December 20, 1982

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
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WISCONSIN ELECTRIC POWER COMPANY	)	Docket Nos. 50-266
	)	50-301
(Point Beach Nuclear Plant,	)	(OL Amendment)
Units 1 and 2)	)	

LICENSEE'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW IN THE FORM OF A PROPOSED INITIAL DECISION

SHAW, PITTMAN, POTTS & TROWBRIDGE

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1. This proceeding concerns the application of Wisconsin Electric Power Company ("Licensee") to amend the operating licenses for Point Beach Nuclear Plant, Units 1 and 2, to permit repair of corroded steam generator tubes by inserting within them "sleeves" that span the corroded areas and reinforce the tubes. The parties to this proceeding are Licensee, the NRC Staff, and Wisconsin's Environmental Decade ("Decade"), which intervened in the proceeding to oppose the proposed repair of the steam generator tubes. This Initial Decision considers whether eddy current testing ("ECT") is adequate to detect serious stress corrosion cracking ("SCC") or intergranular attack ("IGA") in the sleeves that would be inserted within steam generator tubes.

I. BACKGROUND

2. By letter dated July 2, 1981, Licensee filed a Technical Specification Change Request, seeking to amend the Point Beach operating licenses to permit repair of steam generator tubes which have degradation exceeding 40% of the nominal tubewall thickness. The existing plant Technical Specifications require that such tubes be removed from service by "plugging." The proposed Technical Specification change

would permit repair of such tubes by "sleeving," leaving the tubes in service. The sleeving procedure has been previously utilized at the R. E. Ginna nuclear plant and, on a large scale, at San Onofre Unit 1.

3. There are two steam generators at each of the Point Beach units. Each steam generator contains 3260 inverted, U-shaped vertical tubes. The ends of the tubes pass through and are anchored in the tubesheet. The tubesheet is a large circular steel plate, about 22 inches thick, through which holes are drilled for the tubes. The bottom 2 1/2 to 3 inches of the end of each tube is fastened within the bottom of the tubesheet by "rolling," i.e., the tube is mechanically expanded tightly against the walls of the tubesheet hole. The tubes are also welded at the bottom face of the tubesheet. The tubes are not fastened at the top of the tubesheet.

4. The sleeving process involves the insertion of a smaller diameter, thermally treated Inconel 600 metal sleeve inside a steam generator tube so that the bottom of the sleeve is flush with the bottom of the tube The sleeve extends beyond the top of the tubesheet, and bridges the degraded portion of the tube. The sleeve is bonded to the tube at the bottom and just below the top of the sleeve (so as to provide a short length of free sleeve above the upper bond inside the tube).

II. PROCEDURAL HISTORY

5. As explained in Licensee's July 2, 1981 license amendment request, Licensee planned a sleeving demonstration program at Point Beach Unit 1 during the fall 1981 refueling outage, prior to undertaking full-scale sleeving at Point Beach. Anticipating that any hearing on its July 2, 1981 request would not be completed, and a decision issued, prior to completion of the demonstration program, Licensee requested authorization for interim operation of Unit 1 with six degraded steam generator tubes sleeved rather than plugged. Subsequent to an October 29-30, 1981 hearing on the matter, we authorized operation of Unit 1 with six tubes sleeved rather than plugged, pending the outcome of the hearing on Licensee's July 2 amendment request. See LBP-81-55, 14 N.R.C. 1017 (1981).

6. The Board initially admitted a single broad contention into this proceeding. Following completion of discovery, the Board directed Decade to file a "Motion Concerning Litigable Issues," in which Decade was to attempt to show the existence of genuine issues of fact necessitating a hearing in this case. Both Licensee and the Staff filed extensive procedural and substantive comments on Decade's motion, including motions for summary disposition supported by detailed affidavits as appropriate. Then, on September 9, 1982, we held an on-the-record telephone conference in which the parties presented oral argument related to the motion. Applying

summary disposition standards to Decade's motion, the responses of the Staff and Licensee, and Decade's replies, the Board subsequently concluded that summary disposition should be granted with respect to all issues raised by Decade, except for a portion of one issue. The sole genuine issue we found is the following:

> That the license amendment should be denied or conditioned because applicant has not demonstrated that eddy current testing is adequate to detect serious stress corrosion cracking or intergranular attack, in excess of the technical specification prohibiting more than 40 percent degradation of the sleeve wall, in sleeves that would be inserted within steam generator tubes.

See generally "Memorandum and Order (Concerning Summary Disposition Issues)," October 1, 1982.

