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Mr. M. L. Marchi
Manager - Nuclear Business Group
Wisconsin Public Service Corporation
Post Office Box 19002
Green Bay, WI 54307-9002

SUBJECT: AMENDMENT NO. 134 TO FACILITY OPERATING LICENSE NO. DPR-43 - KEWAUNEE NUCLEAR POWER PLANT (TAC NO. M98437)

Dear Mr. Marchi:

The Commission has issued the enclosed Amendment No. 134 to Facility Operating License No. DPR-43 for the Kewaunee Nuclear Power Plant (KNPP). This amendment revises the Technical Specifications (TS) in response to your application dated April 24, 1997, as supplemented on May 15 and 28, and June 5, 1997.

The amendment revises TS Section 4.2.b, "Steam Generator Tubes," to allow repair of steam generator (SG) tubes with Combustion Engineering (CE) leak-tight sleeves in accordance with CE generic topical report CEN-629-P, Revision 2, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak-Tight Sleeves." The TS are also revised to allow re-sleeving of tubes with existing sleeve joints in accordance with KNPP specific topical report CEN-632-P, "Repair of Kewaunee Steam Generator Tubes Using a Re-Sleeving Technique."

A copy of the Safety Evaluation is also enclosed. Notice of issuance will be included in the Commission's next regular biweekly Federal Register notice.

Sincerely,

Original signed by:

Richard J. Laufer, Project Manager
Project Directorate III-3
Division of Reactor Projects III/IV
Office of Nuclear Reactor Regulation

D FOI

Docket No. 50-305

Enclosures: 1. Amendment No. 134 to License No. DPR-43
2. Safety Evaluation

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 7, 1997

Mr. M. L. Marchi
Manager - Nuclear Business Group
Wisconsin Public Service Corporation
Post Office Box 19002
Green Bay, WI 54307-9002

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Project Directorate III-3
Division of Reactor Projects III/IV
Office of Nuclear Reactor Regulation

Docket No. 50-305

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2. Safety Evaluation

cc w/encls: See next page

cc:

Foley & Lardner
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P. O. Box 1497
Madison, Wisconsin 53701-1497

Chairman
Town of Carlton
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Mr. Harold Reckelberg, Chairman
Kewaunee County Board
Kewaunee County Courthouse
Kewaunee, Wisconsin 54216

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Wisconsin Public Service Commission
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Madison, Wisconsin 53705-2729

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

WISCONSIN PUBLIC SERVICE CORPORATION

WISCONSIN POWER AND LIGHT COMPANY

MADISON GAS AND ELECTRIC COMPANY

DOCKET NO. 50-305

KEWAUNEE NUCLEAR POWER PLANT

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 134
License No. DPR-43

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Wisconsin Public Service Corporation, Wisconsin Power and Light Company, and Madison Gas and Electric Company (the licensees) dated April 24, 1997, as supplemented on May 15 and 28, and June 5, 1997, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment, and paragraph 2.C.(2) of Facility Operating License No. DPR-43 is hereby amended to read as follows:

(2) <u>Technical Specifications</u>

The Technical Specifications contained in Appendix A, as revised through Amendment No. 134, are hereby incorporated in the license. The licensees shall operate the facility in accordance with the Technical Specifications.

3. This license amendment is effective as of the date of its issuance, and is to be implemented within 30 days of the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Richard J. Laufer

Richard J. Laufer, Project Manager
Project Directorate III-3
Division of Reactor Projects III/IV
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of issuance: June 7, 1997

ATTACHMENT TO LICENSE AMENDMENT NO. 134

FACILITY OPERATING LICENSE NO. DPR-43

DOCKET NO. 50-305

Revise Appendix A Technical Specifications by removing the pages identified below and inserting the enclosed pages. The revised pages are identified by amendment number and contain vertical lines indicating the area of change.

REMOVE	INSERT
TS ii	TS ii
TS 4.2-6	TS 4.2-6
TS 4.2-7	TS 4.2-7
TS 4.2-8	TS 4.2-8
TS 4.2-9	TS 4.2-9
TS 4.2-10	TS 4.2-10
---------	TS 4.2-11
TS B4.2-3	TS B4.2-3
TS B4.2-4	TS B4.2-4
TS B4.2-5	TS B4.2-5
TS B4.2-6	TS B4.2-6

3. A loss-of-coolant accident requiring actuation of the engineering safeguards, where the cooldown rate of the Reactor Coolant System exceeded 100°F/hr, or

4. A main steam line or feedwater line break, where the cooldown rate of the Reactor Coolant System exceeded 100°F/hr.

d. If the type of steam generator chemistry treatment is changed significantly, the steam generators shall be inspected at the next outage of sufficient duration following 3 months of power operation since the change.

4. <u>Plugging Limit Criteria</u>

The following criteria apply independently to tube and sleeve wall degradation except as specified in TS 4.2.b.5 for the tube support plate intersections for which voltage-based plugging criteria are applied or for degradation except as specified in TS 4.2.b.6 for tubesheet crevice region in which the F* and EF* criteria is applied.

a. Any tube which, upon inspection, exhibits tube wall degradation of 50% or more shall be plugged or repaired prior to returning the steam generator to service. If significant general tube thinning occurs, this criterion will be reduced to 40% wall degradation. Tube repair shall be in accordance with the methods described in the following:

WCAP-11643, "Kewaunee Steam Generator Sleeving Report (Mechanical Sleeves)";

CEN-629-P Revision 2, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak Tight Sleeves";

CEN-632-P Revision 0, "Repair of Kewaunee Steam Generator Tubes Using a Resleeving Technique"; or

WCAP-13088, Revision 3, "Westinghouse Series 44 and 51 Steam Generator Generic Sleeving Report".

b. Any Westinghouse mechanical hybrid expansion joint (HEJ) sleeve which, upon inspection, exhibits wall degradation of 31% or more shall be plugged or repaired prior to returning the steam generator to service. For disposition of parent tube indications (PTI), the following requirements will apply:

1. HEJ sleeved tubes with circumferential indications located within the upper hardroll lower transition shall be inspected with a non-destructive examination (NDE) technique capable of measuring the sleeve ID difference between the sleeve hardroll peak diameter, and the sleeve ID at the elevation of the PTI. If this diameter change is $\geq$ 0.003" (plus an allowance for NDE uncertainty), the indication may remain in service provided the faulted loop steam line break (SLB) leakage limit from all sources is not exceeded. A SLB leakage allowance of 0.025 gpm shall be assumed for each indication left in service regardless of length or depth. For tubes where the diameter difference is > 0.013", SLB leakage can be neglected.

