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SAFETY EVALUATION

BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. TO FACILITY OPERATING LICENSE NO. DPR-24

WISCONSIN ELECTRIC POWER COMPANY

POINT BEACH NUCLEAR PLANT, UNIT NO. 1

DOCKET NO. 50-266

TABLE OF CONTENTS

1.0 INTRODUCTION

By letter dated July 2, 1981, Wisconsin Electric Power Company (licensee) submitted an application for license amendments consisting of proposed changes to the Technical Specifications for Point Beach Nuclear Plant Units 1 and 2. These proposed Technical Specification changes would allow operation at power of Units 1 and 2 with steam generator tubes having degradation exceeding the plugging limit (40% nominal wall thickness) provided these tubes have been repaired by insertion of sleeves into the tubes to bridge the degraded or defective portion of the tubes. The proposed issuance of these amendments was prenoticed in the Federal Register on August 7, 1981 due to the strong public interest on this subject.

The licensee also submitted by letter dated October 12, 1981, a modification to their proposed license amendment for Unit 1 dated July 2, 1981. This modification proposed Technical Specification changes to allow operation of Unit 1 at power with up to six tubes in one steam generator having degradation exceeding the plugging limit provided these tubes have been repaired by insertion of sleeves into the tubes to bridge the degradated or defective portions of the tubes. The licensee also plans to sleeve six tubes having degradation less than the plugging limit. The licensee's stated reason for submitting this modification is to conduct a demonstration sleeving program on Point Beach Unit 1 during the October 9, 1981 refueling outage. This demonstration program will utilize two separate sleeving processes and the licensee hopes it will provide valuable information and experience for use during their full-scale sleeving program.

This Safety Evaluation documents the results of the NRC staff's review and evaluation of the licensee's proposed demonstration steam generator tube sleeving program including the environmental and radiation exposure impact.

2.0 DISCUSSION

2.1 Sleeving Process Description

The sleeving demonstration program scheduled for the fall 1981 refueling outage of Point Beach Unit 1 is expected to include removal of explosive and mechanical plugs from previously plugged tubes where degradation had exceeded the plugging limit in the Technical Specifications. All tubes from which plugs have been removed will be inspected with eddy current techniques throughout their length prior to sleeving. Should indications of progression of degradation, or new indications of degradation be seen outside the proposed sleeved region of the tube, the tube will not be sleeved, but will be plugged in accordance with the Technical Specification requirements.

To provide a tecnnical basis for the proposed sleeving demonstration program, the licensee has submitted Westinghouse Report WCAP-9960 (Proprietary), dated September 28, 1981, and entitled, "Point Beach Steam Generator Sleeving Report for Wisconsin Electric Power Company." The licensee has submitted additional information by letters dated October 9, 16, and 24 in response to questions by the ASLB and the NRC staff. They have also responded to other questions during conference calls with the NRC staff.

The sleeving process consists of installing, inside the steam generator tube, a smaller diameter tube (sleeve) to span the degraded area of the parent tube. The sleeves are intended to restore the integrity of the degraded tubes by providing a new primary pressure boundary which has been sized to the ASME Boiler and Pressure Vessel Code, Section III.

The sleeves are fabricated from thermally treated Inconel 600 tubing to provide a maximum resistance to stress corrosion cracking. The sleeves will be inserted inside the existing tube (mill annealed Inconel 600) and joined to the tube ID at the upper and lower sleeve ends. The sleeves will span the distance from the tube inlet to a few inches above the top of the tubesheet. The Point Beach sleeves are intended to address the general intergranular attack and stress corrosion cracking which has been confined to the tubesheet area.

The sleeves used in the demonstration program will employ two different upper sleeve joint designs. The "reference" upper joint design is a structural joint which provides a leak limiting seal. A functional requirement for "reference" upper joints is that they must be sufficiently leak limiting such that the total leakage between the primary and secondary for all the sleeves taken together is less than the Technical Specification leak rate limit during normal operation. In addition, total leakage must be maintained to within tolerable limits during postulated accidents. The acceptance criteria imposed during verification leak testing of the joint is based upon these total leakage limits divided by the total number of tubes eventually planned for sleeving (approximately 2500 tubes).

