ATTACHMENT 1

Letter from C. R. Steinhardt (WPSC)

To

Document Control Desk (NRC)

Dated

April 24, 1997

Proposed Amendment 146

Background
Description of Proposed Change
Safety Evaluation
Significant Hazards Determination
Environmental Considerations

INTRODUCTION

The current Kewaunee Nuclear Power Plant (KNPP) Technical Specifications (TS) allow steam generator tube repair using Combustion Engineering (CE) leak tight sleeves in accordance with CE topical report CEN-413-P. The purpose of this TS amendment request is to revise TS 4.2.b.4.a, to specify installation of CE leak tight sleeves in accordance with CE generic topical report CEN-629-P, Revision 2, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak Tight Sleeves," dated January 1997, and to allow re-sleeving of tubes with existing sleeve joints in accordance with KNPP specific topical report CEN-632-P, "Repair of Kewaunee Steam Generator Tubes Using a Re-sleeving Technique," dated April 1997.

Generic report CEN-629-P describes three types of sleeves for repair of 7/8-inch OD steam generator (SG) tubes. There are two types of tubesheet sleeves; one of which is welded to the parent tube at both the upper and lower end of the sleeve; and the other of which is welded near the sleeve upper end and hardrolled into the tube and tubesheet at the sleeve lower end. A variation on the tubesheet sleeve design is the use of a pre-curved sleeve which allows access to the outer periphery of the tube bundle. The topical report covers tubesheet sleeves up to and including a total length of 30 inches. The third type of sleeve design spans the area of degradation at the tube support plate intersections. This type of sleeve is welded to the tube near each end of the sleeve.

KNPP specific topical report CEN-632-P describes the steps required to re-sleeve tubes which have existing Westinghouse hybrid expansion joint (HEJ) sleeves already installed. This report describes the sleeve/tube preparation, re-sleeve installation and the design of a leak tight full depth tubesheet sleeve that is up to 39 inches in length.

BACKGROUND

The KNPP has two Westinghouse model 51 SGs with 7/8-inch OD tubing. KNPP has been experiencing tube wall degradation attributed to outside diameter integranular attack and outside diameter stress corrosion cracking (ODSCC). As a result of this degradation, significant tube plugging and sleeving has been required. During the 1988 and 1989 outages a large scale sleeving program was implemented in the hot leg tubesheet crevice region. All of the sleeves installed were Westinghouse mechanical HEJs. Additional sleeving occurred in 1991 using the Westinghouse HEJs and in 1992 with the CE TIG welded sleeves. As a result of these sleeving programs a total of 2195 HEJs and 12 CE sleeves were installed in SG A, and 2133 HEJs and 4 CE sleeves were installed in SG B.

During the 1994 refueling outage the upper HEJs were inspected using the I-coil, a motorized rotating pancake coil (MRPC) probe developed for sleeve inspections. A total of 77 circumferential crack-like indications were detected in the parent tube, i.e., PTIs. Sixty-six of the indications were within the pressure boundary as defined in the KNPP TSs and were removed from service by plugging the tube. The remaining 11 indications were below the upper joint pressure boundary. During the 1995 refueling outage, the upper HEJs were examined using the MRPC +point probe. During this inspection 753 PTIs were detected; 657 in the TS defined pressure boundary and 92 below the pressure boundary. The 657 PTIs located within the defined pressure boundary were removed from service by plugging the tubes.

On September 21, 1996, the KNPP shutdown for a refueling and SG tube inspection outage. As a part of the planned outage work scope, plugs were removed from 550 previously plugged HEJ sleeved tubes. All of the in-service and unplugged HEJs were inspected using the +point probe. The results of this eddy current inspection found 1202 HEJ sleeved tubes in SG A, and 708 HEJ sleeved tubes in SG B with PTIs within the pressure boundary as defined in TS 4.2.b.4.b. Based on the number of tubes affected, KNPP elected to perform a laser weld repair (LWR) on all 1910 tubes with PTIs. A proposed TS amendment request to allow the LWR was submitted to the NRC staff on September 6, 1996.

A number of problems were encountered during the LWR efforts. The most recent of which was reported to the NRC in LER 97-002-00; that is, a number of the LWRs failed during the post-weld stress relief process. Activities to determine the cause of the weld failure are still in progress. Meetings to discuss the LWR TS amendment request have been held amongst the NRC staff, WPSC and Westinghouse on October 10, 1996, December 17, 1996, January 14, 1997 and March 24, 1997.

