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May 27, 2004
L-04-068

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Subject: Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
Response to Request for Additional Information in Support of LAR No. 322 Steam Generator Tube Repair Using Alloy 800 Leak Limiting Sleeves

This letter provides the FirstEnergy Nuclear Operating Company (FENOC) response to an NRC request for additional information (RAI) dated May 11, 2004, pertaining to FENOC letter L-04-009 dated January 27, 2004.

FENOC letter L-04-009 submitted License Amendment Request (LAR) No. 322 that proposed changes to the Beaver Valley Power Station (BVPS), Unit No. 1 Technical Specifications to allow steam generator repair using Alloy 800 leak limiting sleeves. The FENOC response information is provided in Attachment A of this letter. Attachment B of this letter provides revised proposed Technical Specifications as described in Attachment A. Attachment C provides revised proposed information-only changes to the Technical Specification Bases as described in Attachment A. Attachment D provides a list of the regulatory commitments made in this submittal.

This information does not change the evaluations or conclusions presented in FENOC letter L-04-009. If there are any questions concerning this matter, please contact Mr. Larry R. Freeland, Manager, Regulatory Affairs/Performance Improvement at 724-682-5284.

I declare under penalty of perjury that the foregoing is true and correct. Executed on May 27, 2004.

Sincerely,

L. W. Pearce

L. William Pearce

A001

Attachments

c: Mr. T. G. Colburn, NRR Senior Project Manager
Mr. P. C. Cataldo, NRC Sr. Resident Inspector
Mr. H. J. Miller, NRC Region I Administrator
Mr. D. A. Allard, Director BRP/DEP
Mr. L. E. Ryan (BRP/DEP)

Letter L-04-068 – Attachment A

REQUEST FOR ADDITIONAL INFORMATION
BEAVER VALLEY POWER STATION UNIT 1 (BVPS-1)
ALLOY 800 LEAK-LIMITING SLEEVE LICENSE AMENDMENT REQUEST
DOCKET NO. 50-334

By letter dated January 27, 2004 (ADAMS Accession No. ML040300696), FirstEnergy Nuclear Operating Company (FENOC, licensee) requested a license amendment to modify the BVPS-1 Technical Specifications (TSs) to allow the use of Westinghouse Alloy 800 leak-limiting sleeves to repair defective steam generator tubes as an alternative to plugging the tubes. The Nuclear Regulatory Commission (NRC) staff has reviewed FENOC's proposed TS change and is aware that the licensee does not expect the Alloy 800 leak limiting sleeves to be in operation for more than one cycle due to planned replacement of the steam generators following Cycle 17. However, since unscheduled inservice inspections (ISIs) may require the inspection of Alloy 800 leak-limiting sleeve/tube assemblies before the steam generators are replaced, the staff is requesting the following additional information concerning the licensee's proposed ISI requirements.

1. In the BVPS-1 proposed TSs, FENOC refers to the sleeves as both "Alloy 800 leak limiting sleeves" and as "Alloy 800 sleeves." Please modify the BVPS-1 proposed TSs to consistently refer to the sleeves as "Alloy 800 leak limiting sleeves."

   RESPONSE: FENOC agrees and Attachment B provides a complete set of the proposed Technical Specification changes which refer to the sleeves as "Alloy 800 leak limiting sleeves." Changes made in response to this item are shown by a second revision bar in the margin.

2. The proposed TSs are not clear as to the disposition of Alloy 800 leak-limiting sleeves following Cycle 17 operation should the steam generators remain in service. If the proposed footnotes, which state, "Applicable only to Cycle 17" are intended to mean that steam generator tubes sleeved with Alloy 800 leak-limiting sleeves will be plugged before Cycle 18 begins (if the steam generators remain in service), then the footnotes should be clarified. For example: "All tubes with Westinghouse Alloy 800 leak limiting sleeves shall be plugged prior to the beginning of Cycle 18."

   RESPONSE: The current footnote(s) (Technical Specification 4.4.5.4.a.6.d & 4.4.5.4.a.9.c) accurately state that this applies to Cycle 17, and only to Cycle 17. This does not apply to any other Cycle other than Cycle 17. As the Technical Specifications are a part of the operating license, BVPS Unit 1 would not be legally allowed to operate using Alloy 800 tubes in Cycle 18 with the Technical Specifications written as proposed. Thus, it is not necessary at this time to determine how the leak limiting sleeves will be dispositioned following Cycle 17. This will be addressed prior to Cycle 18 operation if and when the extremely improbable situation occurs where the current steam generators (SGs) need to operate another cycle.

3. On page 7 of the submittal, the operational experience of Alloy 800 tubes and sleeves is discussed.

   Describe the operational experience (under any condition including operating conditions) in which Alloy 800 leak limiting sleeves have leaked. If only sleeves have leaked, describe the conditions under which leakage was observed, and compare the magnitude of the observed leakage to the leakage values provided in WCAP-15919-P, Rev. 0.

   RESPONSE: Westinghouse is not aware of any reported leakage in operational steam generator tubes in which Alloy 800 leak limiting sleeves have been installed.