2. HEJ sleeved tubes with a sleeve ID difference of < 0.003" (plus an allowance for NDE uncertainty) between the sleeve ID hardroll peak diameter and sleeve ID at the elevation of the PTI shall be plugged or repaired prior to returning the steam generator to service.

3. HEJ sleeved tubes with axial indications located within the parent tube pressure boundary as defined on Figure TS 4.2-1 shall be plugged or repaired prior to returning the steam generator to service.

4. HEJ sleeved tubes with parent tube indications located outside of the parent tube pressure boundary as defined on Figure TS 4.2-1 may remain in service.

c. Any Combustion Engineering leak tight sleeve which, upon inspection, exhibits wall degradation shall be plugged prior to returning the steam generator to service. This plugging limit applies to the sleeve up to and including the weld region.

d. Any Westinghouse laser welded sleeve which, upon inspection, exhibits wall degradation of 25% or more, shall be plugged prior to returning the steam generator to service. This plugging limit applies to the sleeve up to and including the weld.

5. Tube Support Plate Plugging Limit

The following criteria are used for the disposition of a steam generator tube for continued service that is experiencing predominantly axially oriented outside diameter stress corrosion cracking confined within the thickness of the tube support plates. At tube support plate intersection, the repair limit is based on maintaining steam generator tube serviceability as described below:

a. Degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with bobbin voltage ≤ 2.0 volts will be allowed to remain in service.

b. Degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage > 2.0 volts will be repaired or plugged except as noted in TS 4.2.b.5.c below.

c. Indications of potential degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage > 2.0 volts but ≤ the upper voltage repair limit, may remain in service if a rotating pancake coil inspection does not detect degradation. Indications of outside diameter stress corrosion cracking degradation with a bobbin voltage > the upper voltage repair limit will be plugged or repaired.

d. If an unscheduled mid-cycle inspection is performed, the following repair limits apply instead of TS 4.2.b.5.a, b and c. The mid-cycle repair limits are determined from the following equation:

$$V_{MURL} = \frac{V_{SL}}{1.0 + NDE + Gr\left(\frac{CL - \Delta t}{CL}\right)}$$

$$V_{MLRL} = V_{MURL} - (V_{URL} - 2.0)\left(\frac{CL - \Delta t}{CL}\right)$$

Where:

V_{MURL} = mid-cycle upper voltage repair limit based on time into cycle
V_{SL} = structural limit voltage
NDE = 95% cumulative probability allowance for NDE uncertainty
Gr = average growth rate per cycle length
CL = cycle length (time between scheduled inspections)
Δt = length of time since last scheduled inspection during which V_{URL} and V_{LRL} were implemented
V_{MLRL} = mid-cycle lower voltage repair limit based on V_{MURL} and time into cycle
V_{URL} = upper voltage repair limit

Implementation of these mid-cycle repair limits should follow the same approach as in TS 4.2.b.5.a, b and c.

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

6. F* and EF* Tubesheet Crevice Region Plugging Criteria

The following criteria are to be used for disposition or repair of steam generator tubes experiencing degradation in the tubesheet crevice region.

a. Tubes with indications of degradation within the roll expanded region below the midpoint of the tubesheet may remain in service provided the distance from the bottom of the uppermost roll transition to the tip of the crack is greater than 1.12" (plus an allowance for NDE uncertainty). This criteria is called the F* criteria and applies to the factory roll expansion, or to additional roll expansions formed as an extension of the original roll. Any degradation existing below the F* (plus an allowance for NDE uncertainty) is acceptable for continued service.

b. Indications of degradation not repairable by 4.2.b.6.a may be repaired using the EF* criteria. The EF* region is located a minimum of 4" below the top of the tubesheet, and is formed by an additional roll expansion of the tube in the originally unexpanded length. Tubes with indications of degradation within the EF* region may remain in service provided the distance from the bottom of the uppermost roll transition to the tip of the crack is greater than 1.44" (plus an allowance for NDE uncertainty). Any degradation existing below EF* (including uncertainty) is acceptable for continued service.

7. Reports

a. Following each in-service inspection of steam generator tubes, if there are any tubes requiring plugging or repairing, the number of tubes plugged or repaired shall be reported to the Commission within 30 days. This report shall include the tubes for which the F* or EF* criteria were applied.

b. The results of the steam generator tube in-service inspection shall be included in the Annual Operating Report for the period in which this inspection was completed. This report shall include:

1. Number and extent of tubes inspected.

2. Location and percent of wall-thickness penetration for each indication of a degradation.

3. Identification of tubes plugged.

4. Identification of tubes repaired.

c. Results of a steam generator tube inspection which fall into Category C-3 require prompt (within 4 hours) notification of the Commission consistent with 10 CFR 50.72(b)(2)(i). A written follow up report shall be submitted to the Commission consistent with Specification 4.2.b.7.a, using the Licensee Event Report System to satisfy the intent of 10 CFR 50.73(a)(2)(ii).

d. For implementation of the voltage-based repair criteria to tube support plate intersections, notify the NRC staff prior to returning the steam generators to service should any of the following conditions arise:

   1. If estimated leakage based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds the leak limit (determined from the licensing basis dose calculation for the postulated main steamline break) for the next operating cycle.

   2. If circumferential crack-like indications are detected at the tube support plate intersections.

   3. If indications are identified that extend beyond the confines the tube support plate.

   4. If indications are identified at the tube support plate elevations that are attributable to primary water stress corrosion cracking.