The second or "alternate" upper joint design is also a structural joint. This joint is fabricated using a proprietary heating process to form a leak tight seal. The lower sleeve joint also provides a structural and leak tight seal, but is not fabricated with the proprietary heating process.

The Point Beach sleeves and sleeve joints are basically similar to those at San Onofre Unit 1 from the standpoint of design and joint fabrication techniques. The San Onofre sleeves have been extensively tested for structural, metallurgical, corrosion, and leak tight (or leak limiting) integrity.

2.2 Structural Verification Analyses

Structural analyses of the sleeved tube assembly are being performed to the requirements of Section III of the ASME Boiler and Pressure Vessel Code. These analyses are intended to demonstrate adequate fatigue performance and structural margins for the full range of normal operating, transients, and accident (e.g., LOCA, MSLB) condition loadings. The structural and fatigue analyses include consideration of stresses in the sleeved tube assemblies which could result from hourglassing (deformation) of the support plate flow slots, and from flow induced vibration. The analyses have essentually been completed; however, some additional processing of finite element stress data must yet be performed before they can be evaluated against the 3 Sm limit for primary plus secondary stress. The preliminary results submitted by letter dated October 24, 1981, indicate the Code allowables for primary membrane, primary membrane plus bending stress, and fatique usage have been met.

Strength analyses have been performed to establish the minimum wall thickness requirement (or allowable wall degradation) to assure compliance with the Regulatory Guide 1.121 "no yield" criterion under normal operating conditions. These analyses have also established the minimum wall thickness requirements (and allowable wall degradation) to preclude a gross tube burst under the pressure loadings associated with a postulated MSLB accident, consistent with the Regulatory Guide criterion and the Code limits on primary membrane stress under faulted conditions. The results of these analyses will be used to set the Technical Specification plugging limit for the sleeves.

2.3 Verification Testing of Sleeve Joints

The structural analyses of the sleeved tube assemblies are being supplemented by extensive mechanical testing to verify acceptable structural strengths, fatigue performance and leaktight integrity of the upper and lower joints. The test mockups for the lower joint include tubesheet mockups from which the effects of removing both mechanical and explosive type plugs have been simulated. The joints have been formed using the same fabrication techniques and parameters as will be used in the field. Each of the joints is being subjected to axial load (to simulate loads caused by differential thermal expansion) and pressure cycling tests to verify the long term sealing integrity of the joints under the specified operating transients (e.g., heatup/cooldown and plant loading/unloading cycles). Specimens for each type joint will also be tested to the maximum pressure and axial load levels expected during postulated accident conditions. For each of the three joint designs, testing has proceeded to as much as the equivalent of five years of operation with no adverse findings reported to date. Further testing is in progress and will be continued for an equivalent 35 years of operation.

Similar mechanical tests have been completed for the San Onofre joints to support thirty years operation with the results indicating acceptable structural and leak limiting performance.

2.4 Verification of "Leak Before Break"

Westinghouse tests indicate that margin to burst exists at the MSLB pressure differential for a through wall crack which is leaking at less than the Technical Specification limit during normal operation. The tests indicate that the required through wall crack length for a tube burst under MSLB conditions is .5 inches, whereas a through wall crack longer than .4 inches will result in leakage in excess of the Technical Specification leakage rate limit during normal operation.

2.5 Effect of Proprietary Heating Process on Upper Alternate Joint Integrity

The proprietary heating process for the "alternate" upper joint design will result in some degradation of the mechanical properties of the sleeve and tube wall material local to the seal between the sleeve and the tube.