As discussed at the March 24, 1997 meeting, a number of the LWRs are acceptable for continued operation and it is WPSC's intent to place these tubes back in-service, however, there are a large number of tubes in which the LWR attempt was not successful and these tubes need to be either further repaired or plugged prior to returning the SGs to operation. The proposed repair process, as described in report CEN-632-P, is to re-sleeve the tube. This involves removing the lower section of the HEJ sleeve; expanding the remaining upper sleeve joint to allow clearance for a new sleeve to be inserted; installing a new sleeve up to 39 inches in length; attaching the replacement sleeve upper joint to the parent tube with a TIG weld; and forming a lower hardroll joint. The upper weld joint will be inspected with the enhanced NDE techniques as discussed in CEN-629-P.

Provided below is a description of the proposed change, a safety evaluation, a 10 CFR 50.92 significant hazards determination and an environmental considerations statement. Attachment 2 contains the affected TS pages and Attachment 3 contains the referenced topical reports.

DESCRIPTION OF PROPOSED CHANGE

This proposed amendment request will modify KNPP TS 4.2.b, "Steam Generator Tubes," and the associated basis to allow SG tube repair with CE leak tight sleeves in accordance with generic topical report CEN-629-P, revision 2; and re-sleeving of SG tubes which have existing Westinghouse HEJ sleeves in accordance with topical report CEN-632-P. In addition, TS 4.2.b.4.c which specifics the plugging limit for the CE sleeve, is being revised from allowing sleeve wall degradation of up to 40% to remain in service, to requiring plugging upon detection of sleeve wall degradation.

SAFETY EVALUATION

The basis for SG tube surveillance and plugging/repair is to ensure that the structural integrity of the tube is maintained. Sleeving technology was developed to span degraded regions of tubing with new tubing material such that the integrity of the tube is maintained. Removal of a tube from service by plugging results in a reduction of reactor coolant system flow. Repair of the tube by sleeving maintains the heat transfer area and results in a very small reduction in reactor coolant system flow. This minimizes loss of margin for reactor coolant flow through the SG in the loss-of-coolant accident (LOCA) and non-LOCA safety analysis, and maintains the heat transfer area of the SGs.

This TS amendment is being proposed to address tube degradation which is occurring within the tubesheet region, above the top of the tubesheet, at the tube support plate intersections, and within the free span of the tube in areas accessible to the sleeving equipment by using the sleeving process and equipment described in report CEN-629-P. In addition, this proposed amendment request also addresses the use of a longer sleeve to re-sleeve tubes that have existing HEJs. The longer sleeve design, and steps for tube preparation and sleeve installation are described in report CEN-632-P. The two topical reports are contained in Attachment 3 of this submittal.

This safety evaluation provides a summary discussion of the sleeve designs, installation process, installation examination, in-service examination, corrosion testing, mechanical testing, structural analysis and leakage assessment.

Sleeve Designs

Report CEN-629-P describes three types of CE leak tight sleeves that are generically applicable to Westinghouse model 44 and 51 SGs. These are:

- Full Depth Tubesheet (FDTS) sleeve which spans the tubesheet region and is attached to the parent tube near both ends of the sleeve with a welded joint,

- A FDTS sleeve which spans the tubesheet region and is attached to the parent tube with a welded upper joint and hardrolled lower joint, and

- A tube support plate sleeve which spans the tube support region and is welded near both the upper and lower joint.

The standard FDTS sleeve covered by CEN-629-P is up to 30 inches in total length. A variation on both FDTS sleeves is the pre-curved sleeve design which allows access to the outer periphery of the tube bundle.

In addition to these generic sleeve designs, KNPP intends to re-sleeve a number of tubes which have Westinghouse HEJs that have been unsuccessfully laser weld repaired. The proposed repair process is two steps: (1) preparation of the HEJ sleeved tube, and (2) re-sleeving the tube with a FDTS sleeve that can be up to 39 inches in length. The re-sleeving process and longer sleeve design are discussed in report CEN-632-P.

An optional post weld heat treatment process is available for the welded joints above the tubesheet to reduce the level of residual stress in the weld and in the Alloy 600 parent tubing at the welded joint region. At this time KNPP plans not to use the post weld heat treatment due to: the relatively low hot leg operating temperature of 591 degrees F, and the fact that CE TIG welded sleeves which did not employ post-weld heat treatment are currently in service at KNPP and other plants, and have not experienced in-service degradation in over 7 years of operation.

Installation Process

The basic installation process for each type of sleeve involves cleaning the inside diameter of the tube in the joint region, visual examination (VT) of the tube ID surface in the weld region, installation of the sleeve, hydraulic expansion of the sleeves in the weld joint region to provide sleeve-to-parent tube contact, welding of the joint, ultrasonic examination (UT) of the weld, a VT of the weld, an optional post-weld-heat-treatment, completion of the lower joint (welded or rolled), and eddy current examination (ECT) of the sleeve.