   5. If the calculated conditional burst probability based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds 1×10^{-2}, notify the NRC and provide an assessment of the safety significance of the occurrence.

Technical Specification 4.2.b.4

Steam generator tubes found with less than the minimum wall thickness criteria determined by analysis, as described in WCAP-7832[1][2], must either be repaired to be kept in service or removed from service by plugging.

Steam generator tube plugging is a common method of preventing primary-to-secondary steam generator tube leakage and has been utilized since the inception of PWR nuclear reactor plants. This method is relatively uncomplicated from a structural/mechanical standpoint as flow is cut off from the affected tube by plugging it in the hot and cold leg faces of the tubesheet.

To determine the basis for the sleeve plugging limit, the minimum sleeve wall thickness was calculated in accordance with the ASME Code and is consistent with Draft Regulatory Guide 1.121 (August 1976).

For the Westinghouse mechanical sleeves, the sleeve plugging limit of 31% is applied to the sleeve as shown on Figure TS 4.2-1. The sleeve plugging limits allow for eddy current testing inaccuracies and continued operational degradation per Draft Regulatory Guide 1.121 (August 1976).

Repair by sleeving, or other methods, has been recognized as a viable alternative for isolating unacceptable tube degradation and preventing tube leakage. Sleeving isolates unacceptable degradation and extends the service life of the tube, and the steam generator. Tube repair, by sleeving in accordance with WCAP-11643[3] and WCAP-13088[4], has been evaluated and analyzed as acceptable. The Westinghouse mechanical hybrid expansion joint (HEJ) sleeve spans the degraded area of the parent tube in the tubesheet region. The sleeves are either 36", 30" or 27" to allow access permitted by channel head bowl geometry. The sleeve is hydraulically expanded and hard rolled into the parent tubing.

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[1]WCAP 7832, "Evaluation of Steam Generator Tube, Tube Sheet, and Divider Plate Under Combined LOCA Plus SSE Conditions."

[2]E. W. James, WPSC, to A. Schwencer, NRC, dated September 6, 1977.

[3]WCAP 11643, Kewaunee Steam Generator Sleeving Report, Revision 1, November 1988 (Proprietary).

[4]WCAP 13088, Revision 3, "Westinghouse Series 44 and 51 Steam Generator Generic Sleeving Report," January 1994.

The pressure boundary for HEJ sleeves is shown on Figure TS 4.2-1. The pressure boundary used to disposition parent tube indications (PTIs) detected in the upper joint of HEJ sleeved tubes is discussed in WCAP-14641[5]. The pressure boundary will allow PTIs located such that there is a minimum diameter change of 0.003 inch (plus an allowance for NDE uncertainty) between the peak diameter of the sleeve hardroll, and the diameter at the elevation of the PTI, to remain in service. The 0.003 inch interference lip is derived from structural and leakage testing. When inspecting and dispositioning the PTIs, the acceptance criteria will be adjusted to account for measurement uncertainties associated with the technique used to measure the relative change in ID sleeve diameters. During field application, the PTI elevation will be measured by comparing the diameter reported at the peak amplitude of the flaw, and the diameter at the center of the plus point coil's field, and using the more conservative of the two diameters to perform the ΔD determination. Application of the pressure boundary for HEJ sleeved tubes provides allowance for leakage in a faulted loop during a postulated steam line break (SLB) event. A SLB leakage of 0.025 gpm is assumed for each applicable indication. Steam line break leakage from all sources must be calculated to be < 34 gpm in the faulted loop. Maintenance of the 34 gpm limit ensures off-site doses will remain within a small fraction of the 10 CFR Part 100 guidelines for a SLB.

Topical CEN-629-P[6] describes three types of Combustion Engineering leak tight sleeves. The first type, the straight tubesheet sleeve, spans the degraded area of the parent tube in the tubesheet crevice region. The sleeve is welded to the parent tube near each end. The second type of sleeve is a full depth tubesheet sleeve which is welded near the sleeve upper end and hard rolled into the tube and tubesheet at the sleeve lower end. A variation on the tubesheet sleeve design is the use of a pre-curved sleeve which allows access to the outer periphery of the tube bundle. The third type of sleeve, the tube support plate sleeve, spans the degraded area of the tube support plate and is installed up to the sixth support plate. This sleeve is welded to the parent tube near each end of the sleeve. CEN-632-P[7] describes the steps required to re-sleeve tubes which have existing HEJ sleeves. This report describes the sleeved/tube preparation, re-sleeve installation and the design of a leak tight full depth tubesheet sleeve that is up to 39 inches in length.

Two types of Westinghouse laser welded sleeves can be installed, tube support plate sleeves and tubesheet sleeves.

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[5]WCAP-14641, "HEJ Sleeved Tube Structural Integrity Criteria: Diameter Interference at PTIs," April 1996.

[6]CEN-629-P Revision 2, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak Tight Sleeves," January 1997.

[7]CEN-632-P Revision 0, "Repair of Kewaunee Steam Generator Tubes Using a Resleeving Technique," April 1997.

The tube support plate sleeve is 12" long and spans the degraded area of the tube adjacent to the support plate intersection. The tube support plate sleeve is hydraulically expanded and laser welded at each end. The pressure boundary portion of the tube support plate sleeve is the weld and the sleeve section between the welds. Tubesheet sleeves extend from the tube end to above the top of the tubesheet. Standard and bowed or peripheral tubesheet sleeves can be installed. The upper or free span joint is hydraulically expanded and laser welded. The lower joint is hydraulically expanded and roll expanded. Standard tubesheet sleeves extend from 27" to 36" in length while bowed tubesheet sleeves extend from 30" to 36" in length. The pressure boundary portion of the tubesheet sleeve is the weld and below, down to the tubesheet primary face.

