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Subject: Arkansas Nuclear One - Unit 2
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Additional Information Pertaining to Arkansas Nuclear One, Unit 2 Steam Generator Tube Sleeves

Gentlemen:

On May 20, 1996, the NRC Staff forwarded a request for information (2CNA059601) to support an assessment of steam generator tube sleeves installed by ABB Combustion Engineering Nuclear Operations at Arkansas Nuclear One, Unit 2 (ANO-2). The requested information is attached. If you have any questions concerning this submittal, please contact me.

Very truly yours,

Dwight C. Mims

Dwight C. Mims
Director, Nuclear Safety

DCM/jjd

attachment

A001/1

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Response to NRC Request for Additional Information Pertaining to Arkansas Nuclear One, Unit 2 (ANO-2) Steam Generator Tube Sleeves

1. What are the process control feed back criteria that are used to determine the circumstances under which a visual inspection (VT-1), will be performed? (Section 8.3.1.1 of CEN-628-P, Revision 0, indicates that a VT-1 inspection is not always performed).

RESPONSE

In the past, not every sleeve installation required a post weld visual inspection. The field procedure required a visual test (VT) at the request of the process engineer, or to resolve questions from the ultrasonic test (UT) results. Additionally, all repair welds required a VT. Some utilities, including ANO-2, also implemented a program to VT all tubes with either eddy current test (ET) or UT indications, for newly installed sleeves. Additionally, ANO-2 (1995) and Prairie Island (1996) required a post weld VT for all new installations.

Note that the statement on VT in the second paragraph on page 8-8 of CEN-628-P, Revision 0, should read: "All installed sleeves with welded zone indication (WZI) results from the Plus Point eddy current test were visually inspected at Zion 1 and 2; all sleeves were visually inspected at ANO and for the 1996 Prairie Island campaign...."

A VT-1 inspection will be performed in accordance with the ASME Code Section XI on new welds. The VT-1 inspection program will be reduced to the previously existing requirements following completion of additional qualification work which establishes the adequacy of the eddy current and ultrasonic tests.

2. **If one ultrasonic testing (UT) pass over a weld indicates complete fusion for the width of the UT pickup, it is considered an acceptable weld. Based on this acceptance criterion, discuss the basis for leaving indications in service given that the continuous fusion could be above and/or below the weld centerline.**

   Given that the different techniques (visual inspection, ultrasonic inspection, eddy current testing (ECT)) are complementary rather than supplementary, discuss the ability to align the VT, UT, and ECT results (i.e., if ECT detects an indication, how is it known whether this indication is above or below the continuous fusion path given that the continuous fusion path may be above or below the weld centerline). Provide supporting metallurgical data.

RESPONSE

The UT results are used to confirm a leak-tight path around the tube/sleeve circumference. The stated concern is that, in the presence of a weld imperfection, the fusion could be above the imperfection. Either UT, ET, or VT is self-sufficient to establish whether the identified imperfection is above or below the pressure boundary (weld centerline). VT is used for conditions detectable on the surface, such as blow holes or incomplete welds. For these cases, the image is self-evident regarding relative location. UT is used to identify the complete lack of fusion through the entire height of the weld, but can also be used to detect blow holes and can demonstrate whether there is a weld fusion path below the detected blow hole from the B and C scan images. Using the Appendix H qualification process, the ET method has been used to correctly locate imperfections relative to the pressure boundary using laboratory samples. The Appendix H qualification report was previously submitted by Commonwealth Edison on September 3, 1996. The results of this qualification are summarized in the ABB Combustion Engineering Nuclear Operations (CENO) letter, 96-3-9038T, Revision 1, dated June 14, 1996 (previously submitted by Northern States Power on June 27, 1996). As described in this letter, the correct location was assigned in 23/24 (95.8%) instances of all flaws and 17/17 (100%) instances for flaws exceeding 40% throughwall in the sleeve. These results are tabulated in Table 3 "Indication/Flaw Location Evaluation," in the attached letter. As described in Section 5 of CEN-628-P, Revision 0, both the suckback and inclusions have been shown to originate at either the upper or lower edge of the weld, which reduces ambiguity in the ET analysis.

