



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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELATED TO AMENDMENT NO. 213 TO FACILITY OPERATING LICENSE NO. DPR-53
AND AMENDMENT NO. 190 TO FACILITY OPERATING LICENSE NO. DPR-69
BALTIMORE GAS AND ELECTRIC COMPANY
CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-317 AND 50-318

1.0 INTRODUCTION

By letter dated November 30, 1995, as supplemented on March 15, 1996, the Baltimore Gas and Electric Company (BGE/the licensee) submitted a request for changes to the Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2 (Calvert Cliffs), Technical Specifications (TSs). The requested changes would allow the use of laser welded sleeves designed by Westinghouse Electric Corporation for repairing steam generator (SG) tubes. BGE also requested approval of repair techniques developed by ABB Combustion Engineering, Inc., for repairing SG tubes. The NRC staff is still reviewing that portion of BGE's request. This Safety Evaluation (SE) only relates to the laser welded sleeves designed by Westinghouse. The March 15, 1996, letter specifically identified the approved Westinghouse reports in the TSs which were previously indicated as reports currently approved by the NRC. Identifying the specific approved reports does not change the initial proposed no significant hazards consideration determination.

The technical justification supporting the Westinghouse laser welded sleeve process is given in WCAP-13698, Revision 2, "Laser Welded Sleeves for 3/4 Inch Diameter Tube Feeding-Type and Westinghouse Preheater Steam Generators," Generic Sleeving Report (Proprietary) and WCAP-14469, "Specific Application of Laser Welded Sleeves for the Calvert Cliffs Power Plant Steam Generators" (Non-Proprietary).

The generic sleeving report, WCAP-13698, presents the technical bases developed to support the licensing of the laser welded sleeve installation process for use in 3/4 inch diameter tubes in feeding-type SGs such as those at Calvert Cliffs. The Combustion Engineering (CE) SGs at Calvert Cliffs are slightly different than the one modeled in WCAP-13698. The major difference is that the tubesheet is thicker in the Calvert Cliffs SG, which reduces deflections and causes the calculations in the generic report to be conservative with respect to the Calvert Cliffs Nuclear Power Plant SGs. All of the sleeve design, mechanical testing, stress corrosion testing, installation processes, and non-destructive examination procedures discussed

in WCAP-13698 apply to the Calvert Cliff SGs. In WCAP-14469, BGE provided a review and evaluation of the applicability of the generic analysis to the plant specific operating parameters and to the plant design-basis parameters.

The NRC staff found that BGE's technical justification for using laser welded sleeves is within the Calvert Cliffs licensing basis. The Calvert Cliffs licensing basis, as it relates to sleeving repairs of defective SG tubes, is provided in the Attachment to this SE.

2.0 DISCUSSION

2.1 Background

Tubes in an operating pressurized water reactor (PWR) SG can be degraded by mechanisms such as primary water stress corrosion cracking (PWSCC), outer diameter stress corrosion cracking (ODSCC), intergranular attack (IGA), pitting, or by other phenomena such as denting and vibration induced wear. Tubes that become excessively degraded reduce the integrity of the primary-to-secondary pressure boundary and must be removed from service or repaired. Degradation of SG tubes has typically been monitored using eddy current testing (ECT) techniques. Plant TSs have historically required that SG tubes be plugged at both the inlet and outlet ends of the tubes, when tubes are determined to have degraded below a calculated minimum wall thickness value (termed the "plugging limit"). However, installing plugs in a SG tube reduces the heat transfer surface area available for reactor core cooling. For this reason, design restrictions limit the total number of SG tubes which may be plugged in any one SG during the lifetime of a plant.

Alternatively, SG tubes experiencing localized degradation can be fitted with sleeves over the degraded area to reestablish the integrity of the reactor coolant pressure boundary (RCPB). The sleeves are expanded and sealed inside the tubes to provide an acceptable leak resistant load-carrying path. The reductions in heat transfer area and primary flow resulting from sleeving are slight in comparison to that resulting from tube plugging. ECT methods have been developed for monitoring any degradation in the sleeve and the underlying parent tube. However, because the sleeve becomes part of the RCPB, licensees are required to submit amendments to its TSs for review and approval before the NRC will authorize a given sleeving technique as an acceptable SG tube repair method. Licensees typically implement the TS amendments by referencing the generic or plant specific sleeving topical report(s) in the appropriate SG Limiting Condition for Operation (LCO) or Surveillance Requirement (SR).

In this case, where a licensee has amended its TS to allow for sleeving of SG tubes, the licensee may use either plugging or sleeving as a SG tube repair method. Should subsequent ECT measurements of installed sleeves indicate that a sleeved tube has degraded beyond the plugging limit for its design, the TSs would then require that the defective SG tube be plugged and removed from service. The tube and sleeve plugging limits conservatively account for the uncertainties in ECT measurements and contain additional margins for expected or postulated degradation which may occur between inspections.