4. In proposed TS 4.4.5.2.b.3, it is stated that all inservice Alloy 800 leak limiting sleeves shall be inspected over the full length using a +Point™ coil or equivalent qualified technique during each refueling outage, and that the inspections would include both the tube and the sleeve.

   A. Historically, the NRC staff has not specified an exact technique for performing steam generator tube inspections, since the staff's interpretation of steam generator tube inspection requirements in the TSs in conjunction with Appendix B of Title 10 of the Code of Federal Regulations (10 CFR), Part 50, is that the inspections are to be performed with techniques capable of detecting all flaw types which may potentially be present at the locations that require inspection. The NRC staff acknowledges there are some exceptions, particularly when the technique is important in assessing the severity of the degradation (e. g, the bobbin coil inspections required for implementation of the voltage-based repair criteria). Given that the proposed TSs specifically reference the +Point™ coil for performing the sleeve inspections, discuss the extent to which the +Point™ coil will be able to detect all forms of potential degradation in the sleeve/tube assembly. For example, discuss the effectiveness of the +Point™ coil in detecting 45° circumferential cracks, etc.

      RESPONSE: The response to Question 11A lists the forms and locations of potential degradation for which the +Point coil is qualified according to Appendix H of EPRI PWR Steam Generator Examination Guidelines, TR 1003138. Industry experience regarding primary water stress corrosion cracking below the expansion transition indicates that the observed flaws are predominantly either axially or circumferentially oriented, with little oblique characteristics. Those with oblique characteristics have not approached a 45° angle. Therefore, 45° angle indications are not included in the Appendix H qualification.

      Furthermore, previous evaluation of residual stresses in explosive and hydraulically expanded tubesheet joints suggests that the residual stresses are likely compressive below the expansion transition. Thus, an external stress riser must be present to initiate a flaw. This stress riser is believed to be artifact of tubesheet hole drilling, and as such would not be expected to be oriented at 45°. All observed indications to date existing below the expansion transition have been either axially or circumferentially oriented.

Nevertheless, should a flaw with a 45° angle be present, the design of the plus point coil is such that a perfect 45 degree flaw should produce no signal when the coil is static and centered over the flaw. However, when the coil is rotating in a helical scan and approaches the flaw, the circumferentially sensitive coil leg senses the flaw before the axially sensitive coil reaches the flaw resulting in detection. Plus point testing of an Outside Diameter Electro Discharge Machining (OD EDM) notch in a lab sample clearly demonstrates detection of a 45 degree flaw. The probe manufacturer was also consulted on this issue. Their effort indicates the same result.

B. Clarify that it is FENOC's intent to perform eddy current inspections with equipment and techniques capable of detecting all flaw types which may potentially be present in the pressure boundary of the sleeve/tube assembly (the pressure boundary is discussed in WCAP-15919-P, Rev 0).

RESPONSE: FENOC will perform eddy current inspections with equipment and techniques capable of detecting all flaw types which may potentially be present in the pressure boundary of the sleeve/tube assembly. The parent tube will be inspected (prior to sleeve installation) in the area of the sleeve lower hardroll joint using a +Point coil. Any indication of degradation in this region will preclude sleeve installation.

The +Point coil has a documented qualification, per Appendix H of EPRI Technical Report TR-107569, "PWR Steam Generator Examination Guidelines: Revision 5", dated September 1997, of the Alloy 800 leak limiting sleeve for 3/4" (0.750) tubing. An equivalency assessment was performed to establish that the essential variables developed for the eddy current examination of the Alloy 800 leak limiting sleeve for a 3/4" (0.750) tube can be applied to a 7/8" (0.875) tube.

5. In proposed TS 4.4.5.4.a.6.d, it is stated that tubes with Alloy 800 leak limiting sleeves will be plugged upon detection of any service induced imperfection, degradation, or defect in the sleeve and/or pressure boundary portion of the original tube wall in the sleeve/tube assembly. In TS 4.4.5.4.a.1, it is stated that, "...Eddy-current testing indications below 20 percent of the nominal tube wall thickness, if detectable, may be considered as imperfections." As a result, the wording in TS 4.4.5.4.a.1 leaves open the possibility that sleeves with indications up to 20% through-wall may not be classified as imperfections and, therefore, left in service.

A. If it is FENOC's intent to plug all tubes with indications in the sleeve/tube assembly, upon detection, regardless of indication depth, modify proposed TS 4.4.5.4.a.6.d to indicate so. For example: "All tubes repaired with Westinghouse Alloy leak limiting sleeves shall be plugged upon detection of imperfections in the (a) sleeve and/or (b) pressure boundary portion of the original tube wall in the sleeve/tube assembly (i. e., the sleeve-to-tube joint). In the case of Westinghouse Alloy 800 leak limiting sleeve/tube assemblies, an imperfection is considered to include all eddy current indications that are less than 20% of the nominal sleeve wall thickness."

B. If it is not FENOC's intent to plug all tubes with indications in the sleeve/tube assembly, upon detection, regardless of indication depth, provide the technical basis for this defacto 20% plugging limit. In the RAI response, describe the testing programs used in determining the growth rate and non-destructive examination uncertainty used in the determination of this plugging limit.