The interrelation among the nondestructive examination (NDE) methods is depicted in the Sleeve NDE Process Flow Charts, Figures 2.1 and 2.2, from the ABB CE letter dated April 28, 1996 (previously submitted by Northern States Power on June 27, 1996). The VT is used only for confirmation that a signal is associated with a surface detectable condition. UT is used to confirm the

presence of a bond below the UT indication of a blow hole, therefore no position relationship with VT is required. ET methods are used to locate flaws above or below the weld centerline in a stand alone manner. The generic enhanced UT analysis guidelines (previously submitted by Northern States Power on June 27, 1996) have been implemented for future installations to improve the ability to detect lack of fusion (LOF) throughout the weld height.

3. **The UT field data analysis missed several unbonded regions (e.g., inclusions) in the Prairie Island pulled tubes. This observation required further modifications to the UT screening criteria (i.e., the voltage thresholds were adjusted and the types of scans analyzed were modified). Given these modifications, discuss the basis for not repeating the review of all previously obtained UT data to ensure the tubes have adequate bonding. Given that different types of scans may be needed to detect such unbonded regions (e.g., inclusions), discuss the basis for not reperforming the baseline UT examination for all inservice sleeves.**

It was noted in section 8.3.1.4 of CEN-628-P, Revision 0, that historical UT and ET techniques were capable of detecting all rejectable welds (16 of 16). If this is the case, discuss why the unbonded regions of several tubes were missed at Prairie Island. Discuss the possibility that the sensitivity of the analysts was heightened as a result of the recent industry experience thereby resulting in the detection of these defects. Given that recent industry experience may have potentially heightened the analysts' sensitivity, discuss the need for reanalyzing all historic ECT and UT data.

RESPONSE

Given these modifications, discuss the basis for not repeating the review of all previously obtained UT data to ensure the tubes have adequate bonding.

To the extent possible, UT data was re-analyzed for all sleeves with WZI calls from the Plus Point eddy current inspection. An evaluation of the NDE methods in use at the time of the inspections was evaluated and reported in CEN-628-P, Revision 0, and updated in ABB CENO letter 96-3-9038T, Revision 1. This assessment indicates a small (3.3%) probability of missing a lack of fusion condition. From another perspective, the data set, including Prairie Island removed tubes and intentionally faulted welds, has only 5% of the welds with LOF conditions without associated radial inclusions segments that would lead to a WZI call (2/40 samples in the table in the attached letter). Overall, the probability of non-detection is even lower. Of the LOF conditions not detected, even though a WZI was reported, the effected area was less than 30 degrees of arc. For this type of condition, the measured leak rate in lab samples was less than 0.0027 gpm as reported in Table 6.1 in CEN-628-P, Revision 0. Taking into consideration the

plant leak monitoring requirements in the technical specifications, it is our conclusion that sufficient defense in depth exists without re-analyzing UT data.

Given that different types of scans may be needed to detect such unbonded regions (e.g., inclusions), discuss the basis for not re-performing the baseline UT examination for all inservice sleeves.

The probability of detection (POD) was evaluated extensively in the laboratory program reported in CEN-628-P, Revision 1, and updated in ABB CENO letter 96-3-9038T, April 30, 1996. In the former, 16 metallographic results were available, while in the latter sixty four sections were completed. For this study, both the historical NDE practices previously used and the enhanced NDE methods using detailed analysis guidelines were evaluated for POD. The results are summarized below.

NDE POD STUDY

	HISTORICAL METHOD POD%	ENHANCED METHOD POD%
UT ALONE, LOF	87.5	100
ET ALONE, ALL FLAWS	87.5	90
ET ALONE, FLAWS > 40% OR LOF	90	93.3
COMBINED ET AND UT FLAWS > 40% OR LOF	96.7	100

These POD results exceed the industry standard of Appendix H for both the historical and enhanced methods. The 96.7% POD for the historical methods was factored into the operability assessments to estimate the number of affected tubes. These assessments were handled conservatively, assigning the maximum observed possible leak rate to all affected tubes. All Combustion Engineering (CE) sleeves currently in service have been inspected by both UT and ET (using the Plus Point coil).

Given the high POD and minimal consequences of a missed imperfection of the types observed from the pulled tubes, re-performing the baseline UT examination for inservice sleeves is not warranted.

Discuss why the unbonded regions of several tubes were missed at Prairie Island.