Tensile tests of individual San Onofre tube and sleeve specimens following a simulated joint heating process indicated a significant reduction in the ultimate and yield strength at the location where the peak temperature had been reached. This corresponds to the center of the region where the tube and sleeve would be sealed. As evidenced by variations in hardness and grain size measurements as one proceeds away from this location, heat process effect on the yield and ultimate strength is localized to within the width of the seal. Tensile tests of a number of joint specimens resulted in tensile failures of the sleeve wall invariably between two and three inches below the sealed location, at levels in excess of minimum requirements (Ref. 1). Westinghouse has also reported that the stress strain curve of the "alternate" upper joint almost duplicates that of virgin Inconel 600 material

Westinghouse has reported that confirmatory tests for the actual Point Beach "alternate" joint configuration have indicated similar results and that the overall joint strength exceeds Code requirements.

Internal pressure tests to three times normal operating pressure, and external pressure tests to 1.5 times the maximum LOCA pressure loading resulted in no failures for the San Onofre "alternate" upper joint specimens. Similarly, load cycling tests (to simulate pressure plus thermal cycling) for the expected number of operating cycles over a 30 year lifetime were completed with no failures. Similar confirmatory tests are in progress for the actual Point Beach configuration, with the exception of the collapse test.

2.6 Discussion of Corrosion Aspect and Verification Testing

The corrosion that has occurred on the outer surface of the tubes has been attributed to caustic corrosion resulting from the use of phosphate water chemistry in the secondary water with massive phosphate additions and the formation of caustics due to impurities from persistent leaky tubes in the steam condenser. The chemistry control program of the secondary side water was switched to an all-volatile treatment in September of 1974, though free hydroxide continued to be present in the blowdown water until 1978.

Most of the steam generator tube corrosion and degradation has occurred in the central region of the inlet end of the tube bundle. Some intergranular stress corrosion cracking, wastage, and thinning has occurred at a location just above the tubesheet in the sludge zone, but the more extensive intergranular corrosion has occurred in the tubesheet crevices. Although the licensee's tube degradation rate has slowed recently, tube degradation could continue.

We have reviewed the corrosion test program performed in support of the Southern California Edison (SCE) plant, San Onofre Unit 1. This work was cited by the licensee in support of the present request application. The corrosion tests performed were extensive, involving the use of capsule tests and modified boiler tests in which the environment that existed in San Onofre Unit 1 was simulated and its effect on the sleeved tubes was studied. The environment in the tubesheet crevice at Point Beach Unit 1 is similar. An extensive test program was performed studying the effects of caustic on the corrosion resistance and stress corrosion cracking of the sleeving material. Confirmatory testing of the corrosion and stress-corrosion cracking resistance of both the upper and lower joints of the Point Beach configuration is in progress.

2.7 Eddy Current Test Capabilities

Eddy current data is provided in the Repair Report to demonstrate the applicability of the conventional bobbin type ECT probe to the inspection of the sleeved tube assemblies. (This data was actually obtained for San Onofre sleeved assemblies.) At the optimum test frequency for the sleeve,

the amplitudes of the ECT signals ranged from 70% to 100% of those for a non-sleeved tube for calibration holes of 40% and 100% throughwall depth, respectively. This data is indicative of the relative flaw sensitivity outside the tubesheet, whereas most of the sleeve length will be located within the thickness of the tubesheet. The Westinghouse investigation indicates that within the thickness of the tubesheet the "signal to noise ratio" associated with a sleeving defect is substantially less than that associated with a flaw in a non-sleeved tube. Thus, Westinghouse has concluded that the sleeve in the tubesheet region will have a higher degree of inspectability than an unsleeved tube in this region.

The inspectability of the tube wall is of interest at and above the upper sleeve joints. The Westinghouse study indicates that the amplitude of the ECT signals for calibration holes in excess of 40% through wall were approximately 50% of those for non-sleeved tubes at a test frequency of 100 KHZ. At a test frequency of 350 KHZ, the amplitude sensitivity was reduced to approximately 30% to 40% of that for a non-sleeved tube.