RESPONSE: As stated in the submitted proposed change to Technical Specification 4.4.5.4.a.6.d, the plugging or repair limit for Westinghouse Alloy 800 leak limiting sleeves is to plug on detection of any service induced imperfection, degradation or defect in the (a) sleeve and/or (b) pressure boundary portion of the original tube wall in the sleeve/tube assembly (i.e. the sleeve-to-tube joint). This assures that any type of defect, regardless of percent through-wall degradation, will be removed from service upon detection in the areas being examined.

6. Since both the WCAP report and FENOC responses to the RAI questions reflect the technical basis for your license amendment request, discuss any plans for including references to FENOC's RAI responses in the TSs. For example, the expression ". . . as clarified by letter dated...." could be added to the appropriate locations in the TSs to refer to the RAI response letter.

RESPONSE: The technical basis for this technical specification change is WCAP-15919-P, which is referenced in the proposed change to Technical Specification 4.4.5.4.a.9.c. Attachment C provides revised information-only proposed TS bases changes which now refer to the sleeves as "Alloy 800 leak limiting sleeves" and adds a reference to WCAP-15919-P and this RAI response letter (L-04-068). Changes made in response to this item are shown by a second revision bar in the margin.

<u>Questions on Westinghouse Report WCAP-15919-P Rev. 0, August 2003 (for 7/8-in. sleeves)</u>

7. On page 4-3, Section 4.3 (Sleeve/Tube Assembly), it is stated that an installed Westinghouse Alloy 800 leak limiting sleeve may be re-rolled (for a rolled joint) or re-expanded (for a hydraulically expanded joint), if the sleeve does not meet the minimum requirements.

A. Discuss in detail the sleeve installation steps necessary to minimize the need to perform re-rolls or re-expansions.

RESPONSE: The sleeve expansion process is controlled by repair software loaded on the work station. After the sleeve is positioned at the proper location, the expansion process is activated. This program will determine when the sleeve contacts the tube and when tube yield begins. This value (in psi) is then utilized to determine the amount of piston stroke required to properly expand the tube. The piston stroke is measured by a Linear Voltage Displacement Transducer (LVDT) mounted in the expansion cabinet. There is no operator control of this process, other than to terminate it. If a bladder or fitting fails during the expansion process,

then the expansion is unacceptable. If this expansion is the first set of three, then the tool may be lowered and another set of expansions performed in the same tube. Should this set of expansions be properly performed, the tool can be re-positioned at the unacceptable expansions and re-expanded using pressure control. The pressure is determined from the successful set of expansions and must be performed in the same tube. The same concept applies if the lower set of expansions is unacceptable. The pressure reading from the upper set of expansions may be used to re-expand the lower set. In both cases, an acceptable set of expansions must be made in a sleeved tube using software control in order for a re-expansion to be performed.

The total number of rolling operations that can be performed on a sleeve to tube joint is six, two of which must meet the torque value requirements. This number was based on testing performed on plug rolled joints and sleeve roll joints. The reason for performing a re-roll is that if the minimum torque value is not reached, then proper wall thinning is not established. The re-roll operation is intended to increase the wall thinning value by increasing the torque applied. There is a necessary increase in cold working due to this operation, but no more than had the proper torque value (and wall thinning) been reached on the initial rolling operation. Based upon testing, the sleeve/tube pullout loads and leak rate characteristics of the joint are not affected by the re-roll operation.

In the case of the expansion joint, the same logic applies, except that a pressure value is trying to be reached instead of a torque value. A total of six expansions may be attempted in order to reach the proper pressure value, and subsequent expansion size. Based upon testing, the sleeve/tube pullout loads and leak rate characteristics of the joint are not affected by the re-expansion operation.

Alloy 800 sleeve installation was recently performed at a plant with Model D4 steam generators. Approximately 540 Alloy 800 tubesheet sleeves were installed. Only two sleeves required rerolling. Thus, the likelihood that rerolls will be performed is small.

The details provided in this response, regarding minimizing the number re-rolls and criteria for plugging, will be included in the vendor's sleeving installation process procedures.

B. On page 1-1, Section 1.1 (Purpose), it is stated that tube plugs will be installed if a sleeve installation is unsuccessful or if there is degradation in the pressure boundary section of the sleeve or sleeved tube. List and discuss the installation conditions that would lead to a conclusion that the installation was unsuccessful.

RESPONSE: The following sleeve installation conditions would be cause to take a sleeved tube out of service by plugging:

An unacceptable set of expansions would be a cause to plug a sleeved tube. This condition would occur if an acceptable set of expansions, with software control,

could not be performed. If the torque value for the rolled joint did not fall within the proper torque range, a sleeved tube would be plugged.

If the two sets of expanded joints were not positioned at the proper elevation, then the sleeved tube would be plugged. This could occur due to operator error in positioning the sleeve and performing the first set of expansions with the tool in the lower position, resulting in a sleeve positioned in the tube lower than required. Additionally, there is a requirement that the lowest of the upper expansions be separated from the highest of the lower expansions by a minimum of 0.4". This condition would result from the operator positioning the tool incorrectly during sleeve installation and would be identified during the baseline eddy current test (ECT) program.

