NORTHEAST UTILITIES

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WESTERN MASSACHUSETTS ELECTRIC COMPANY
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November 17, 1983

Docket No. 50-336
B10943

Director of Nuclear Reactor Regulation
Attn: Mr. James R. Miller, Chief
Operating Reactors Branch #3
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

References: (1) W. G. Counsil letter to R. A. Clark, dated August 26, 1983.

(2) R. A. Wiesemann letter to H. R. Denton, dated August 9, 1983.

Gentlemen:

Millstone Nuclear Power Station, Unit No. 2
Steam Generator Sleeving Report
Supplementary Information

By Reference (1), Northeast Nuclear Energy Company (NNECO) docketed WCAP-10267, the Millstone Unit No. 2 Steam Generator Sleeving Report, to support a proposed license amendment allowing sleeving as a repair method for defective steam generator tubes. The attached information supplements that provided in Section 7 of WCAP-10267 concerning the non-destructive examination capabilities for sleeved steam generator tubes at Millstone Unit No. 2.

The attached information supports the results and conclusions documented in the Reference (1) report.

Portions of the material included in Attachment 2 are proprietary to Westinghouse Electric Corporation. It is requested that Attachment 2 be withheld from public disclosure in accordance with the provisions of 10CFR2.790 and that this material be safeguarded. The reasons for the classification of this material as proprietary are delineated in the affidavit accompanying Reference (2).

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

W. G. Counsil

W. G. Counsil
Senior Vice President

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Docket No. 50-336

Attachment 1

Millstone Nuclear Power Station, Unit No. 2

Supplementary Information
Steam Generator Sleeving Report
Non-Proprietary

November, 1983

The Non-Destructive Examination (NDE) development effort for sleeved steam generator tubes has concentrated on two aspects of the sleeve system. First a method of confirming that the joints meet critical process dimensions is required. Secondly, it must be shown that the tube/sleeve assembly is capable of being evaluated through subsequent routine in-service inspection. In both of these efforts, the inspection process has relied upon eddy current technology.

EDDY CURRENT INSPECTIONS

The eddy current inspection equipment, techniques, and results presented herein apply to the Westinghouse sleeving process used in steam generators at Millstone Unit No. 2. Overall, the bimetallic sleeve used in the Millstone Unit No. 2 sleeving program has no unique impact on the inspectability of the sleeve/tube assembly, and techniques to be utilized for bimetallic sleeves are equivalent or improved upon from previous Westinghouse sleeving programs.

Eddy current inspections are routinely carried out on the nuclear steam generators at Millstone Unit No. 2 in accordance with the Technical Specifications. The purpose of these inspections is to detect at an early state tube degradation that may have occurred during plant operation so that corrective action can be taken to minimize further degradation and reduce the potential for primary-to-secondary leakage.

The standard inspection procedure involves the use of an eddy current probe with two circumferentially wound coils which are displaced axially along the probe body. The coils are connected in the so-called differential mode; that is, the system responds only when there is a difference in the properties of the material surrounding the two coils. The coils are excited by using an eddy current instrument which displays changes in the material surrounding the coils by measuring the electrical impedance of the coils. In the past, eddy current instruments normally excited the coils at a single frequency; however, Westinghouse and the industry are now using multi-frequency instrumentation for the inspection of steam generator tubing. This involves simultaneous excitation of the coils with several different test frequencies.

The outputs of the various frequencies are both combined and recorded. The combined data yield an output in which signals resulting from conditions that do not affect the integrity of the tube are reduced. By reducing unwanted signals, improved inspectability of the tubing results. Regions in the steam generator, such as the tube supports or tube sheet, are examples of areas where multifrequency processing has proven valuable in providing improved inspectability.

A number of eddy current probes and signal processing systems are available for the eddy current inspection of the tube/sleeve assembly. A few of the probes available are shown in Figure 1. In addition to the conventional probe and the rotating pancake coil (RPC), there is a cross-wound coil probe (CWC) and a multicoil surface riding probe (MSR). Any of these probes may be used with either single frequency or multifrequency instrumentation.

After sleeve installation, all sleeved tubes are subjected to a series of eddy

current inspections. Some of these inspections are intended as a process control procedure to verify correct installation. However, each tube/sleeve assembly receives an eddy current inspection for base line purposes to which all subsequent inspections will be compared.