For the HEJ sleeved tubes that will be re-sleeved, there are additional steps required prior to the basic sleeve installation process. These steps, as described in report CEN-632-P, are to remove the lower HEJ sleeve section and expand the remaining upper HEJ to allow clearance for a new sleeve to be installed.

Installation Examination

During the installation process, a combination of VT, UT and ECT are used at different stages to ensure an acceptable installation. These inspection techniques and equipment use state-of-the-art practices and may change as new techniques become available.

The first inspection is an optional VT of the inner diameter of the tubing after the tube brushing (cleaning) has been completed. This VT confirms the adequacy of the brushing step in order to prevent weld failures due to oxide inclusions. If adequate cleanliness is not confirmed, the tube brushing is repeated until acceptable cleanliness is observed. KNPP intends to perform the VT to verify tube cleanliness on 100% of the tubes to be sleeved and re-sleeved during the 1997 campaign. Relaxation of this requirement during future outages depends on demonstrating a high degree of cleanliness acceptance in the field during the 1997 effort.

After the weld is made, the weld is inspected with UT to confirm a leak tight bond has been achieved by the welding process. Upon completion of the sleeve installation process, an ECT is done (currently using the +point probe) over the entire length of the sleeve pressure boundary including the parent tube in the pressure boundary behind the sleeve. The acceptance criteria for the ECT is covered in the following section, "In-service Examination."

An optional VT examination of the upper sleeve weld is available to help resolve uncertainties in the surface conditions detected by either the UT or ECT inspections. KNPP intends to perform the post weld VT examination on 100% of the new sleeve and re-sleeve installations during the 1997 campaign. Relaxation of this requirement during future outages depends on demonstrating a high degree of acceptable welds during the 1997 effort.

For the 1997 and future sleeving campaigns, KNPP intends to use a lower hardrolled joint. However, if a lower edge weld is used a 100% VT will be performed.

During the 1997 campaign KNPP intends to perform an ECT inspection of all the tubes that are re-sleeved. The inspection will be from the cold leg tube end, to the top of the re-sleeve. The purpose of this inspection is to baseline the condition of the tubes following all of the activities that were performed on the tubes during the 1996-1997 outage. Any tube with indications that exceed the TS repair limits will be repaired or removed from service.

In-Service Examination

In-service examination is to be conducted using ECT techniques qualified in accordance with the EPRI PWR Steam Generator Examination Guidelines. The +point probe, or equivalent probe, will be used to examine the sleeve full length. Inspection scope will be in accordance with TS 4.2.b.2.a, which requires that a minimum of 20% of repaired tubes be inspected at each in-service inspection outage. Scope expansion is in accordance with Table TS 4.2-3.

The acceptance criteria will be based on the logic presented in Section 5 of CEN-629-P. ECT indications in the weld zone are separated into the two categories of surface and subsurface. Surface indications can be caused by weld sag or local irregularities in the weld surface. Additional VT reviews are used to evaluate surface related indications prior to acceptance. If no surface condition is observed, then the ECT signal is considered as a subsurface weld zone indication. Subsurface weld zone indications are acceptable for service if located outside the pressure boundary region portion of the weld.

Corrosion Testing

Combustion Engineering sleeves are fabricated from Alloy 690 which is procured to ASME Boiler and Pressure Vessel Code Case N-20 and ASME Specification SB-163. In addition, a thermal treatment process is applied to impart greater corrosion resistance and lower residual stress level in the sleeve. The primary selection criterion for Alloy 690 as the sleeve material is its high corrosion resistance to pure water cracking in primary water and caustic corrosion cracking in normal and faulted secondary water PWR environments.

CE conducted tests to evaluate the corrosion resistance of the welded sleeve joint. Of particular interest is the effect of the mechanical expansion and weld residual stresses and the condition of the weld and the weld heat affected zone. Tests conducted demonstrate that the welded sleeve-tube joint performs well in corrosion tests designed to simulate typical fault and normal conditions on an accelerated basis. General corrosion under anticipated service conditions is expected only for the SG tube and not for the sleeve or weld material. None of the CE sleeves installed to date have exhibited any indication of corrosion using state-of-the-art ECT. Actual pulled tubes from the Prairie Island plant showed no in-service degradation of the weld, or the parent tube in the vicinity of the weld joint.