If the baseline ECT program identifies any type of unacceptable indication in the pressure boundary of the tube/sleeve assembly, then the tube would be plugged.

The details provided in this response, regarding minimizing the number re-rolls and criteria for plugging, will be included in the vendor's sleeving installation process procedures.

C. Discuss the limits on the number of re-rolls and re-expansions that can be applied to a sleeve. Discuss whether the cold work loads generated by the re-roll or re-expansion affect the structural integrity of the sleeve/tube assembly.

RESPONSE: The total number of rolling operations that can be performed on a sleeve to tube joint is six, two of which must meet the torque value requirements. This number was based on testing performed on plug rolled joints and sleeve roll joints. The reason for performing a re-roll is that if the minimum torque value is not reached, then proper wall thinning is not established.

The re-roll operation is intended to increase the wall thinning value by increasing the torque applied. There is a necessary increase in cold working due to this operation, but no more than had the proper torque value (and wall thinning) been reached on the initial rolling operation. Based upon testing, the sleeve/tube pullout loads and leak rate characteristics of the joint are not affected by the re-roll operation.

In the case of the expansion joint, the same logic applies, except that a pressure value is used instead of a torque value. A total of six expansions may be attempted in order to reach the proper pressure value, and subsequent expansion size. Based upon testing, the sleeve/tube pullout loads and leak rate characteristics of the joint are not affected by the re-expansion operation.

The details provided in this response, regarding minimizing the number re-rolls and criteria for plugging, will be included in the vendor's sleeving installation process procedures. It should be noted that during a recent Alloy 800 leak limiting sleeve

installation campaign at another plant, over 500 sleeves were installed with only 2 requiring reroll after the initial roll application.

8. Discuss whether a pre-installation inspection, using a technique capable of detecting all potentially present flaw types, is performed on the parent tube at the locations where the sleeve joints are to be established to verify that these areas are free of degradation. If these inspections are not performed at all locations where sleeve joints will be installed, provide a technical basis.

   RESPONSE: The parent tube will be inspected with a +Point probe in the hardroll joint area prior to sleeve installation. Based on the application of chemical cleaning during the BVPS 1R14 outage, detection capabilities between the bobbin coil and +Point coil for the free-span region of tubes are expected to be equivalent. Therefore, the free span region of the parent tubes, coincident with the upper expansion joint of the sleeve, may be examined with either the bobbin or +Point probes.

9. On pages 4-6 to 4-7, Section 4.5.6 (Nondestructive Examination), the WCAP-15919-P, Rev. 0 report, does not include any reference to visual examination of the tube inside diameter (ID) after installation of the sleeve was deleted. This visual examination is performed, in part, to verify that the conditioning process was successfully performed.

   Discuss how the successful completion of the conditioning process will be verified without visual examination of the tube ID after installation of the sleeve.

   RESPONSE: Westinghouse determined, subsequent to publication of WCAP-15919-P, Rev.0, that sufficient controls exist to ensure adequate conditioning of the tube surface without visual inspection. Verification will be performed by the use of the normal in-process instructions and quality assurance surveillance.

10. On page 5-2, Section 5.1 (Background), it is stated that flaw detection capability was demonstrated for flaws $\geq$ 50% through-wall for the parent tube and $\geq$ 45% for the sleeve, based on cracking, in order to provide an operational margin between the detection limit and the structural limit for defect growth.

    Given that one of the possible sleeve degradation mechanisms is wall thinning, discuss what the structural limit is for sleeve wall thinning and whether the techniques to be used during the inspections are qualified to detect degradation at or below the wall thinning structural limit.

    RESPONSE: Thinning is not postulated to be a credible degradation mechanism in the sleeve nor would the current operating chemistry regime utilized by BVPS Unit #1 suggest that thinning would be an anticipated degradation mechanism. However, thinning, if it should occur, would be expected to produce a greater probability of detection than cracking mechanisms based on the volume of affected material. Wear scars of approximately 5%TW are readily detectable with the +Point coil and any significant volumetric wall loss of the parent tube or sleeve is expected to be detected by the +Point coil.

11. On page 5-2, Section 5.1 (Background), the inspection detection capability for the sleeve and tube was discussed.

    A. Clarify whether the eddy current techniques intended for inspection of the sleeve/tube assembly are qualified to detect cracks that may by present, given the sleeve/tube configuration. Discuss the basis which shows that flaws can be reliably detected, given the sleeve/tube configuration. Discuss the number of sleeve/tube samples having stress corrosion cracking (SCC) flaws and the inspection results for these samples.

    RESPONSE: The capabilities of the ECT technique used to inspect the sleeve/tube assembly are described in the Appendix H qualification document referenced in Section 5 of WCAP 15919-P, Rev. 0.

    The eddy current technique was qualified for the following flaw types and locations:

    a. PWSCC in the upper hydraulic expansion region and transitions, free span, and in the lower roll expansion in the sleeve ID.

    b. IGA/SCC in the upper hydraulic expansion region and transitions, free span, and in the lower roll expansion transition in the sleeve OD.

    c. PWSCC in the parent tube ID behind the sleeve starting at the lowest hydraulic expansion in the top set of expansions up to the top of the sleeve.

    d. IGA/SCC in the parent tube OD behind the sleeve starting at the lowest hydraulic expansion up to the top of the sleeve.