The inspection of the tube/sleeve assembly has, in the past, been performed using conventional bobbin coil probes operated with multifrequency excitation. For the straight length regions of the tube/sleeve assembly, the inspection of the sleeve and tube is consistent with normal tubing inspections. In those regions such as where the tube/sleeve assembly joint formation occurs, data evaluation becomes more complex. The results discussed below suggest the limits on the volume of degradation that can be detected in the vicinity of the geometric discontinuities. For the parent tube, these limits are on the order of two to three times the response of the ASME calibration standard using the conventional bobbin coil probe.

In the regions of the parent tube above the sleeve, conventional bobbin coil inspections will continue to be used. However, since the diameter of the sleeve is smaller than that of the tube, the fill factor of a probe inserted through the sleeve may result in a decreased detection capability for tubing degradation. Thus, it may be necessary to inspect the unsleeved portion of the tube above the sleeve by inserting a standard size probe over the U-bend from the unsleeved leg of the tube.

While there are a number of probe configurations that lend themselves to improving the inspection of the tube/sleeve assembly in the regions of configuration transitions, the cross-wound coil probe has been selected as offering a significant improvement over the bobbin coil probe, yet retaining the simplicity of the inspection procedure.

The overall inspection procedure involves the use of the cross-wound probe which significantly reduces the responses of the transitions, coupled with a multifrequency technique for further reduction of the remaining signals. This system reduces the interference from all discontinuities which have 360-degree symmetry providing improved visibility for discrete discontinuities. As is shown in the accompanying figures, in the laboratory this technique can detect OD tube wall penetrations with acceptable signal-to-noise ratios when the volume of metal removed is equivalent to the ASME calibration standard.

The detection and quantification of degradation at the transition regions of the sleeved assembly depends upon the signal-to-noise ratio between the degradation response and that of the transitions. As a general rule, lower frequencies tend to suppress the transitions relative to the degradation at the expense of the ability to quantify. Similarly, the inspection of the tube through the sleeve requires the use of low frequencies to achieve detection with an associated loss in quantification. Thus, the search for an optimum eddy current inspection represents a trade-off between detection and quantification. For the conventional bobbin type inspection, this optimization leads to a primary inspection frequency for the sleeve on the order of ( )^{a,c,e} and for the tube and transition regions on the order of ( )^{a,c,e}. Figure 2 shows the response of the ASME tube calibration standard using a conventional bobbin coil.

Figure 3 shows the response of a typical expansion transition at the same frequencies as Figure 2 but at a factor of two lower sensitivity for the non-mixed channels. In both Figures 2 and 3, the results of combining the ( )^{a,c,e} responses to eliminate the transition signals are depicted. Note that a signal with twice the amplitude of the standard would be detectable. However, with present instrumentation the actual noise level from the electronics limits the usefulness of this approach.

For those regions of the sleeve where the assembly has no transition, a conventional bobbin inspection provides detection and quantification capability. Figure 4 shows a typical ( )^{a,c,e} phase versus depth curve for the sleeve from which OD sleeve penetrations can be assessed.

The use of the cross-wound coil significantly reduces the response from the tube/sleeve assembly transitions as shown by a comparison of Figures 5, 6 and 7 for the sleeve and tube standards and transitions, respectively. Again this is further improved by the combination of the various frequencies. For the cross-wound probe, two frequency combinations are shown; the ( )^{a,c,e} combination provides an overall detection capability with the ( )^{a,c,e} combination providing improved sensitivity for the sleeve and some quantification capability for the tube. Figure 8 shows the phase depth curve for the tube using this combination. As examples of the detection capability at the transitions, Figures 9 and 10 show the responses of a 20% OD penetration in the sleeve and 40% OD penetration in the tube, respectively.

Thus far, the discussion has centered around the expansion transition regions of the assembly. Another difficult region of the assembly to inspect is the region at the end of the sleeve. Here, for the conventional bobbin inspection the transition response is still larger than that of the expansion regions as shown in Figure 11. Thus, the signal-to-noise ratios for this part of the tube/sleeve assembly is about a factor of four less sensitive than that of the expansions. Some improvement has come from modifying the end of the sleeve by tapering it. This reduces the end of sleeve signal by about a factor of two. The cross-wound coil, however, again significantly reduces the response of the sleeve end. Figure 12 shows the response of various ASME tube calibration standards placed at the end of the sleeve using the cross-wound coil and the ( )^{a,c,e} frequency combination. Note that under these conditions, all can be detected.

