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SAFETY EVALUATION

BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO FULL SCALE STEAM GENERATOR TUBE SLEEVING AT

POINT BEACH NUCLEAR PLANT UNITS 1 AND 2

DOCKET NOS. 50-266 AND 50-301

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POINT BEACH UNITS 1 AND 2

STEAM GENERATOR TUBE SLEEVE REPAIRS

SAFETY EVALUATION REPORT

1.0 Introduction

By letter dated July 2, 1981, Wisconsin Electric Power Company (WE or licensee) submitted an application for license amendments consisting of proposed changes to the Technical Specifications for Point Beach Nuclear Plant Units 1 and 2. These proposed Technical Specification changes would allow operation of Units 1 and 2 with steam generator tubes having degradation exceeding the plugging limit (40% nominal wall thickness) provided these tubes have been repaired by insertion of sleeves into the tubes to bridge the degraded or defective portion of the tubes.

To provide a technical basis for proposed sleeve repair program, the licensee has submitted (Reference 3) Westinghouse Report WCAP-9960 (Proprietary), Revision 1 dated February 1982, and entitled "Point Beach Steam Generator Sleeving Report Prepared for Wisconsin Electric Power Company." Additional information relating to the scope and technical justification of the proposed sleeve repair program have been documented by the licensee in References 4 through 10.

The proposed sleeve repairs are similar in design to those which have previously been approved for San Onofre Unit 1 (Reference 11). Approximately 7000 sleeves were installed at San Onofre during 1980-81. San Onofre has subsequently operated for approximately 4 1/2 effective full power months with no significant difficulties related to the sleeve repairs.

The scope of the proposed sleeve repairs as originally defined in the licensee's July 2, 1981 letter involved the installation of as many as 2500 sleeves in each of the Unit 1 and 2 steam generators. As part of this program, the licensee has proposed to recover previously plugged tubes for future service by first deplugging these tubes, and then installing sleeves to restore the original integrity of these tubes.

On November 10, 1981, the staff issued an amendment (Reference 12) to the Point Beach Unit 1 license authorizing the repair by sleeving of up to six tubes degraded beyond the plugging limit as part of a demonstration program at Point Beach Unit 1. This demonstration program was conducted during Fall 1981. Unit 1 has subsequently operated for approximately five calendar months with no leaks directly attributable to sleeving. One tube which was deplugged and sleeved during the Fall 1981 outage did develop a minor leak on the non-sleeved cold leg side, possibly as a result of damage incurred during the deplugging operation.

By letter dated May 27, 1982 (Reference 10), the licensee informed the staff that it plans to repair the Unit 1 steam generators by replacing major components starting in October 1983. The licensee has not described its plans for any further sleeving in Unit 1 prior to replacement of the steam generators but has not withdrawn its application to sleeve that unit in order to retain the sleeving option. The licensee is planning to commence large scale sleeving of the Unit 2 steam generators in April 1983.

This Safety Evaluation documents the results of the NRC staff's review and evaluation of full scale sleeve repairs, as described in Reference 3, for both Units 1 and 2.

2.0 Sleeve Process Description

2.1 Sleeve Configuration

The sleeving process consists of installing, inside the steam generator tube, a smaller diameter tube (sleeve) to span the degraded area of the parent tube. The sleeves have been designed and analyzed in accordance with Section III of the ASME Boiler and Pressure Vessel Code and applicable regulatory guides to restore integrity of degraded steam generator tubes as a primary pressure boundary. Associated materials and processes also meet the requirements of the Code.

The sleeves are fabricated from thermally treated Inconel 600 tubing to provide a maximum resistance to stress corrosion cracking. The sleeves will be inserted inside the existing tube (mill annealed Inconel 600) and joined to the tube inner diameter (ID) at the upper and lower sleeve ends. The sleeves will span the distance from the tube inlet to a few inches above the top of the tubesheet. The Point Beach sleeves are intended to address the general intergranular attack, stress corrosion cracking, and wastage corrosion which has occurred at or near the tubesheet area.

The sleeves will employ either of two different upper sleeve joint designs. The "reference" upper joint design is a structural joint which provides a leak limiting seal. This joint is fabricated by hydraulically and mechanically expanding the sleeve against the outer tube. A functional requirement for "reference" upper joints is that they must be sufficiently leak limiting such that the total leakage between the primary and secondary for all the sleeves taken together is less than the Technical Specification leak rate limit during normal operation. In addition, total leakage must be maintained to within acceptable limits during postulated accidents. The acceptance criteria imposed during verification leak testing of the joint is based upon these total leakage limits divided by the total number of tubes eventually planned for sleeving (approximately 2500 tubes per steam generator).

The second or "alternate" upper joint design is also a structural joint. This joint features a braze seal to form a leak tight joint and a hydraulic and mechanical expansion joint immediately below the braze seal for added strength. The braze has been designed to transmit all structural loadings between the sleeve and the outer tube, taking no credit for the mechanical joint which is part of the "alternate" upper joint design. The mechanical joint has also been designed as an acceptable structural joint and leak limiting seal, taking no credit for the braze.

Both the "reference" and "alternate" type upper joints are located some distance below the top of the sleeve to provide a section of unstressed, undeformed sleeve wall above the upper joints to preclude a double ended break condition, even if the tube were to become completely severed at the upper joint.

The lower sleeve joint also involves an expansion process and provides a structural and essentially leak tight seal.

The precise configuration of the sleeves and sleeve joints including the methods of fabrication are Westinghouse proprietary information.

2.2 Plug Removal Process

Approximately 800 and 120 tubes at Point Beach Units 1 and 2, respectively, have been plugged to date. The licensee had originally proposed in its July 2, 1981 letter to recover some of these tubes for future service by removing the plugs, and then installing sleeves to restore the integrity of the tubes.

The type of plugs used at Point Beach includes welded and explosively welded plugs and mechanical plugs. Removal of welded and explosively welded plugs involves a drilling operation which is not necessary for mechanical type plugs. Following removal of the plugs, the surface defects on the inner surface are removed and a visual inspection of the tube surface is performed prior to installing sleeves. The mechanical plug removal process has been qualified by Westinghouse so as to produce no unacceptable loadings or cracks in the pre-existing tube to tubesheet welds (Reference 3).

A tube from which explosive plugs had been removed previously (from tube inlet and outlet) and which was subsequently sleeved on the hot leg side during the demonstration program in Fall 1981 recently developed a small leak on the non-sleeved, cold leg side. The source of the leak could not be identified with eddy current testing. However, damage to the outer tube at the roll transition as a result of the drilling operation is a possible explanation. Damage of this kind does not present any concerns from a safety standpoint because the leak path between the primary and secondary would have to negotiate the narrow tube to tubesheet crevices which severely limits the resulting leakage. Nonetheless, any future plug removals at Units 1 and 2 will involve only mechanical plugs to preclude any potential for drill damage to the tubes (Reference 9).

2.3 Post Sleeve Process Inspection

Post sleeve process inspection will be performed to verify that the field installation has produced acceptable joints. I. D. measurements will be performed in approximately 10% of the sleeves to verify proper amounts of expansion. However, the staff is requiring the licensee to submit for staff review and concurrence a plan for additional sample inspections of this kind in the event that diameter measurements not meeting the acceptance criteria are found. After all sleeves have been installed, a final eddy current inspection will be performed on all sleeved tubes to verify that all sleeves have received the required hydraulic and roll expansions, and to provide baseline data for the entire length of the sleeved portion of the tube.