Two of the sleeves (R7C52 and R9C57) removed from Prairie Island had lack of fusion that was not detected by UT which could create a leak path. However, both of these tubes had ET indications that would have resulted in a decision to repair the tube. Metallographic analysis reported in CEN-628-P, Rev. 1, indicated that these tubes had local, narrow unbonded fingers approximately 5-20 degrees wide. The analysis concluded that an indigenous oxide layer was left on the tube wall which remained in the weld. This oxide film could either remain laminar or break up and "float" in the weld puddle with a resultant radial extent into the sleeve weld portion. If the oxide remains predominantly laminar, the UT method detects this condition. If the film breaks up into fingers, some may remain laminar while other portions become radial. The radial fingers were shown to be detected by the ET methods. The condition that may lead to a miss by UT increases the detectability by ET; therefore, in combination, the different techniques are capable of detecting these imperfections.

Discuss the possibility that the sensitivity of the analysts was heightened as a result of recent industry experience thereby resulting in the detection of these defects.

The detection of the previously undetected LOF regions at Prairie Island was not due to heightened sensitivity, but rather by an additional analysis technique using amplitude based on B scans. The earlier method of threshold crossing C scans does not provide objective evidence of an unbonded region for these instances.

Given that recent industry experience may have potentially heightened the analysts' sensitivity, discuss the need for reanalyzing all historic ECT and UT data.

The POD evaluation for the combined NDE methods showed that there was adequate detection capability for degraded weld conditions. The Plus Point eddy current inspection alone has a high POD . The possibility of a small number of flaws being undetected was considered in the estimate of the number of potentially degraded welds, with the conservative assumption of assigning the maximum measured leak rate to this estimated number of degraded welds.

In order to further evaluate the assumption that the Plus Point probe data provided adequate detection for any flaw condition, the Prairie Island ultrasonic data was reanalyzed for 36 welds with WZI indications and 234 welds that were no detectable defect (NDD) in the eddy current inspection. Of the WZI sleeves, four were found that also had lack of fusion as reported in the Prairie Island LER 96-11. Of the 234 NDD sleeves reanalyzed, none had LOF indications with the

ultrasonic inspection. This is consistent with the laboratory evaluation of the NDE methods that concluded that degraded sleeves were detected by the Plus Point.

4. **Clarify figure 8.3.1.3.A of CEN-628-P, Revision 0. If this flow chart had been used, all volumetric indications should have been removed from service.**

RESPONSE

The error noted in the flow chart was corrected in CEN-628-P, Rev. 1, which was transmitted to the NRC by Northern States Power on May 3, 1996.

5. **Discuss the qualification data supporting the use of the magnetic bias plus point in dispositioning signals obtained with the non-magnetically biased plus point.**

RESPONSE

The qualification study undertaken did not specifically address magnetically biased probes as an essential variable. The magnet field strength to completely saturate inconel materials is approximately 5 kilogauss (per C.V. Dodd), which would reduce the eddy current depth of penetration and suppress the eddy current field to a point where it would be considered unacceptable with the current coil design. The Zetec manufactured magnetically biased Plus Point probes used to date contain four Super Neodymium post type permanent magnets which generate a saturation field between 0.1 and 0.15 kilogauss as measured between the poles. With this weak field there is a slight reduction in the eddy current depth of penetration and slight focusing of the eddy current field, but these variables are not considered as essential variables. The variations in the eddy current field have been accounted for during the analysis calibration setup by normalizing the span setting on the same calibration discontinuity and verifying detection of all calibration standard discontinuities. The magnetically biased probes in sleeve examinations have only been used in a supplemental or diagnostic capacity to date due to physical constraints on the manufacturer's ability to both articulate the probe head and deploy permanent magnets. In the future, the same examination methodology will be utilized or, if these manufacturing constraints are overcome, examinations will be performed exclusively with magnetically biased probes.