Eddy current inspection of the sleeve joints will present some difficulties particularly for the "reference" type upper joint. The sleeve joints contain a number of features which will produce competing ECT signals making it more difficult to discriminate sleeve or tube wall defects at these locations. The application of the multifrequency techniques will provide enhanced capability to discriminiate flaw signals from these competing signals. Westinghouse is currently investigating ECT procedures to further improve the inspectability of these regions including the use of magnetic bias techniques and alternate probe types such as the crosswound probe, the rotating pancake (RPC) probe, and the multicoil surface riding probe.

3.0 EVALUATION

3.1 Structural and Leak Tight Integrity

We have reviewed the extensive program of verification analysis and tests to qualify the structural and leak tight (or leak limiting) integrity of the sleeved tube assemblies and the results thus far available. Although an assessment of primary plus secondary stresses against the 3 Sm limit ("shakedown") of the ASME Code remains to be completed, the licensee has sufficiently demonstrated by analysis that adequate margin will exist against a burst failure of the sleeve during the full range of normal, transient, and postulated accident conditions, consistant with the primary membrane and primary plus bending stress limits of the Code. Mechanical load cycling tests to verify the long term structural, fatigue, and leak tight (or leak limiting) performance of the sleeve joints have reached the equivalent of five years of operation

with no adverse results. This preliminary data, coupled with the results of the fatigue analysis performed to the ASME Code requirements provides reasonable assurance against a fatigue or shakedown failure of the demonstration sleeve joints during the interim period before the remaining analytical effort and testing is complete.

Regarding this sealing integrity of the joints, even if the demonstration sleeve joints should leak (between the sleeve and tube wall) at several orders of magnitude higher than what has been indicated by the test results thus far, the total leakage would be insignificant compared to the licensee's criteria for allowable total leakage. This is due to the relatively small number of sleeves involved in the demonstration program and the inherent leak limiting geometry of the sleeve joint.

We have also reviewed the licensee's "leak before break" analysis. We find that the available margins are consistant with those which exist for the original tubing and are acceptable.

3.2 Plugging Limit

The licensee has not yet proposed a plugging limit for the sleeves should they become degraded. Based upon our review and assessment of the minimum wall thickness requirements calculated by Westinghouse, we find that a 35% plugging limit (sleeves with greater than 35% through wall degradation due to be plugged) will assure acceptable margins to failure consistent with the criteria of Regulatory Guide 1.121. Pending additional information from the licensee to justify a less restrictive limit, we are imposing a 35% plugging limit as an interim requirement.

3.3 Alternate Upper Joint Integrity

Laboratory testing has shown a significant reduction in the ultimate and yield strength of the sleeve and tube material in the zone local to where the sleeve wall is sealed to the tube wall. However, tensile tests of the San Onofre and Point Beach joint configurations has demonstrated that the sleeve and tube wall at the seal will reinforce each other that the overall strength of the joint exceeds that of a sleeve wall exhibiting a tensile strength equal to the design minimum strength in the ASME Code. Based upon this, the extensive mechanical tests (proof pressure tests, pressure and axial load cycling tests) which have been completed for San Onofre, and the confirmatory testing which has been completed to date for the actual Point Beach joint configuration, we conclude that there is reasonable assurance against a structural falure of the joint during the interim period before all tests are completed. Primary side and secondary side hydrotests will be performed on the sleeved tube assemblies subsequent to the sleeving operation and provide additional assurance of joint integrity.

We have also reviewed the difficulties experienced at San Onofre regarding localized erosion of the sleeve and tube wall at the joint as a result of the heating process. Based upon the metallographic examinations which have been performed on the San Onofre joints and revised heating parameters which have been implemented at Point Beach, we have concluded that this phenomenon will not have any significant adverse affect on the integrity of the Point Beach joints. Additional assurance is provided by the on-going mechanical testing of these joints which have been fabricated to the process parameters to be used in the field and the eddy current and hydrostatic tests that will be performed following the sleeving operation.