A proprietary non destructive examination (NDE) inspection will be performed on approximately 10% of the brazes to verify the brazing process. The licensee and Westinghouse believe that additional sampling using this NDE is unnecessary, since the "alternate" joint features a mechanical joint with adequate structural and leak limiting capabilities in addition to the braze. As will be discussed in Section 4.1, the staff is requiring additional information from the licensee before making its findings regarding the proposed sampling inspection of the brazes.

3.0 Design Verification Analysis and Test

Tests have been performed on the San Onofre lower sleeve joint configuration which demonstrate that the sleeving process will not adversely affect the integrity of the tube to tubesheet welds (Reference 3, Sec. 6.1). These tests considered the effect of a light rolling of the tube ends which is performed to provide a uniform tube opening for sleeving, and the effect of forming the lower sleeve joint. The radial forces which will be transmitted to the tube to tubesheet welds at Point Beach are comparable to those at San Onofre, thus conclusions drawn on the basis of the San Onofre tests are valid for Point Beach. Tests have been performed on the Point Beach configuration which verify that the pulling loads associated with the removal of mechanical plugs (prior to sleeving) will have no adverse effect on tube to tubesheet weld integrity (Reference 3, Sec. 6.1).

A substantial data base exists from tests verifying the sleeve design adequacy of the San Onofre Nuclear Generating Station Unit 1 sleeving repair (SCE Sleeve Repair). These tests are identified in Reference 3. Much of the testing performed for the SCE Sleeve Repair supports the design of the Point Beach sleeve repair. Corrosion resistance and mechanical properties of the materials used in the sleeve repair were directly applicable. The mechanical test apparatus and procedures were essentially the same. The overall Point Beach sleeve repair corrosion and mechanical test programs are described in Tables 6.1-2 and 6.1-3 of Reference 3. These tables also provide a correlation to the SCE Sleeve Repair test program and results. The additional mechanical testing performed for the Point Beach sleeve repair is discussed in the following paragraphs. All of these tests are described in Reference 3.

3.1 Mechanical Test Program

The primary functions of the sleeve repair are to restore the integrity of the steam generator tubing and to maintain the steam generator tubing as an acceptable primary-to-secondary pressure boundary under normal and accident conditions. A rigorous testing program was conducted to verify the sleeve design. The objectives of the mechanical testing program were to:

- Verify the structural strength of the sleeved tube under normal and accident conditions.
- Verify the fatigue strength of the sleeved tube under transient loads representing 35 years of operation.
- Confirm satisfactory performance of tubes sleeved in non-optimal conditions.
  - . deep secondary side hard sludge
  - . tube support plate denting
  - . plugged tube recovery
- Establish the process parameters required to achieve satisfactory performance.

The acceptable leakage criteria used to evaluate the sleeve performance during normal operation were based on plant technical specifications. Over 100 test specimens were used to verify the design and to establish process parameters. Testing encompassed static and cyclic pressures, temperatures and loads.

Leak rate criteria have been provided for both normal operating conditions as well as under postulated accident conditions such as a feedline break and postulated loss of coolant (LOCA) accidents.

The test program consisted of subjecting specimens of the lower joint, the hybrid expansion joint (HEJ) and the dual joint to normal operating and postulated accident conditions and measuring the leak rate for all of these conditions. Not all three types of joints were subjected to each of the various test conditions. Reference 3 explains exactly which of the various test conditions applied to a given joint.

Tests to verify the following capabilities of the sleeve joint were performed as part of the design verification test program. A description of the test procedure and the test results have been provided in Reference 3.

1. Leak-limiting capabilities of HEJ.
2. Structural capabilities of HEJ after axial cyclic loading.
2A. Structural capabilities of HEJ after axial and radial cyclic loading.
3. Leak-limiting capabilities of HEJ after axial cyclic loading.
4. Structural capabilities of HEJ during feedline break (FLB) accident conditions.
5. Leak-limiting capabilities of HEJ during accident conditions.
6. Leak-tight capabilities of lower joint after cyclic loading.
7. Structural capabilities of lower joint after cyclic loading.
8. Internal pressure capabilities of braze joint.
9. External pressure capabilities of braze joint.
10. Structural capabilities of braze joint after axial and radial cyclic loading.
11. Structural capabilities of braze joint after axial cyclical loading.
12. Structural capabilities of braze joint after FLB accident conditions.

3.2 Analytical Verification

A stress evaluation of the sleeve and tube assembly in relation to the requirements of the ASME Boiler and Pressure Vessel Code Section III was performed. The assembly was modeled mathematically and evaluated in detail.

By changing the modeling parameters, the braze or roll region can be included or deleted from any particular evaluation. The longest sleeve proposed for use was the one evaluated by the staff. The actual length of the longest sleeve is Westinghouse proprietary information. Evaluating the longest sleeve length assures that the maximum sleeve/tube thermal interaction loads are developed by the analysis. The tolerances used in developing the braze and roll region of the model were such that the maximum outer diameter (O.D.) sleeve and tube were evaluated in combination with the minimum tube and sleeve wall thickness. This resulted in maximum stress levels being calculated in the braze and roll transition regions.

Both the sleeve and tube are INCONEL-600 alloy. The sleeve material, however, is thermally treated to provide higher strength properties. The tubesheet is low alloy carbon steel with INCONEL cladding on the primary face. The material properties of the tube and sleeve are in accordance with ASME Boiler and Pressure Vessel Code, Section III.

The ASME Code stress categories which have been considered and the corresponding loading conditions are as follows. The various terms used in the stress categories are defined at the end of the listing of these categories.

a. Primary General Membrane Stress Intensity P_m

- Design or Upset Conditions $P_m \leq S_m$
- Test Conditions $P_m \leq S_y$
- Faulted Conditions $P_m \leq .7S_u$ or $2.4S_m$

b. Primary Local Membrane Stress Intensity P_L

- Design or Upset Conditions $P_L \leq 1.5\ S_m$
- Test Conditions $P_L \leq 1.35\ S_y$
- Faulted Conditions $P_L \leq 1.5 \times .7 \times S_u$ or $1.5 \times 2.4 \times S_m$

c. Primary Membrane + Bending $P_L + P_b$

- Design or Upset Conditions $P_L + P_b \leq 1.5\ S_m$
- Test Conditions $P_L + P_b \leq 1.35\ S_y$
- Faulted Conditions $P_L + P_b \leq 1.5 \times .7 \times S_u$ or $1.5 \times 2.4 \times S_m$

d. Range of Primary + Secondary Stress Intensities $P_L + P_b + Q$

- Test Conditions $P_L + P_b + Q \leq 3\ S_m$
- Transient Conditions $P_L + P_b + Q \leq 3\ S_m$
- Upset Conditions $P_L + P_b + Q \leq S_m$

e. Range of Total Stress Intensities $P_L + P_b + Q + F$

- Test Conditions - Cumulative Usage Factor <1.0
- Transient Conditions - Cumulative Usage Factor <1.0
- Upset Conditions - Cumulative Usage Factor <1.0

P_L = Primary local membrane stress

P_b = Primary bending stress

S_m = Allowable stress intensity at design temperature

S_y = Material yield stress

S_u = Material ultimate stress

Q = Membrane and bending stresses

F = Peak stress

S_a = Alternating stress intensity

The loading conditions considered in this analysis are as defined in Appendix B of Reference 3. The loading conditions are specified in two categories, steady state and non-steady state conditions. They are also stated in terms consistent with current code requirements. In addition, the specific full range of the mechanical loads should not result in load stresses whose range exceeds the S_a value obtained from the applicable design fatigue curves.