7. Although this single remaining issue was a very narrow one indeed, the Board's approach to this proceeding has encompassed consideration of virtually all safety aspects of sleeving -- either through the substantial summary disposition procedure or through questions which we posed in our order on summary disposition, for address at the evidentiary hearing. On November 2, 1982, in accordance with our instructions, Licensee filed the testimony of W. D. Fletcher, Manager of the Steam Generator Development and Performance Engineering in the Nuclear Technology Division of the Westinghouse Electric Corporation. ("Licensee's Testimony of W. D. Fletcher,"

hereinafter "Fletcher," following Tr. 1422). In response to our November 8, 1982 oral request on November 8, 1982, during a telephone conference, Licensee produced for questioning at the hearing Clyde J. Denton and Edward O. McKee of Zetec, Inc. Mr. Denton originated ECT of steam generators both in the Navy nuclear program and in the commercial world, and is presently General Manager of Zetec. Tr. 1457-58. Mr. McKee has 11 or 12 years' experience interpreting ECT data, and has evaluated all ECT data for both Point Beach units, from the first inspections, with the exception of two inspections.

8. Also on November 2, 1982, the Staff submitted the testimony of Emmett L. Murphy, a Senior Systems Engineer in its Operating Reactors Assessment Branch ("Testimony of Emmett L. Murphy," hereinafter "Murphy," following Tr. 1828). Mr. Murphy's testimony addressed the single genuine issue of fact remaining after summary disposition, as formulated by the Board in its October 1 order -- the adequacy of ECT to detect serious SCC or IGA in sleeves. The Staff also submitted the testimony of Ledyard B. Marsh, a Section Leader in its Reactor Systems Branch. ("Testimony of Ledyard B. Marsh," hereinafter "Marsh," following Tr. 1822). Mr. Marsh's testimony responded to the questions raised by the Board with respect to the safety significance of a failure to detect a defect in the sleeved portion of a steam generator tube. Messrs. Timothy G. Colburn and Conrad E. McCracken also testified on behalf of the Staff

at the hearing, but submitted no written direct testimony. Mr. Colburn appeared in his capacity as Project Manager for the Point Beach reactors, Tr. 1812, and Mr. McCracken, Section Leader of the Chemical Technology Section of the NRC's Chemical Engineering Branch, appeared for the purpose of addressing the Board's concerns in the area of corrosion. Tr. 1815.

9. Decade filed no direct testimony and presented no witnesses at the evidentiary hearing.

10. The hearing was held in Milwaukee, Wisconsin on November 17 and 18, 1982. Limited appearances were heard in Two Rivers, Wisconsin on November 17, 1982. The matters examined during the evidentiary hearing which are not discussed here were considered by the Board and found either to be without merit or not to affect our decision herein. In preparing our decision, we reviewed and considered the entire record and the Findings of Fact and Conclusions of Law proposed by the parties. Those proposed findings and conclusions not incorporated directly or inferentially in this Initial Decision are rejected as being unsupported by the record of the case or as being unnecessary to the rendering of this decision.

III. SAFETY CONSIDERATIONS OF SLEEVING

11. To place ECT in its proper safety perspective, we have, as background for the issue before us, inquired into the overall safety considerations of sleeving and the extent of the

safety role played by ECT. Because pressurized primary coolant water passes through the steam generator tubes, the tubes are a part of the reactor coolant pressure boundary, sometimes referred to as the primary pressure boundary. Sleeving, in effect, substitutes a new primary pressure boundary in the region in and a little above the tubesheet. We are concerned in this proceeding with the capability of ECT to detect corrosion of the sleeves in the form of SCC and IGA, resulting from impurities in the secondary cooling water, which could affect the integrity of the pressure boundary.

12. SCC entails distinct separation of the metal grains resulting from corrosion. IGA is corrosion of the metal grain boundaries of the tube material which does not initially result in separation of the metal grains, as does SCC. Tr. 1427-31 (Fletcher). Eventually, as the IGA progresses, the pressure within the tube will cause SCC. Tr. 1429, 1450-51 (Fletcher). The SCC, if it penetrates entirely through the wall, can result in leakage. Fletcher, ff. Tr. 1422, at 7-8.