3.4 Corrosion Resistance

We have reviewed the test data from the San Onofre corrosion program for the sleeve repair and find that the tests and their results are directly applicable to the Point Beach sleeving repair test program. The small difference is the tube dimensions that cause slightly different operating values in the fabrication procedure do not affect significantly the corrosion resistance of the tubes or the joints. The test program has studied the behavior of the repair program materials in pure water, in primary coolant, and in 10% caustic solutions to simulate the continued hide out of caustic in the crevices and sludge on the secondary side of the steam generator. This work has shown that the thermal treatment to be given to the Inconel sleeves is effective in reducing the probability of caustic stress corrosion developing on these sleeves. It has also been shown that the small, controlled amount of cold work performed on the Inconel in attaching the sleeve to the steam generator tube was not sufficient to cause a significant increase in the susceptibility of the tube to stress corrosion cracking from the primary side water. This amount of cold work is significantly less than that which occurred where the tube was expanded into the lower portion of the tubesheet during the original fabrication. To date no cracking has developed in that area in Point Beach, San Onofre, or in model boilers and heat crevice tests. Further the tests have shown that there is only minor degradation of the material properties and corrosion resistance of the tubes at the upper joints. This has been shown by hardness test traverses and corrosion tests in caustic.

3.5 Eddy Current Inspectability

The eddy current inspectability of the sleeve walls between upper and lower joints will be comparable to that for an unsleeved tube without a significant loss of sensitivity. Geometric discontinuities at the sleeve joints will produce signal interference. However, the use of non-standard eddy current probe types and multifrequency techniques should permit adequate inspections

of these areas. One local area that may present special difficulties is the sleeve joint which has received the proprietary heating process. Westinghouse is investigating methods to improve the inspectability of this area.

In the meantime, the preservice eddy current inspection of the sleeves will be supplemented by primary side and secondary side hydrostatic tests (2000 psid and 800 psid, respectively) to provide added assurance of the joint integrity.

4.0 ALARA Considerations

The licensee has taken into account ALARA considerations for each of the radiation activities involved in the proposed steam generator sleeving demonstration at Point Beach. ALARA activities specifically directed to reduction of occupational radiation exposures include: deconamination of steam generators, personnel training in full-size mockups, installation of shielding if necessary to reduce radiation exposures to repair personnel.

Administrative control of personnel exposures will be effected by careful planning of maintenance procedures for the job, in order to minimize the nnumber of personnel used to perform the various tasks involving relatively high doses and dose rates. TV surveillance of personnel during tasks will be used to identify areas resulting in high exposures, and thus to initiate suitable dose-reducing actions.

Based on prior inplant experience with channel head decontamination and laboratory decontamination, no significant increase in airborne radioactivity is to be expected. However, vapors from the channel head will be drawn through a high efficiency air particulate filtration system before release to the plant filter system. All sleeving operations will be monitored to keep airborne releases to a minimum. The licensee does not expect that auxiliary ventilation or special enclosures will be necessary.

The licensee had made use of experience gained in prior channel head decontamination in planning for the proposed tube sleeving activities. Data was available for Point Beach Unit 1, Takahoma Unit 1, San Onofre Unit 1, and Turkey Point Unit 3. In particular, the applicant considered information on mechanisms used in prior decontamination. The licensee has provided information relevant to projected occupational radiation exposures resulting from the demonstration decontamination/sleeving program at Point Beach Unit 1, as well as from the proposed full-scale sleeving program for both units.

The licensee has estimated the radiation doses likely to be associated with the processes involved in the sleeving program:

(a) installation of remoting tools and equipment - 5 person-rems,

(b) decontamination of the steam generator - 10 person-rems (including tube decontamination),

(c) installation of additional shielding, if necessary - 10.6 person-rems (9.5 for the channel head, 1.1 for nozzle shield removal),

(d) inspection and testing - 2.9 person-rems (92 millirems/sleeve eddy current inspection, 300 millirems/sleeve test),

(e) de-plugging tubes for sleeving - 3.4 person-rems/tube (explosive),

(f) sleeving - 4-5 person-rems/tube.

The licensee has provided realistic estimates of dose rates and occupancy factors, as the bases for these dose estimates, and has estimated that the total person-rem dose resulting from the demonstration sleeving program at Point Beach Unit 1 at 48-60 person-rems assuming a decontamination factor of about 2.5.

