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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 151 TO FACILITY OPERATING LICENSE NO. DPR-58

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK NUCLEAR PLANT, UNIT NO. 1

DOCKET NO. 50-315

1.0 INTRODUCTION

By letter dated June 27, 1990, Indiana Michigan Power Company (the licensee) submitted a license amendment request to obtain authorization to use steam generator sleeves to repair defective steam generator tubes. A response to additional staff questions was subsequently submitted on October 9, 1990. The Technical Specifications currently require that all defective tubes be plugged. Sleeving has been demonstrated to be a safe and effective method of repair for certain types of defects. Use of sleeve repairs will reduce the number of steam generator tubes that must be removed from service and plugged.

The licensee has stated that they have no specific plan for steam generator tube sleeving. They further stated that the results of a complete steam generator inspection to be performed in late 1990 may make sleeving a desirable alternative to plugging.

2.0 BACKGROUND

The steam generator sleeving program at Cook Nuclear Plant Unit 1 would involve the installation of thermally treated Inconel 690 sleeves primarily in the hot leg of the steam generators. The steam generator tubes to be sleeved are the tubes where tube degradation in the tubesheet and just above the top of the tubesheet has exceeded the plant technical specification plugging limit. Also, tubes for which such a level of degradation is possible in the future may be sleeved in anticipation of such degradation. The sleeves will span from the bottom of the tube projecting out of the tubesheet to a point above the secondary face of the tubesheet. The sleeves to be used in the sleeving process are long enough to span the degraded areas of the tubing in the tubesheet region on either the hot or cold legs. The sleeve is secured in the tube by mechanical or welded joints at the top and the bottom of the sleeve.

To maintain tube integrity, allowable levels of tube wall degradation, referred to as "plugging limits," are established. Tubes which have eddy current indications of degradation in excess of the plugging limits must be repaired or plugged. Tubes to be sleeved are determined by the results and trends of eddy current test (ECT) indications. Tooling access, i.e., location of the tube within the tubesheet, is also considered in determining whether a tube is to be sleeved.

3.0 DISCUSSION

The licensee stated that a variety of tube sleeving designs had been reviewed and two designs were selected for potential use at Cook Nuclear Plant Unit 1. Reports that describe these sleeving designs and provide the technical and safety evaluations to support their use were provided as follows:

> WCAP-12623, "D.C. Cook Unit 1 Steam Generator Sleeving Report (Mechanical Sleeves)," Westinghouse Electric Corporation.
>
> CEN-313-P, "D. C. Cook Unit 1 Steam Generator Tube Repair Using Leak Tight Sleeves," Combustion Engineering, Incorporated.

These reports provide a description of the analysis and testing performed to demonstrate the acceptability of these designs. In the reports, mechanical strength, corrosion resistance, installation methods, and inservice inspection techniques are described.

For each described sleeving process, analytical verification was performed using design and operating transient parameters selected to envelope loads imposed during normal operating, upset and accident conditions. Fatigue and stress analysis of sleeved tube assemblies were completed in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section III. The results of the qualification testing, analyses and plant operating experience was cited to demonstrate that each sleeving process is an acceptable means of maintaining steam generator tube integrity. The sleeve assemblies can be inspected by current techniques in accordance with Regulatory Guide (RG) 1.83 recommendations.

The function of the sleeve is to restore the integrity of the tube pressure boundary. The sleeves have been shown not to be subject to stress levels in excess of allowable limits for normal and postulated accident loading conditions. The sleeves have been designed and analyzed in accordance with the applicable sections of the ASME Boiler and Pressure Vessel Code. To determine the basis for the sleeve plugging limits, the minimum wall thickness of each of the sleeve designs was calculated in accordance with RG 1.121.

The material of construction of the sleeves will be nickel alloy 690. The staff has found that the use of Inconel 690 thermally treated (TT) sleeves is an improvement over the Inconel 600 material used in the original steam generator tubing. Corrosion tests conducted under the Electric Power Research Institute (EPRI) sponsorship confirm test results regarding the improved corrosion resistance of Inconel 690 TT over that of Inconel 600. Accelerated stress corrosion tests in caustic and chloride aqueous solutions have also indicated that Inconel 690 TT resists general corrosion in aggressive environments. Isothermal tests in high purity water have shown that, at normal stress levels, Inconel 690 TT has high resistance to intergranular stress corrosion cracking in extended high temperature exposure. EPRI concluded as a result of these laboratory corrosion tests, that Inconel 690 TT material could be used for PWR steam generator tubing with all volatile treatment secondary water systems. Inconel 690 is a Code approved material (ASME SB-163), covered by

ASME Code Case N-20, and is acceptable to NRC under RG 1.85 (Rev. 24, July 1986). The NRC staff has approved use of Inconel 690 TT tubing in replacement steam generators as well as previous sleeving applications.