    B. With regard to transition zone (TZ) sleeves, discuss the number of flaws situated in the portion of the parent tube that is adjacent to (i.e. behind) the sleeve's nickel band. Discuss (1) the size and location of these cracks, (2) the orientation of these cracks, (3) the effectiveness of the eddy current inspection method in detecting these cracks, and (4) if the eddy current technique is not effective at detecting these cracks, discuss which method will be used for this inspection and the technical basis for this method.

    RESPONSE: The plus point coil qualification for the Alloy 800 leak limiting sleeve did not include flaws behind the nickel band. However, calibration standards fabricated for the inspection of the TIG welded sleeve included axial EDM notches in the parent tube at the location of the nickel band as well as the microlok band immediately above. The lower roll joint in the TIG sleeve is identical to that of the Alloy 800 leak limiting sleeve. The notches are all nominally 0.375 inches in length and are 100%, 70%, and 50% deep. The notches are separated by approximately 120°. In the lower band (nickel) only the 100% notch is clearly detectable. In the upper band (microlok) all three notches are clearly detectable. As the parent tube will be inspected in the hardroll joint region prior to sleeve installation, and no parent tubes with detectable degradation in this area will be sleeved, detection capabilities involving the nickel band are not applicable. Subsequent inspection

after operation, if required, will identify partial through-wall degradation of the parent tube above and below the nickel band. Furthermore, it should be noted that axial degradation of the parent tube in the hardroll region coincident with the nickel band will not prevent the sleeve from performing its intended design function.

The compressive nature of residual stresses below the expansion transition, coupled with the thermal expansion characteristics of the tubesheet, tube, and sleeve, and inherent residual preload associated with mechanical roll expansion are expected to result in a condition where the design function of the sleeve is not compromised for postulated axial degradation within the nickel band region.

C. With regard to TZ sleeves, if there were no flaws situated in the parent tube behind the nickel band, provide a methodology (and technical basis) for addressing the structural and leakage integrity for the TZ sleeve/tube assembly, assuming that degradation (e.g., a 360°, 100% through-wall circumferential flaw) could be occurring in the portion of the tube that is adjacent to (i. e. behind) the sleeve's nickel band.

RESPONSE: Degradation of the type referred to in this question has not been reported to date in Model 51 steam generators. Testing performed in support of the laser welded sleeve design shows that for inordinate joint lengths as short as 3/4" that the hardroll joint retained first slip load resistance of approximately 5 times normal operating pressure differential, with maximum resistive load capabilities of approximately twice the first slip load. Leakage testing at operating temperature conditions following fatigue cycling indicates no leakage. Testing performed as part of the F* alternate repair criterion indicates that hardroll joint lengths as short as 1/4" are sufficient to preclude leakage for all operating plant conditions. For an assumed 360°, 100%TW circumferential flaw, located at the upper edge of the nickel band, the sound roll expansion length above this location is approximately 5/8". Therefore, a 360°, 100%TW circumferential flaw, located within the nickel band, will not prevent the sleeved tube from performing its intended design function.

Furthermore, should postulated degradation of this type occur within the sleeve to tube hardroll joint, it will most likely occur at the lower edge of the hardroll region as this is the only portion of tube exposed to primary water. In this case the effective roll length is the nominal roll length of approximately 1.25". For postulated degradation of the parent tube sufficient to represent a leakage potential, a substantial indication would have to be present extending from below the nickel band to above the hardroll joint length. In this case, the indication would be expected to be observed through the microlok region.

Additionally, any postulated degradation of the nature described herein would not represent a significant increase in faulted conditions as the tube and sleeve are constrained by the tubesheet; thus, no crack face opening, as might be postulated to occur in the free span would be credible. At the postulated elevation of such a flaw, 10.00" below the top of tubesheet, the resistive load capabilities documented

in WCAP-14797 (W* Alternate Repair Criterion) indicate that the tube expansion above this location is sufficient to preclude tube displacement, even in the case of a postulated separated tube. Resistive load increase, due to the sleeve to tube hardroll, are conservatively neglected in this example.

12. On page 6-2, Section 6.2.1 (Primary Side Performance), it is stated that, "Some oxygen will initially be present within the sleeve/tube crevice, however any tendency to trap oxygen will be reduced with this design because of joint leakage at lower temperatures. Based on this, oxygen-rich crevice conditions are not considered to last long enough after startup to be of concern." This statement implies that there could be a path for oxygen or corrosive impurities to enter and exit the crevice/annulus between the sleeve and tube joint during heat-up and cool-down of the plant. Oxygen may not be trapped, but the impurities may be trapped in the annulus.

    Discuss whether there is a potential corrosion problem as a result of trapping corrosive materials in the crevice. Discuss whether these deposits could degrade the performance of the sleeve/tube assembly.

    RESPONSE: Experience with Alloy 800 tubes in European steam generators, as well as testing in faulted secondary environments referenced in Section 6, indicates Alloy 800 exhibits excellent corrosion resistance under both primary and secondary nominal and faulted environments. Further examination of in-service sleeved tubes with similar crevices, although of the welded Alloy 690 design, have not shown any corrosion attack associated with crevice deposits.

