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SUBJECT: Application for exigent amend to license DPR-58,modifying TS 4.4.5.4 &.4.4.5.5 for repair of hybrid expansion joint sleeved SG tubes.Proprietary W rept WCAP-14446, "Repair...of Hybrid Expansion Joint...Tubes" encl.W rept withheld.

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PRIORITY 1

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AEP
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August 4, 1995

AEP:NRC:1129E

Docket Nos.: 50-315

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

Gentlemen:

Donald C. Cook Nuclear Plant Unit 1
TECHNICAL SPECIFICATION CHANGES TO ALLOW
FOR REPAIR OF HYBRID EXPANSION JOINT (HEJ)
SLEEVED STEAM GENERATOR TUBES

This letter and its attachments constitute an application for an exigent amendment to the technical specifications (T/Ss) for the Donald C. Cook Nuclear Plant unit 1. Specifically, we are proposing to modify T/Ss 4.4.5.4 and 4.4.5.5 (Steam Generators) to allow for repair of HEJ sleeves under redefined repair boundary limits. As discussed with your staff as recently as August 3, 1995, the reasons for requesting this change on an exigent basis are that 1) the change is associated with steam generator tube repairs during the unit 1 refueling outage currently in progress and 2) the empirical data compiled from the Kewaunee Nuclear Plant steam generator tube pulls in March 1995 is the primary support for this amendment and the final implications and conclusions from assessment of that data are just now being formulated. The unit 1 tube repairs are currently scheduled to begin on August 29, 1995. Therefore, we request approval of this amendment by August 20, 1995, in order to avoid outage delays.

A detailed description of the proposed changes and our analysis concerning significant hazards considerations are included in Attachment 1 to this letter. Attachment 2 contains marked up pages of the current T/Ss. Attachment 3 contains the proposed revised T/Ss pages. Attachment 4 contains a copy of the proprietary report, WCAP 14446, prepared by Westinghouse Electric Corporation, describing the redefined sleeving repair boundary. Attachment 5 contains a Westinghouse authorization letter, Application For Withholding Proprietary Information From Public Disclosure and accompanying affidavit.

A001

We believe the proposed changes will not result in (1) a significant increase in the amounts, and no significant change in the types, of any effluent that may be released offsite, or (2) a significant increase in individual or cumulative occupational radiation exposure.

These proposed changes have been reviewed by the Plant Nuclear Safety Review Committee and will be reviewed at the next regularly scheduled meeting of the Nuclear Safety and Design Review Committee.

In compliance with the requirements of 10 CFR 50.91(b)(1), copies of this letter and its attachments have been transmitted to the Michigan Public Service Commission and to the Michigan Department of Public Health.

The T/S pages submitted with this letter will be impacted by the T/S page changes in our letter AEP:NRC:1166R, "2.0 Volt Interim Steam Generator Tube Plugging Criteria for Cycle 15," and AEP:NRC:1129D, "Technical Specification Changes to Allow Use of Laser Welded Sleeves for Steam Generator Tubes." The markups attached to this submittal do not account for any approval or incorporation of those other submittals (i.e., reflect T/S pages as-is today).

Sincerely,

E E Fitzpatrick

E. E. Fitzpatrick
Vice President

SWORN TO AND SUBSCRIBED BEFORE ME

THIS 4th DAY OF August 1995

Peter D Hess
Notary Public

My Commission Expires: 6-28-99

eh

Attachments

cc: A. A. Blind
G. Charnoff
H. J. Miller
NFEM Section Chief
NRC Resident Inspector - Bridgman
J. R. Padgett

ATTACHMENT 1 TO AEP:NRC:1129E

DESCRIPTION OF THE PROPOSED CHANGES AND

ANALYSIS CONCERNING SIGNIFICANT HAZARDS CONSIDERATIONS

JUSTIFICATION FOR THIS EXIGENT T/S REQUEST

The precedents for this T/S request were similar applications by the Kewaunee and Point Beach Nuclear Power Plants. The Kewaunee and Point Beach applications for redefined pressure boundary were denied by the NRC because insufficient data existed to justify the redefinition. As a result of the NRC denial of the previous applications, steam generator tubes from the Kewaunee Nuclear Plant were selected and pulled in March 1995 for laboratory analysis. These laboratory analyses have just now become available for presentation to the NRC and form the base justification for this redefined pressure boundary. While this late date would have been just within the limits for a normal T/S approval, the early entry into the Cook Nuclear Plant (CNP) unit 1 outage necessitates an exigent request. The CNP unit 1 main transformer failure experienced in late July has forced the prudent decision to move the refueling outage to an earlier date, specifically August 11, 1995, instead of September 15, 1995. We regret any inconvenience this may cause the NRC.