The loading conditions specified for Level A or those loadings which the sleeves may be subjected to during normal operation are:

1. Primary Side Design Conditions

   P = 2486 psig T = 650°F

2. Secondary Side Design Conditions

   P = 1085 psig T = 556°F

The loading conditions specified for Level B or loading which the sleeves must withstand without damage requiring repair are subdivided into three categories:

Transient Conditions

Abnormal Conditions

Pressure Tests Conditions

There are portions of the sleeve/tube configuration which have essentially no axial temperature gradient. Since this is the case, it was possible to develop refined element models of the regions of interest and use a coarse element mesh elsewhere.

One model was developed for evaluating both the reference sleeve design (HEJ) and the alternate configuration (dual joint). By modifying material properties and fabrication parameters at the braze region, the dual joint model can be transformed into a HEJ model for further evaluation.

Some significant considerations in developing the model were:

1. The nodes along the expanded tube/sleeve intersection can be coupled in the radial direction for both the thermal and stress analyses. These nodes are not coupled in the axial direction for the braze joint stress analyses which would force any axial load passing from the sleeve to the tube to be transferred through the brazed joint. This is a conservative approach since laboratory tests have shown the expanded connection to retain its structural integrity during anticipated cyclic loadings.

2. An air gap is included below the brazed joint between the tube and the sleeve. Though this space may become filled with fluid in the event of a degraded tube, it is a more conservative approach for the thermal stress analysis to assume that this space remains filled with air.

3. By varying node coupling conditions at a specified region of the model, the conditions of either an intact tube or degraded tube can be simulated.

4. Since there is no braze junction at the upper end of the braze reservoir, the condition of primary pressure acting throughout the reservoir and upper expanded junction was considered.

For the degraded tube condition and secondary pressure loadings, the nodes along the lower expanded interface are uncoupled up to the brazed junction. The braze junction stress analysis considers the conservative case condition of these coupled/uncoupled variances.

The element chosen for the solution was the WECAN element, STIFF53, "Iso-parametric 2-Dimensional Quadrilateral". Most of the elements are quadratic, having a single node placed in the center of each edge in addition to each corner node.

3.3 Thermal Analysis

The purpose of the thermal analysis is to provide temperature distributions used in the thermal stress analysis evaluation. Since the thermal stress solutions are used for the fatigue evaluation, the maximum range of stress intensities during any of the loading conditions considered must be calculated. The transient conditions considered can be categorized by fluid temperature fluctuations and rate of temperature changes. The transient conditions with high temperature fluctuations and/or rates of temperature change will induce more extensive or higher thermal stress solutions than the other transients considered. Again, since the maximum range of stress intensities between the transient conditions considered is to be evaluated for fatigue considerations, the transient conditions can be further categorized into conditions resulting in an increase in primary fluid temperature and conditions which result in a decrease in primary fluid temperature. An evaluation of the categorized transients results in the determination of "umbrella" transients. The umbrella transients chosen for detailed thermal analysis are:

1. Increase in Primary Fluid Temperature - Loss of Load
2. Decrease in Primary Fluid Temperature - Loss of Flow
3. Maximum ($T_{Primary}$ - $T_{Secondary}$) - Loss of Secondary Pressure

Both transient and steady state thermal analyses are performed using the WECAN model which has been provided in Reference 3.

In order to perform the WECAN thermal analysis, boundary conditions consisting of fluid temperatures and convective heat transfer coefficients for the corresponding element surfaces were developed. Two methods are used in calculating the boundary conditions. For steady state conditions, the computer code GENF is used to provide steady state fluid temperatures and film coefficients for the primary and secondary side of the WECAN model. For transient conditions, conservative primary and secondary fluid conditions were developed for the three umbrella transients and evaluated as equivalent steady state conditions. The heat transfer coefficients are calculated on the primary and secondary surface of the tubes with the aid of the Colburns Equation as discussed in Reference 3 Section 6.2.6.2.

3.4 Stress Analysis

The Westinghouse computer analysis code, WECAN, which is currently under review by the staff is used to determine the stress levels in the tube/sleeve/braze configurations and roll transition region for pressure and temperature loading conditions. Because this is a linear elastic analysis, thermally induced and pressure induced stresses are calculated separately and then combined to calculate the total stress distribution using computer program WECEVAL. In addition, WECEVAL performs the stress categorization required for an ASME Boiler and Pressure Vessel Code - Section III stress analysis as well as a complete fatigue evaluation of specified locations in the WECAN model. The criteria used in the evaluation is that specified in Subsection NB of the ASME Boiler and Pressure Vessel Code.

For superposition purposes, the WECAN model was used to determine stress distributions induced by a 1000 psi primary pressure and a 1000 psi secondary pressure. The results of these "unit pressure" runs are then scaled to the actual primary side and secondary side pressures corresponding to the loading conditions considered in order to determine the total pressure stress distribution. As mentioned previously, there were several modeling considerations in determining the nit pressure load stress distributions. They are:

a. Tube intact or tube degraded

b. With or w/o pressure acting inside the braze volume.

The boundary conditions applied to the WECAN model for each of unit pressure loading conditions have been provided (Reference 3 Section 6.2.6.3).

The WECAN model is used to determine the stress levels in the tube/sleeve/braze configurations that are induced by the temperature distributions calculated by the thermal analysis. Each of the steady state conditions is evaluated as well as those times during the transient thermal solutions which are anticipated to be limiting from a stress standpoint. The times chosen for stress analysis from the transient thermal solutions were chosen using the following guidelines:

a. Time at which pressures maximize/minimize.

b. Time at which maximum sleeve-to-tube temperature differences occur.

c. Time at which maximum through thickness temperature gradients occur in the braze region.

At any given point or section of the model, the program WECEVAL can determine the total stress distribution for a given loading condition and categorize that total distribution per Subsection NB requirements. That is, the total stress of a given cross-section thru the thickness is categorized into membrane, linear bending, and non-linear components. These categorized stresses can then be compared to Subsection NB allowables. In addition when supplied with a transient history at a given location in the model, program WECEVAL will calculate the total cumulative fatigue usage factor per Code paragraph NB-3216.2. The stress range due to the specified mechanical loads is calculated and compared with the value obtained from the applicable design fatigue curves. For the fatigue evaluation, the effect of local discontinuities must be considered. The WECAN model is refined sufficiently to include the effects of local discontinuities at all locations except the braze volume. At this location in the model, sharp discontinuities exist which would tend to drive the calculated stress levels unrealistically high. These discontinuities result in singularity points in the finite element model which mathematically result in artificially high calculated stresses in these regions. Therefore, the stresses at these locations are linearized to remove any peak effects. The remaining linearized stresses are then multiplied by a fatigue strength reduction factor of 5.0, the maximum required per paragraph NB-3222.4(e) of the Code, in order to obtain the total stress for the fatigue evaluation at that point. In the actual configuration, a small radius exists at this location and the fatigue strength reduction factor of 5.0 adds additional conservatism to the analysis.