The hydraulic equivalency ratios for the application of normal operating, upset, and accident condition bounding analyses have been evaluated. Design, installation, testing, and inspection of steam generator tube sleeves requires substantially more engineering than plugging, as the tube remains in service. Because of this, the NRC has defined steam generator tube repair to be an Unreviewed Safety Question as described in 10 CFR 50.59(a)(2). As such, other tube repair methods will be submitted under 10 CFR 50.90; and in accordance with 10 CFR 50.91 and 92, the Commission will review the method, issue a significant hazards determination, and amend the facility license accordingly. A 90-day time frame for NRC review and approval is expected.

Technical Specification 4.2.b.5

The repair limit of tubes with degradation attributable to outside diameter stress corrosion cracking contained within the thickness of the tube support plates is conservatively based on the analysis documented in WCAP-12985, "Kewaunee Steam Generator Tube Plugging Criteria for ODSCC at Tube Support Plates" and EPRI Draft Report TR-100407, Rev.1, "PWR Steam Generator Tube Repair Limits - Technical Support Document for Outside Diameter Stress Corrosion Cracking at Tube Support Plates." Application of these criteria is based on limiting primary-to-secondary leakage during a steam line break to ensure the applicable 10 CFR Part 100 limits are not exceeded.

The voltage-based repair limits of TS 4.2.b.5 implement the guidance in Generic Letter 95-05 and are applicable only to Westinghouse-designed steam generators with outside diameter stress corrosion cracking (ODSCC) located at the tube-to-tube support plate intersections. The voltage-based repair limits are not applicable to other forms of tube degradation nor are they applicable to ODSCC that occurs at other locations within the steam generators. Additionally, the repair criteria apply only to indications where the degradation mechanism is predominantly axial ODSCC with no indications extending outside the thickness of the support plate. Refer to GL 95-05 for additional description of the degradation morphology.

Implementation of TS 4.2.b.5 requires a derivation of the voltage structural limit from the burst versus voltage empirical correlation and the subsequent derivation of the voltage repair limit from the structural limit (which is then implemented by this surveillance).

The voltage structural limit is the voltage from the burst pressure/bobbin voltage correlation, at the 95 percent prediction interval curve reduced to account for the lower 95/95 percent tolerance bound for tubing material properties at 650°F (i.e., the 95 percent LTL curve). The voltage structural limit must be adjusted downward to account for potential flaw growth during an operating interval and to account for NDE uncertainty. The upper voltage repair limit, V_{URL}, is determined from the structural voltage limit by applying the following equation:

$$V_{URL} = V_{SL} - V_{GR} - V_{NDE}$$

Where V_{GR} represents the allowance for flaw growth between inspections and V_{NDE} represents the allowance for potential sources of error in the measurement of the bobbin coil voltage. Further discussion of the assumptions necessary to determine the voltage repair limit are discussed in GL 95-05.

The mid-cycle equation should only be used during unplanned inspection in which eddy current data is acquired for indications at the tube support plates.

Technical Specification 4.2.b.6

Tubes with indications of degradation in either the original factory roll expansion in the tubesheet or the unexpanded portion of tube within the tubesheet may be dispositioned for continued service or repaired through application of the F* or EF* criteria. The F* and EF* criteria are described in WCAP-14677[8]. The F* and EF* criteria are established using guidance consistent with RG 1.121. Neither the F* or EF* criteria will significantly contribute to offsite dose following a postulated main steam line break such that contributions from these sources need to be included in offsite dose analyses. Inherent to these criteria is the ability to perform an additional roll expansion of the tube, either as an extension of the original factory roll expansion, in which case F* criteria applies, or in the area starting approximately 4" below the top of the tubesheet, in which case EF* criterion apply. The additional roll expansion procedure can be applied over existing degradation, provided the F* or EF* requirements for non-degraded roll expansion lengths of 1.12" (plus an allowance for NDE uncertainty) and 1.44" (plus an allowance for NDE uncertainty), respectively, are satisfied. The NDE uncertainty applied to the F* and EF* distance is a function of the eddy current probe and technique used. Current state-of-the art inspection technology will be used with implementation of the F* and EF* criteria. The uncertainty in such inspections has been shown to be as small as 0.06", however, for field application, an eddy current uncertainty of 0.20" will be applied. Any and all indications of degradation existing below the F* or EF* distance is acceptable for continued service.

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[8]WCAP 14677, F* and Elevated F* Tube Alternate Repair Criteria for Tubes With Degradation Within the Tubesheet Region of the Kewaunee Steam Generators, June 1996 (Proprietary).

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO AMENDMENT NO. 134 TO FACILITY OPERATING LICENSE NO. DPR-43

WISCONSIN PUBLIC SERVICE CORPORATION

WISCONSIN POWER AND LIGHT COMPANY

MADISON GAS AND ELECTRIC COMPANY

KEWAUNEE NUCLEAR POWER PLANT

DOCKET NO. 50-305

1.0 INTRODUCTION

By letter dated April 24, 1997, as supplemented on May 15 and 28, and June 5, 1997, Wisconsin Public Service Corporation (WPSC), the licensee, requested a revision to the Kewaunee Nuclear Power Plant (KNPP) Technical Specifications (TSs). The proposed amendment would revise KNPP TS Section 4.2.b, "Steam Generator Tubes," and its associated Basis, to allow repair of steam generator (SG) tubes with Combustion Engineering (CE) leak-tight sleeves in accordance with CE generic topical report CEN-629-P, Revision 02, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak-Tight Sleeves." The TS would also be revised to allow re-sleeving of tubes with existing sleeve joints in accordance with KNPP specific topical report CEN-632-P, "Repair of Kewaunee Steam Generator Tubes Using a Re-sleeving Technique." Finally, the TS would be revised by deleting references to the previous CE sleeve topical report and incorporating a "plug on detection" criteria for CE sleeve degradation.

The May 15 and 28, and June 5, 1997, submittals provided clarifying information that did not change the initial proposed no significant hazards consideration determination published in the Federal Register on May 7, 1997 (62 FR 24989).