I. INTRODUCTION

This license amendment proposes to add technical specifications (T/Ss) 4.4.5.4.a.13 to redefine the hybrid expansion joint (HEJ) sleeved tube repair boundary limits for indications of degradation in the parent tube at the upper HEJ hardroll lower transition region of steam generator tubes which have HEJ sleeves installed. Under current T/S 4.4.5.4, steam generator tubes with eddy current indications exceeding the current plugging limit in the area of the hydraulically expanded region of the sleeve attachment joint must be repaired by plugging. The portion of the tube in the free span (upper joint) sleeve attachment joint region originally defined as part of the primary pressure boundary was established to be the entire length of tube experiencing hydraulic expansion. This area includes the upper HEJ roll expanded region. (See attachment 4, WCAP 14446, figure 1-2, page 1-7.) In 1994 and 1995, circumferential eddy current indications were detected at a plant with the same type of steam generators and sleeves as those at CNP unit 1. Based on the location of the indications and their proximity to the tube plugging limit, many of these indications were, in retrospect, unnecessarily removed from service. The design and geometric configuration of the tube/sleeve joint continue to provide tube structural and leakage resistance capability consistent with existing regulations for completely separated parent tubes, provided the elevation of the degradation is within the limits established in this evaluation.

II. DESCRIPTION OF THE CHANGES

The proposed additions are necessary to incorporate the redefined HEJ sleeved tube repair boundary limits. The specific additions are as follows.

1. T/S 4.4.5.4.a.6. page 3/4 4-10

This definition does not apply to parent tube wall degradation in HEJ sleeved tubes for the tube elevation in the free span (upper) HEJ hardroll area. See 4.4.5.4.a.13 below for the plugging limits for the HEJ sleeved tubes in the free span HEJ hardroll region.

2. T/S 4.4.5.4.a.10 page 3/4 4-11

Including sleeved tube leakage allowance as discussed in 4.4.5.4.a.13 below.

3. T/S 4.4.5.4.a.13 page 3/4 4-11

The HEJ sleeved tube repair boundary is used for disposition of parent tube wall degradation in HEJ sleeved tubes in or below the free span (upper) HEJ hardroll area. The dimensions specified below do not include eddy current uncertainty.

A. Hybrid expansion joint sleeved tubes with circumferential indications located from 1.1 inches to 1.3 inches (inclusive) below the bottom of the free span HEJ hardroll upper transition may remain in service provided the faulted loop steam line break (SLB) leakage limit of 12.6 gpm from all sources is not exceeded. A SLB leakage of 0.033 gpm shall be assumed for each indication, regardless of the actual indication length or depth.

B. Hybrid expansion joint sleeved tubes with circumferential and/or axial indications whose uppermost extent is located greater than 1.3 inches below the bottom of the free span HEJ hardroll upper transition may remain in service.

C. Hybrid expansion joint sleeved tubes with axial indications whose uppermost extent is located less than or equal to 1.3 inches below the bottom of the free span HEJ hardroll upper transition shall be plugged.

4. T/S 4.4.5.5.e. page 3/4 4-12

T/S 4.4.5.4.a.13

5. Paragraph 3/4.4.5 page B 3/4 4-3

The repair boundary for parent tube degradation in the upper joint region of HEJ sleeved tubes is outlined in WCAP-1446. The repair boundary maintains structural integrity consistent with draft Regulatory Guide (RG) 1.121 (August 1976). Application of the repair boundary for indications in the hardroll lower transition provides allowance for leakage in the faulted loop during a postulated SLB event. A SLB leakage of 0.033 gpm is assumed for each applicable indication. Steam line break leakage from all sources must be calculated to be less than 12.6 gpm in the faulted loop. Maintenance of the 12.6 gpm limit ensures offsite doses will remain within 10% of the 10 CFR 100 guidelines for a SLB.

III. DESCRIPTION OF THE AMENDMENT REQUEST

As required by 10 CFR 50.91 (a)(1), this analysis is provided to demonstrate that a proposed license amendment to implement the HEJ sleeved tube repair boundary for parent tube degradation for the CNP unit 1 steam generators represents no significant hazards consideration. In accordance with 10 CFR 50.92(c), implementation of the proposed license amendment was analyzed using the following standards and found not to: 1) involve a significant increase in the probability or consequences for an accident previously evaluated; 2) create the possibility of a new or different kind of accident from any accident previously evaluated; or 3) involve a significant reduction in a margin of safety.

The Westinghouse HEJ sleeve extends entirely through the tubesheet primary side face and is attached to the tube by first performing a hydraulic expansion of the sleeve and tube at the ends of the sleeve. A mechanical roll expansion is then produced at the bottom end of the sleeve and within the upper hydraulically expanded region. The hydraulic expansion serves to reduce tube residual stresses due to solely mechanical roll expansion to the diameters specified for the HEJ hardroll. Both the as-designed lower hardroll and free span HEJ provide structural integrity characteristics which exceed the structural requirements for the sleeve. The sleeve structural integrity requirements include safety factors inherent to the requirements of the ASME Code.

Removal of a tube from service results in a reduction of reactor coolant flow through the steam generator. This small reduction in flow has an impact on the margin in the reactor coolant flow through the steam generator with regard to core cooling capacity and on the heat transfer efficiency of the steam generator. Therefore, application of the HEJ sleeved tube repair boundary for parent tube indications in lieu of plugging would minimize loss of margin in reactor coolant system flow and assist in assuring that minimum flow rates are maintained in excess of that required for operation at full power.

