cycle 24 is 0.042. Therefore, it can be concluded that all PTIs left in service at the end of cycle 24 will meet RG 1.121 guidelines with regard to structural integrity. This is without consideration of tube restraint provided by the tube support plates.