2.2 Sleeve Design

Sleeves are of three basic designs: full-length tubesheet sleeve (FLTS), elevated tubesheet sleeve (ETS) and tube support sleeve (TSS). The FLTS spans from the end of the tube, at the bottom surface of the tubesheet, to a point above the secondary-side surface of the tubesheet. The ETS spans from an intermediate location within the tubesheet, up from the bottom surface of the tubesheet, to a point above the secondary-side surface outside of the tubesheet. The TSS may be installed centered approximately on a tube support intersection or in a free span section of the tube.

Tubesheet sleeves are secured by first hydraulically expanding the upper and lower portions of the sleeve. The hydraulic expansion brings the sleeve into contact with the parent tube to optimize weld performance and minimize tube deformation. A continuous circumferential laser weld is applied in the area of the hydraulically expanded region of the upper joint and stress relieved with a post weld heat treatment (PWHT). This weld structurally supports the sleeve and at the same time forms a seal.

At the lower hydraulically expanded joint, an additional mechanical roll expansion is performed on the FLTS and ETS. The lower joint is known as a hybrid expansion joint (HEJ) and it provides structural integrity under all plant conditions. Because it is a mechanical seal, the HEJ has not historically been considered leak-tight, although the test data indicate that the joint will be essentially leak-tight at operating and accident temperatures and pressures. According to BGE, the results of laboratory mock-up leak tests which were used to qualify the process are applicable to the 3/4-inch tubes used in Calvert Cliffs. The Generic Sleeving Report qualifies an optional continuous circumferential laser seal weld without PWHT that can be applied to the HEJ to provide additional leak-tightness.

2.3 Tube Lock-up (FIXITY)

BGE has discussed the consequences of the assumption that tubes might be locked to the support plate structure of the SG. An estimate was derived based on a model developed from laboratory far field stress tests of laser welded sleeves under conditions of full lock up. The model included effects of span length and stress relief temperature. A reduction of residual stress results from the current practice of hard rolling the sleeve into the tubesheet after the stress relief operation. Based on laboratory accelerated corrosion tests and experience in plants known to have some degree of lock up, resistance to stress corrosion cracking is expected for Calvert Cliffs when tube fixity is assumed. This issue was the subject of additional testing and analysis related to the use of laser welded sleeves at the Main Yankee facility recently. BGE will have the benefit of this experience and the staff recommends that the issue of tube lock-up and bowing be examined for plant specific concerns at Calvert Cliffs.

2.4 Service Experience

About 28,000 laser welded sleeves have been installed in foreign and domestic plants since 1988 including sleeves installed in both 7/8 inch and 3/4 inch tubes. It reports that at one plant there was no indication of corrosion, either at the laser weld or the hydraulic expansion of the upper joint, or at the hydraulically expanded and rolled joint in the tubesheet, after five cycles of operation.

The sleeves are manufactured from thermally treated, ASME SB-163, Alloy 690. This material, also known as Alloy 690 TT (thermally treated), has been demonstrated to be highly resistant to intergranular stress corrosion cracking (IGSCC) under SG conditions. The resistance of the laser welded sleeve joint to in-service cracking depends primarily on the resistance of the parent Alloy 600 tubing to IGSCC. As mentioned previously, stresses in the tubing, either service operating stresses or residual stresses, can potentially cause cracking. Two sources of residual stresses are related to hydraulic expansion during sleeve placement and to stresses introduced as a result of welding.

A testing program was conducted under conditions which accelerate corrosion in SG materials to simulate long term SG service. Each test contained a rolled tube transition, which served as a control sample. The stress levels in the control sample were representative of the residual stress conditions in the hard rolled transitions found at the top of the tubesheets in operating SGs and are considered a bounding stress level.

The accelerated corrosion testing was performed in high temperature-high pressure autoclaves. A doped steam environment was utilized to accelerate crack initiation and propagation. Results of the accelerated corrosion tests indicate that laser welded sleeve joints with post-weld heat treatment have a corrosion resistance greater than that of the as-welded joint.

2.5 Licensee Commitments

In its November 30, 1995, submittals, BGE has committed to the use of a post weld stress relief heat treatment for the laser welded sleeving method in accordance with staff positions.

BGE has also committed to use qualified processes for periodic inservice inspection and to evaluate improved inspection techniques as they are developed and qualified for use.

By letters dated June 27, 1995, and October 5, 1995, BGE responded to Generic Letter 95-03, "Circumferential Cracking of Steam Generator Tubes," in which they made the commitment to perform their SG inspections in conformance with EPRI recommendations.