The proposed license amendment request will establish a physical length-based inspection requirement for the parent tube in the upper HEJ hardroll expanded region which can be used to show that implementation of the repair boundary will retain tube burst capability consistent with RG 1.121 and that offsite doses in the event of a postulated SLB will remain within currently analyzed values.

The proposed amendment would modify technical specifications 3/4 4.5 "Steam Generators," and Bases B 3/4 4.5, "Steam Generators," to permit the use of the repair boundary, and to include the effects of tubes left in service as a result of the application of the repair boundary into the existing SLB leak rate limit of 12.6 gpm in the faulted loop. This leak rate value includes primary to secondary leakage contribution from tubes left in service due to application of the interim plugging criteria (for tube support plate (TSP) intersections).

Details of the Amendment Request Items

The details of the amendment request are based on test data for pulled tubes, prototypic test specimens in which the parent tubes were completely machined away at various crack elevations, and evaluation of the axial displacement potential for postulated circumferentially separated tubes.

1. Establishment of Upper Limit Elevation for Parent Tube Circumferentially Oriented Degradation (See attachment 4, WCAP 14446, figure 1-2, page 1-7.)

   The license amendment will establish a distance of 1.1 inch from the bottom of the HEJ hardroll upper transition (approximately 2.85 inches from the end of the sleeve) not including eddy current uncertainty, down towards the tube entry, such that any indications of parent tube degradation below this point would not require repair by plugging, except as noted in 2. below. Parent tube indications located greater than

1.3 inch below the bottom of the HEJ hardroll upper transition do not require repair and are not limited based on leakage allowances.

For simplicity, axial indications existing in the 1.1 to 1.3 inch distance below the bottom of the hardroll upper transition will be plugged, even though axial indications would not represent a potential for tube separation and would not be expected to leak at SLB conditions. Axial indications whose uppermost portion is greater than 1.3 inch below the bottom of the hardroll upper transition may remain in service, due to high confidence in the continued leak and structural integrity of the tube/sleeve combination above that point.

2. Establishment of SLB Leak Rate Allowances for Tubes Left Inservice due to Implementation of the Repair Boundary

A SLB leakage allowance will be established for tubes remaining in service due to application of the repair boundary. If the calculated SLB leakage is projected to exceed 12.6 gpm in the faulted loop from all sources, additional tubes will be removed from service by plugging until this limit is met. The 12.6 gpm value includes SLB leakage allowances from tubes in which the voltage based interim plugging criterion for axial outer diameter stresses corrosion cracking (ODSCC) at drilled hole carbon steel TSP intersections has been applied. For tubes with indications between 1.1 and 1.3 inch below the bottom of the hardroll upper transition, a SLB leakage allowance of 0.033 gpm per tube is applied. The SLB leakage allowance is applied to all tubes with circumferentially oriented indications in this region, regardless of the throughwall depth or circumferential extent of such indications. Steam line break leakage for indications below 1.3 inch below the bottom of the hardroll upper transition can be neglected.

IV NDE INSPECTION PLAN

Sample Size and Probes

Per the current CNP unit 1 technical specifications, HEJ sleeved tubes are considered no different from other steam generator tubes, and would be subject to the same inspection requirements as for non-sleeved tubes. However, for the upcoming outage at CNP unit 1 an inspection of 100% of the HEJ sleeved tube upper joint regions will be conducted. This

practice will establish a new baseline inspection of the HEJ sleeved tubes using an advanced probe specifically designed to detect circumferential and axial degradation in the parent tube. The Cecco-5 probe will be used to establish this new baseline. The Cecco-5 probe has been qualified for use according to EPRI PWR Steam Generator Examination Guidelines Appendix H guidelines. Information previously provided to the NRC by Westinghouse indicates the detection capability of the Cecco-5 probe to be consistent with other currently available advanced probes. Test results indicated 100% detection of 50% deep circumferential and axial EDM parent tube notches in the hydraulic and hardroll expanded regions of sleeved tubes. The Cecco-5 probe can be used for both baseline establishment and screening and also for indication elevation determination. If it is judged that the Cecco-5 should not be used for indication elevation determination, further crack definition can be provided by using a 3-coil RPC probe or zetec Plus-Point probes. Further crack definition can be provided by using a 3-coil rotating pancake coil (RPC) probe or zetec plus point probes. Future HEJ sleeved tube inspection programs will include an initial 20% sample in a minimum of one steam generator using the Cecco-5 probe (or other probe with similarly rapid probing capabilities). If one tube with degradation in the hardroll lower transition is detected, the sample will be increased to 40% of the sleeved tubes in that steam generator and 20% of the HEJ sleeved tubes in the other steam generators. If a second tube degraded HEJ sleeved tube is detected, the sample size will be increased to 100% of the sleeved tubes in that steam generator. Sample expansion in the other steam generators will follow the same program. If circumferential degradation in the upper hardroll upper transition or upper hydraulic transition is detected, the sample size will be increased to 100% of the sleeved tubes in that steam generator.