13. The NRC's General Design Criterion 14, Appendix A, 10 C.F.R. Part 50, requires that:

> The reactor coolant pressure boundary shall be designed, fabricated, erected and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

ECT is only one of a number of factors taken into consideration in the satisfaction of GDC 14 as it pertains to the portion of the primary pressure boundary consisting of the steam generator tubes. The steam generators, including the tubes and sleeves, are designed, fabricated and tested in accordance with design criteria which include compliance with the ASME Boiler and Pressure Vessel Code. Licensee Exhibit 1, §3.1. During reactor shutdown, periodic hydrostatic tests of the steam generators are conducted to locate leaks in the tubes. The tests involve pressure differentials substantially in excess of normal operating pressure differentials, and approximate those which would be expected to occur during postulated main steam line break and LOCA events. Murphy, ff. Tr. 1828 at 2, 10; Fletcher, ff. Tr. 1422 at 5. In addition, primary to secondary leakage is evaluated continuously during plant operation by monitoring the secondary system condenser air ejector and steam generator blowdown for radioactivity. Limits on this leakage have been established, with the licensing requirement that the plant be shut down for repair of the leaking tubes if the limits are reached. The limits are established such that the unit would be shut down before the integrity of the leaking tube or tubes would become sufficiently impaired so as to potentially rupture during normal operating and postulated accident conditions. Fletcher, ff. Tr. 1422 at 5-6; Murphy, ff. Tr. 1828 at 2, 10.

14. Another safety factor derives from the inherent characteristics of Inconel 600, the material of which the tubes and sleeves are fabricated. The characteristics are such that a crack progressing through the tube or sleeve wall will result in leakage before the time when the potential for rupture during accident or normal operating conditions would occur. This "leak-before-break" characteristic is based on the concept that a corrosion crack, initiating from the outer diameter ("OD"), would penetrate through-wall and result in a small but detectable leak before the crack would propagate to the "critical crack length," i.e., such a length that the tube or sleeve could develop a large leak rate in the event of a postulated accident. This concept is particularly applicable to materials such as Inconel 600 with high ductility and toughness, that is, with the capability to withstand high stresses by deforming rather than fracturing. Fletcher, ff. Tr. 1422 at 7.

15. The primary to secondary leakage would provide an early indication of degradation, permitting an orderly shutdown for inspection and resolution should the cracking process continue with an accompanying increase in leakage rate to the licensing limits. For the sleeve, the maximum through-wall crack length which could exist without exceeding the limits for leakage (500 gpd or 0.3 gpm per steam generator) would be about 0.4" at normal operating pressures. If, assuming a 0.4"

through-wall crack length, one would also postulate the simultaneous occurrence of a steam line break accident, the leakage would not be expected to be excessive, because the 0.4" long crack could withstand the increased pressure differential without bursting. Fletcher, ff. Tr. 1422, at 8.

16. Laboratory and operating experience confirm the validity of the leak-before-break concept, and any leakage would be expected to be small. Degraded tubes normally do not result in large breaks, but penetrate locally resulting in minor leakage which is readily detectable and can be remedied. Virtually all leakage events in Westinghouse steam generators were of this kind. Fletcher, ff. Tr. 1422, at 8. Of over 200 leaks reported to the NRC, only four have involved large leak rates. None of the four occurrences resulted in any unacceptable offsite radiological consequences, and all resulted from unusual circumstances which do not invalidate the leak-before-break characteristics of steam generator tubes in the vicinity of the tubesheet. Murphy, ff. Tr. 1828, at 10; Tr. 1774-78 (Fletcher); see also Marsh, ff. Tr. 1822, at 3.1/

1/ In both the Prairie Island and Ginna events, the degradation of the tubes was caused by the presence of loose parts. Since the leak-before-break concept is related to degradation attributable to corrosion (and not extraneous loose parts), those events do not undermine the concept. Similarly, the Surry event involved very high stresses caused by the pressing inward of the legs of the U-bend at the uppermost tube support plate, leading to leakage at the apex of the U-bend. Again, that event does not undermine the leak-before-break concept, as it relates to corrosion. Finally, the 1975 Point Beach event

(Footnote Continued Next Page)

17. As a further safety precaution, the NRC requires that steam generator tubes be inspected periodically by ECT on a sampling basis to detect corrosion or other defects of the wall material. ECT is effective in minimizing the potential for leakage, although, as we will discuss in more detail in Part IV, below, it is not expected to eliminate it entirely. Fletcher, ff. Tr. 1422, at 5-6; Murphy, ff. Tr. 1828, at 2-3. The ECT licensing requirement (Technical Specification 15.4.2.A of the Point Beach operating licenses), which is consistent with NRC Regulatory Guide 1.83, "Inservice Inspection of Pressurized Water Steam Generator Tubes," defines "plugging limit" as an imperfection of 40% of the tube wall thickness. The technical specification requires Licensee to plug (take out of service) tubes which leak or have degradation exceeding the 40% plugging limit. Fletcher, ff. Tr. 1422, at 2.