13. On pages 7-11 and 7-12, Section 7.3.2 (Leak Test Evaluation), the assessment of leakage under post accident conditions is discussed. Provide your plant-specific limit for accident-induced primary-to-secondary leakage.

    RESPONSE: For BVPS Unit #1, accident-induced leakage is limited to 14.5 gpm at postulated main steam line break (MSLB) conditions.

14. On page 8-19, of Section 8.3,3 (Effect of Tube Prestress Prior to Sleeving), the stress state of a locked-in tube is discussed. Clarify whether sleeve installation would add additional residual stresses to a locked-in tube, causing the tube to exceed the allowable stresses in the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code).

    RESPONSE: Installing a sleeve will provide additional support to an existing tube. In general, tubes that become locked into a tube support do so during normal operation (e.g., from tube denting). Thus, during normal operation the tube will be in a zero-stress condition. As the tube cools a small tensile stress could develop in the tube between the attachment points in the tubesheet and the lock-in point at the first tube support plate. It is then assumed that a sleeve is installed while the tube is in a tensile stress condition.

As the tube-sleeve assembly is heated during plant startup both components will expand and the preload on the tube will decrease. Since the Alloy 800 leak limiting sleeve will want to expand more than the tube, the tube will expand back to the zero-stress condition at normal operation and the sleeve will be in compression.

During a transient the sleeve will restrain the tube from contracting as much as it would if it were unsleeved, thereby limiting the amount of tensile stress on the tube. Thus, the amount of stress on a sleeved tube will be less than an unsleeved tube that is locked in the first tube support plate. A more detailed discussion of installation stresses is contained in Section 7.4 of WCAP 15919-P, Rev. 0.

15. On page 8-25, of Table 8-4 (Tube Sleeve Expansion Section - Transients Considered for a Westinghouse "44", "44F", or "51" Steam Generator), verify that the number of transient cycles in the licensee's design basis is bounded by the number of applied transient cycles in the table.

    RESPONSE: As stated on Page 7 (last sentence) of our submittal, "The loading conditions assumed in WCAP-15919-P as supplemented by Westinghouse calculation CN-SGDA-04-4 bound the loading conditions listed in BV Unit 1 UFSAR Table 4.1-10."

16. On pages 8-27 to 8-32, of Section 8.51 (Analysis of Sleeve Material), higher thermal stresses were calculated for various transient conditions for the 7/8" sleeve/tube assembly than for the 3/4" sleeve/tube assembly. For example (per Table 8-5C for Westinghouse "51" steam generators), after a postulated reactor trip, the calculated value for skin thermal stresses was higher for the 7/8" sleeve/tube than for the 3/4" sleeve/tube (see pages 8-38 and 8-39 of WCAP-15918-P, Rev. 0 (Nov. 2002)). From this data, the calculated maximum stress intensity ranges (Sxr) were calculated to be higher for the 7/8" sleeve/tube than for the 3/4" sleeve/tube (Westinghouse plants).

    Noting that the staff recognizes that Sxr for both the 7/8" and 3/4", sleeve/tube configurations is within the ASME allowable, discuss the reason and significance of the higher value for Sxr for the 7/8" sleeve/tube configuration.

    RESPONSE: There are two reasons why the 7/8" tube sleeve assembly has higher thermal stresses than the 3/4" tube sleeve assembly. First, the sleeve used in 7/8" steam generator tubes is 48 mils thick while the sleeve used in 3/4" steam generator tubes is 40 mils thick. For a given temperature difference, there is a higher ΔT (and therefore a higher thermal stress) across the thicker sleeve.

    The second reason the 7/8" sleeve-tube assembly has higher thermal stresses is the primary and secondary temperatures assumed in the analysis. The analysis of the 7/8" tube-sleeve assembly assumes a ΔT of (594 - 467) = 127 °F. The analysis of the 3/4" tube-sleeve assembly assumes a ΔT of (620 - 526.5) = 93.5 °F. The higher ΔT for the 7/8" tube-sleeve assembly results in significantly higher thermal stresses.

It should be noted that the thermal stress calculations presented in WCAP-15918-P and WCAP-15919-P assume a linear temperature gradient across the sleeve and tube that is equal to the ΔT between the sleeve ID and the tube OD.

This assumption is conservative because it ignores any non-linearity of the thermal gradient. As noted in the response to Question 15, Westinghouse has recalculated the thermal gradients based on a one-dimensional steady-state heat balance. This evaluation documented a reduction in the thermal stress for both the 7/8" and 3/4" tube sleeve assemblies. However, no changes were made to the associated reports since they represent conservative, yet still acceptable, thermal stress values.

17. On page 8-36, Table 8-8C (Accumulated Fatigue in Sleeve Material for Spxr Peak Stress Range for Westinghouse "51" Steam Generator), the accumulated fatigue in the sleeve material for Spxr peak stress range for 7/8" sleeves was many times higher than that for 3/4" sleeves (see pages 8-50 and 8-51 of WCAP-15918-P, Rev. 0 (Nov. 2002)).