3.5 Evaluation

Fatigue and stress analyses of the sleeved tube assemblies for Point Beach have been completed in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section III ("ASME Code"). Analyses were performed for two joint configurations: 1) dual joint-braze only and 2) hybrid expansion joint (HEJ) only. All analyses were performed assuming a 100 percent degraded tube below the upper joint, since this condition results in higher sleeve joint loadings.

The maximum primary (pressure) stresses for the analysis sections have been reviewed. All primary stresses for the sleeved tube assemblies are within allowable ASME Code stresses. This includes the allowables for the local membrane stresses and local membrane plus bending stresses.

Maximum range stress intensity values for the sleeved tube assemblies were reviewed. For both configurations, the requirements of the ASME Code, Paragraph NB-3222.2 were met directly at most locations and required no further consideration. At the remaining locations indicated, the $3S_m$ limit was met by excluding thermal bending stresses as permitted by the ASME Code, Figure NB-3222.1, Footnote 5, and applying the additional requirements of Paragraph NB-3228.3(a) through (f). After exclusion of thermal bending stresses, stress intensities were less than $3S_m$ as required by NB-3228.3(a). Fatigue factors were applied in accordance with NB-322.4(e) and NB-3228.3(b) and a fatigue analysis was performed in accordance with NB-3228.3(c). For the thermal stress ratcheting requirement of NB-3228.3(d), Case 2 of NB-3222.5 was used. The allowable thermal stress range for the dual joint was calculated and found to be well in excess of the calculated maximum total stress intensity for this joint. The allowable thermal stress range for the HEJ was also calculated in excess of the calculated maximum total stress intensity. Thus, the thermal sleeve ratcheting requirement is met. The maximum temperature of the sleeved tube assemblies is within the range of temperatures specified in NB-3228.3(e) and the ratio of minimum yield strength to minimum tensile strength is less than the limit of 0.80 specified in NB-3228.3(f). Thus, all of the additional requirements of NB-3228.3 are satisfied at the locations where the requirements of NB-3222.2 were not met directly and the sleeved tube assemblies satisfy the applicable requirements of the ASME Code.

Based on the sleeve design criteria presented in Section 3.1 of the Sleeving Report, the fatigue analysis considered a design life objective for the sleeved tube assemblies of 35 years. Tables 6.2-4 through 6.2-6 of the Sleeving Report describe the transient conditions considered in the fatigue analysis. Since these tables provide transients for a 40-year design life objective, the values used in the fatigue analysis were 35/40 of these values. The maximum fatigue strength reduction factor of 5.0 (NB-3222.4(e)) was applied in the radial direction at all points along the braze in the dual joint configuration which conservatively satisfies the requirements of a simplified elastic-plastic analysis (NB-3228.3) and associated fatigue analysis. In the HEJ configuration, fatigue factors (NB-3228.3(b)) were calculated and used at all of the critical fatigue points. The results of the fatigue analysis for the sleeved tube assemblies were reviewed for all points of maximum fatigue usage. All of the cumulative usage factors are below the allowable value of 1.0 specified in the ASME Code.

In addition, the stress range due to the specified mechanical loads does not exceed the alternating stress value obtained from the applicable design fatigue curve.

As a result of the mechanical test program described in the subject report, it has been demonstrated that the leak limiting capabilities of the HEJ and the lower sleeve joint after cyclic loading and during postulated accident conditions meet the leak criteria. The structural capabilities of the HEJ, lower joint, and braze joint after cyclic loading and during postulated accident conditions meet the structural criteria.

Analytical assessments were done to predict model natural frequencies and related dynamic bending stresses attributed to flow-induced vibration for sleeved tubes. The purpose of the assessments was to evaluate the effect on the natural frequencies, amplitude of vibration, and bending stress by the installation of the sleeves. The analysis was done on the basis of: (1) vibration excited by vortex shedding; (2) vibration caused by fluid elastic excitation.

Based upon the staff's review of the vibration analysis, the staff finds that the installation of sleeves will not contribute to cyclic fatigue with respect to flow induced vibration.

The licensee has not proposed a plugging limit for the sleeves but has calculated the minimum required sleeve wall thickness to sustain normal and accident condition loads (Reference 3 Section 6.3.4). The licensee has also demonstrated that its calculations were performed in accordance with Regulatory Guide 1.121. In the absence of a proposed plugging limit for the sleeves and based upon a review of the licensee's calculations with regard to minimum required wall thickness, the staff intends to impose the same plugging limit on the sleeves (i.e. degradation equal to 40% nominal wall thickness) as exists for the non-sleeved tubes.

As a result of our review of the design criteria, design verification tests and analyses of HEJ and dual joint sleeves, the staff concludes that the applicable ASME code stress and fatigue requirements have been met by the licensee. Therefore, the proposed sleeving program for Point Beach Units 1 and 2 is acceptable.

3.6 Discussion of Corrosion Aspect

The corrosion that has occurred on the outer surface of the tubes has been attributed to caustic corrosion resulting from the use of phosphate water chemistry in the secondary water with massive phosphate additions and the formation of caustics due to impurities from persistent leaky tubes in the steam condenser. The chemistry control program of the secondary side water was switched to an all-volatile treatment in September of 1974 though free hydroxide continued to be present in the blowdown water until 1978.

Most of the steam generator tube corrosion and degradation has occurred in the central region of the inlet end of the tube bundle. Some intergranular stress corrosion cracking, wastage, and thinning has occurred at locations just above the tubesheet in the sludge zone, but the more extensive intergranular corrosion has occurred in the tubesheet crevices. Although the licensee's tube degradation rate has slowed recently, tube degradation could continue.

Evaluation

The NRC staff has reviewed the corrosion test program performed in support of the Southern Calfornia Edison (SCE) plant, San Onofre Unit 1; this work was cited by the licensee in support of the present request application (Reference 3). The corrosion tests performed were extensive, involving the use of capsule tests and modified boiler tests in which the environment that exists in San Onofre was simulated and its effect on the sleeved tubes was studied. The environment in the tubesheet crevice at Point Beach Unit 1 is similar. An extensive test program was performed studying the effects of caustic on the corrosion resistance and stress corrosion cracking of the sleeving material. Confirmatory testing of the corrosion and stress-corrosion cracking resistance of both the upper and lower mechanical rolled joint of the Point Beach configuration was performed. The NRC staff has reviewed the test data from the above programs and finds that the tests and their results are directly applicable to the Point Beach sleeving repair test program. The small differences in the tube dimensions that cause slightly different operating values in the fabrication procedure do not affect significantly the corrosion resistance of the tubes or the joints. The test program has studied the behavior of the repair program materials in pure water, in primary coolant, and in 10% caustic solutions to simulate the continued hideout of caustic in the crevices and sludge on the secondary side of the steam generator. This work has shown that the thermal treatment to be given to the Inconel sleeves is effective in reducing the probability of caustic stress corrosion developing on these sleeves. It has also been shown that the small, controlled amount of cold work performed on the Inconel in attaching the sleeve to the steam generator tube was not sufficient to cause a significant increase in the susceptibility of the tube to stress corrosion cracking from the primary side water. This amount of cold work is significantly less than that which occurred where the tube was expanded into the lower portion of the tubesheet during the original fabrication. To date no cracking has developed in that area in Point Beach, San Onofre, or in any steam generator in the U.S. of similar design to those at Point Beach. Further the tests have shown that there is only minor degradation of the material properties and corrosion resistance of the tubes at the thermally fastened joint. This has been shown by hardness test traverses, tensile tests and corrosion tests in caustic.