18. The NRC's 40% plugging limit takes into account margins for eddy current testing uncertainty, as well as margin for continued degradation for operating intervals between

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(Footnote Continued)

involved a tube just above the tubesheet, in a region that had undergone substantial generalized thinning, which experienced superimposed SCC. The thinning was attributed to phosphate water chemistry, which is no longer used at Point Beach, and the thinned tubes were plugged as appropriate. In any event, thinning is readily detectable by ECT. Tr. 1774-81 (Fletcher). We therefore have no reason to doubt the leak-before-break concept is applicable to the sleeved tubes.

inspections. When a tube or sleeve has 40% indicated degradation, it still has margin to resist rupture under both normal operating and accident condition differential pressures. Fletcher, ff. Tr. 1422, at 9; Murphy, ff. Tr. 1828, at 3.

19. The maximum primary-to-secondary pressure differential occurs following a postulated feedline break or steam line break accident, which reduces the secondary side pressure to zero. Analysis of this accident condition for the sleeve, contained in the Point Beach Sleeving Report, WCAP-9960, Rev. 1, pp. 6.120-6.121 (Licensee Exhibit 1), indicates that for uniform thinning completely around the circumference, the sleeve can degrade to 38% of its original wall thickness and still resist rupture under both the normal operating and accident loads. This corresponds to 62% degradation, or a margin of 22% beyond the 40% degradation limit. Thus, the NRC's 40% plugging limit is conservative. Fletcher, ff. Tr. 1422, at 9; Murphy, ff. Tr. 1828, at 3-4.

20. The above analysis is generic, and assumes a maximum pressure differential of 2560 psi. For Point Beach, this value is conservative. The effect of this conservatism on the minimum sleeve wall thickness calculation is to increase the amount of degradation that can be tolerated and still resist rupturing. Fletcher, ff. Tr. 1422, at 9.

21. Burst tests were performed on portions of tubes removed from Point Beach which had IGA on the order of 40% to

60% penetration of the tube wall. This testing required differential pressures in excess of 5000 psi to cause bursting of the degraded tubes. This indicates substantial additional margin over the conservatively estimated pressures resulting from postulated accidents. Fletcher, ff. Tr. 1422, at 9-10.

22. Both the sleeves and the tubes are fabricated of Inconel 600. However, the Inconel 600 used for the sleeve is thermally treated to provide significantly increased resistance to corrosion as compared to the mill annealed Inconel 600 used for the original tubes. Laboratory tests indicate that the rate of propagation of IGA through thermally treated Inconel 600 was 2 or 3 times less than the rate of propagation through the mill annealed tube material. A larger reduction, by a factor of about 10, was observed in the rate of propagation of SCC for thermally treated Inconel 600. Fletcher, ff. Tr. 1422, at 6-7; Murphy, ff. Tr. 1828, at 2; Tr. 1483-88 (Fletcher).

23. The rate of corrosion in tubes or sleeves is dependent on the environment to which they are exposed. The OD of the sleeve will not be exposed to the secondary side environment unless degradation in the original tubing propagates through-wall and opens sufficiently to permit solution to enter the annulus. In any event, the sleeve would be more resistant to attack even if the same combination of environmental factors which led to attack in the original tubing were to develop in the annulus. Fletcher, ff. Tr. 1422, at 6.

24. The consequences of sleeve degradation would be no worse than, and in all probability less than, the consequences of degradation in the corresponding portion of an unsleeved tube. Extensive examination of removed tube samples has shown that IGA occurs in the Point Beach steam generator tubes only within the tubesheet. Further, recent experience with Point Beach steam generators has shown that there is no longer tube degradation of any kind occurring above the tubesheet to any significant degree. Fletcher, ff. Tr. 1422, at 10; Tr. 1767-69 (Fletcher); Tr. 1851 (McCracken). The tight radial constraint of the tube by the tubesheet minimizes any potential for rupture within the tube sheet. Murphy, ff. Tr. 1283 at 6. If rupture of the sleeve were nevertheless assumed to occur within the tubesheet as a result of IGA or SCC, the leak path would be obstructed by the narrow tube-to-tubesheet crevice, and the leak rate would be significantly reduced compared to the rate from a ruptured tube postulated to occur above the tubesheet. Fletcher, ff. Tr. 1422, at 10; Murphy, ff. Tr. 1828, at 6.