Summary

Eddy current techniques have been modified to incorporate the most recent state of the art technology for the inspection of the sleeved assembly. The resultant inspection of the tube/sleeve assembly involves the use of both the conventional bobbin coil for the straight length regions of the tube/sleeve assembly and a cross-wound coil for transition regions. It must be emphasized that the transition regions of the assembly where the cross-wound coil and multifrequency processing are necessary for detection are a small percentage of the overall tube/sleeve assembly, being restricted to only the regions where the geometry of the assembly changes, and that the conventional inspection would constitute the bulk of the remaining eddy current inspection. While there is a significant improvement in the inspection of the assembly using the cross-wound

coil, efforts continue to advance the state of the art in eddy current inspection techniques. As improved techniques are developed, they will be utilized. For the present, the cross-wound coil probe represents an inspection technique which provides additional sensitivity and support for eddy current techniques as a viable means of assessing the tube/sleeve assembly.

Conventional

Crosswound

Rotating Pancake

FIGURE 1 Eddy Current Probes

FIGURE 2 E.C. signals from the ASTM standard machined on the tube O.D. of the sleeve tube assembly without expansion (conventional differential coil probe).

FIGURE 3 E.C. signals from the expansion transition region of the sleeve-tube assembly (conventional differential coil probe).

FIGURE 4

FIGURE 5 E.C. signals from the ASTM standard machined on the sleeve O.D. of the sleeve-tube assembly without expansion (cross wound coil probe).

FIGURE 6 E.C. signals from the ASTM standard machined on the tube O.D. of the sleeve-tube assembly without expansion (cross wound coil probe).