The Cecco-5 inspection is used as a rapid screening tool to identify degradation in the upper hardroll lower transition. The Cecco-5 probe can also be used for elevation determination. If used for indication position determination, the Cecco-5 should be shown to limit uncertainties consistent with the 3-coil RPC. Alternatively, the 3-coil RPC probe can be used to characterize the indication identified in the Cecco-5 screening. The 3-coil RPC with a 0.080 inch diameter pancake coil can be used to limit the positioning error. Together with the superior detection capability of the Cecco-5 probe, this combination will provide satisfactory elevation characterization of parent tube indications in the upper joint hardroll lower transition region if the Cecco-5 probe is not used for both functions.

Eddy Current Uncertainty

Using the 3-coil RPC probe with 0.08 inch diameter sensing coils, the position uncertainty is generally taken to be half of the coil diameter, or 0.04 inch. For application of the HEJ sleeved tube repair boundary limit for parent tube degradation in the upper HEJ hardroll lower transition, the uncertainty value for the difference in positions is the Root Mean Square of the position uncertainty: i.e.,

$$\text{Uncertainty}_{(\text{3-coil RPC})} = \left((0.040)^2 + (0.040)^2 \right)^{1/2} = 0.06$$

Therefore, considering the criteria as described above, circumferentially oriented parent tube indications of degradation ≥ 1.16 but ≤ 1.36 inch below the bottom of the upper hardroll upper transition do not require repair by plugging unless the total steam generator leakage allowance of 12.6 gpm in the faulted loop is exceeded. If the calculated SLB leakage exceeds 12.6 gpm in the faulted loop from all sources, additional tubes must be removed from service so that the projected SLB leakage at end of cycle conditions is less than or equal to 12.6 gpm in the faulted loop. Circumferentially oriented indications of parent tube degradation greater than 1.36 inch below the bottom of the upper hardroll upper transition do not require repair by plugging and do not contribute to the total calculated SLB leakage allowance.

V EVALUATION

The evaluation of parent tube degradation in HEJ sleeved tubes supports the conclusions that tube structural integrity consistent with RG 1.121 is provided, along with maintenance of offsite doses within 10% of the 10 CFR 100 guidelines in the event of a postulated SLB event. By supporting these two criteria, compliance with 10 CFR 50.92 can be supported.

Sleeve Geometry and Terminology Clarification (see attachment 4,WCAP 14446, figure 1-1, page 1-6)

Starting from the upper end of the in-place, expanded sleeve and moving downwards towards the tube lower end, the following regions of the sleeve (and tube) are encountered:

1) Non-expanded free end, approximately 1/2 inch long
2) Expansion transition from non-expanded length to hydraulically expanded region
3) Hydraulically expanded region, approximately 1 inch long, includes expansion transition
4) Expansion transition from hydraulically expanded region to roll expanded region (HEJ hardroll upper transition), approximately 1/4 inch long

5) Expansion transition from roll expanded region to hydraulically expanded region (HEJ hardroll lower transition), approximately 1/4 inch long
6) Hydraulically expanded region, approximately 2 1/2 inches long, includes lower expansion transition
7) Expansion transition from hydraulically expanded region to non-expanded center length.

The repair boundary addresses indications coincident with region 6), ". . .expansion transition from the roll expanded region to the hydraulically expanded region (HEJ hardroll lower transition)." This location is approximately 5.46 to 5.21 inches above the top of the tubesheet for a 30 inch long sleeve and 2.46 to 2.21 inches above the top of the tubesheet for a 27 inch long sleeve. This area (in which indications may be concentrated) extends from approximately 1.0 to 1.25 inch below the bottom of the hardroll upper transition.

Pulled Tube Results

In March 1995, three HEJ sleeved tubes were removed from the Kewaunee Nuclear Plant steam generator A. These tubes were cut and removed from the secondary side of the steam generator at elevations immediately above the top of the tubesheet and below the first tube support plate. The removed tubes were R2 C32, R2 C54, and R2 C61. Field gathered Plus Point RPC eddy current results for R2 C32 identified a 300 - 360° circumferential indication in the hardroll lower transition, and 360° indications for R2 C54 and R2 C61. Evaluation of 1994 I-coil data suggests 270° (approximate) circumferential indications. The laboratory Plus Point evaluation was consistent with the field results. Both evaluations concluded that the degradation was probably throughwall. As discussed below, neither tube contained throughwall degradation. Tube R2 C54 was leak tested upon receipt at the laboratory. No leakage was detected.

Tubes R2 C32 and R2 C54 were tensile tested to open the parent tube circumferential crack faces. Load versus deflection curves were generated for these two specimens. Maximum loads were achieved at the point of ligament separation in the parent tubes. The tubes and sleeves were welded at the lower end and affixed to the stationary head of the tensile machine while the tube was solely affixed to the moveable crosshead of the tensile machine. By testing in this condition the actual configuration as in the steam generators was simulated. Peak loads and deflections at ligament failure were 10,350 lb;0.44 inch, and 10,700 lb;0.53 inch, respectively for R2 C32 and R2 C54. Peak frictional loads after ligament failure were 2800 lb and 4000 lb, respectively.