Conclusions

The NRC staff has reviewed the details of the corrosion test programs performed in support of the sleeving operations in both San Onofre and Point Beach and finds that they are adequate to provide reasonable assurance that the sleeving process will not induce accelerated attack on the tube itself and that the sleeving material is more resistant to stress corrosion cracking than the original tubing. Further, the effects of the joining cycle, including the thermal joint, on the corrosion and stress corrosion resistance of the tube and the sleeve have been studied and found to be negligible.

Therefore, based upon the above, the staff finds the test program for sleeve repair of steam generators acceptable and one which will not lead to an increased potential for corrosion degradation.

4.0 Braze Joint Integrity

4.1 Braze Metal Integrity

There are two major aspects to braze joint integrity; the integrity of the braze seal itself, and the integrity of the local base metal in the tube and sleeve. The integrity of the braze seal, in terms of its ability to sustain structural loads and to function as a leak tight seal, is a function of how much braze flow takes place during the fabrication process. At San Onofre, where a number of braze joints were fabricated without a redundant mechanical joint, post sleeve process NDE revealed that a number of brazes exhibited insufficent braze flow to meet acceptance criteria based upon minimum strength requirements and the functional requirement that the braze function as a leak tight seal. This was the motivation for incorporating a mechanical joint as part of the overall "alternate" type joint. This mechanical joint has been designed, analyzed, and tested to provide an adequate structural and leak limiting seal, taking no credit for the braze. It is the licensee's position that more than 10% sampling of the brazes during the post-process NDE is unnecessary, since the only function of the braze is to provide additional leak tightness to the "alternate" joint. It is our understanding that the 10% sampling is intended primarily to verify the adequacy of the braze process to achieve good braze flow, and not to accept or reject sleeve repairs on the basis of the braze flow which has been actually achieved.

Although the staff agrees that the licensee's position has some justification, the staff believes that additional justification for this position should be provided. What the staff is after is assurance that poor or minimal amounts of braze flow will not lead to a fatigue failure or damage to the Inconel tube at the braze location. Information the staff requires to be included in the licensee's response, if credit is to be taken for the mechanical joint, includes (1) the "yield" load characteristics of the mechanical joint and supporting test data, (2) how the "yield" load characteristics relate to the fatigue integrity of the Inconel tube at the braze, and (3) the effect of wastage corrosion of the tube on the "yield" load of the mechanical joints. The staff has concluded that the effect of minimal braze flow on the tensile strength of the tube is not a function of the amount of braze flow. (The effect of the braze heating cycle is evaluated below in Section 4.2.) The braze seal becoming unbonded is not a concern, since the mechanical joint will provide an adequate leak limiting joint. The staff is requesting a licensee response by the end of July 1982 to permit the staff to make its findings regarding the licensee's proposed (10%) post-process NDE sampling plan of the brazes and whether there is any need for braze flow acceptance criteria in a supplement to this Safety Evaluation Report.

Difficulties encountered at San Onofre in achieving satisfactory braze flow have been attributed to a number of factors including the adverse effect of sludge as a heat sink for brazes formed below the top of the sludge, and restraint conditions imposed on the sleeved tube assemblies as a result of denting at the support plates. If the "alternate" (brazed) joint is selected for use at Point Beach, the location of the braze is expected to be above the sludge. However, some degree of restraint may exist at Point Beach since it has experienced some denting. Some adjustments have been made to the brazing process to improve the quality of braze flow based upon lessons learned at San Onofre 1. Post sleeve process NDE examinations of six brazed joints fabricated during the Point Beach sleeving demonstration program in Fall 1981 indicated good braze flow for each of these brazes (Reference 8).

4.2 Base Metal Integrity at Braze

The high temperatures associated with the brazing process will result in some local degradation of the Inconel base metal mechanical properties. However, tensile tests of brazed joint specimens performed as part of the ASME Code Section IX procedure qualification requirements have indicated ultimate strength values in excess of 95 ksi, which exceeds the 80 ksi Code requirement.

The braze heating cycle could create the potential for excessive dissolution of the Inconel base metal at the braze if the heating cycle is not properly controlled. Dissolution is basically a melting of the surface base metal where it comes into contact with the molten braze. San Onofre experienced problems with excessive dissolution of the Inconel which caused several tubes to leak during hydrotesting. As a result of this experience, Westinghouse performed an extensive laboratory examination (References 13 and 14) to determine the process parameters necessary to reproduce this condition in the laboratory. A number of deficiencies in the braze cycle procedures and controls were noted as a result of this investigation, and the lessons learned have been applied to Point Beach. Metallographic examinations of braze joint specimens fabricated with the revised procedures and controls over a broad range of process parameters indicate that dissolution effects at Point Beach will be small, less than 15% of the base metal thickness (Reference 7). Tensile and pressure tests indicate acceptable strength for dissolution of the tube wall up to 70% of the nominal wall thickness. Dissolution of the sleeve wall occurs outside the load path through the joint and does not affect the strength of the joint.

Although excessive tube wall dissolution is not expected to occur, it is important that this can be verified subsequent to the sleeving process. A post sleeve process eddy current test will be performed on all brazed joints. Eddy current test capabilities are very limited in the braze region. However, eddy current test procedures are available which should be capable of identifying whether significant dissolution of tube wall has occurred, well before the strength of the joint has become unacceptably degraded. Metallurgical studies of joint specimens (References 13 and 14) have shown that 100% penetration of the sleeve wall occurs before tube wall penetration exceeds 35%. This characteristic is attributable to the fact that the sleeve is heated to a somewhat higher temperature than the tube during the brazing process. As noted previously, sleeve wall dissolution itself is not a concern; however 100% penetration of the sleeve wall will produce an identifiable signal (Reference 14) from which it can be inferred that tube wall dissolution may be as much as 35% and thus the tube should be plugged.

Hydrotesting will provide added assurance of joint integrity. The proposed hydrotest (1900 psid primary to secondary followed by 800 psid secondary to primary) is evaluated in Section 6.0 below. Still additional assurance of safety is provided by the physical design of the joint. A complete 360^{o} severance of the sleeve at or near the braze joint would not result in any significant leakage. This is because any leakage between the primary and secondary side would have to go through the mechanical joint, which has been verified by test as an acceptably leak tight joint. A complete (360^{o}) severance of the outer tube at or near the braze joint would be constrained against a double ended failure mode by the presence of the sleeve which extends in excess of one inch above the top of the joint. Westinghouse has stated (Reference 15) that the resulting leakage (for the San Onofre sleeves) under these circumstances would be limited to 34 gpm.

Whereas minor dissolution of the Inconel base metal has been observed generally to occur around the circumference of the joint, Westinghouse has stated during meetings with the staff (References 13 and 14) that severe dissolution (when it occurs) tends to affect only a small or local portion of the joint circumference. The staff has concluded that the process procedures and controls are adequate to prevent severe dissolution and that post sleeve process inspection would be expected to reveal that an unacceptable condition existed. However, even if it existed and went undetected prior to service, any resulting failure would be expected to be less severe than a double ended failure of both the sleeve and tube wall at the joint.