Mechanical Testing

Mechanical tests were performed using allowable ASME code stresses on sleeve assemblies to determine axial load, collapse, burst and thermal cycling capability. The load capability of the upper and lower sleeve joints is sufficient to withstand the thermally induced stresses in the weld resulting from the temperature differential between the sleeve and tube and the pressure induced stresses resulting from normal operating and postulated accident conditions. The burst and collapse pressure of the sleeve provides a large safety factor over the limiting pressure differentials. Mechanical testing revealed that the installed sleeve will withstand the cyclical loading from power changes in the plant and plant transients. Load cycle testing was performed on the lower hardroll joint for a 3/4-inch tube and 7/8-inch tube sleeve. Hydrostatic and helium leak testing confirmed joint effectiveness. All of the hardrolled joints were leak tight.

Structural Analysis

The CE welded and welded-hardrolled sleeves were designed to conform to the stress limits and margins of safety in the ASME Boiler and Pressure Vessel Code. The methodology used is in accordance with Section III of the 1989 Edition of the ASME Code. Safety factors of 3 for normal operating conditions and 1.5 for accident conditions were applied. In performing the analytical evaluation of the sleeves, the operating and design conditions for all of the Westinghouse plants operating with 7/8-inch Inconel tubing were considered. Stress evaluations were done for the above the tubesheet weld (which is also the weld for the tube support plate sleeve) at the nominal weld height and at the minimum weld height. The stress intensity values are less than the ASME Code allowable values and fatigue usage factors are less than 1. Evaluations of the tube support plate sleeve upper and lower welds show that the stresses and loads calculated for the FDTS sleeve upper weld are bounding. The details are in CEN-629-P.

Using the guidance of draft RG 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes," and the ASME Code, the % allowable degradation for the KNPP is 52% sleeve wall thickness. Making allowances for NDE uncertainty and degradation growth, a plugging criteria of 40% thru-wall degradation has been established for all the sleeve designs. Other types of sleeve degradation such as stress corrosion cracking located in the pressure boundary would be plugged on detection. This plugging limit requirement is already covered in KNPP TS 4.2.b.4.c.

Leakage Assessment

The CE welded sleeve joint is inherently a leak tight joint. UT examination of the weld is used to confirm that no leak path exists. Load cycle testing was performed on the lower rolled joint for both 3/4-inch and 7/8-inch tube sleeves. Hydrostatic and helium leak testing was conducted to confirm the joint effectiveness. All of the hardrolled joints were leak tight.

Sleeving of Previously Plugged Tubes

The sleeve installation requirements described are applicable to the tube support plate sleeve and the 30-inch FDTS for tubes which may or may not have been previously plugged, and the longer 39-inch FDTS that will be used at KNPP to re-sleeve previously plugged tubes. The existing requirements for tube integrity in the region outside of the sleeve pressure boundary must be met.

An ECT will be performed over the entire tubing length prior to restoring the tube to service by sleeving or re-sleeving if the tube was previously plugged. The tubing must be free of degradation in the area of the hydraulic expansion for the welded joint, in the area of the hardroll for the lower joint, and from the tube end cold leg to above the welded joint there will be no degradation which exceeds the repair limits.

Conclusion

Based on the aforementioned testing results and performance history, there is a reasonable assurance that the health and safety of the public will not adversely be affected by the proposed TS amendment changes.

SIGNIFICANT HAZARDS DETERMINATION

This proposed change was reviewed in accordance with the provisions of 10 CFR 50.92 to show no significant hazards exists.

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

The supporting technical evaluation and safety evaluation for the CE leak tight sleeves demonstrate that the sleeve configuration will provide SG tube structural and leakage integrity under normal operating and accident conditions. The sleeve configurations have been designed and analyzed in accordance with the requirements of the ASME Code. Mechanical testing has shown that the sleeve and sleeve joints provide margin above acceptance limits. UT is used to verify the leak tightness of the weld above the tubesheet. Testing has demonstrated the leak tightness of the hardroll joint as well as the structural integrity of the hardroll joint. Tube rupture can not occur at the hardroll joint due to the reinforcing effect of the tubesheet. Tests have demonstrated that tube collapse will not occur due to postulated LOCA loadings.

The existing TS leakage rate requirements and accident analysis assumptions remain unchanged in the event that significant leakage does occur from the sleeve joint or that the sleeve assembly ruptures. Any leakage through the sleeve assembly is fully bounded by the existing SG tube rupture analysis included in the KNPP Updated Final Safety Analysis Report. The proposed sleeving and re-sleeve repair processes do not adversely impact any other previously evaluated design basis accidents.

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

Installation of the sleeves or re-sleeves does not introduce any significant changes to the plant design basis. The use of a sleeve to span the area of degradation of the SG tube restores the structural and leakage integrity of the tubing to meet the original design bases. Stress and fatigue analysis of the sleeve assembly shows that the requirements of the ASME Code are met. Mechanical testing has demonstrated that margin exists above the design criteria. Any hypothetical accident as a result of any degradation in the sleeved tube would be bounded by the existing tube rupture accident analysis.