3.1 Evaluation of Westinghouse Sleeves

The Westinghouse steam generator sleeving program involves the installation of thermally treated alloy 690 sleeves in both the hot and cold legs of the steam generators. The steam generator tubes to be sleeved are the tubes in which tube degradation within the tubesheet and just above the top of the tubesheet has exceeded the Technical Specification plugging limit of 40 percent of the nominal tube wall thickness. Also, tubes in which such a level of degradation is possible in the future may be sleeved in anticipation of such degradation. The sleeves span from the end of the tube, at the bottom surface of the tubesheet, to a point above the secondary side of the tubesheet. The sleeves to be used in the sleeving process are long enough in length to span the degraded areas of the tubing in the tube sheet region in either the hot or cold legs. The sleeve is secured in the tube by mechanical joints at the top and bottom of the sleeve. Tooling access, i.e., location of the tube within the tube sheet, is considered in determining tubes to be sleeved. The Code of Federal Regulations, 10 CFR 50.55a, requires that components which are a part of the primary pressure boundary be built to the requirements of Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. Section 5.2.1.1 of the Standard Review Plan (SRP) (NUREG-0800), entitled "Compliance with the Codes and Standards Rule, 10 CFR 50.55a", addresses evaluations to be done by the NRC staff of the standards used. Any modifications, repair or replacement of these components must also meet the requirements of the Code to assure that the basis on which the unit was evaluated is unchanged. RG 1.121, "Basis for Plugging Degraded PWR Steam Generator Tubes," is used as the basis to determine the sleeve plugging limit. RG 1.83, "Inservice Inspection of Pressurizer Water Reactor Steam Generator Tubes," is used as the basis to determine the inspection requirements for the sleeve.

The sleeve design and installation process has been qualified through laboratory testing and actual field performance. Analytical verification has been performed using design and operating transient parameters selected to envelope all loads. Fatigue and stress analyses of sleeved tube assemblies have been completed in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section III. The results of the qualification testing, analyses, and plant operating experience have been used to demonstrate that the sleeving process is an acceptable means of maintaining steam generator tube integrity.

The function of the sleeve is to restore the integrity of the tube pressure boundary in the region between the sleeve joints. The sleeve has been designed and analyzed in accordance with the applicable sections of the ASME Boiler and Pressure Vessel Code including the implicit safety factors. The sleeve has been shown not to have stress levels in excess of appropriate limits for normal and postulated accident loading conditions for the analytical case of a complete guillotine break in that portion of the tube between the joints. To determine the basis for the sleeve plugging limits, the minimum wall thickness was calculated in accordance with the recommendations of

RG 1.121. Use of the ASME Code and RG 1.121 for the design and evaluation of the sleeves provides the basis for acceptance. Margins of safety are provided by the safety factors and assumptions in the ASME Code and RG 1.121.

3.2 EVALUATION OF COMBUSTION ENGINEERING SLEEVES

The CEN-313-P report describes the Combustion Engineering, Inc. sleeve design and installation processes, the analytical methods, laboratory testing programs and results that were used to verify the adequacy of their sleeving methodology for sleeving degraded or defective steam generator tubes. The sleeve dimensions, materials, and joints were designed to the applicable ASME Boiler and Pressure Vessel Code. An extensive analysis and test program was undertaken to prove the adequacy of the welded sleeve. This program determined the effect of normal operating and postulated accident conditions on the sleeve-tube assembly, as well as the adequacy of the assembly to perform its intended function. Design criteria were established prior to performing the analysis and test program which, if met, would prove that the welded sleeve is an acceptable repair technique. Based upon the results of the analytical and test programs, the welded sleeve fulfills its intended function as a leak tight structural member and meets or exceeds all the established design and operating criteria.

In as much as each sleeve is welded at both ends to each tube being sleeved, this process is considered to provide a leak tight repair. Essentially the process consists of cleaning the tube to be sleeved at the areas of the welds, insertion of the sleeve, expansion in the upper weld area, welding and inspection.