In summary, the staff has concluded that Westinghouse has demonstrated that the braze joint can be fabricated in a manner that will produce acceptable strength and metallurgical properties and that the preservice integrity of the fabricated joints can be ensured by implementing the proposed nondestructive examinations. The staff would consider any eddy current or hydrostatic test findings of significant base metal dissolution to be unexpected and a cause for concern. For this reason, the staff is requiring that it be notified immediately of any finding of abnormal base metal degradation and that the licensee's proposed corrective actions be submitted for staff review and approval prior to plant restart.

5.0 Eddy Current Test (ECT) Capabilities

Eddy current data is provided in the Repair Report (Reference 3) to demonstrate that the sleeved tube assemblies can be inservice inspected to assess structural and leak tight integrity as required by General Design Crite¬ia (GDC) 32 and Regulatory Guide 1.83. Data is presented in the report to demonstrate the applicability of the conventional bobbin type ECT probe to the inspection of the sleeved tube assemblies. (This data was actually obtained for San Onofre sleeved assemblies.) At the optimum test frequency for the sleeve, the amplitudes of the ECT signals ranged from 70% to 100% of those for a non-sleeved tube for calibration holes of 40% and 100% through wall depth, respectively. This data is indicative of the relative flaw sensitivity outside the tubesheet, whereas most of the sleeve length will be located within the thickness of the tubesheet. The Westinghouse investigation indicates that within the thickness of the tubesheet the "signal to noise ratio" associated with a sleeving defect is substantially more than that associated with a flaw in a non-sleeved tube. Thus, Westinghouse has concluded that the sleeve in the tubesheet region will have a higher degree of inspectability than an unsleeved tube in this region.

The inspectability of the tube wall is of interest at and above the upper sleeve joints. The Westinghouse study indicates that the amplitude of the ECT signals for calibration holes in excess of 40% through wall were approximately 50% of those for non-sleeved tubes at a test frequency of 100 KHZ. At a test frequency of 350 KHZ, the amplitude sensitivity was reduced to approximately 30% to 40% of that for a non-sleeved tube.

Eddy current inspection of the sleeve joints will present some difficulties, particularly at the braze for the "alternate" type upper joint. The sleeve joints contain a number of features (e.g. expansion transitions, sleeve ends, brazes) which will produce competing ECT signals making it more difficult to discriminate sleeve or tube wall defects at these locations. The application of the multifrequency techniques will provide enhanced capability to discriminate flaw signals from these competing signals. Westinghouse is currently investigating ECT procedures to further improve the inspectability of these regions including the use of magnetic bias techniques and alternate probe types such as the crosswound probe, the rotating pancake (RPC) probe, and the multicoil surface riding probe.

Westinghouse reported on its progress in resolving these difficulties during a recent meeting with the staff (Reference 14). Laboratory investigations indicated that a crosswound probe is adequately sensitive to detect ASME calibration hole standards in the expansion transitions of the sleeve joints. It is expected that further development of this probe will make it sufficently reliable for field application. The sensitivity of existing techniques to detect flaws at the braze location of the "alternate" joint and of the tube opposite the sleeve ends remains low compared to other regions of the sleeved tube assembly. As previously discussed, however, eddy current techniques are available which are expected to detect any condition of excessive base metal dissolution at the braze location. In addition, Westinghouse has recently performed laboratory tests to demonstrate the capability to detect a 0.01" wide Electro Discharge Machining (EDM) notch (simulating a crack) which is ¼" in length and which penetrates through the tube wall to the braze. Based upon available burst strength data (References 16 and 17), the staff believes that such a flaw is of insuffient length to cause a gross tube failure during normal operation or postulated accidents. Similarly, Westinghouse has performed laboratory tests to demonstrate the detectability of EDM notches and uniform thinning flaws on the tube opposite the sleeve ends which are also smaller than those necessary to produce a tube failure.

The licensee proposes to perform a 1900 psid, primary to secondary, and a 800 psid, secondary to primary, hydrostatic pressure test as part of the periodic inservice inspections of the steam generator tubes. In addition, the staff believes that a few (i.e. 2) sleeved tubes with brazed joints should be removed and metallurgically examined after at least one year's operation following sleeve installation. Such examinations would provide an early indication of any unexpected degradation mechanism affecting the brazed area and if necessary could serve as a basis for future action. Southern California Edison has committed to such a program for San Onofre. The staff is requiring that WE commit to such a program for Point Beach prior to commencing large scale sleeving involving the use of "alternate" type joints.

6.0 Preservice Hydrostatic Test

As previously discussed, the licensee has proposed to perform a 1900 psid primary to secondary and a 800 psid secondary to primary hydrostatic test following the sleeving operation to provide added assurance of joint integrity.

The staff believes that it would be desirable to upgrade the proposed 1900 psid primary to secondary pressure test to 2250 psid to provide a test of comparable severity, in terms of differential pressure, to that which is performed for weld repairs of pressure retaining components in accordance with Section XI of the Code. (Section XI does not specifically address hydrostatic test requirements for sleeves and brazed joints.) There may exist some practical difficulties in meeting this objective entirely, and the staff is continuing to investigate this matter. The staff expects to reach its conclusions regarding an acceptable hydrostatic test program for sleeves with "alternate" type joints in the near future at which time the staff will issue a supplement to this Safety Evaluation Report. In the meantime, the staff sees no need to consider more stringent hydrotest requirements for non-brazed sleeves, since the only concern for these sleeves is that they are sufficiently leak tight. This is more of an operational than a safety concern, since the only consequence of inadequate leak tightness would be small leaks during service which may eventually force shutdown of the unit for appropriate corrective action in accordance with the Technical Specifications.

7.0 Operating Experience with Sleeved Tubes

Previous operating experience with sleeve repairs of steam generator tubing is as follows:

	Start-up Date Following Initial Installation	No. installed to date	Operating experience
Palisades	1978	33	No reported problems
Oconee 1	Not reported	16	" " "
Ginna 1	12/80	21	" " "
San Onofre 1	6/81	6508	3 small leaks at joints
Point Beach 1	12/81	12	No reported problems

With the exception of San Onofre 1, the staff is not aware of any leaks or problems associated with sleeving to date. The leaks at San Onofre were found during hydrotesting following 4-1/2 effective full power months of operation. These leaks were very minor and were not the cause of the plant shutdown which was a scheduled shutdown. Two of the leaks involved the "reference" type (i.e., mechanical) joint, and one involved a joint similar to the "alternate" type joint. The braze for this latter joint had not been inspected for braze flow prior to service, and thus it is likely that the braze was not a fully continuous seal. Leaks of these kinds are not unexpected and present no safety significance in view of the inherent leak limiting configuration of these joints.

8.0 ALARA Considerations

Wisconsin Electric (WE) has taken into account ALARA (as low as reasonably achievable) considerations for each of the radiation activities to be involved in the proposed full-scale generator sleeving program at Point Beach Units 1 and/or 2. ALARA activities specifically directed to reduction of occupational radiation exposures include: decontamination of steam generators, personnel training in full-size mock-ups, installation of shielding as appropriate to reduce radiation exposures to repair personnel, and remote control of the sleeving processes.