With respect to the staff position regarding primary-to-secondary leakage limits to account for the installation of the sleeves into the SGs, BGE has already implemented a change to TS 3.4.6.2 adopting a 100 gpd per SG leakage limit (TS Change dated July 13, 1992).

3.0 EVALUATION

3.1 Sleeve Design and Analysis and Testing

The laser welded sleeves (both tubesheet and tube support plate sleeves) have been analyzed to ensure they will maintain SG tube structural and leak integrity during all plant conditions. The sleeve joint designs have been qualified through laboratory testing and analysis. Analytical verification has been performed using design and operating transient parameters which have been determined to apply to Calvert Cliffs conditions.

The function of the sleeve is to restore the integrity of the RCPB in the region between the sleeve joints to a level which is consistent with the original tube. The sleeve has been designed according to Section III of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code). Fatigue and stress analyses of sleeved tube assemblies have been completed in accordance with the requirements of the ASME Code, Section III. The analyses include a primary stress intensity evaluation, primary plus secondary stress intensity range evaluation, and a fatigue evaluation for mechanical and thermal conditions. WCAP-14469 compared the current set of transient and operating parameters for Calvert Cliffs to those used in the generic analysis used in WCAP-13698 to confirm that the generic analysis provides a valid analysis for Calvert Cliffs. It was concluded that all applicable code and regulatory requirements were met.

3.2 Sleeve Plugging Limits

The sleeve minimum acceptable wall thickness is determined using the criteria of Regulatory Guide (RG) 1.121, the ASME Code Section III allowable stress values, and the pressure stress equation in NB-3324.1 of Section III of the ASME Code. According to RG 1.121 criteria, an allowance for non-destructive evaluation (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. Therefore, a conservative tube wall combined allowance for postulated degradation growth and eddy current uncertainty of 20% through-wall per cycle have been assumed for the purpose of determining the sleeve plugging limit. The sleeve plugging limit, which was calculated based on the most limiting of normal, upset or faulted conditions for Calvert Cliffs was determined to be 40% of the sleeve nominal wall thickness. Removal of tubes and/or sleeves from service when degradation reaches the plugging limit provides assurance that the minimum acceptable wall thickness will not be violated during the next subsequent cycle of operation.

3.3 Leakage

While a laser weld should be inherently leak-tight, in practice, the lower joint of a tubesheet sleeve may be installed with or without a seal weld; therefore, the leakage characteristics must be considered. BGE has analyzed the effects of an abnormal tubesheet sleeve lower joint seal. The analysis shows that even under extreme postulated conditions, it will have satisfactory leakage integrity.

3.4 Non-Destructive Examination

The welding parameters are computer controlled. The essential variables, in accordance with the ASME Code, are monitored and documented to produce repeatability of the weld process. In addition, the NDE of the laser welded sleeves utilizes two techniques. Ultrasonic testing (UT) is performed after welding to confirm that the laser welds are consistent with critical process dimensions and are of acceptable weld quality. BGE has presented data on a UT system that demonstrates post weld examinations of the sleeve-tube assembly will be adequate. Standards, which simulated a leakage path along the weld metal, were used in the qualification of the UT technique. The results of the qualification tests demonstrate that the system can confirm that there is a metallurgical bond between the sleeve and the tube and determine if a leak path exists across the weld.

Eddy current testing (ET) is used to establish baseline inspection data for every installed sleeve/tube to be utilized during subsequent inservice inspections. Furthermore, in accordance with the criteria in RG 1.83, Revision 1, "Inservice Inspection of Pressurized Water Reactor Steam Generator Tubes," BGE has presented data, which demonstrates that structural integrity of sleeved tubes can be monitored by performing periodic eddy current examinations. However, for future inservice inspections, BGE has stated in its November 30, 1995, submittal, that it will evaluate improved inspection techniques as they are developed and qualified for use. A number of proprietary advanced inspection techniques that are currently under development were described.

3.5 Sleeving of Previously Plugged Tubes

In the event that previously plugged tubes are unplugged and returned to service by using the sleeving process, the plant TSs would require that the sleeving requirements be applied to the tubes designated for sleeving. This includes provisions to ensure that the new sleeve joints are located a minimum acceptable distance apart from the degraded tube area. Following installation, a new "baseline" inspection of the tube and sleeve would then be required for any sleeved tube placed back in service.

4.0 SUMMARY

Based on the preceding analysis, the NRC staff concludes that the repair of SG tubes using laser welded sleeves designed by Westinghouse is acceptable, as supplemented by additional BGE commitments, as discussed above, to 1) using enhanced and improved eddy current testing inspection techniques as they are developed and verified for use, 2) performing post-weld heat treatment of installed laser welded sleeves, 3) maintaining requirements to provide for appropriate inservice inspection for any steam generator tubes containing sleeves and 4) continuing the existing TS requirements for a primary-to-secondary leakage limit of 100 gpd maximum per steam generator. Thus, the proposed changes to TSs 3/4.4.5, "STEAM GENERATORS," and their supporting Bases is acceptable for the laser welded sleeves designed by Westinghouse.