The separation point of R2 C32 was in the parent tube at the top of the hardroll lower transition while the separation point for R2 C54 was approximately half way down the lower transition of the parent tube. Tube R2 C32 had a normal (0.25 inch long) lower transition while R2 C54 experienced roll down and had an elongated roll transition of about 1/2 inch. Examination of the fracture face of R2 C32 indicated the macrocrack length was 360° with an average depth of penetration of 62% and maximum penetration depth of 92%. Limit load analysis of the non-degraded cross sectional areas of the two parent tubes estimate the overload forces to be 5980 lb and 5170 lb, for R2 C32 and R2 C54. Twenty-one ligaments were observed on the circumferential macrocrack located at the top of the hardroll lower transition, indicating a highly segmented profile. All intergranular corrosion was ID initiated. Macrocrack length for R2 C54 was also 360°, with average and maximum crack depths of 60% and 92%. Again, a segmented crack profile was detected as nineteen ligaments were observed. All corrosion was ID initiated. Crack profiles for both tubes were segmented, and the crack initiation sites were scattered in elevation, i.e., the macrocrack network is not found in a single plane.

The Kewaunee pulled tube results are considered applicable to CNP unit 1. The Kewaunee and CNP unit 1 steam generators are Westinghouse Model 51 steam generators. The Point Beach unit 2 plant utilizes Westinghouse Model 44 steam generators. Both models of steam generator use 7/8 inch OD by 0.050 nominal wall thickness Alloy 600 MA tubing and utilize a partial depth roll expansion in the tubesheet region.

Sleeve/Tube Integrity

Sleeved tube integrity for tubes with circumferential indications in the HEJ hardroll lower roll transition region involve both structural and leakage integrity concerns.

A. Structural Issues

Per RG 1.121, tube rupture should be precluded at a pressure loading equal to three times the normal operating primary to secondary pressure differential, or 1.43 times the SLB pressure differential, depending upon which is the most limiting. For CNP unit 1, the most stringent RG 1.121 loading is the 3ΔP recommendation. Tube rupture is normally thought of as a double ended guillotine break of a steam generator tube, or a failure of a tube involving localized burst with ductile tearing of the tube material at the edges of the crack. In the case of a sleeved tube with postulated circumferential degradation in the parent

tube at the HEJ hardroll lower transition, tube rupture will be considered as an uncontrolled release of reactor coolant exceeding the normal makeup capacity of approximately 120 gpm for CNP unit 1. The tube will not experience failure or burst as a result of internal pressurization resulting in tube failure with crack tearing, but from disassociation of the separated tube end and sleeve by axial displacement of the postulated circumferentially separated parent tube.

For the configuration of an HEJ sleeved tube with a postulated 100% throughwall, 360° circumferential crack in the HEJ hardroll lower transition, tube rupture can only occur if the tube is displaced axially by a distance of approximately 3 to 3.25 inches. Tube displacement of this magnitude would result in complete disassociation between the separated tube end and sleeve resulting in sufficient flow area such that a release rate of 120 gpm would be realized. Hybrid expansion joint sleeved tube test specimens and pulled tube HEJ samples (from an operating plant) are used to support the conclusion that indications which have the criteria applied will retain structural integrity such that tube slippage and axial displacement will not be expected. As a defense in depth backup to these data, analysis of the S/G dimensions, fitup, and manufacturing practices has been performed to determine the lengths over which a postulated circumferentially separated tube could become displaced. This axial displacement analysis can only be realized if it is assumed that the hardroll interaction friction force and packed TSP crevice friction forces are neglected. The postulated levels of tube slippage are calculated for plant operation during; 1) normal operation, 2) a postulated SLB, and 3) at pressure differential loadings equal to the RG 1.121 safety limits. End cap loads which could cause tube axial displacement are developed by the primary to secondary ΔP acting over the tube ID area. For CNP unit 1, a maximum normal operating condition end cap load of 755 lb (ΔP = 1600 psi) is established. During a postulated SLB, the end cap load would be approximately 1207 lb (ΔP = 2560 psi), and the most limiting RG 1.121 end cap load would be approximately 2264 lb ($3\Delta P$ = 4800 psi). Therefore, the structural integrity characteristics of the postulated degraded joint must be sufficient to resist these potential loadings in order for sleeved tube structural integrity to be maintained. It should be noted that the current normal operating primary to secondary ΔP at CNP unit 1 is approximately 1420 psi.

Structural Capability Test Results

When indications were first detected in the HEJ hardroll lower roll transition in the parent tube, structural capability tests were performed to determine the structural characteristics of the degraded joint. Since the T/Ss consider sleeved tubes no different than non-sleeved tubes and considering that RG 1.121 supplies structural integrity recommendations independent of sleeved or non-sleeved tubes, the applicability of criteria can be established using current NRC documents and regulations.