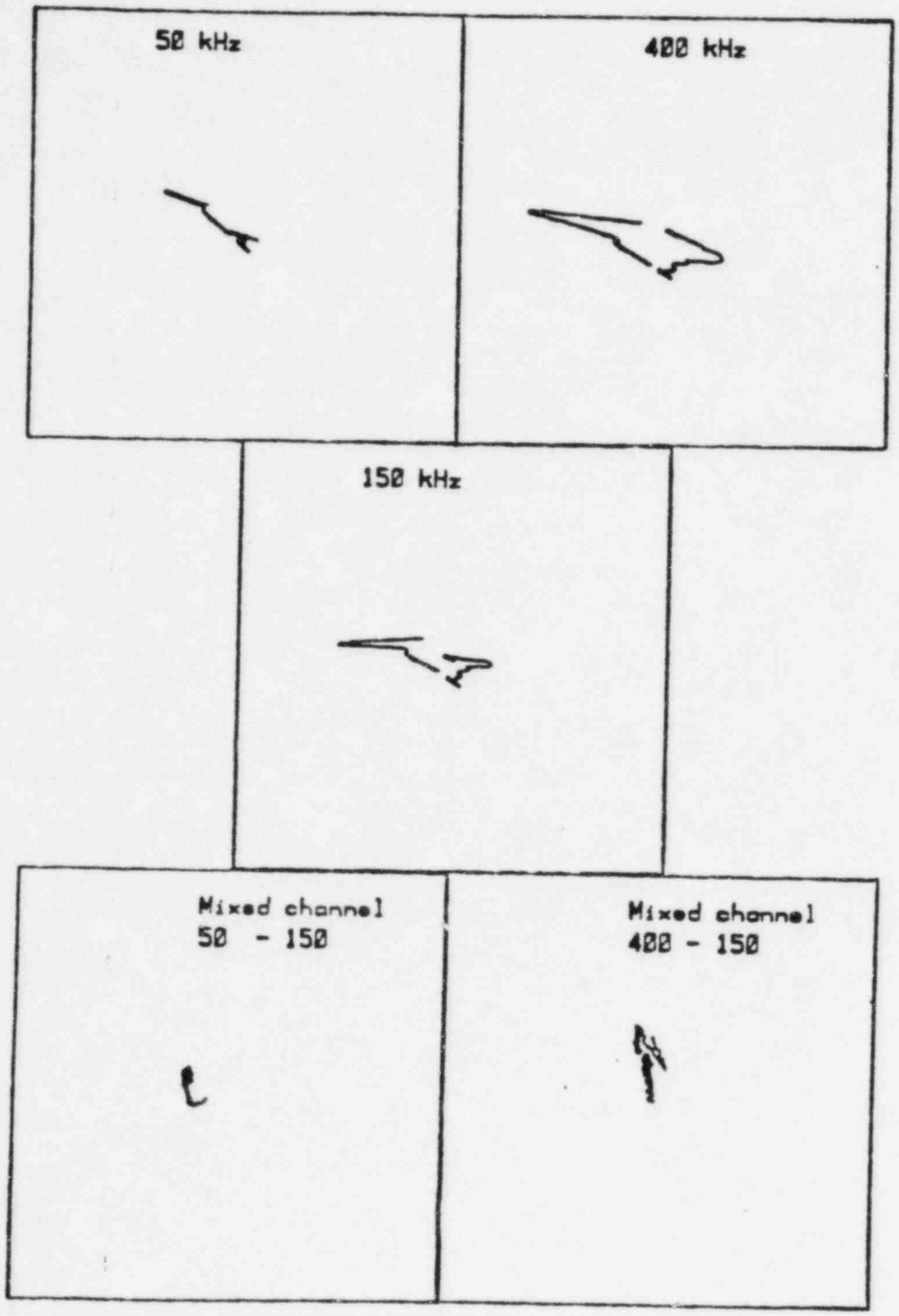

FIGURE 7 E.C. Signals from the expansion transition region of the tube-sleeve assembly (cross wound coil probe).

FIGURE 8

FIGURE 9 E.C. signal from a 70% deep half the volume of ASTM standard machined on the sleeve O.D. in the expansion transition region of the sleeve-tube assembly (cross wound coil probe).

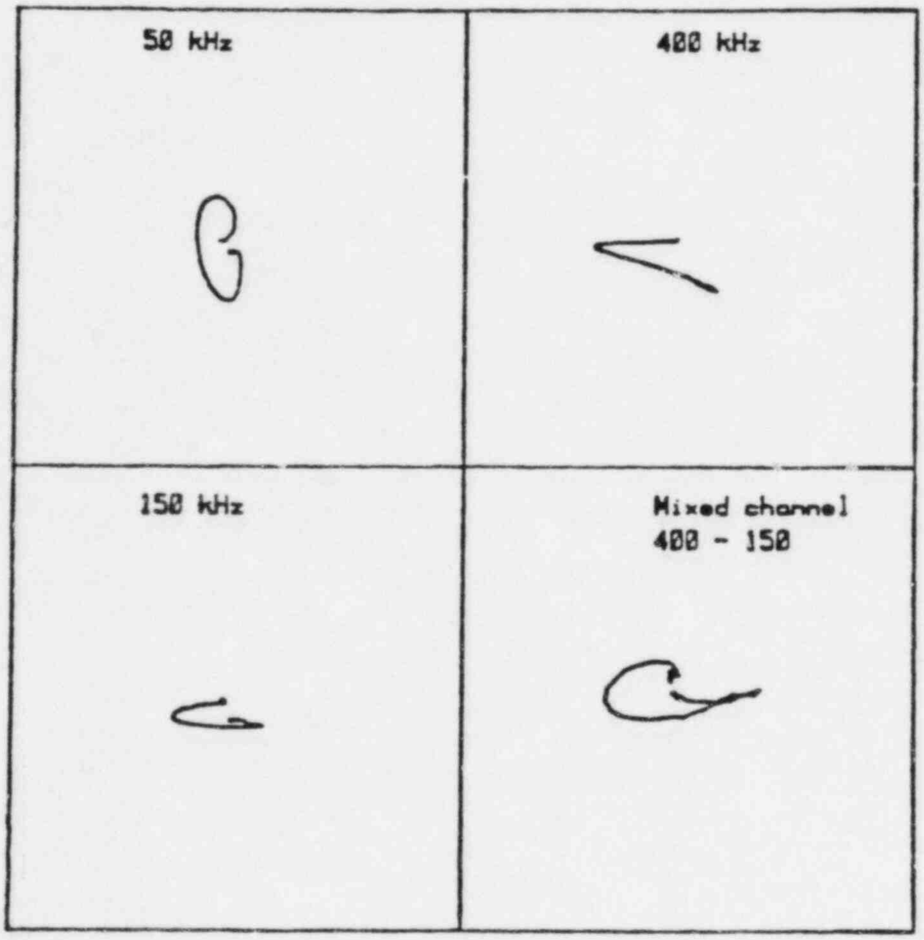

FIGURE 10 E.C. signal from a 40% ASTM standard machined on the tube O.D. in the expansion transition region of sleeve-tube assembly (cross wound coil probe).

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FIGURE 11 Eddy current response of square and tapered sleeve ends compared to the expansion transitions for the conventional Bobbin coil probe.

FIGURE 12 Eddy current response of the ASME tube standard at the end of the sleeve using the cross wound coil probe and multifrequency combination.