25. Sleeving would tend to reduce the leakage rate even more, both above and below the top of the tubesheet. The presence of the sleeve, with the narrow sleeve-to-tube gap (annulus), will create an additional restriction of the leakage pathway. Fletcher, ff. Tr. 1422, at 10-11; Murphy, ff. Tr. 1828, at 6; Marsh, ff. Tr. 1822, at 2-3. Also, there are no technical reasons why the rupture of a sleeved tube (i.e., a

"fish mouth" opening in the sleeve) would be more severe than the same size rupture of an unsleeved tube. In fact, the sleeve and tube in tandem could afford extra mechanical support that may act to restrict the size of the opening. Therefore, the transient and offsite consequences are expected to be less severe for the rupture of a sleeved tube than for an unsleeved tube. Marsh, ff. Tr. 1822, at 3-4; Murphy, ff. Tr. 1828, at 4.

26. We inquired about the potential for creation of a hostile environment within the sleeve-to-tube annulus which might cause SCC or IGA in the sleeve above the tubesheet where leakage, if it occurred, would not be constrained by the tube-to-tubesheet crevice. Mr. Fletcher testified that, for several reasons, the presence of the annulus does not increase the likelihood of degradation to the pressure boundary of the sleeved tube. Tr. 1766-70 (Fletcher).

27. For corrosion of the sleeves to occur, there would first have to be a through-wall leak of the tube which would permit secondary side water to enter the annulus. Since corrosion of the tube is essentially found only within the tubesheet crevice, such leakage would likely be through the tube wall below the top of the tubesheet. The sleeve, in contact with the heated and pressurized primary cooling water, is at a higher temperature than the secondary side water entering the annulus. The leaking water would form steam within the annulus. The steam would limit the amount of water

that could enter the annulus, at least above the point of entry at the leak. The amount of water entering the annulus would be small, with correspondingly small potential for concentrating impurities within the annulus. Thus, it would be unlikely that a corrosive environment would develop above the tubesheet in the annulus region. Tr. 1766-73 (Fletcher); Tr. 1851-52 (McCracken); Tr. 1853 (Murphy).

28. Above the tubesheet, corrosion of the tubes is no longer occurring to any significant degree at Point Beach, Tr. 1767-69 (Fletcher), and will be even less likely to occur in the future because the presence of the sleeve and the annulus reduces the temperature of the tube. Murphy, ff. Tr. 1828, at 2; Tr. 1769-70 (Fletcher); Tr. 1851, 1859-60 (McCracken). Moreover, as we will discuss below, above the tubesheet the sleeve has better inspectability than the unsleeved tube in the crevice region because of the absence of interference from the tubesheet, and the thermally treated Inconel 600 provides added resistance to corrosion. Thus, Mr. Fletcher testified that the presence of the sleeve would, in fact, enhance the integrity of the pressure boundary. Tr. 1770 (Fletcher).

29. The uncontradicted evidence shows that sleeving enhances safety, both from the point of view of increased integrity of the primary pressure boundary and decreased consequences of a breach in the pressure boundary. Sleeving will provide lower probabilities of the occurrence of the three

events -- abnormal leakage, rapidly propagating failure, and gross rupture -- which are required to be minimized by GDC 14. Fletcher, ff. Tr. 1422, at 12.

IV. EDDY CURRENT TESTING

30. The narrow issue for litigation in this proceeding, regarding the eddy current inspectability of the sleeves, is a subpart -- remaining after the resolution of the motions for summary disposition -- of Intervenor's original broad allegation that the presence of the sleeve will make the interpretation of eddy current test results "extremely difficult". In view of the foregoing findings, that sleeving enhances the integrity of the primary pressure boundary in the sleeved region of the steam generator tubes, we next explored the question of whether eddy current inspectability of the sleeves is less effective than that of the unsleeved tubes and, if so, whether this would in any way offset our findings of improved safety with sleeving. The uncontradicted evidence shows, and we so find, that the ECT inspectability of the sleeves is actually improved over that of the unsleeved tubes in the sleeving region.

31. For ECT, a probe is inserted into the steam generator tube. Electric current within the coils in the probe produces an electromagnetic field. As the probe is moved within the tube, an electric current is induced in the conductive material

of the tube or sleeve. This is the eddy current signal which is recorded and interpreted. Degradation in the wall of the tube or sleeve causes variations in the effective electrical conductivity and/or magnetic permeability of the wall material. These variations are measured directly by changes in the coil voltage of the eddy current probe. Fletcher, ff. Tr. 1422, at 3-4; Tr. 1462-64 (Denton).