By letter dated April 10, 1992, the NRC staff issued Amendment No. 95 for KNPP allowing the repair of SG tubes using CE-designed sleeves as described in the CE topical report CEN-413-P, "Kewaunee Steam Generator Tube Repair Using Leak-Tight Sleeves," dated January 1992. The requested TS changes will reference a new generic topical report, CEN-629-P, Revision 02, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak-Tight Sleeves," dated January 1997 (Reference 1). The latter report is not significantly different from CEN-413-P other than it addresses issues identified previously at Prairie Island Unit 1 (PI-1) associated with indications detected in weld joints of CE sleeves resulting from inadequate cleaning. The report also renders optional a postweld heat treatment (PWHT) of the sleeve welds. Because the bulk of the technical and regulatory issues for the present request to incorporate Reference 1 in the KNPP TSs are identical to those reviewed in the previous Safety Evaluation (SE) described in our

April 10, 1992, letter, this SE discusses only those issues warranting revision, amplification, or inclusion based on current experience.

Details of prior staff evaluations of CE-designed sleeves may also be found in the SEs for Byron Nuclear Power Station, Units 1 and 2, Docket Nos. 50-454, 50-455, and Braidwood Nuclear Power Station, Units 1 and 2, Docket Nos. 50-456, and 50-457, dated April 12, 1996; Zion Nuclear Power Station, Units 1 and 2, Docket Nos. 50-295 and 50-304, dated October 29, 1996; and Arkansas Nuclear One, Unit 2, Docket No. 50-368, dated May 20, 1997. These evaluations apply to the proposed KNPP license amendment.

The requested TS changes will also reference a KNPP specific topical report, CEN-632-P, Revision 00, "Repair of Kewaunee Steam Generator Tubes Using a Re-sleeving Technique," April 1997 (Reference 2). This report describes the steps required to re-sleeve SG tubes previously repaired with Westinghouse-designed mechanical hybrid expansion joint (HEJ) sleeves. The CE sleeve design for re-sleeving is identical to the full-depth tubesheet (FDTS) sleeve described in Reference 1 except for a longer length. The re-sleeve topical report discusses the additional structural analyses performed to support the longer FDTS sleeve length and describes the SG tube/HEJ sleeve preparation and re-sleeve installation processes.

2.0 BACKGROUND

The licensee proposes using CE-designed sleeves to repair degraded SG tubes, including already sleeved tubes. An FDTS sleeve will be used to repair SG tubes with degradation in the tubesheet region and to repair SG tubes with previously installed HEJ sleeves. A tube support sleeve will be used to repair SG tubes with degradation in the freespan or tube support plate regions.

The sleeve material is a nickel-iron-chromium alloy, alloy 690, a Code-approved material (ASME SB-163), incorporated in ASME Code Case N-20. The CE sleeves are installed using gas tungsten arc welding to join the sleeve to the parent tube at the upper (freespan) end of the FDTS sleeve and at both ends of a tube support sleeve. The lower FDTS sleeve tube joint is either welded or hard-rolled into the tubesheet below the expansion zone.

The SEs referenced earlier document the staff's conclusion that sleeving in accordance with the CE generic topical report can be accomplished to produce sleeved tubes of acceptable metallurgical properties, structural and leakage integrity, and corrosion resistance. This SE focuses on:
(1) modifications to the freespan weld joint installation and inspection processes described in Reference 1, and (2) modifications to the welded and rolled FDTS sleeve length and SG tube/HEJ sleeve preparation.

2.1 Modifications to CE-Designed Sleeves

During the spring 1996 refueling outage at PI-1, roughly 60 upper weld joints in CE sleeved tubes had eddy current testing (ECT) indications. Discovery of most of the indications was the result of the licensee employing a new, more sensitive ECT probe for its periodic inspection of SG tubes. Tube/sleeve assemblies were removed from the SGs for metallurgical examination and root cause determination. It was found that the ECT indications were due to entrapped oxides and/or weld suckback within the sleeve to tube weld. The cause of these weld defects was traced to a previously revised tube cleaning procedure.

As a result of the metallurgical examination, the tube cleaning procedure was revised and revised post-cleaning visual inspections (VT) were adopted. The initial weld acceptance inspection, an ultrasonic test (UT), was revised to give greater sensitivity. As an added measure, the initial baseline ECT, normally used only as reference for later periodic reinspection, was modified to supplement the UT as part of the initial weld acceptance inspection. All of these refinements to the sleeving procedure were confirmed using a large number of laboratory samples and field mockups. These modifications were incorporated into the generic sleeve topical report, Reference 1, and are discussed in more detail in Section 3.1.

2.2 Re-sleeving with CE Welded and Rolled FDTS Sleeves

During the 1988, 1989, and 1991 outages, WPSC installed a total of 4,328 Westinghouse-designed mechanical HEJ sleeves at KNPP. The licensee inspected the upper joint of the HEJs during the 1994 outage using a motorized rotating pancake coil (RPC) I-coil probe. Seventy-seven (77) circumferential cracklike indications were detected in the parent tube (PTIs). WPSC plugged 66 sleeved tubes with PTIs located within the pressure boundary. During the 1995 outage, the licensee inspected the upper joint of the HEJs using an RPC plus point probe. Seven hundred fifty-three (753) PTIs were detected; WPSC plugged 657 sleeved tubes with PTIs located within the pressure boundary.

During the 1996 outage, the licensee removed plugs from 550 previously plugged HEJ sleeved tubes at KNPP. WPSC inspected the upper joint of the HEJs of all inservice and unplugged HEJ sleeved tubes using the plus point probe. A total of 1,910 HEJ sleeved tubes were identified with PTIs within the pressure boundary. The licensee elected to perform a laser weld repair of the defective sleeved tubes. The laser weld repair effort was largely unsuccessful; thus, the defective HEJ sleeved tubes must be either repaired by another method or plugged. WPSC proposed repairing the defective HEJ sleeved tubes by re-sleeving using CE-designed welded and rolled FDTS sleeves. The re-sleeving process involves removing the lower section of the HEJ sleeve and expanding the remaining upper section of the HEJ sleeve to allow clearance for the new sleeve. The new sleeve is then installed in the same fashion as a normal sleeve installation job. The upper joint of the new sleeve is then welded to the parent tube while the lower joint is formed by rolling into the tubesheet. The re-sleeve certification and installation processes described in the re-sleeve topical report, Reference 2, are discussed in more detail in Section 3.2.