The installation of welded tube sleeves will be performed in a manner consistent with the applicable standards, will preserve the existing design bases, and will not adversely impact any plant systems. The design, installation and inspection of the welded sleeve will be done in accordance with ASME Boiler and Pressure Vessel Code criteria. By adherence to industry standards, the pressure boundary integrity will be preserved.

Three types of nondestructive examinations are used during the sleeving process. They are as follows: eddy current testing (ECT), ultrasonic testing (UT), and visual examination.

A dual cross wound probe and bobbin probe using the multifrequency eddy current method will be used to perform a baseline inspection of the installed sleeve for future reference. The ECT fixture is used on a manipulator arm to position the probe.

Ultrasonic testing using an immersion technique with demineralized water as a couplant is used to inspect the upper tube to sleeve weld. A transducer is positioned in the weld area and is rotated with an electric motor to scan the weld. The pulse echo tester has the ability to interface with an on-line data reduction computer to produce a display/hardcopy during radial and axial scanning.

An eddy current test has been qualified for the inspection of installed welded sleeves to detect flaws in the pressure boundary. Eddy currents circulating in the sleeve and steam generator tube are interrupted by the presence of flaws in the material which results in a change in test coil impedance. This impedance change is processed and displayed on the test instrument to indicate the presence of a flaw.

The pressure boundary is considered to be the sleeve up to and including the upper weld joint and the steam generator tube above the weld. Consequently, there are the three distinct regions relative to the inspection methods: (1) the sleeve below the weld, (2) the steam generator tube behind the top section of the sleeve (above the weld), and (3) the steam generator tube above the sleeve.

Using specialized probes and multifrequency eddy current techniques, it has been demonstrated that a 40 percent through wall defect (ASME calibration standard) is detectable anywhere in the tube behind the sleeve and above the weld. These techniques are also capable of detecting and sizing a 40 percent through wall flaw (ASME calibration standard) in the weld region. These inspection capabilities are documented in the Combustion Engineering Report CEN-313-P. The basis for the plugging limit of 40 percent is acceptable.

Visual examinations can be performed on the upper welds to support UT results and are performed on the lower welds to determine their integrity and acceptance. The welds are examined using a borescope examination system. The lighting is supplied as an integral part of the visual examination system. Each examination is recorded on video tape for optional later viewing and to provide a permanent record of each weld's condition.

The inspections are performed to ascertain the mechanical and structural condition of each weld. Critical conditions which are checked include weld width and completeness and the absence of visibly noticeable indications such as cracks, pits, blow holes, and burn through.

A post weld heat treatment (PWHT) has been developed that has been shown to increase the resistance of the welded joint in the Inconel 600 to stress corrosion cracking. The licensee has estimated that their steam generator tubes are not in a highly susceptible category and should complete the planned life of the plant (20-30 EFPY) without cracking in view of the reduction in hot leg temperature initiated in 1989. They also cite that welded sleeves without PWHT have been in service, with NRC approval, at Zion (1980), Ginna (1987) and Prairie Island (1988) without detected cracking to date. The staff strongly recommended the use of PWHT, but since there have been no reports of inservice problems, has accepted the licensee's position, in view of the commitment to inspection techniques which will incorporate state-of-the-art improvements as they are developed, verified and commercially available.

Based upon the review and evaluation of the information and data presented in WCAP 12623, "D.C. Cook Unit 1 Steam Generator Sleeving Report (Mechanical Sleeves)" and CEN-313-P "D.C. Cook Unit 1 Steam Generator Tube Repair Using Leak Tight Sleeves," the staff has concluded that the request by proposed amendment request to permit repair of steam generator tubes by installation of sleeves using the Westinghouse and Combustion Engineering, Inc. methodologies is acceptable. The staff concludes that the proposed sleeving repairs can be accomplished to produce a sleeved tube of acceptable metallurgical properties, strength, and mechanical stability, leak tightness and corrosion resistance. We also find that the pre-service integrity of the sleeved tubes can be assured by implementing the proposed sleeve installation examinations.

4.0 ENVIRONMENTAL CONSIDERATION

Pursuant to 10 CFR 51.21, 51.32, and 51.35 an environmental assessment and finding of no significant impact has been prepared and published in the Federal Register on December 4, 1990 (55 FR 50063). Accordingly, based upon the environmental assessment, the Commission has determined that the issuance of this amendment will not have a significant effect on the quality of the human environment.

5.0 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, and (2) such activities will be conducted in compliance with the Commission's regulations, and the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

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Principal Contributor: H. Conrad