Administrative control of personnel exposures will be effected by careful planning of maintenance procedures for the job, in order to minimize the number of personnel used to perform the various tasks involving relatively high doses and dose rates. TV surveillance of personnel during tasks will be used to identify areas and activities involving high exposures, and thus to initiate suitable dose-reducing actions.

Based on prior inplant experience with channel head decontamination and laboratory decontamination, no significant increase in airborne radioactivity is to be expected. Vapors from the channel head will be drawn through a high efficiency air particulate filtration system before release to the plant filter system. All sleeving operations will be monitored to keep airborne releases to a minimum. The licensee does not expect that auxiliary ventilation or special enclosures will be necessary.

WE has made use of experience gained in prior channel head decontamination in planning for the proposed tube sleeving activities. Data were available for Point Beach (Unit 1), Takahoma (Unit 1) (Japan), San Onofre (Unit 1), and Turkey Point (Unit 3). In particular, WE considered information on mechanisms used in prior decontaminations, and has provided information relevant to projected occupational radiation exposures resulting from the demonstration decontamination/sleeving program at Point Beach Unit 1 (Reference 3).

WE concludes that the sleeving of the steam generators at Point Beach Units 1 and 2 will require a considerable amount of personnel access to the steam generator channel heads. Prior to decontamination, conservatively assumed to reduce doses by a factor of 10, initial dose rates are conservatively assumed to be 30 rems per hour in the channel heads, 12 rems per hour in the channel head manways, and 3 rems per hour in the general platform areas around the channel head. Based on experience from the demonstration sleeving project at Unit 1 and the sleeving projects at other plants, occupancy times in these three areas yield a projected total collective dose of 750 rems per steam generator. The estimated occupancy times have been presented to the staff as proprietary information. WE has estimated that about 2000 tubes will be sleeved per generator.

The major source of the radiation dose rate inside the steam generator channel head is a tenacious layer of "oxide" which includes deposited activated corrosion products. In order to remove this deposited activity from the inside of the channel head and thereby reduce dose rates in this region, WE will use a Westinghouse mechanical decontamination process involving a slurry compound in a high pressure water spray. A manipulator arm inside the channel head with two jet nozzles will be operated remotely from a low dose rate area.

Based on our review of the Point Beach Sleeving Report, and the additional information provided by WE, we conclude that the projected activities and estimated person-rem doses for this project appear reasonable. WE intends to take ALARA considerations into account, and to implement reasonable dose-reducing activities. We conclude that WE will be able to maintain individual occupational radiation exposures within the applicable limits of 10 CFR Part 20, and maintain total person-rem doses ALARA, consistent with the guidelines of Regulatory Guide 8.8. Therefore, the proposed radiation protection aspects of the proposed program sleeving are acceptable.

9.0 Flow Considerations

The NRC staff has determined that no detailed thermal hydraulics review is necessary to sleeve steam generator tubes for Point Beach Units 1 and 2. The Technical Specifications require that the reactor coolant system (RCS) total flow rate be at least 178,000 gallons per minute at rated power.

Although the operational limitations require the RCS flow to be maintained above a minimum rate, no direct means of measuring absolute flow during power operation exists. However, the Technical Specification basis states that during initial startup reactor coolant flow was measured and correlated to core ΔT. The licensee has provided assurance that the correlation between ΔT and RCS flow is still valid after completion of the steam generator modifications and that if a change in full power ΔT greater than $3^{0}F$ occurs, flow measurements will be performed as stated by the Technical Specification basis. The licensee has also performed a secondary side heat balance on Unit 1 to ensure that the minimum RCS flow requirement is met.

Since the licensee has committed to meeting their current Technical Specifications and Basis for minimum reactor coolant flow we find it acceptable to allow power operation with sleeved steam generator tubes for Point Beach Units 1 a. d 2 without any licensing actions related to the effects of the tube sleeving on RCS flow.

10.0 Accident Evaluation

For a full scale steam generator tube sleeving, the only mechanism to increase potential offsite radiological consequences would be increased primary-to-secondary leakage. An extensive leak testing program was performed by Westinghouse prior to the tube sleeving demonstration at Point Beach 1 (Reference 3). To establish leakage rate criteria, the licensee used the primary-to-secondary limits in the technical specifications for normal operation, and also determined the maximum allowable total leak rate for: 1) a feed line break accident, and 2) post-LOCA secondary-to-primary leakage. The staff has determined that a more appropriate accident to consider for leakage criteria is a main steam line break rather than main feed line break. Rather than determining a maximum allowable leakage based upon how much leakage is required to exceed the 10 CFR Part 100 guidelines, the staff noted that the leakage tests show that the projected leakage during normal operation from the maximum number of sleeves (based on the average per-tube leakage in the testing program multiplied by the total estimated number of sleeved tubes) is less than the primary-secondary leakage limit specified in the Technical Specifications during normal operation (0.35 gallons per minute primary leakage to a steam generator). For those tests that the licensee designed to simulate accidents like a main steam line break (namely, a high primary side pressure and a secondary side pressure of zero), the results of the tests indicate that sleeving is unlikely to increase the chances that the dose associated with primary-to-secondary leakage would exceed the guidelines of 10 CFR Part 100. In fact, these tests indicate that leakage during accident conditions would be only slightly higher than the Technical Specification limit for normal operation. The staff then performed a new analysis of the main steam line break (MSLB) accident dose consequences to determine if the technical specification limits on primary-to-secondary leakage and reactor and secondary coolant iodine concentration were sufficiently low to result in dose consequences which are fractions of the 10 CFR Part 100 guidelines and are consistent with the recommendations of Standard Review Plan section 15.1.5. The staff review has determined that a main steam line break accident is very unlikely to cause cladding or fuel failures. Therefore, the major source for activity release would be from the primary and secondary coolants, and from iodine spiking. However, the Point Beach 2 technical specifications have no specific limits on iodine concentration in the reactor coolant. The staff has resolved with the licensee by telephone conversation that the Westinghouse Standard Technical Specifications (STS) for reactor coolant iodine activity concentration and surveillance will be adopted by the licensee for Point Beach 2, as they have been for Point Beach 1. The MSLB dose analysis includes iodine activity assumptions based on the STS limits. Only iodine releases were analyzed, because previous MSLB evaluations for these and similar plants show that noble gas doses are not limiting and are within 10 CFR Part 100 dose guidelines.

For calculation of iodine releases, it was assumed that all the secondary coolant in one steam generator was released to the environment shortly after the MSLB. (The staff notes that the secondary coolant iodine activity limits for Point Beach 2 are non-standard. However, adoption of STS on primary coolant activity limits will assure low iodine concentrations in the secondary coolant.) Additional releases occur, we assume, by continued leaking of primary coolant to the secondary side of the affected steam generator, at the rate equal to the leakage obtained by multiplying the average per tube leakage rate obtained from the simulated accident test times the projected number of sleeves (approximately 1 gpm for both units).

Two cases were analyzed: the first assumes that the reactor coolant iodine activity is at the upper, short-term limit of 60 μCi/g dose-equivalent I-131 (DE I-131); doses from this case must be within 10 CFR Part 100 guidelines. The second case assumes that the iodine concentration is initially at the lower, equilibrium STS limit of 1.0 μCi DE I-131, and that iodine spiking follows the accident. Doses from the second case must be within 10% of 10 CFR Part 100 guidelines.