3.0 DISCUSSION

3.1 Modifications to CE-Designed Sleeves

The licensee proposes repairing degraded SG tubes by re-sleeving using CE-designed welded and rolled FDTS sleeves. As discussed above, KNPP was previously approved to use CE sleeves in accordance with CEN-413-P. However, experience with all types of SG tube sleeves has led to several areas of concern outside the scope of basic sleeve design and qualification discussed in previous SEs. These include weld preparation, weld acceptance inspections, sleeve plugging limits, and PWHT of welded joints. CE addressed these areas of concern in CEN-629-P, which the licensee has proposed using for future sleeving. These areas of concern and how they are addressed in CEN-629-P are discussed below.

3.1.1 Weld Preparation

Prior to performing any weld, the surface of the metal(s) to be welded must be cleaned. For sleeve installation, the inner diameter of the parent tube at the desired weld location must be cleaned of service-induced oxides. For the CE sleeving process, this is accomplished using motorized wire brushes.

Based upon the metallurgical findings from the PI-1 experience, CE revised the cleaning method to ensure optimum removal of service-induced oxides. The revised cleaning procedure entailed some equipment changes. More significantly, from a quality assurance standpoint, a 100% VT of the cleaning process was instituted. After the wire brush cleaning step, every tube is given a VT using a remote fiber optic camera system to confirm that adequate surface cleaning has been accomplished. CE advises the 100% VT is an interim step until enough field experience is gained to consider adoption of a statistical sampling plan in the future.

3.1.2 Weld Acceptance Inspections

For compliance with the Code and regulatory requirements, initial and periodic examinations of SG tubes and sleeves are performed. Sleeve welds were historically accepted based on VT and UT examinations. ECT was used for an initial baseline inspection for comparison with later required periodic inspections. The reason for the different types of nondestructive examinations (NDE) being used for initial acceptance versus periodic reinspection is due to the differences between potential flaws from initial installation defects and service-induced degradation. The different NDE techniques have normally been better suited for the respective types of anticipated flaws.

The PI-1 event suggested that the current initial acceptance examinations (VT and UT) may not be sufficient in every circumstance. As a result, the weld acceptance NDE was modified to include:

* 100% UT with an enhanced digitized amplitude system; and
* 100% ECT using the plus point probe.

The PI-1 event indicated that cleaning the parent tube prior to welding is a critical step in forming a defect-free sleeve to tube weld. Thus, the new CE sleeve topical report requires a 100% VT of the parent tube after cleaning.

The original UT procedure was based upon the absence of a mid-wall reflection. In that procedure, the sleeve outside diameter wall reflection was readily apparent beyond the fusion zone of the weld, thus, signifying lack of fusion with the parent tube. When fusion existed, the mid-wall reflection (mid-wall of the fused sleeve and tube combination) would not appear since no interface would exist. The PI-1 event led CE to discover that lack of fusion caused by axially oriented oxide inclusion from a poorly cleaned weld would not be detected since the oxides did not cause a large sound reflection.

In the enhanced UT procedure, the back wall signal from the outside of the parent tube is also monitored for presence in the fused area. Additionally, the back wall signal strength is examined for excessive attenuation. Attenuation beyond the normal amount can be interpreted, along with other signal artifacts, as either a weld that is too narrow or one with inclusions or patches of unfused material. The modified UT procedure was extensively tested on laboratory-produced welds containing a variety of inclusion/lack of fusion defects. Samples were destructively examined and the metallurgical sections compared with the UT results. Comparison of results demonstrated the revised UT procedure was highly reliable, and that no significant defects could remain undetected by the enhanced UT procedure.

ECT with the plus point probe is now part of the sleeve weld acceptance criteria. The PI-1 event led CE to discover that weld suckback and circumferentially oriented oxide inclusions from a poorly cleaned weld would not be detected by UT. CE has shown the plus point probe reliably detects the various process-induced weld defects including blowholes, weld suckback and circumferentially oriented oxide inclusions. CE has also shown the plus point probe can reliably locate the position of the defect with respect to the weld centerline, which is considered the pressure boundary. ECT indications located outside the pressure boundary that meet UT requirements can be left in service. Any ECT indication found within the pressure boundary requires the tube to be plugged.

For future sleeve inspections, the licensee will use Electric Power Research Institute's, "PWR Steam Generator Tube Examination Guidelines," Appendix G, qualified personnel, and Appendix H, qualified ECT techniques. The licensee has updated the TSs with appropriate inspection scope and expansion criteria specific to sleeves.

3.1.3 Sleeve Plugging Limits

The sleeve minimum acceptable wall thickness is determined using the criteria of Regulatory Guide (RG) 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes," and ASME Code, Section III, allowable stress values and pressure stress equations. According to RG 1.121 criteria, an allowance for NDE uncertainty and postulated operational growth of tube wall degradation within the sleeve must be accounted for when using NDE to determine sleeve plugging limits. The sleeve plugging limit, which was calculated based on the most limiting of normal, upset, or faulted conditions for Westinghouse Series 44 and 51 SG tubes, was determined to be 52% of the sleeve nominal wall thickness based on ASME Code minimum material properties in accordance with staff positions. In consideration of NDE uncertainties and degradation growth rates, WPSC proposes to revise KNPP TSs to remove sleeved SG tubes from service upon detection of degradation.

3.1.4 Postweld Heat Treatment

Accelerated corrosion tests confirm a PWHT significantly improves the intergranular stress corrosion cracking (IGSCC) resistance of the alloy 600 parent tube material in the weld zone. The CE generic sleeve topical report provides an optional PWHT process for the welded joints. WPSC does not elect to perform a PWHT based on the successful service of as-welded CE sleeves at KNPP (in service for approximately 3 effective full-power years) and at other U.S. plants (in service for as long as 8 effective full-power years). The staff will continue to monitor the service performance of the as-welded CE sleeves at KNPP and at other U.S. plants. At this time, the staff does not consider PWHT to be necessary for the successful installation and full-cycle safe operation of CE-welded sleeves at KNPP.