    Noting that the staff recognizes that the accumulated fatigue value for both 7/8" and 3/4" sleeves in Westinghouse steam generators is within the ASME allowable, discuss the reason and significance of the higher value for accumulated fatigue for the 7/8" sleeves.

    RESPONSE: The largest contribution to accumulated fatigue for the Westinghouse Model 51 steam generators (Table 8-8C in WCAP 15919-P) is from the alternating stress (Sa) that results from the difference between 0% power steady-state conditions and 100% power steady-state conditions. The corrected Sa for this condition is 34.0 ksi. The largest contribution to accumulated fatigue for the Westinghouse Model D4 steam generators (Table 8-8D in WCAP 15918-P) is from the alternating stress that results from the difference between feedwater cycling and 100% power steady-state conditions. The corrected Sa for this condition is 30.6 ksi. Although these values are within approximately 10% of each other, small differences in stress conditions can make relatively large differences in accumulated fatigue since the fatigue curves are not linear. Westinghouse does not consider the difference in fatigue usage factor between the 3/4" and 7/8" tube sleeves to be significant.

    As stated in the response to Question 15, Westinghouse has recalculated fatigue of the Alloy 800 leak limiting sleeve for a revised set of design transients that includes transients not previously addressed in WCAP-15919-P. The results of this calculation confirm that the methodology used in WCAP-15919-P to calculate accumulated fatigue of the 7/8" sleeve is bounding for BVPS Unit #1.

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Proposed Technical Specification Changes

The following are the affected pages:

3/4 4-9

3/4 4-10b

3/4 4-10c

Note: Changes made in response to this FENOC response to the NRC RAI are shown by a second revision bar in the margin.

SURVEILLANCE REQUIREMENTS (Continued)

2. Tubes in those areas where experience has indicated potential problems, and

3. Except for Alloy 800 leak limiting sleeves, at least 3 percent of the total number of sleeved tubes in all three steam generators. A sample size less than 3 percent is acceptable provided all the sleeved tubes in the steam generator(s) examined during the refueling outage are inspected. All inservice Alloy 800 leak limiting sleeves shall be inspected over the full length using a plus point coil or equivalent qualified technique during each refueling outage. These inspections will include both the tube and the sleeve, and

4. A tube inspection pursuant to Specification 4.4.5.4.a.8. If any selected tube does not permit the passage of the eddy current probe for a tube or sleeve inspection, this shall be recorded and an adjacent tube shall be selected and subjected to a tube inspection.

5. Indications left in service as a result of application of the tube support plate voltage-based repair criteria (4.4.5.4.a.10) shall be inspected by bobbin coil probe during all future refueling outages.

c. The tubes selected as the second and third samples (if required by Table 4.4-2) during each inservice inspection may be subjected to a partial tube inspection provided:

1. The tubes selected for these samples include the tubes from those areas of the tube sheet array where tubes with imperfections were previously found, and

2. The inspections include those portions of the tubes where imperfections were previously found.

d. Implementation of the steam generator tube-to-tube support plate repair criteria requires a 100-percent bobbin coil inspection for hot-leg and cold-leg tube support plate intersections down to the lowest cold-leg tube support plate with known outside diameter stress corrosion cracking (ODSCC) indications. The determination of the lowest cold-leg tube support plate intersections having ODSCC indications shall be based on the performance of at least a 20-percent random sampling of tubes inspected over their full length.

The results of each sample inspection shall be classified into one of the following three categories:

SURVEILLANCE REQUIREMENTS (Continued)

6. Plugging or Repair Limit means the imperfection depth at or beyond which the tube shall be removed from service by plugging or repaired by sleeving in the affected area because it may become unserviceable prior to the next inspection. The plugging or repair limit imperfection depths are specified in percentage of nominal wall thickness as follows:

   a) Original tube wall 40%

      This definition does not apply to tube support plate intersections for which the voltage-based repair criteria are being applied. Refer to 4.4.5.4.a.10 for the repair limit applicable to these intersections.

   b) ABB Combustion Engineering TIG welded sleeve wall 32%

   c) Westinghouse laser welded sleeve wall 25%

   d) Westinghouse Alloy 800 leak limiting sleeve*: Plug on detection of any service induced imperfection, degradation or defect in the (a) sleeve and/or (b) pressure boundary portion of the original tube wall in the sleeve/tube assembly (i.e., the sleeve-to-tube joint).

7. Unserviceable describes the condition of a tube if it leaks or contains a defect large enough to affect its structural integrity in the event of an Operating Basis Earthquake, a loss-of-coolant accident, or a steamline or feedwater line break as specified in 4.4.5.3.c, above.

8. Tube Inspection means an inspection of the steam generator tube from the point of entry (hot-leg side) completely around the U-bend to the top support to the cold-leg.

9. Tube Repair refers to sleeving which is used to maintain a tube in-service or return a tube to service. This includes the removal of plugs that were installed as a corrective or preventive measure. The following sleeve designs have been found acceptable:

   a) ABB Combustion Engineering TIG Welded Sleeves, CEN-629-P, Revision 02 and CEN-629-P Addendum 1.

   b) Westinghouse laser welded sleeves, WCAP-13483, Revision 1.