6. **Discuss the nature of the two rejectable welds missed during UT examination (Section 8.3.1.4 of CEN-628-P, Revision 0). Discuss the nature of the two rejectable welds missed during ET examination (Section 8.3.1.4 of CEN-628-P, Revision 0). Discuss any conclusions which can be drawn with respect to the capability and/or limitations of the two non-destructive examination methods based on these results (i.e., the types of defects that can be detected and/or missed).**

RESPONSE

The two welds with LOF missed during the field UT examinations at Prairie Island were described in the response to Question 3. The two welds with a LOF that were not detected by the Plus Point eddy current coil were laboratory samples. In these samples, the oxide inclusion remained laminar rather than curling and becoming predominantly radial, and thus were not detectable by the ET method. Sample C scans using the amplitude threshold method (historical method) were previously submitted by Northern States Power on June 27, 1996. The poor quality of the weld and the LOF are clearly detectable for this situation (samples OS-15 and OS-17 in the table of the ABB CE April 28, 1996, letter). For comparison, a typical good weld C scan was also submitted (CT-36). The overall NDE capability was addressed in the response to Question 3.

7. **In several plant assessments, a comparison is made to the indications at Prairie Island. This comparison is made with respect to both voltage and arc length. Discuss the sizing accuracy of the NDE techniques. If the sizing accuracy is limited, discuss the limitations of this comparison. Provide the supporting technical justification for the responses.**

It was indicated that work is on-going with respect to using voltage to assess certain forms of weld degradation. In the plant's assessments, discuss if voltage was used at all to assess the severity of degradation. If it was, discuss how voltage is related to the severity of the degradation for all forms of degradation for which voltage was used to assess the severity of the degradation.

RESPONSE

In the NDE assessment, a standardized method for reporting indications was used for arc length and amplitude. The arc length was done using the EPRI guidelines issued on January 15, 1996, as part of the outside diameter stress corrosion cracking (ODSCC) programs. Various amplitude measurement techniques had been used, but a normalization factor was applied to standardize these so that a relative comparison could be made among the signals from the various plants.

In a plot of amplitudes of weld zone indications, tube R7C52 removed from Prairie Island had the highest amplitude compared to both the lab samples produced and tubes left in service at other plants. A plot of amplitude versus maximum radial degradation depth is provided in Figure 7.1 of CENO letter 96-3-9038T, Revision 1, for Prairie Island pulled tubes and the Appendix H data set (previously submitted by Northern States Power on June 27, 1996). This figure indicated that the laboratory samples were representative of the actual field responses. The comparisons were made solely on the basis of indication amplitude under the assumption that for the imperfection type encountered, more severe conditions would produce larger indications. No attempt has been made to use the depth to voltage correlation as a direct assessment of degradation; only relative comparison among plant signals has been made.

In the ANO-2 operability assessment, the conservative approach of assigning the highest potential leak rate to all tubes adds margin to the analysis.

8. **For Zion, Unit 2, it was indicated that one tube which was originally called no detectable degradation (NDD) was reevaluated as having a volumetric indication. Discuss whether the data for all the NDD tubes were reevaluated in this analysis or just this one tube. If only a limited sample was reevaluated, discuss the basis for not expanding the reevaluation given the possibility that larger undetected defects could exist.**

RESPONSE

The basis for not expanding the reanalysis was given in the answer to Question 3 and is based on the high POD of combined flaws from the Prairie Island pulled tubes. The NDD tube at Zion 2 was compared to various signals from a suckback condition and an estimate of 10 to 15% depth was included in CEN-628-P, Revision 1. Subsequently, this tube was compared to various tubes with radial inclusions. The signal was comparable to one sample with a 43% inclusion condition, which is still considerably less than the initial allowable degradation calculation of 63.3% provided in CEN-628-P Rev 1 (page 7-9).

9. **For the ANO-2 review, it was indicated that two tubes had noisy C scan displays. Discuss the limits that are placed on the amount of noise in the data.**

RESPONSE

Noisy C scans may cause false positive indications of LOF that require additional analysis using B scans to resolve. This condition is easily detected and resolved by the analyst and does not pose any technical concern over the quality of the data.

10. **Since the root cause of these indications has been attributed to the cleaning process, additional weld indications would not be expected. As a result, a reporting requirement to notify the staff when indications are detected in newly installed sleeves in the weld area would seem appropriate. Such indications may indicate a breakdown in the sleeving process. Discuss the appropriateness of such a reporting requirement.**

RESPONSE

Within 90 days following the next installation of CE welded sleeves at ANO-2, a report will be submitted to the NRC. The following information will be provided:

1. Number of sleeves successfully installed, and

2. Number of sleeves installed and then rejected and the reasons for rejection.