3.2 Re-sleeving with CE Welded and Rolled FDTS Sleeves

The licensee proposes repairing degraded SG tubes with previously installed HEJ sleeves by re-sleeving using CE-designed welded and rolled FDTS sleeves. The process for re-sleeving of SG tubes with HEJ sleeves is described in Reference 2, which supplements the generic sleeve topical report (Reference 1) in that a revised structural analysis supports the installation at KNPP of welded and rolled FDTS sleeves up to 39 inches in length. The re-sleeving topical report also describes the SG tube/HEJ sleeve preparation as well as the qualification of the re-sleeve installation process.

3.2.1 Structural Analyses to Support Longer Welded and Rolled FDTS Sleeves

The welded and rolled joints of the FDTS sleeve are subjected to axial loads resulting from the differential thermal expansion of the sleeve and tube and from pressure differentials during normal operating and postulated accident conditions. The axial loads in the sleeve are a function of their location within the bundle, the degree of tube and support plate lockup, and to a minor extent, the sleeve length. The most severe combination is for an unlocked tube near the tube bundle periphery at 100% steady state power. For conditions at KNPP, CE determined a maximum load of -1,412 lbs. for the 39-inch welded and rolled FDTS sleeve design with an upper weld joint and a lower rolled joint. Under accident conditions, CE determined the sleeve joints may be subjected to a maximum load of +1,208 lbs. during a main steam line break event and a maximum load of -652 lbs. during a loss of cooling accident. Mechanical testing of both welded and rolled sleeve joints documented in Reference 1 demonstrated adequate margin with respect to both normal operating and accident condition loads.

CE also considered the possibility of fatigue failure of the welded upper joint or rolled lower joint. In Reference 1, CE described the analytical tools used in the fatigue evaluation of the welded upper joint of the FDTS sleeve. The parameters used in this evaluation bounded the conditions at KNPP; therefore, the acceptable stresses and usage factors determined in Reference 1 also apply for the longer length welded and rolled FDTS sleeves to be used at KNPP. With respect to the lower rolled joint, fatigue test results documented in Reference 1 also bounded the worst case conditions at KNPP. As discussed above, a maximum axial load of -1,412 lbs. was calculated for the 39-inch length welded and rolled FDTS sleeve for conditions at KNPP. Fatigue testing of 7/8-inch rolled joints between 0 and -1,500 lbs. for 22,500 cycles did not result in any leakage through or slippage of the rolled lower joint. CE also performed limited fatigue testing of rolled joints with applied tubesheet ligament stresses that bound the KNPP conditions. Results were satisfactory.

The staff considers the analyses and test results documented in References 1 and 2 adequately demonstrate acceptable structural and leakage integrity of the welded and rolled FDTS sleeve for lengths up to 39 inches long to be used at KNPP.

3.2.2 Qualification of the Re-sleeve Process

This section of the SE focuses on the steps taken to prepare the SG tube/HEJ sleeve for re-sleeving. The installation of CE welded and rolled FDTS sleeves is described in Reference 1. The staff reviewed Reference 1 as documented in the aforementioned SEs.

The re-sleeve topical report (Reference 2) describes in more detail the following steps taken to prepare a SG tube previously repaired with an HEJ sleeve for re-sleeve installation:

(1) Release the hard-rolled lower HEJ sleeve joint using a tungsten inert gas (TIG) welding process;

(2) Sever the HEJ sleeve approximately 5 inches below the upper HEJ sleeve end, and remove the lower HEJ sleeve section;

(3) Expand the SG tube and upper HEJ sleeve remnant out to or beyond the nominal tube inner diameter;

(4) Sever the SG tube in the tubesheet region;

(5) Inspect the SG tube and HEJ sleeve remnant region to ensure clear passage of the welded and rolled FDTS sleeve; and

(6) Install the welded and rolled FDTS sleeve.

CE focussed its initial qualification efforts on the development of a kinetic expansion process for the SG tube/HEJ sleeve remnant. Approximately 25 SG tube/HEJ sleeve mockups, some with laser weld repairs, were tested using a full U-bend mockup to develop acceptable expansion parameters.

CE further demonstrated the viability of the re-sleeve process through a field demonstration at KNPP. Twenty-five (25) SG tubes with previously installed HEJ sleeves were prepared for re-sleeving. CE verified acceptable SG tube/HEJ sleeve remnant expansion through ECT profilometry. An RPC probe was used to ensure no previously existing parent tube defects propagated into the sleeve weld region. CE also used physical gaging to verify the ability to insert the new sleeve. Finally, CE visually examined the expanded components to verify their integrity.

After the 25 SG tubes/HEJ sleeve remnants were prepared, CE installed the welded and rolled FDTS sleeves. CE encountered difficulties with the SG tube/HEJ sleeve remnant cleaning process, but these difficulties were resolved through adjustments made in procedures and tooling. No problems were encountered during sleeve installation. Three weld blowholes were discovered by both UT and VT examinations. Four additional welds contained WZIs detected by ECT. One SG tube/re-sleeve assembly was removed for metallurgical evaluation. The WZI was attributed to weld suckback.

Based on the results discussed above and documented in Reference 2, the staff concludes CE adequately demonstrated the viability of the re-sleeve process to repair degraded SG tubes previously repaired with HEJ sleeves.

3.2.3 Far Field Stresses Due to the Re-sleeve Process

The re-sleeve topical report (Reference 2) describes four SG tube mockups used to demonstrate acceptable far field stresses resulting from the SG tube/HEJ sleeve preparation and re-sleeve processes. The assemblies consisted of a length of SG tube welded at each end to a steel plate with four threaded rods used to apply preloads on the tube. The 48-inch span between the steel plates simulated the distance from the secondary face of the tubesheet to the bottom of the first support plate and is a conservative representation of the span found in Westinghouse Series 51 SGs.

