SUMMARY TECHNICAL REPORT

EVALUATION OF FLAW INDICATION(S) IN THE PERRY FEEDWATER NOZZLE TO SAFE-END WELDS EXAMINED DURING RFO-3

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STRESS FIELD DISCUSSION

No supporting analysis is necessary for flaws in the region a/t <= 30% since the Mechanical Stress Improvement Process (MSIP) has been applied for flaws in this envelope, thus introducing compressive stresses (negative stress intensity (K_I)) which prevent further flaw growth. Growth of any flaw that may exist within the envelope a/t <= 30% and ($L/2\pi r$) <= 10% is assumed to be fully mitigated by application of MSIP as discussed previously in letter PY-CEI/NRR-1463L dated March 4, 1992, and in Generic Letter 88-01 and NUREG-0313, Rev. 2.

Concerning the NRC staff concern involving shrinkage effects on the piping system from application of mechanical stress improvement (reference Generic Letter 88-01, Supplement 1, Item #5), it is actually the case that MSIP produces elongation. The change in axial length is hardly field measurable, with typical elongation in the range of 10 to 15 mils, producing negligible impact on the piping system.

The two feedwater nozzle safe-ends are loaded by the feedwater pipe which was analyzed in GE Report 23A6987, Revision 1. The GE steady state piping analysis results were used and included the effects of snubber reduction and provide axial, bending and thermal expansion effects on the nozzle safe-end. The GE generated piping reaction loads were previously considered in determination of the Acceptance Criteria.

ACCEPTANCE CRITERIA

The flaws in the safe ends are at or close to the Inconel 182 buttering and SA 508 Class 1 interface. Figure IWB-3641-1 in ASME Section XI indicates flaws in [illegible]oximity of the weld are considered to be in the weld. The affected welds were made by the SMAW process which dictates using ASME Section XI, Paragraph C3320 (c) for the acceptance criteria for the flaw.

The equations found there are based on a relationship between the collapse load and flaw size at incipient plastic collapse. The acceptance level a/t (flaw depth to thickness) is set at a maximum 60% by the ASME so that any calculated allowable values of a/t greater than 60% default to this value, while a/t values calculated to be less than 60% retain their calculated values. The horizontal a/t acceptance line in Figure 1 herein for all flaw lengths illustrates that all calculated values of allowable a/t, from $(L/2\pi r)$ = 0% to 100%, exceed the 60% limit and defaulted to the a/t = 60% limit.

Figure 1 shows the acceptance envelope of 60% a/t for all service levels, since emergency and faulted conditions produce negligible effects on the final projected flaw depth. The acceptance envelope is based on the combination of Primary Membrane Stress (P_m), Primary Bending Stress (P_b) and Thermal Expansion Stress (P_e), including seismic loadings obtained from the feedwater piping analysis. Included in these stresses are the effects of snubber reduction analyses performed by GE on the feedwater piping.

CRACK GROWTH DISCUSSION

The two initial flaws detected during RFO-2 were both 0.15 inches deep (12.5% of wall thickness) and oriented circumferentially on the inside surface of the nozzle safe end. The longest and therefore bounding flaw was detected in nozzle N4C and measured 2.9 inches in length (7.5% of circumference). The sizing results of both the pre-MSIP and post-MSIP examinations conducted during RFO-3 are included in Table 1. The RFO-3 pre-MSIP examination detected insignificant change in the nozzle N4C bounding flaw and insignificant change in the initial flaw detected in nozzle N4E, as compared to RFO-2 sizing results. Figure 1 demonstrates the ample margin that exists between the size of the existing bounding flaw (Nozzle N4C) and the ASME Code Section XI acceptance criteria.

RFO-3 examination of nozzle N4E detected one additional nonreportable (small) flaw, not previously detected, approximately 160° circumferentially distant from and independent of the initial flaw detected during RFO-2. This nonreportable flaw is also bounded by the N4C nozzle indication.

All the "intergranular stress corrosion cracking (IGSCC) non-resistant" reactor vessel nozzles were inspected during RFO-3 by ultrasonic examination. Feedwater nozzles N4C and N4E were the only nozzles in which indications were detected. These flaws, located in the feedwater nozzle to safe-end weld areas on nozzles N4C and N4E, are characterized as planar circumferential defects on the inside diameter. As shown on Figure 1, the size of the bounding indication remained within the 30% depth/10% circumference envelope provided within NUREG-0313, Rev. 2. MSIP has been performed on the nozzles containing

CRACK GROWTH DISCUSSION

(continued)

these indications. MSIP is assumed to be effective and curtails flaw growth inside the envelope $a/t <= 30\%$ and $(L/2\pi r) <= 10\%$. A net compressive stress occurs inside the envelope when MSIP is applied, thus producing a negative stress intensity K_I so that flaws in this region would not continue to grow. Therefore, no further crack growth calculations are necessary.