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

The use of sleeves to repair degraded SG tubing has been demonstrated to maintain the integrity of the tube bundle commensurate with the requirements of the ASME Code and draft RG 1.121 and to maintain the primary to secondary pressure boundary under normal and postulated accident conditions. The safety factors used in the verification of the strength of the sleeve assembly are consistent with the safety factors in the ASME Boiler and Pressure Vessel Code used in SG design. The operational and faulted condition stresses and cumulative usage factors are bounded by the ASME Code requirements. The sleeve assembly has been verified by testing to prevent both tube pullout and significant leakage during normal and postulated accident conditions. A test program was conducted to ensure the lower hardrolled joint design was leak tight and capable of withstanding the design loads. The primary coolant pressure boundary of the sleeve assembly will be periodically inspected by NDE to identify sleeve degradation due to operation.

Installation of the sleeves and re-sleeves will decrease the number of tubes which must be taken out of service due to plugging. There is a small amount of primary coolant flow reduction due to the sleeve for which an equivalent plugging sleeve to plug ratio is assigned based on sleeve length. The ratio is used to assess the final equivalent plugging percentage as an input to other safety analyses. Because the sleeve maintains the design basis requirements for the SG tubing, it is concluded that the proposed change does not result in a significant reduction in the margin of safety.

ENVIRONMENTAL CONSIDERATION

This proposed amendment request involves a change to the inspection requirements with respect to the installation or use of a facility component located within a restricted area. WPSC has determined that the proposed amendment request involves no significant hazard consideration and no significant change in the type of effluent that may be released offsite and that there is no significant increase in individual or cumulative occupational radiation exposure. Accordingly, this proposed amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22 (c)(9). This amendment also involves changes in record keeping, reporting or administrative procedures or equipment. Accordingly, with respect to these items, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22 (c)(10). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with this proposed amendment.

ATTACHMENT 2

Letter from C. R. Steinhardt (WPSC)

To

Document Control Desk (NRC)

Dated

April 24, 1997

<u>Proposed Amendment 146</u>

Affected TS Pages:

TS ii
TS 4.2-6 thru TS 4.2-11
TS B4.2-3
TS B4.2-4
TS B4.2-5

3. A loss-of-coolant accident requiring actuation of the engineering safeguards, where the cooldown rate of the Reactor Coolant System exceeded 100°F/hr, or

4. A main steam line or feedwater line break, where the cooldown rate of the Reactor Coolant System exceeded 100°F/hr.

d. If the type of steam generator chemistry treatment is changed significantly, the steam generators shall be inspected at the next outage of sufficient duration following 3 months of power operation since the change.

4. Plugging Limit Criteria

The following criteria apply independently to tube and sleeve wall degradation except as specified in TS 4.2.b.5 for the tube support plate intersections for which voltage-based plugging criteria are applied or for degradation except as specified in TS 4.2.b.6 for tubesheet crevice region in which the F* and EF* criteria is applied.

a. Any tube which, upon inspection, exhibits tube wall degradation of 50% or more shall be plugged or repaired prior to returning the steam generator to service. If significant general tube thinning occurs, this criterion will be reduced to 40% wall degradation. Tube repair shall be in accordance with the methods described in the following:

WCAP-11643, "Kewaunee Steam Generator Sleeving Report (Mechanical Sleeves)";

CEN-629-P Revision 2, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak Tight Sleeves";

CEN-632-P, "Repair of Kewaunee Steam Generator Tubes Using a Resleeving Technique"; or

WCAP-13088, Revision 3, "Westinghouse Series 44 and 51 Steam Generator Generic Sleeving Report".

b. Any Westinghouse mechanical hybrid expansion joint (HEJ) sleeve which, upon inspection, exhibits wall degradation of 31% or more shall be plugged or repaired prior to returning the steam generator to service. For disposition of parent tube indications (PTI), the following requirements will apply:

1. HEJ sleeved tubes with circumferential indications located within the upper hardroll lower transition shall be inspected with a non-destructive examination (NDE) technique capable of measuring the sleeve ID difference between the sleeve hardroll peak diameter, and the sleeve ID at the elevation of the PTI. If this diameter change is $\geq$ 0.003" (plus an allowance for NDE uncertainty), the indication may remain in service provided the faulted loop steam line break (SLB) leakage limit from all sources is not exceeded. A SLB leakage allowance of 0.025 gpm shall be assumed for each indication left in service regardless of length or depth. For tubes where the diameter difference is > 0.013", SLB leakage can be neglected.