32. ECT at Point Beach is performed by Westinghouse Electric Corporation, which subcontracts the reading and interpretation of the eddy current data to Zetec, Inc. Tr. 1460-61 (Denton). Messrs. Denton and McKee, of Zetec, offered testimony in considerable detail about ECT equipment, the physics of the ECT process, the interpretation of eddy current signals, and the capabilities of ECT for detecting SCC and IGA in tubes and sleeves in the field. Tr. 1462-78 (Denton); Tr. 1608-1723 (Denton, McKee); Licensee Exhibits 2 and 3.

33. The eddy current signals for each tube are recorded on a magnetic tape. The tape is used to produce a strip chart which indicates the presence or absence of defect signals along the tube wall. The ECT signal on the tape also can be displayed on an oscilloscope which is used to determine the depth of penetration of degradation into the wall material. Tr. 1608-11; 1473 (Denton).

34. An eddy current indication of a defect in the tube wall appears as a deviation from a vertical base line on the

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34. An eddy current indication of a defect in the tube wall appears as a deviation from a vertical base line on the

strip chart -- the greater the volume of the defect, the greater the amplitude of the deviation from the vertical base line. Tr. 1611, 1620 (Denton). Unwanted signals, or "noise," also appear as deviations from the base line on the chart. Noise is caused by such extraneous sources as conductive impurities deposited on the surface of the tube, magnetite in sludge surrounding the tube, or the uneven inner surface of the tube sheet hole surrounding the tube. Fletcher, ff. Tr. 1422, at 4. The ratio of the amplitude of the defect deviation to the noise deviations on the strip chart is known as the "signal-to-noise" ratio. Multifrequency mixing techniques are used to eliminate most -- but not all -- of the noise, i.e., the amplitude of the noise signals is significantly reduced. Fletcher, ff. Tr. 1422, at 4; Murphy, ff. Tr. 1828, at 8; Staff Exhibit 1, at 32. This increases the signal-to-noise ratio and enables the detection of small defects which might otherwise have been masked by the noise. Murphy, ff. Tr. 1828, at 8. The amplitude of the eddy current signal is indicative of the volume of the degradation, but says nothing about the depth of penetration into the tube wall. Tr. 1611 (Denton); Tr. 1495-96 (Fletcher); Tr. 1672 (Denton).

35. When the eddy current interpretor sees a signal which might indicate degradation, he examines the signal on the oscilloscope. Tr. 1473, 1610 (Denton); Tr. 1631 (McKee). A crack in the wall would typically appear on the scope in the

shape of a flattened figure eight. Tr. 1471-73, 1618-20 (Denton); Licensee Exhibit 2, at 1; Licensee Exhibit 3. The phase angle of the figure, as measured with an electronic protractor, indicates the depth of the penetration. Tr. 1611-12, 1677 (Denton). For defects of very small volume, the figure on the scope may be small, and the phase angle is difficult to measure with precision. In such cases, the interpretor takes the most conservative reading of the angle, thus tending to overstate the depth of penetration. Tr. 1622 (Denton).

36. While eddy current testing provides a reliable method of detecting defects of significant volume, it is expected that a defect of small volume may remain undetected, as the small amplitude signal from such a defect may be masked by the amplitude of the noise signal. Fletcher, ff. Tr. 1422, at 3, 5-6; Tr. 1497 (Fletcher). This could result in a through-wall penetration which would allow minor leakage of primary coolant into the secondary side of the steam generators. Murphy, ff. Tr. 1828, at 3-4; Marsh, ff. Tr. 1822, at 2-3. As we discussed previously, NRC operating license conditions for pressurized water reactors allow operation with such leakage, but require that the leakage be constantly monitored, and that the reactor be shut down should the leak rate reach a predetermined level. Fletcher, ff. Tr. 1422, at 5-6; Murphy, ff. Tr. 1828, at 2-3.

37. Technical Specification 15.4.2.A of the Point Beach operating licenses, which requires periodic eddy current inspection and the plugging of tubes which leak or have degradation exceeding the 40% plugging limit, also requires that the tubes be examined for degradation in accordance with Appendix IV, "Eddy Current Examination Method of Nonferromagnetic Steam Generator Heat Exchanger Tubing," of the ASME Boiler and Pressure Vessel Code, Section XI, "Inservice Inspection of Nuclear Plan Components." Mr. Fletcher testified that ECT, as performed by Westinghouse at Point Beach, fully complies with the cited requirements of the ASME Boiler and Pressure Vessel Code. Fletcher, ff. Tr. 1422, at 2-3.