CONCLUSIONS

The two reportable flaws, as resized in RFO-3, one in N4C and one in N4E, are well within the NUREG 0313 Revision 2 allowable flaw size "envelope" for stress improvement by MSIP to be considered fully effective in flaw mitigation. MSIP was applied this outage (RFO-3) and post-MSIP UT examinations of nozzles N4C and N4E indicate no appreciable changes in flaw size due to the MSIP application (see Table 1). Since the flaws remained in the 30% depth/10% circumference envelope during the full Operational Cycle 3, and since the MSIP application can thus be considered fully effective in further crack mitigation, no crack growth calculations are required to justify a full Cycle 4 operation (12,000 hours). Per NUREG 0313 Revision 2, Paragraph 5.3.1.5, the inspection category for these two feedwater nozzles is upgraded to Category E for subsequent inspections as a result of stress improvement. Figure 1 illustrates the position of the bounding flaw from RFO-2 and RFO-3 flaws (nozzle N4C) in the 30% depth/10% circumference envelope of the flaw acceptance criteria. The change of the flaw size from RFO-2 to RFO-3 is insignificant so the two points are coincident on Figure 1. Figure 1 also shows the ample design margin that exists between the size of the current bounding flaw and the ASME Code acceptance limit.

CONCLUSIONS

(continued)

Although no crack growth calculations were required this outage, it should be noted that snubber optimization has been implemented on the NSSS portion of the feedwater lines during this outage (RFO-3). As discussed in Letters PY-CEI/NRR-1374L dated October 18, 1991 and PY-CEI/NRR-1463L dated March 4, 1992, this Summary Technical Report serves as the case-specific evaluation required per Regulatory Guide 1.84 when Code Case N-411-1 (alternative damping values for response spectra piping analysis; reference Condition #5) is utilized on piping where IGSCC has occurred. This case-specific evaluation is being submitted for NRC review even though the presence of intergranular stress corrosion cracking could not be definitively confirmed based upon the results of the inspections. The case-specific evaluation by CEI has considered the RFO-3 inspection results and MSIP mitigation effectiveness, as discussed above, as well as revised nozzle loadings [illegible] snubber optimization re-analyses for the feedwater system. The [illegible] of this evaluation find the use of Code Case N-411-1 to be fully acceptable. Due to the above, no additional actions pursuant to Regulatory Guide 1.84/Code Case N-411-1 are considered necessary.

ASME XI IWA 3200 REPORTED SIZE

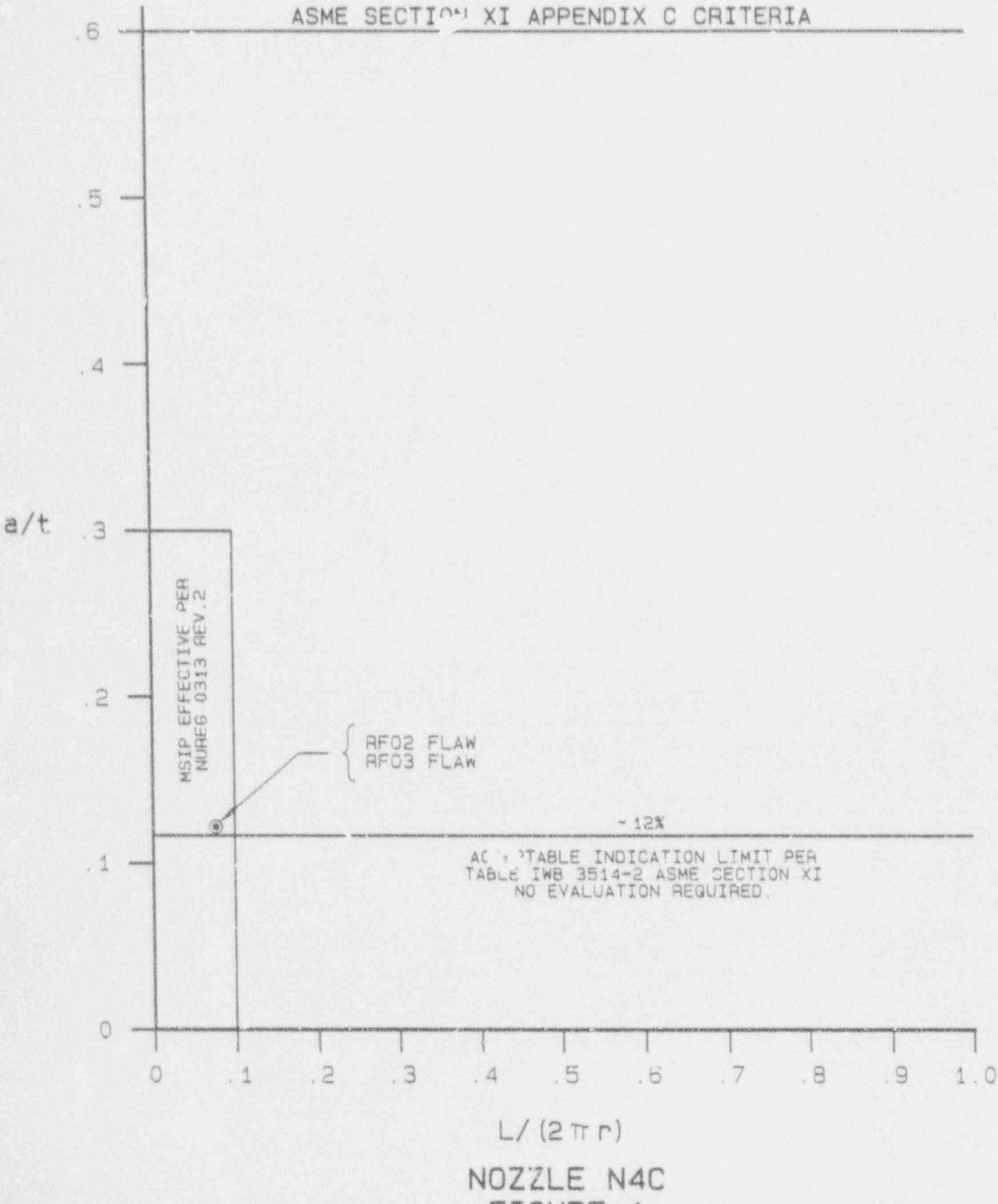
FEEDWATER NOZZLE TO SAFE - END WELD INDICATION SIZING (PERRY UNIT 1)