A series of tests were conducted on HEJ sleeved tube specimens in which the tubes were completely machined away at various postulated crack elevations. For specimens where the tubes were completely removed by machining at the elevation corresponding to the bottom of the hardroll lower transition (approximately 1.25 inches below the bottom of the hardroll upper transition and approximately 3.0 inches below the upper end of the sleeve) structural capability of the joints was found to be approximately twice the most limiting RG 1.121 3ΔP end cap loading for CNP unit 1 (based on a 3ΔP pressure load of 4800 psi). Tube structural integrity is expected to be provided for circumferential indications 1.1 inch below the bottom of the hardroll upper transition based on the presence of a "lip" of metal formed by the transition (since the hardroll length is approximately 1.0 to 1.03 inch). This lip must be drawn over the sleeve hardroll length, and could be considered similar to the manufacturing process used for drawn over mandrel (DOM) tubing. The force required to cause this deflection of the tube would be expected to exceed the most limiting RG 1.121 recommendations. For specimens where the tubes were completely removed by machining at the elevation corresponding to the approximate midlength of the hydraulically expanded region (approximately 2.25 inches below the bottom of the hardroll upper transition and approximately 4.0 inches below the upper end of the sleeve) structural capability of the joints was found to be approximately 3.5 to 4 times the most limiting RG 1.121 3ΔP end cap load for CNP unit 1.

A second series of tests were conducted for HEJ sleeved tubes with simulated throughwall cracks of less than 360° arc. Results of these tests are furnished in WCAP-14157, Addendum 1. Tubes were first slit 100% throughwall over varying arc lengths from 120° to 240° and the specimens prepared such that the slits were

positioned at the top of the HEJ hardroll lower transition. Specimens were installed in a tensile testing machine and axially loaded to failure. The specimens were configured such that the tube end was attached to the movable crosshead of the machine and the sleeve end was attached to the stationary base. Test results and observations indicated that upon loading, the bending moment applied through the non-degraded ligament caused a deflection of the tube and sleeve in the direction of the slit, and produced a sufficiently large bending lockup that in most cases, even with a 240° throughwall slit, the sleeve failed in tension at approximately 8,000 lb load. For the specimens that failed in the ligament (slit location elevation 1.00 to 1.03 inch below the bottom of the hardroll upper transition), the ligament failure loads were approximately twice the tensile overload capacity of the tube considering only nondegraded ligament area loaded in tension and considerably greater than the most limiting RG 1.121 loading. In the specimens that failed in the ligament, the frictional forces developed by the interaction of the hardroll expanded areas was sufficiently large to exceed the most limiting RG 1.121 loading. These tests were performed at 600° F with no internal pressure. Therefore, it can be concluded that for a postulated sleeved tube with non-degraded ligaments in the subject area of the tube, that structural integrity characteristics would be provided in excess of the most limiting RG 1.121 loading.

For the pulled tubes, field RPC results indicate 300 - 360° degradation while parent tube ligament failure loads exceeded 10,000 lb. Frictional loads after ligament separation exceeded the most limiting RG 1.121 loading. For tube R2 C32, the crack location was at the top of the hardroll lower transition, and comparison of post ligament failure frictional loads for R2 C32 would be considered conservative compared to tubes left in service as a result of the criteria.

B. Leakage Integrity

Elevated temperature leak tests were conducted on specimens which had the tube machined away at the bottom of the HEJ hardroll lower transition (approximately 1.25 inches below the bottom of the HEJ hardroll upper transition). Leak test results indicated essentially zero leakage under all conditions (maximum SLB leakage of 0.008 gpm, average of 0.0012 gpm). Leak tests for specimens with the tube machined away at the approximate midpoint of the HEJ hardroll

lower transition (approximately 1.12 to 1.13 inch below the bottom of the hardroll upper transition) also showed a large resistance to primary to secondary leakage. Steam line break condition leakage was found to be a maximum of 0.016 gpm. These tests suggest that the presence of a "lip" of tube material below the edge of the transition provides sufficient leakage restriction.

This configuration would include a lip of approximately 0.10 to 0.07 inch below the top of the HEJ hardroll lower transition, and therefore would provide the geometric configuration such that neither significant tube axial displacement nor significant tube leakage would be expected during a postulated SLB event.

Leakage testing was also conducted on non-360° throughwall slitted tube specimens. Again, tubes were pre-slit to a throughwall condition over 240° and the slits were located at the top of the hardroll lower transition (approximately 1.0 to 1.03 inch below the bottom of the hardroll upper transition). The maximum test leakage was found to be 0.015 gpm at a ΔP of 2450 psi.

Application of Leakage Limits for Indications Left Inservice as a Result of the Criteria

For indications between 1.1 inch and 1.3 inch (not including eddy current uncertainty) below the bottom of the HEJ hardroll upper transition, a bounding SLB leak rate of 0.033 gpm will be applied. Conservatively, a factor of 2 is applied to the largest leakage test data point to establish a 0.033 gpm per tube leakage allowance. Application of this per tube allowance is conservative for tubes with less than 360° throughwall degradation and also conservative for tubes with non-throughwall degradation. The pulled tube eddy current results indicated 360° degradation, however, neither of the three pulled tubes had throughwall degradation. Application of the leakage allowance is applied for all tubes with circumferential indications between 1.1 and 1.3 inch below the bottom of the hardroll upper transition, regardless of indicated RPC angle and throughwall extent. For indications 1.3 inch or greater below the bottom of the HEJ hardroll upper transition, SLB leakage can be neglected.