CE installed four strain gages at 90° around the outside surface of the freespan portion of the SG tube. The gages were oriented to measure longitudinal stresses in the tube and were located approximately 12 inches below the bottom of the simulated tube support plate. CE locked the threaded rods and zeroed the strain gages.

Westinghouse then installed HEJ sleeves in each SG tube assembly using field representative processes and equipment. In two of the mockups, Westinghouse subsequently cut a 360° circumferential notch in the SG tube at the lower hardroll transition of the HEJ sleeve upper joint to simulate a PTI. Lastly, Westinghouse laser weld repaired each mockup using field representative processes and equipment. Two repairs were made in the hardroll region; two repairs were made in the hydraulic expansion region. Westinghouse recorded the strain gage values after these processes were complete.

Framatome Technologies Incorporated (FTI) prepared the SG tube/HEJ sleeve mockups for re-sleeving. FTI TIG relaxed the HEJ sleeve lower hard-rolled joint, cut the HEJ sleeve below the expansion region of the upper HEJ sleeve joint and removed the lower HEJ sleeve section. FTI recorded the strain gage values for each of these steps. Three of the four mockups were then explosively expanded, and the SG tubes severed in the tubesheet region. For the remaining mockup, FTI severed the SG tube and then explosively expanded the SG tube/HEJ sleeve remnant. FTI recorded the strain gage values at the completion of these processes.

After FTI completed the SG tube/HEJ sleeve preparation, CE installed a welded and rolled FDTS sleeve. CE recorded the strain gage measurements after completing each of the sleeve process steps (sleeve expansion into the tube, sleeve to tube welding, and sleeve to tube hard-rolling).

The HEJ sleeve installation and laser weld repair process introduced tensile stresses into the locked tube span above the sleeve region ranging from approximately 6,250 to 14,000 psi. The subsequent TIG relaxation process generally reduced these stresses to values less than 6,000 psi. The HEJ sleeve whip cut further reduced these stresses to values less than 5,000 psi. For the three SG tubes/HEJ sleeve remnants then subjected to the expansion process, the stresses increased to values ranging from approximately 4,000 psi to 11,000 psi. Severing the SG tube in the tubesheet region substantially reduced these stresses and in fact resulted in compressive stresses ranging from approximately -2,500 psi to -15,000 psi. The one tube/HEJ sleeve remnant mockup that had the SG tube severed prior to expansion resulted in a final tensile stress value of approximately 3,000 psi after expansion.

CE attributed some of the variation in stress measurements to the different configurations of the mockups (e.g., different SG tube material yield strengths, presence or absence of a simulated PTI, location of the laser weld repair, etc.). Based on the results, CE determined the optimum time to sever the SG tube is after the expansion process to take advantage of the relatively large compressive stresses introduced by the whip cut since the whip cut tended to push the faces of the tube cut apart.

CE also measured the stresses resulting from re-sleeving. Tensile stresses on the tube freespan ranged from 1,250 to 5,230 psi. These results were consistent with previous work performed by CE in this area.

The results from the mockups exhibited considerable variations in stresses between the samples; this may be a reflection of the variety of configurations and process variables used in the mockups. The general magnitude and direction of the stresses appear reasonable and, thus, the staff believes the mockup results adequately represent the re-sleeve process. The staff concludes CE demonstrated the far field stresses generated due to the re-sleeve process will remain well below the yield stress of the tube material and do not appear to be large enough to be of a concern with respect to tensile stress driven corrosion mechanisms such as IGSCC.

4.0 SUMMARY

The NRC staff concludes that the proposed sleeving repairs, as described in the CE sleeve topical reports CEN-629-P and CEN-632-P, will produce sleeved tubes with acceptable metallurgical properties, structural and leakage integrity, and corrosion resistance. Therefore, the NRC staff concludes the repair of SG tubes, with or without previously installed HEJ sleeves, using sleeves designed by CE and described in the aforementioned topical reports is acceptable.

The licensee proposed the following changes in the TSs to implement the CE sleeving and re-sleeving repair methodologies discussed above:

1. CEN-629-P, Revision 2, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak-Tight Sleeves," and CEN-632-P, Revision 0, "Repair of Kewaunee Steam Generator Tubes Using a Re-sleeving Technique," would be added to the list of methods allowed for tube repair in TS 4.2.b.4.a. This TS would also be reformatted to highlight the listing.

2. TS 4.2.b.4.c, which specifies the plugging limit for the CE sleeve, would be revised from allowing sleeve wall degradation of up to 40% to remain in service to require plugging upon detection of sleeve wall degradation (as discussed in Section 3.1.3 above).

3. The Bases for TS Section 4.2 would be revised to add a description of the CE sleeving and re-sleeving repair processes, and to reference the applicable CE topical reports.

4. The TS pages that are affected by inserting the new requirements would be revised to accomodate the additional language.

The staff has reviewed the TS changes discussed above and finds that they consistently incorporate the CE sleeving and re-sleeving repair processes previously discussed in this SE and will provide adequate assurance of SG tube integrity. Therefore, the proposed changes are acceptable.

5.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Wisconsin State official was notified of the proposed issuance of the amendment. The State official had no comments.

6.0 ENVIRONMENTAL CONSIDERATION

This amendment involves a change to a requirement with respect to the installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 or changes a surveillance requirement. The staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluent that may be released offsite and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that this amendment involves no significant hazards consideration and there has been no public comment on such finding (62 FR 24989). Accordingly, this amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of this amendment.

7.0 CONCLUSION

The staff has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner; (2) such activities will be conducted in compliance with the Commission's regulations; and (3) the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public.

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G. Hornseth

Date: June 7, 1997

References

1. CEN-629-P, Revision 02, "Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak-Tight Sleeves," January 1997.

2. CEN-632-P, Revision 00, "Repair of Kewaunee Steam Generator Tubes Using a Re-sleeving Technique," April 1997.