The radiation exposure data and the operational experience resulting from the proposed demonstration of the sleeving process at Point Beach Unit 1 will be a test of proposed radiation control techniques, and will provide a basis for a more refined and more precise estimation of doses likely to result from the proposed future sleeving process of both units.

5.0 REDUCED FLOW CONSIDERATIONS

The licensee has stated that the sleeving of 20 steam generator tubes is equivalent to the reduction in flow through the steam generator caused by plugging one steam generator tube. The licensee plans to sleeve 12 steam generator tubes. Acccording to the licensee's estimates this will cause less effect than plugging one tube.

Further, some of the tubes the licensee plans to sleeve will be tubes previously degraded beyond the plugging limit. The licensee plans to remove the plugs from these tubes and insert sleeves to bridge the degraded or defective portions of these tubes. Based on the licensee's estimates, this would result in a net increase in flow through the steam generators.

Even if the licensee's estimates on the amount of flow reduction associated with sleeving a steam generator tube are in error, and even if the licensee does not recover any previously plugged tubes by sleeving, this will not present an unreviewed safety question for the demonstration sleeving program. Point Beach Unit 1 is operating with an 18% plugging limit for its steam generators. This is based upon an 18% tubes plugged ECCS (Emergency Core Coolant System) analysis submitted by the licensee and approved by the NRC staff. Currently between 12-13% of the steam generator tubes in Unit 1 are plugged. Since 1% of the total number of tubes is approximately 32 tubes for each steam generator, even assuming that the reduction of flow caused by sleeving a steam generator tube was equivalent to that caused by plugging a tube, this is still well within the limits of the previously approved analysis.

For the reasons stated above, the staff finds the effect of the steam generator demonstration sleeving program to be insignificant from a flow reduction standpoint.

6.0 CONCLUSIONS

Based upon the above evaluation, we conclude that the verification analyses and tests completed to date for the Point Beach sleeves, plus the similar program which has been completed for the San Onofre sleeves, provides reasonable assurance that the sleeves and sleeve joints will exhibit acceptable mechanical strength corrosion resistance and leak tight (or leak limiting) capability for the interim period before the Point Beach sleeve verification program is completed. Even if the demonstration sleeves joints develop substantially more leakage than indicated by test, the total leakage will be insignificant.

The preservice eddy current inspection and primary side and secondary side hydrostatic tests to be performed prior to startup, and the stringent primary to secondary leak rate limits in the Plant License, will provide additional assurance that the sleeved assemblies will maintain adequate tube integrity during normal operation and postulated accidents. If leakage in excess of the leakage rate limit does occur, the plant will be shutdown for evaluation of the cause of the leak and appropriate corrective action. Until such time as the licensee submits justification for a less restrictive plugging limit, we require that sleeved tube assemblies containing sleeve indications equal to or greater than 30% through-wall be plugged.

Based on the staff's review of the Point Beach Steam Generator Tube Sleeving Report, and the additional information provided, we conclude that the licensee's estimated dose for this project appears reasonable and that the licensee intends to implement reasonable radiation protection actions that should maintain inplant radiation exposures within the applicable limits of 10 CFR Part 20, and should maintain exposures ALARA.

Based upon the staff's review of the reduced flow considerations associated with the demonstration sleeving project, the staff finds the effects to be within the range of the previously approved ECCS analysis for operation with up to 18% of Unit 1's steam generator tubes plugged. Therefore, the staff finds its impact upon the health and safety of the public to be insignificant.

REFERENCE:

1. Transcript of "Steam Generator Sleeving Review Board Meeting, San Onofre Unit 1, Steam Generator Sleeve Repair for Southern California Edison, Westinghouse Electric Corporation, Forest Hills Division, Pittsburgh, Pennsylvania, 15221, Thursday, October 23, 1980 - 8:15 A.M., Friday, October 24, 1980 - 8:05 A.M.".