2. HEJ sleeved tubes with a sleeve ID difference of < 0.003" (plus an allowance for NDE uncertainty) between the sleeve ID hardroll peak diameter and sleeve ID at the elevation of the PTI shall be plugged or repaired prior to returning the steam generator to service.

3. HEJ sleeved tubes with axial indications located within the parent tube pressure boundary as defined on Figure TS 4.2-1 shall be plugged or repaired prior to returning the steam generator to service.

4. HEJ sleeved tubes with parent tube indications located outside of the parent tube pressure boundary as defined on Figure TS 4.2-1 may remain in service.

c. Any Combustion Engineering leak tight sleeve which, upon inspection, exhibits wall degradation shall be plugged prior to returning the steam generator to service. This plugging limit applies to the sleeve up to and including the weld region.

d. Any Westinghouse laser welded sleeve which, upon inspection, exhibits wall degradation of 25% or more, shall be plugged prior to returning the steam generator to service. This plugging limit applies to the sleeve up to and including the weld.

5. Tube Support Plate Plugging Limit

The following criteria are used for the disposition of a steam generator tube for continued service that is experiencing predominantly axially oriented outside diameter stress corrosion cracking confined within the thickness of the tube support plates. At tube support plate intersection, the repair limit is based on maintaining steam generator tube serviceability as described below:

a. Degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with bobbin voltage $\leq$ 2.0 volts will be allowed to remain in service.

b. Degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage > 2.0 volts will be repaired or plugged except as noted in TS 4.2.b.5.c below.

c. Indications of potential degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage > 2.0 volts but $\leq$ the upper voltage repair limit, may remain in service if a rotating pancake coil inspection does not detect degradation. Indications of outside diameter stress corrosion cracking degradation with a bobbin voltage > the upper voltage repair limit will be plugged or repaired.

d. If an unscheduled mid-cycle inspection is performed, the following repair limits apply instead of TS 4.2.b.5.a, b and c. The mid-cycle repair limits are determined from the following equation:

$$V_{MURL} = \frac{V_{SL}}{1.0 + NDE + Gr\left(\frac{CL - \Delta t}{CL}\right)}$$

$$V_{MLRL} = V_{MURL} - (V_{URL} - 2.0)\left(\frac{CL - \Delta t}{CL}\right)$$

Where:

V_{MURL} = mid-cycle upper voltage repair limit based on time into cycle
V_{SL} = structural limit voltage
NDE = 95% cumulative probability allowance for NDE uncertainty
Gr = average growth rate per cycle length
CL = cycle length (time between scheduled inspections)
Δt = length of time since last scheduled inspection during which V_{URL} and V_{LRL} were implemented
V_{MLRL} = mid-cycle lower voltage repair limit based on V_{MURL} and time into cycle
V_{URL} = upper voltage repair limit

Implementation of these mid-cycle repair limits should follow the same approach as in TS 4.2.b.5.a, b and c.

NOTE: The upper voltage repair limit is calculated according to the methodology in Generic Letter 95-05 as supplemented.

6. F* and EF* Tubesheet Crevice Region Plugging Criteria

The following criteria are to be used for disposition or repair of steam generator tubes experiencing degradation in the tubesheet crevice region.

a. Tubes with indications of degradation within the roll expanded region below the midpoint of the tubesheet may remain in service provided the distance from the bottom of the uppermost roll transition to the tip of the crack is greater than 1.12" (plus an allowance for NDE uncertainty). This criteria is called the F* criteria and applies to the factory roll expansion, or to additional roll expansions formed as an extension of the original roll. Any degradation existing below the F* (plus an allowance for NDE uncertainty) is acceptable for continued service.

b. Indications of degradation not repairable by 4.2.b.6.a may be repaired using the EF* criteria. The EF* region is located a minimum of 4" below the top of the tubesheet, and is formed by an additional roll expansion of the tube in the originally unexpanded length. Tubes with indications of degradation within the EF* region may remain in service provided the distance from the bottom of the uppermost roll transition to the tip of the crack is greater than 1.44" (plus an allowance for NDE uncertainty). Any degradation existing below EF* (including uncertainty) is acceptable for continued service.