Considering that the interim plugging criteria for TSP indications is licensed at CNP unit 1, offsite doses in the event of a postulated SLB have been calculated

consistent with the Standard Review Plan. The SLB leakage value for CNP unit 1 has been determined to be 12.6 gpm in the faulted loop. Leakage from TSP intersections has typically been less than 1 gpm, leaving up to 11.6 gpm of available leakage from other sources. At current conditions, 350 tubes with parent tube indications between 1.1 and 1.3 inch below the bottom of the hardroll upper transition can remain inservice as a result of application of the criteria. An unlimited number of indications greater than 1.3 inch below the bottom of the HEJ hardroll upper transition can remain in service. The number of indications between 1.1 and 1.3 inch below the bottom of the upper transition to which the repair boundary can be applied could be increased by lowering the technical specification Iodine-131 concentration.

Defense in Depth Assessment

As a worst case evaluation consideration, the effects of a postulated circumferentially separated tube are considered with regard to tube rupture potential. In order to evaluate this condition, the results of the dimensional study are used to establish sleeved tube structural integrity. As stated previously, the RG 1.121 recommendations are structured to prevent tube rupture during the specified conditions. The results of the dimensional analysis indicate that at a 95% cumulative probability, separated tube axial displacement for both normal operating and SLB conditions would be less than the 1.1 inch minimum value established by the proposed repair boundary. These values are established by averaging the maximum displacements of the tube apex and tangent points for the various plant conditions. At these displacements, remaining metal to metal contact of approximately 0.22 to 0.13 inch would be provided between the tube and sleeve in the original HEJ hardroll region. At this configuration, primary to secondary leakage would be much less than makeup capacity, and therefore, a tube rupture condition would be precluded. (See attachment 4, WCAP 14446, figure 7-2, page 7-14.) The establishment of the axial displacement values of the postulated circumferentially separated tube not only neglect the frictional forces developed by the HEJ hardroll, but also neglect any frictional forces developed at the tube to tube support plate intersections generated by corrosion product buildup in addition to neglecting any frictional forces developed at the tube to tube support plate intersections due to lateral displacement of the tube as the U-bend region

is rotated. The 1.1 inch value used in the development of the criteria is the 95% cumulative probability displacement of the tube tangent point, and is the most limiting SLB displacement value.

For the postulated axial displacements listed above, a ring of tube to sleeve contact will be provided in the original HEJ hardroll region. Previous leakage calculations for tubes which have slipped such that there is no remaining metal to metal contact in the hardroll region (about 1.25 to 1.5 inch axial displacement) primary to secondary leakage was calculated to be on the order of 25 gpm. In this configuration, leakage restriction is provided by the thin gap created by the diameter difference between the tube hardroll region ID and sleeve hydraulically expanded OD. For the expected conditions at the 95% cumulative probability tube axial displacements, primary to secondary leakage would be expected to be far less than 25 gpm. For SLB conditions, a tube experiencing an axial displacement at the 95% cumulative probability would be expected to leak at less than 2.5 gpm. Supplemental leakage testing scheduled for August 1995 will be performed to establish leak rates for tubes which are postulated to experience axial displacements. The intent of these tests is solely to validate the conclusions that axially displaced tubes do not represent a potential for leakage in excess of the CNP unit 1 normal makeup capacity. Results of these tests will be transmitted to the NRC.

Flow Margin Considerations

By reducing the numbers of tube plugs installed in the steam generator, the proposed amendment would minimize the loss of margin in reactor coolant flow through the steam generator during a postulated event when core cooling capacity is required.

VI ANALYSIS

Conformance of the proposed amendments to the standards for a determination of no significant hazard as defined in 10 CFR 50.92 (three factor test) is shown in the following:

1) Operation of the CNP unit 1 in accordance with the proposed license amendment does not involve a significant increase in the probability or consequences of an accident previously evaluated.

Mechanical testing has shown that the inherent structural strength of the HEJ joint provides sufficient integrity such that the tube rupture capability recommendations of RG 1.121 are met, even for instances of 100% throughwall, 360° circumferentially oriented degradation in the HEJ hardroll lower transition region. Structural integrity recommendations consistent with RG 1.121 are supplied for all tube degradation 1.1 inch or greater below the bottom of the HEJ hardroll upper transition. Based on test data, a bounding SLB leak rate of 0.033 gpm for indications between 1.1 and 1.3 inch below the bottom of the hardroll upper transition is applied. As the leakage data base is expanded and statistical basis established, this SLB leakage allowance may be reduced. For indications existing greater than 1.3 inch below the bottom of the hardroll upper transition, SLB event leakage can be neglected.

Additional prevention from tube rupture is inherently provided by the HEJ geometry. For RCS release rates to exceed the normal makeup capacity of the plant, approximately 120 gpm, the tube must be postulated to experience a complete circumferential separation at the lower transition, and become axially displaced by 3 to 3.25 inches, resulting in complete geometric disassociation between the tube and sleeve resulting in sufficient flow area to support leakage of 120 gpm. During the 1989 plug top release event at North Anna unit 1, primary to secondary release rates were calculated to be less than 80 gpm, for a flow area approximately 4 times larger than the flow area created by a tube which has axially displaced by about 1.25 to 1.5 inch. Analysis of the steam generator indicates that at a 95% cumulative probability, the tube would experience an axial displacement of less than the 1.1 inch boundary. At this level of axial displacement, a ring of metal to metal contact would remain between the tube and sleeve, and leakage would be far less than 120 gpm. Projected leakage at this point is expected to be less than 2.5 gpm. Therefore, implementation of the proposed repair boundary will not result in tube rupture, even for a tube postulated to not behave as predicted by the available test and pulled tube data.