* Applicable only to Cycle 17.

SURVEILLANCE REQUIREMENTS (Continued)

c) Westinghouse Alloy 800 leak limiting sleeves, WCAP-15919-P, Revision 00. *

10. Tube Support Plate Plugging Limit is used for the disposition of an alloy 600 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 intersections, the plugging (repair) limit is based on maintaining steam generator tube serviceability as described below:

a) Steam generator tubes, whose degradation is attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with bobbin voltages less than or equal to 2.0 volts will be allowed to remain in service.

b) Steam generator tubes, whose degradation is attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage greater than 2.0 volts will be repaired or plugged, except as noted in 4.4.5.4.a.10.c below.

c) Steam generator tubes, with indications of potential degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage greater than 2.0 volts but less than or equal to the upper voltage repair limit(1) may remain in service if a rotating pancake coil or acceptable alternative inspection does not detect degradation. Steam generator tubes, with indications of outside diameter stress corrosion cracking degradation with a bobbin voltage greater than the upper voltage repair limit(1) will be plugged or repaired.

d) If an unscheduled mid-cycle inspection is performed, the following mid-cycle repair limits apply instead of the limits identified in 4.4.5.4.a.10.a, 4.4.5.4.a.10.b, and 4.4.5.4.a.10.c.

* Applicable only to Cycle 17.

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

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Proposed Technical Specification Bases Changes

Technical Specification Bases changes are provided for information only.

The following is the only affected page:

B 3/4 4-2a

Note: Changes made in response to this FENOC response to the NRC RAI are shown by a second revision bar in the margin.

BASES

3/4.4.5 STEAM GENERATORS (Continued)

operation would be limited by the limitation of steam generator tube leakage between the Primary Coolant System and the Secondary Coolant System (primary-to-secondary LEAKAGE = 150 gallons per day per steam generator). Axial cracks having a primary-to-secondary LEAKAGE less than this limit during operation will have an adequate margin of safety to withstand the loads imposed during normal operation and by postulated accidents. Operating plants have demonstrated that primary-to-secondary LEAKAGE of 150 gallons per day per steam generator can readily be detected. Leakage in excess of this limit will require plant shutdown and an unscheduled inspection, during which the leaking tubes will be located and plugged or repaired by sleeving. The technical bases for sleeving are described in the approved vendor reports listed in Surveillance Requirement 4.4.5.4.a.9.

Wastage-type defects are unlikely with the all volatile treatment (AVT) of secondary coolant. However, even if a defect of similar type should develop in service, it will be found during scheduled inservice steam generator tube examinations. Plugging or repair will be required of all tubes with imperfections exceeding the plugging or repair limit. Degraded steam generator tubes may be repaired by the installation of sleeves which span the degraded tube section. A steam generator tube with a sleeve installed meets the structural requirements of tubes which are not degraded, therefore, the sleeve is considered a part of the tube. The surveillance requirements identify those sleeving methodologies approved for use. Except for Alloy 800 leak limiting sleeves, if an installed sleeve is found to have through wall penetration greater than or equal to the plugging limit, the tube must be plugged. The plugging limit for the sleeve is derived from R.G. 1.121 analysis which utilizes a 20 percent allowance for eddy current uncertainty in determining the depth of tube wall penetration and additional degradation growth. Steam generator tube inspections of operating plants have demonstrated the capability to reliably detect degradation that has penetrated 20 percent of the original tube wall thickness. All tubes with Alloy 800 leak limiting sleeves will be plugged upon detection of any service induced imperfection, degradation or defect in the sleeve and/or the pressure boundary of the original tube wall in the sleeve/tube assembly (i.e., the sleeve-to-tube joint). (Reference: WCAP-15919-P and L-04-068)

The voltage-based repair limits of these surveillance requirements (SR) implement the guidance in Generic Letter (GL) 95-05 and are applicable only to Westinghouse-designed steam generators (SGs) 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 SG tube degradation nor are they applicable to ODSCC that occurs at other locations within the SG. Additionally, the repair criteria apply only to indications where the degradation mechanism is dominantly axial ODSCC with

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Commitment Summary

The following list identifies those actions committed to by FirstEnergy Nuclear Operating Company (FENOC) for Beaver Valley Power Station (BVPS), Unit No. 1 in this document. Any other actions discussed in the submittal represent intended or planned actions by BVPS. These other actions are described only as information and are not regulatory commitments. Please notify Mr. Larry R. Freeland, Manager, Regulatory Affairs/Performance Improvement, at BVPS on (724) 682-5284 of any questions regarding this document or associated regulatory commitments.

Commitment	Due Date
The parent tube will be inspected (prior to sleeve installation) in the area of the sleeve lower hardroll joint using a +Point coil. Any indication of degradation in this region will preclude sleeve installation.	Process to address this commitment will be in place prior to the installation of Alloy 800 leak limiting sleeves.
The details provided in the response to RAI Questions 7A, 7B and 7C, regarding minimizing the number re-rolls and criteria for plugging, will be included in the vendor's sleeving installation process procedures.	Process to address this commitment will be in place prior to the installation of Alloy 800 leak limiting sleeves.

The above commitments are only applicable to Cycle 17.