7. Reports

a. Following each in-service inspection of steam generator tubes, if there are any tubes requiring plugging or repairing, the number of tubes plugged or repaired shall be reported to the Commission within 30 days. This report shall include the tubes for which the F* or EF* criteria were applied.

b. The results of the steam generator tube in-service inspection shall be included in the Annual Operating Report for the period in which this inspection was completed. This report shall include:

1. Number and extent of tubes inspected.

2. Location and percent of wall-thickness penetration for each indication of a degradation.

3. Identification of tubes plugged.

4. Identification of tubes repaired.

c. Results of a steam generator tube inspection which fall into Category C-3 require prompt (within 4 hours) notification of the Commission consistent with 10 CFR 50.72(b)(2)(i). A written follow up report shall be submitted to the Commission consistent with Specification 4.2.b.7.a, using the Licensee Event Report System to satisfy the intent of 10 CFR 50.73(a)(2)(ii).

d. For implementation of the voltage-based repair criteria to tube support plate intersections, notify the NRC staff prior to returning the steam generators to service should any of the following conditions arise:

1. If estimated leakage based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds the leak limit (determined from the licensing basis dose calculation for the postulated main steamline break) for the next operating cycle.

2. If circumferential crack-like indications are detected at the tube support plate intersections.

3. If indications are identified that extend beyond the confines the tube support plate.

4. If indications are identified at the tube support plate elevations that are attributable to primary water stress corrosion cracking.

5. If the calculated conditional burst probability based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds 1×10^{-2}, notify the NRC and provide an assessment of the safety significance of the occurrence.

Technical Specification 4.2.b.4

Steam generator tubes found with less than the minimum wall thickness criteria determined by analysis, as described in WCAP-7832[1][2], must either be repaired to be kept in service or removed from service by plugging.

Steam generator tube plugging is a common method of preventing primary-to-secondary steam generator tube leakage and has been utilized since the inception of PWR nuclear reactor plants. This method is relatively uncomplicated from a structural/mechanical standpoint as flow is cut off from the affected tube by plugging it in the hot and cold leg faces of the tubesheet.

To determine the basis for the sleeve plugging limit, the minimum sleeve wall thickness was calculated in accordance with the ASME Code and is consistent with Draft Regulatory Guide 1.121 (August 1976).

For the Westinghouse mechanical sleeves, the sleeve plugging limit of 31% is applied to the sleeve as shown on Figure TS 4.2-1. The sleeve plugging limits allow for eddy current testing inaccuracies and continued operational degradation per Draft Regulatory Guide 1.121 (August 1976).

Repair by sleeving, or other methods, has been recognized as a viable alternative for isolating unacceptable tube degradation and preventing tube leakage. Sleeving isolates unacceptable degradation and extends the service life of the tube, and the steam generator. Tube repair, by sleeving in accordance with WCAP-11643[3], CEN-413-P[4], and WCAP-13088[5], has been evaluated and analyzed as acceptable. The Westinghouse mechanical hybrid expansion joint (HEJ) sleeve spans the degraded area of the parent tube in the tubesheet region. The sleeves are either 36", 30" or 27" to allow access permitted by channel head bowl geometry. The sleeve is hydraulically expanded and hard rolled into the parent tubing.

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(1) WCAP 7832, "Evaluation of Steam Generator Tube, Tube Sheet, and Divider Plate Under Combined LOCA Plus SSE Conditions."

(2) E. W. James, WPSC, to A. Schwencer, NRC, dated September 6, 1977.

(3) WCAP 11643, Kewaunee Steam Generator Sleeving Report, Revision 1, November 1988 (Proprietary).

(4) CEN-413-P, "Kewaunee Steam Generator Tube Repair Using Leak Tight Sleeves," January 1992 (Proprietary).

(5) WCAP 13088, Revision 3, "Westinghouse Series 44 and 51 Steam Generator Generic Sleeving Report," January 1994.

The pressure boundary for HEJ sleeves is shown on Figure TS 4.2-1. The pressure boundary used to disposition parent tube indications (PTIs) detected in the upper joint of HEJ sleeved tubes is discussed in WCAP-14641[6]. The pressure boundary will allow PTIs located such that there is a minimum diameter change of 0.003 inch (plus an allowance for NDE uncertainty) between the peak diameter of the sleeve hardroll, and the diameter at the elevation of the PTI, to remain in service. The 0.003 inch interference lip is derived from structural and leakage testing. When inspecting and dispositioning the PTIs, the acceptance criteria will be adjusted to account for measurement uncertainties associated with the technique used to measure the relative change in ID sleeve diameters. During field application, the PTI elevation will be measured by comparing the diameter reported at the peak amplitude of the flaw, and the diameter at the center of the plus point coil's field, and using the more conservative of the two diameters to perform the ΔD determination. Application of the pressure boundary for HEJ sleeved tubes provides allowance for leakage in a faulted loop during a postulated steam line break (SLB) event. A SLB leakage of 0.025 gpm is assumed for each applicable indication. Steam line break leakage from all sources must be calculated to be < 34 gpm in the faulted loop. Maintenance of the 34 gpm limit ensures off-site doses will remain within a small fraction of the 10 CFR Part 100 guidelines for a SLB.