The proposed technical specification change to support the implementation of the HEJ sleeve tube repair boundary for parent tube degradation in the HEJ hardroll lower transition region does not adversely impact any other previously evaluated design basis accident or the results of accident analyses for the

current technical specification minimum reactor coolant system flow rate. Plugging limit criteria are established using the guidance of RG 1.121. Furthermore, per RG 1.83 recommendations, the sleeved tube assembly can be monitored through periodic inspections with present eddy current techniques.

2) The proposed license amendment does not create the possibility of a new or different kind of accident from any accident previously evaluated.

Implementation of the repair boundary will not introduce significant or adverse changes to the plant design basis. Mechanical testing of degraded sleeve joints supports the conclusions of the calculations that the sleeve retains structural (tube burst) capability consistent with RG 1.121. As with initial the installation of sleeves, implementation of the alternate criteria cannot interact with other portions of the RCS. Any hypothetical accident as a result of potential tube degradation in the HEJ hardroll lower transition region of the tube is bounded by the existing tube rupture accident analysis. Neither the sleeve design nor implementation of the tube repair boundary defined in Attachment 4 affects any other component or location of the tube outside of the immediate area repaired. In addition, as the installation of sleeves and the impact on current plugging level analyses is accounted for, any postulation that the alternate repair criteria for parent tube degradation in the HEJ hardroll lower transition creates a new or different type of accident is not supported.

3) The proposed license amendment does not involve a significant reduction in a margin of safety.

The safety factors used in the establishment of the HEJ sleeved tube alternate repair boundary for the disposition of indications in the hardroll lower transition of potentially degraded parent tubes are consistent with the safety factors in the ASME Boiler and Pressure Vessel Code used in steam generator design. Based on the sleeved tube geometry, it is unrealistic to consider that application of the repair boundary could result in single tube leak rates exceeding the normal makeup capacity during normal operating conditions. The repair boundary established in Attachment 4 has been developed using the methodology of RG 1.121. The performance characteristics of postulated degraded parent tubes of

HEJ tube/sleeve joints have been verified by testing to retain structural integrity and preclude significant leakage during normal and postulated accident conditions. Testing indicates that postulated circumferentially separated tubes which the repair boundary addresses would not experience axial displacement during either normal operation or SLB conditions. The existing offsite dose evaluation performed for CNP unit 1 in support of the voltage based plugging criteria for axial ODSCC at TSP intersections established a faulted loop primary to secondary leak rate of 12.6 gpm using technical specification dose equivalent Iodine-131 activity levels. Following implementation of the criteria, postulated leakage from all sources must not exceed 12.6 gpm in the faulted loop. Maintenance of this limit will ensure that offsite doses would not exceed the currently accepted limit of 10% of the 10 CFR 100 guidelines. The repair boundary uses a conservatively established "per indication" leak rate for estimation of SLB leakage. This leak rate is applied to all indications left in service as a result of the tube repair boundary, including non-throughwall indications and a limited number of indications of circumferential throughwall extent.

For a postulated indication whose performance is not characteristic of the test and pulled tube data, and which would experience axial displacement at the 95% cumulative probability value following a postulated SLB event with no operator intervention, leakage would not be expected to result in an uncontrolled release of reactor coolant in excess of normal makeup capacity.

For the three pulled tubes and nearly 1,000 crack indications detected in the field, there were no instances of degradation of elevations (multiple expansion transitions) on either side of the hardroll expansion in the same tube. This includes no instances of non-detected degradation in the upper hydraulic and hardroll upper expansion transitions for the pulled tubes. One tube was identified in the most recent Kewaunee inspection with two separate circumferential crack elevations within the hardroll lower transition. Rapidly occurring degradation would not be expected at the upper transitions, based partly on the field inspection results. The available inspection results include two inspection programs (1994 and 1995) at Kewaunee and one at Point Beach unit 2 (1994). Through these three inspection programs, approximately 11,000

HEJ sleeved tubes have been inspected using advanced probes.

The portions of the installed sleeve assembly which represent the reactor coolant pressure boundary can be monitored for the initiation and progression of sleeve/tube wall degradation, thus satisfying the requirements of Regulatory Guide 1.83.

VII CONCLUSION

Based on the preceding analysis it is concluded that operation of the CNP unit 1 following the implementation of the tube repair boundary for HEJ sleeved tubes with parent tube indications, in accordance with the proposed amendment, does not result in an increase in the probability or consequences of an accident previously evaluated, create the possibility of a new or different kind of accident from any accident previously evaluated, nor reduce any margins to plant safety. Therefore, the license amendment does not involve a Significant Hazards Consideration as defined in 10 CFR 50.92.