38. To better understand the degree of inspectability of sleeves by ECT, we first asked the parties to discuss the ECT inspectability of unsleeved tubes. SCC entails separation of the metal grains in the wall material, which shows up in ECT as a change in conductivity and/or permeability. Tr. 1428, 1431 (Fletcher). Thus, it is generally expected that SCC that has progressed to 40% of the tube wall thickness will be detected by ECT, although as we noted previously, the signals from very small-volume cracks may be hidden by noise. Fletcher, ff. Tr. 1422, at 3.

39. IGA is more difficult to detect because, until SCC occurs, there is no separation of the metal grains. Murphy, ff. Tr. 1828, at 5-6; Tr. 1430 (Fletcher). ECT techniques in

the field to date have generally relied on detection of the SCC which is expected to eventually occur as the tube wall is weakened by the IGA. Tr. 1450-51 (Fletcher). Mr. Fletcher testified that SCC is usually expected to occur when IGA has penetrated to about 30 to 40% of the tube wall thickness. Tr. 1450, 1498, 1502-3 (Fletcher); Fletcher, ff. Tr. 1422, at 10. However, within the tubesheet, the radial expansion of the tubes which would permit cracking may be constrained by packed sludge in the tubesheet crevice. The NRC Staff testified that this has resulted in the inability to detect large numbers of tubes with IGA penetrations substantially beyond 40% of the wall thickness, possibly to as much as 70% to 80%, but that, in spite of these limitations, ECT has nonetheless been able to detect hundreds of IGA indications within the tubesheet. Murphy, ff. Tr. 1828, at 5-7.

40. Because IGA found at Point Beach has occurred within the tube-tubesheet crevice, where leakage flow during an accident condition would be significantly restricted by the crevice, the uncertainties in detecting IGA have not been considered a safety concern. Fletcher, ff. Tr. 1422, at 10; Murphy, ff. Tr. 1828 at 7, 10; Tr. 1854 (Murphy). Nevertheless, since IGA was discovered in Point Beach steam generator tubes in 1979, Westinghouse has conducted considerable research toward the early detection of IGA. Westinghouse has developed a process for exposing tubing to an acid

condition to produce laboratory samples with IGA of various depths of penetration, unaccompanied by cracking. Westinghouse is testing the eddy current response to the IGA which, rather than the relatively sharp deviation caused by an SCC signal, is a "drift" from the base line on the strip chart. IGA has been detected in the laboratory at 20% wall penetration, and work is continuing on the development of a field standard to enable the eddy current interpretor to recognize and quantify IGA in the field. Tr. 1437-47 (Fletcher).

41. With that background in mind, we turn next to consideration of the eddy current inspectability of the installed sleeves. We found in our Memorandum and Order of October 1, 1982, ruling on the motions for summary disposition filed by Licensee and the Staff, that there was no genuine issue of fact to be determined with respect to the safety and inspectability of the upper joint where the sleeve is joined to the tube.2/ Memorandum and Order at 15. Thus, our consideration is limited to the eddy current inspectability of the sleeve below the upper joint.

42. Mr. Fletcher testified for Licensee that, because of reduced eddy current noise levels, the ability to detect IGA and SCC in the pressure boundary portion of the sleeve between the upper and lower joints is enhanced over the ability of ECT

2/ Intervenor raised no contentions involving the lower joint at the base of the tubesheet.

to detect such degradation in the corresponding portion of an unsleeved tube. Fletcher, ff. Tr. 1422, at 3-5.

43. Most of the length of the sleeve is within the 22" thick metal tubesheet, with a portion of the sleeve extending above the top of the tubesheet. Staff Exhibit 1, at 31; Tr. 1766-70 (Fletcher). The outer edge of the tube is only about 0.007" (7 mils) from the inner surface of the tubesheet hole. As we noted, interfering noise signals result from the uneven characteristics of the surface of the tubesheet hole, as well as from the magnetite in the sludge surrounding the tube in the vicinity of the tubesheet and from conductive impurities which may be deposited on the outer surface of the tube. Fletcher, ff. Tr. 1422, at 4. The noise is reduced by the use of multifrequency mixing techniques such that the adequacy of the inspection is maintained, but some residual interference remains. Fletcher, ff. Tr. 1422, at 4.