	RFO #3 PRE-MSIP MANUAL UT (IN)	RFO #3 PRE-MSIP AUTOMATED UT (IN)	RFO #3 POST-MSIP AUTOMATED UT (IN)	RFO #2 MANUAL UT (IN)
N4E #1	0.15 x 1.8	0.15 x 1.7	0.15 x 1.6	0.15 x 1.6
N4E #2	0.10 x 0.8	0.10 x 0.8	0.10 x 0.55	N/A
N4C #1	0.15 x 2.9	0.15 x 2.8	0.15 x 2.4	0.15 x 2.9

NOTES: I.D. CIRCUMFERENCE - 38.45 (IN)
WALL THICKNESS - 1.2 (IN)

TABLE 1

FLAW ACCEPTANCE CRITERIA
CIRCUMFERENTIAL FLAW IN SMAW



NOZZLE N4C
FIGURE 1

RFO-3 SIZING OF N4C AND N4E FLAWS UTILIZING THE P-SCAN SYSTEM

Historically, automated inspection systems have proven to yield more accurate and repeatable results for planar flaw sizing when compared to manual sizing. In RFO-2 time and procedure contraints prohibited the use of automated sizing on the detected N4C and N4E nozzle to safe-end flaws. In RFO-3, automated sizing utilizing the P-SCAN (Projection Imaging Scanning) system was used to supplement the pre-MSIP manual sizing, and was solely used for the post-MSIP sizing.

After the nozzles had been inspected with the P-SCAN system in the imaging mode, the flaw locations and areas of maximum amplitude were determined during data analysis. Data was then collected from each area with two refracted longitudinal wave probes, ADEPT-60 and 45SEL, and two shear wave probes, 48ET-3 and MWB60-2, with the system in the A-SCAN mode.

Using standard sizing analysis techniques, each individual A-SCAN in the area of interest was analyzed for flaw tip signals and flaw opening signals. In addition, the SuperSAFT (Synthetic Aperture Focusing Technique) software was also used for A-SCAN reconstruction and image enhancement. The purpose of the SAFT process is to provide a more accurate and detailed image of the area of interest. Utilizing these different techniques ensures a high level of confidence in the reported flaw depth and location.

To determine the length of the flaw, a sub-volume scan was performed on each area of interest. This provides higher resolution of the flaw area. During analysis the attenuation is adjusted until the material noise level is attained. By observing where the flaw extremities recede into the material noise level, the flaw length is determined.

As discussed with the NRC Staff in the April 29, 1992 teleconference, the pre-MSIP manual and automated depth sizing results of the N4C and N4E flaws were to be within 2% (of wall) of that reported in RFO-2. The manual and automated depth sizing data correlated well. Both techniques exhibited favorable flaw signal to noise ratio of 15db or greater and indicated essentially the same depth. Due to the good correlation between the pre-MSIP automatic and manual sizing data, the improved accuracy and repeatability of the automatic sizing technique, and the significant ALARA benefits obtained with the automatic sizing technique during the pre-MSIP examinations, only automated sizing was performed following application of MSIP. The data analysis determined there to be no appreciable difference between the pre- and post-MSIP sizing.