The results of the dose calculations are given in Table 1; the assumption used are in Table 2. None of the doses exceed 10 CFR Part 100 guidelines or the 10% fraction defined above. Therefore, the staff concludes that if Westinghouse STS for reactor coolant iodine activity are adopted by Point Beach 2, the off-site doses from a potential MSLB accident for both plants will be within guidelines, and the proposed changes to the Technical Specifications to permit steam generator tube sleeving are acceptable.

As an issue separate from but related to steam generator tube sleeving, the staff notes that steam generator tube rupture accidents are undergoing generic review because of the events associated with the Ginna tube rupture and there is specific concern that two-loop Westinghouse plants may not have been analyzed in an appropriately conservative manner. Also, the Point Beach 2 FSAR steam generator tube rupture analyses did not include the assumptions found in Standard Review Plan Section 15.6.3 regarding iodine spiking and potentially high initial iodine concentration. A steam generator tube rupture occurring while the reactor coolant iodine concentration is above the level allowed by the Westinghouse Standard Technical Specifications could cause offsite doses exceeding 10 CFR Part 100 guidelines. These considerations reinforce the importance of adopting Westinghouse STS for reactor coolant iodine activity for Point Beach 2, because this is the most direct way to assure that potential steam generator tube rupture accident dose consequences will not be excessive.

TABLE 1 CALCULATED MSLB ACCIDENT OFFSITE DOSES

	Thyroid Doses, Rems 0-2 hr. EAB	Thyroid Doses, Rems 0-30 day LPZ
Pre-Accident Iodine Spike Case	20	2.7
Concurrent Iodine Spike Case	17	2

TABLE 2 ASSUMPTIONS USED IN MSLB ACCIDENT DOSE CALCULATIONS

Initial activity in secondary coolant	1. μCi/g DEI-131
Secondary coolant mass, 1 loop	130,000 lb.
Primary-to-secondary leak rate	1 gpm
Primary coolant iodine activity, initial	
Pre-accident iodine spike case	60 μCi/g DEI-131
Concurrent iodine spike case	1 μCi/g DEI-131
Factor for increasing release rate from fuel to coolant, over that rate determined from equilibrium iodine concentration	500
Letdown/cleanup rate for spiking calculation	320 lb/min
Reactor coolant mass, for spiking calculation	269,000 lb.

11.0 Conclusion

Based upon our evaluation, we find the proposed sleeving repair method for degraded steam generator tubes to be an acceptable repair alternative to plugging. We find that the proposed sleeving repairs can be accomplished to produce a sleeved tube of acceptable strength and metallurgical properties, corrosion resistance, leak tightness, and inservice inspectability, and that the preservice integrity of the sleeved tubes can be assured by implementing the proposed post sleeve process examinations. This finding is subject to a submittal by the licensee prior to commencing the sleeving operation of (1) an acceptable post sleeve process sampling plan which provides for additional diameter measurement sampling of the sleeve joints should any measurements not meeting acceptance criteria be found during initial sampling, and (2) an acceptable response to staff questions relating to fatigue adequacy at braze joints where poor or minimal amounts of braze flow have been achieved. Information under item 2 is necessary to enable the staff to complete its evaluation of the proposed post-sleeve process NDE sampling plan for braze joints and whether there is adequate basis for not imposing braze flow acceptance criteria. The licensee is being requested to submit the required information by the end of July 1982 to permit staff review and issuance of findings in a Supplement to this Safety Evaluation.

The staff will also complete its evaluation of the preservice hydrostatic test program by mid-August 1982 for sleeve repairs involving the "alternate" type upper joint. The staff finds the proposed hydrostatic test for sleeve repairs involving the "reference" type upper joint to be acceptable.

Based upon its review of the process procedures and controls to be used for fabricating the braze seal associated with the "alternate" type joint, the staff would consider any eddy current or hydrostatic test findings of significant base metal degradation to be unexpected, and a cause for concern. For this reason, the staff is requiring that it be notified immediately of any finding of abnormal base metal degradation and that proposed corrective actions be submitted for staff review and approval prior to plant restart. Finally, the licensee should commit prior to sleeving to remove and metallurgically examine sleeved tubes with "alternate" type joints (if this type of joint is to be used) from the steam generators after at least one year of operation following installation of the sleeves.

The projected activities and estimated person doses for the full scale steam generator sleeving project at Point Beach Nuclear Plant, Units 1 and 2, appear reasonable. The licensee intends to take ALARA considerations into account and to implement reasonable dose-reducing activities. The licensee's measures appear adequate to maintain individual occupational radiation exposures within the applicable limits of 10 CFR Part 20 and appear consistent with Regulatory Guide 8.8 and are therefore, acceptable.

No detailed thermal hydraulic review relating to the effects of tube sleeving on Reactor Coolant System flow is necessary based on the existing plant Technical Specifications and the licensee's commitments to directly measure flow should a change in full power ΔT of greater than $3^{o}F$ occur.

Because Westinghouse Standard Technical Specifications for reactor coolant iodine activity will be adopted for Point Beach Unit 2, as they have been for Point Beach Unit 1, the offsite doses from a potential main steam line break accident for both units will be within 10 CFR Part 100 guidelines; therefore, the proposed changes to the Technical Specifications to permit steam generator tube sleeving are acceptable.

REFERENCES

1. WE letter to NRC staff dated July 2, 1981.

2. WE letter to NRC staff dated March 11, 1982.

3. Westinghouse Report WCAP-9960, Revision 1, dated February 1, 1982.

4. WE letter to NRC staff dated September 28, 1981.

5. WE response to ASLB questions, dated October 9, 1981 and supplemental response dated November 3, 1981.

6. WE letter to NRC staff dated November 6, 1981.

7. WE letter to NRC staff dated November 18, 1981.

8. WE letter to NRC staff dated January 25, 1982.

9. Letter from Counsel for WE to ASLB dated May 25, 1982.

10. WE letter to NRC staff dated May 27, 1982.

11. Amendment No. 55 to Provisional Operating License No. DPR-13 for San Onofre Nuclear Generating Station, Unit No. 1, dated June 8, 1981.

12. Amendment No. 56 to Facility Operating License No. DPR-24 for Point Beach Nuclear Plant, Unit No. 1.

13. NRC meeting with Southern California Edison in May 1981 on the subject of sleeve repairs at San Onofre 1.

14. NRC meeting with Southern California Edison and Westinghouse on May 12, 1982 on subject of San Onofre steam generators, including sleeving.

15. Transcript of "Steam Generator Sleeving Review Board Meeting, San Onofre Unit 1, Steam Generator Sleeve Repair for Southern California Edison, Westinghouse Electric Corporation, Forest Hills Division, Pittsburgh, Pennsylvania, 15211, Thursday, October 23, 1980 - 8:15 A.M., Friday, October 24, 1980 - 8:05 A.M.".

16. Carolina Power & Light Company letter to NRC staff dated July 29, 1977, transmitting Westinghouse Report WTD-SM-77-058.

17. NUREG/CR-0718, "Steam Generator Tube Integrity Phase I Report," September 1979.