44. Significantly less noise is present when the sleeve is tested. Within the tubesheet, the outer surface of the sleeve is nominally 75 mils away from the surface of the tubesheet hole. This means that, compared to the tube, the sleeve wall being examined is now much farther away from the surface of the tubesheet hole, and much farther away from any sludge and impurities which may be present on the outer surface of the tube. The noise from these three sources is significantly reduced by the greater distance. In addition, the tube

surrounding the sleeve acts as an electromagnetic shield which further reduces the interfering signals from these exterior noise sources. Fletcher, ff. Tr. 1422, at 4.

45. The Staff testified that, for the section of the sleeve within the tubesheet, there will be a significant reduction of competing signal noise from the tubesheet compared to an unsleeved tube because the sleeve is farther away from the tubesheet and because the sleeves will be inspected at a higher test frequency, making the ECT less sensitive to sources located outside the sleeves. The resultant improvement in the signal-to-noise ratio will thus improve the sensitivity of the test. Murphy, ff. Tr. 1828, at 5. See also Murphy, ff. Tr. 1828, at 6-7.

46. Mr. Fletcher testified that the portion of the sleeve above the top of the tubesheet will also experience improved eddy current inspectability because the outer surface of the sleeve is farther away from the sludge and impurities which may be present on the outer surface of the tube, and because of the electromagnetic shielding by the tube. Even if the tube were to leak in the sleeved region, exposing the outer surface of the sleeve to conductive interferences, the adequacy of the inspections is maintained through the use of multifrequency mixing techniques to reduce the resultant noise. Fletcher, ff. Tr. 1422, at 4-5.

47. The Staff testified in its prepared testimony that, above the tubesheet, Westinghouse had reported a reduction in

signal response for the sleeve, compared to the unsleeved tube, ranging from 30% for a standard calibration hole penetrating 40% of the wall to 0% for a 100% through-wall calibration hole. The Staff noted, however, that such reductions are considered too small to have a significant bearing on whether a reliable test can be performed. Murphy, ff. Tr. 1228 at 4. Mr. Fletcher explained that the Westinghouse information referred to by the Staff was a result of laboratory test standards that were calibrated for a sleeve alone, rather than for a sleeve within a tube, and that such signal reductions would not occur in the field. ECT equipment used in the field for inspecting sleeves would be calibrated against a sleeved tube standard which would eliminate the reduction reported in the laboratory response. Tr. 1424-26 (Fletcher).

48. Intervenors offered no testimony on the inspectability of sleeves, and elicited no evidence on cross-examination to contradict the evidence of Licensee and the Staff. The Board therefore finds that ECT sensitivity for detecting IGA and SCC in the installed sleeves will be improved relative to the ability to detect such defects in the corresponding sections of the unsleeved tubes.

V. ORDER

Based on consideration of the entire record in this matter, and the foregoing findings which are supported by

reliable, probative, and substantial evidence in this proceeding, it is this _____ day of _____, 1983

ORDERED

1. Pursuant to the Atomic Energy Act of 1954, as amended, and the Commission's rules and regulations, the Director of Nuclear Reactor Regulation, upon making findings on all other matters not embraced in this Initial Decision in accordance with the Commission's regulations, is authorized to issue a license amendment to Wisconsin Electric Power Company authorizing the operation of Point Beach Nuclear Plant, Units 1 and 2, with steam generator tubes which have been repaired by sleeving.

2. In accordance with 10 C.F.R. § 2.764(a), this Order shall be effective immediately, subject to review by the Commission on its own motion or upon exceptions filed within ten (10) days after service pursuant to 10 C.F.R. § 2.762.

Respectfully submitted,

SHAW, PITTMAN, POTTS & TROWBRIDGE

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Dated: December 20, 1982

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
WISCONSIN ELECTRIC POWER COMPANY	)	Docket Nos. 50-266
	)	50-301
(Point Beach Nuclear Plant,	)	(OL Amendment)
Units 1 and 2)	)	

CERTIFICATE OF SERVICE

This is to certify that copies of "Licensee's Proposed Findings of Fact and Conclusions of Law In The Form Of A Proposed Initial Decision" are being served to all those on the attached Service List by deposit in the U.S. Mail, first class, postage prepaid, this 20th day of December, 1982.

Bruce W. Churchill

Dated: December 20, 1982

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NUCLEAR REGULATORY COMMISSION

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