Topical CEN-629-P[7] describes three types of Combustion Engineering leak tight sleeves. The first type, the straight tubesheet sleeve, spans the degraded area of the parent tube in the tubesheet crevice region. The sleeve is welded to the parent tube near each end. The second type of sleeve is a full depth tubesheet sleeve which is welded near the sleeve upper end and hard rolled into the tube and tubesheet at the sleeve lower end. A variation on the tubesheet sleeve design is the use of a pre-curved sleeve which allows access to the outer periphery of the tube bundle. The third type of sleeve, the tube support plate sleeve, spans the degraded area of the tube support plate and is installed up to the sixth support plate. This sleeve is welded to the parent tube near each end of the sleeve. CEN-632-P[8] describes the steps required to re-sleeve tubes which have existing HEJ sleeves. This report describes the sleeved/tube preparation, re-sleeve installation and the design of a leak tight full depth tubesheet sleeve that is up to 39 inches in length.

Two types of Westinghouse laser welded sleeves can be installed, tube support plate sleeves and tubesheet sleeves.

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(6) WCAP-14641, "HEJ Sleeved Tube Structural Integrity Criteria: Diameter Interference at PTIs," April 1996.

(7) CEN-629-P Revision 2, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak Tight Sleeves," January 1997.

(8) CEN-632-P, "Repair of Kewaunee Steam Generator Tubes Using a Resleeving Technique," April 1997.

The tube support plate sleeve is 12" long and spans the degraded area of the tube adjacent to the support plate intersection. The tube support plate sleeve is hydraulically expanded and laser welded at each end. The pressure boundary portion of the tube support plate sleeve is the weld and the sleeve section between the welds. Tubesheet sleeves extend from the tube end to above the top of the tubesheet. Standard and bowed or peripheral tubesheet sleeves can be installed. The upper or free span joint is hydraulically expanded and laser welded. The lower joint is hydraulically expanded and roll expanded. Standard tubesheet sleeves extend from 27" to 36" in length while bowed tubesheet sleeves extend from 30" to 36" in length. The pressure boundary portion of the tubesheet sleeve is the weld and below, down to the tubesheet primary face.

The hydraulic equivalency ratios for the application of normal operating, upset, and accident condition bounding analyses have been evaluated. Design, installation, testing, and inspection of steam generator tube sleeves requires substantially more engineering than plugging, as the tube remains in service. Because of this, the NRC has defined steam generator tube repair to be an Unreviewed Safety Question as described in 10 CFR 50.59(a)(2). As such, other tube repair methods will be submitted under 10 CFR 50.90; and in accordance with 10 CFR 50.91 and 92, the Commission will review the method, issue a significant hazards determination, and amend the facility license accordingly. A 90-day time frame for NRC review and approval is expected.

Technical Specification 4.2.b.5

The repair limit of tubes with degradation attributable to outside diameter stress corrosion cracking contained within the thickness of the tube support plates is conservatively based on the analysis documented in WCAP-12985, "Kewaunee Steam Generator Tube Plugging Criteria for ODSCC at Tube Support Plates" and EPRI Draft Report TR-100407, Rev.1, "PWR Steam Generator Tube Repair Limits - Technical Support Document for Outside Diameter Stress Corrosion Cracking at Tube Support Plates." Application of these criteria is based on limiting primary-to-secondary leakage during a steam line break to ensure the applicable 10 CFR Part 100 limits are not exceeded.

The voltage-based repair limits of TS 4.2.b.5 implement the guidance in Generic Letter 95-05 and are applicable only to Westinghouse-designed steam generators with outside diameter stress corrosion cracking (ODSCC) located at the tube-to-tube support plate intersections. The voltage-based repair limits are not applicable to other forms of tube degradation nor are they applicable to ODSCC that occurs at other locations within the steam generators. Additionally, the repair criteria apply only to indications where the degradation mechanism is predominantly axial ODSCC with no indications extending outside the thickness of the support plate. Refer to GL 95-05 for additional description of the degradation morphology.

Implementation of TS 4.2.b.5 requires a derivation of the voltage structural limit from the burst versus voltage empirical correlation and the subsequent derivation of the voltage repair limit from the structural limit (which is then implemented by this surveillance).

ATTACHMENT 3

Letter from C. R. Steinhardt (WPSC)

To

Document Control Desk (NRC)

Dated

April 24, 1997

Proposed Amendment 146

CEN-629-P
CEN-629-NP
CEN-632-P
CEN-632-NP
Affidavit Requests