5.0 STATE CONSULTATION

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

6.0 ENVIRONMENTAL CONSIDERATION

The amendments change a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 and changes surveillance requirements. The NRC staff has determined that the amendments involve no significant increase in the amounts, and no significant change in the types, of any effluents 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 the amendments involve no significant hazards consideration, and there has been no public comment on such finding (61 FR 176). Accordingly, the amendments meet 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 the amendments.

7.0 CONCLUSION

The Commission 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 the amendments will not be inimical to the common defense and security or to the health and safety of the public.

Principal Contributor: H. Conrad

Date: March 22, 1996

DISCUSSION OF LICENSING BASIS

1. 10 CFR 50.55a

10 CFR 50.55a, "Codes and Standards," requires that components, which are a part of the reactor coolant pressure boundary to be built to the requirements of Section III of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) 10 CFR 50.55a also requires that throughout the service life of the plant, that licensees meet the inservice inspection requirements of the ASME Code Section XI for ASME Code Class 1, 2 or 3 components.

Section 5.2.1.1 of the Standard Review Plan, entitled "Compliance with the Codes and Standards Rule, 10 CFR 50.55a," provides an outline of the standards used for evaluation by the NRC staff. Any modification, repair or replacement of these components must also meet the requirements of the ASME Code to assure that the basis on which the unit was originally evaluated is unchanged.

2. ASME Code Requirements

The design of the sleeves is predicated on the requirements of the ASME Code Section III, Subarticles NB-3200, "Analysis" and NB-3300, "Wall Thickness." The ASME Code provides criteria for evaluation of the stress levels in the tubes for design, normal operating, and postulated accident conditions. The margin of safety is provided, in part, by the inherent safety factors in the criteria and requirements of the ASME Code.

Section IX of the ASME Code, Subsection QW, and Section III, including Code Case N-395, define the applicable essential variables for the welding procedure specification and welding procedure qualification test.

Section XI, IWB-4334 of the ASME Code defines the extent of examination requirements for installation of laser welded sleeves.

3. Regulatory Guide 1.121

Regulatory Guide (RG) 1.121, issued for comment, entitled "Bases for Plugging Degraded PWR Steam Generator Tubes," addresses tubes with defects. The criteria of RG 1.121 are extended to the laser welded sleeve in order to determine the level of degradation, which will require removal of the sleeve from service by plugging. ASME Code allowable strength values were used for this evaluation. By utilizing the requirements for sleeve design according to the ASME Code and RG 1.121 to define acceptance criteria, the sleeve meets the requirements of General Design Criterion (GDC) 14, "Reactor Coolant Pressure Boundary," GDC 15, "Reactor Coolant System Design," and GDC 31, "Fracture Prevention of Reactor Coolant Pressure Boundary."

ATTACHMENT

4. Regulatory Guide 1.83

Regulatory Guide 1.83, "Inservice Inspection of Pressurizer Water Reactor Steam Generator Tubes" (and the Calvert Cliffs Technical Specifications) is used as the basis to determine the inservice inspection requirements for the sleeve.

5. 10 CFR Part 100

Total plant allowable primary-to-secondary leakage rates, derived from the requirements of 10 CFR Part 100, are determined on a plant specific basis. Offsite doses during either a main steam line break or tube rupture event are not to exceed a small fraction of the 10 CFR Part 100 limits per the Bases to the Calvert Cliffs Technical Specifications.

March 22, 1996

Mr. Charles H. Cruse
Vice President - Nuclear Energy
Baltimore Gas and Electric Company
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657-4702

SUBJECT: ISSUANCE OF AMENDMENTS FOR CALVERT CLIFFS NUCLEAR POWER PLANT,
UNIT NO. 1 (TAC NO. M94205) AND UNIT NO. 2 (TAC NO. M94206)

Dear Mr. Cruse:

The Commission has issued the enclosed Amendment No. 213 to Facility Operating License No. DPR-53 and Amendment No. 190 to Facility Operating License No. DPR-69 for the Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2, respectively. The amendments consist of changes to the Technical Specifications (TSs) in response to your application transmitted by letter dated November 30, 1995, as supplemented on March 15, 1996.

The amendments allow the installation of tube sleeves as an alternative to plugging for repairing steam generator (SG) tubes using repair techniques developed by Westinghouse Electric Corporation. In your November 30, 1995, letter, you also requested approval of repair techniques developed by ABB Combustion Engineering, Inc., for repairing SG tubes. We are still reviewing that portion of your request.

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

Sincerely,

Original signed by:

Daniel G. McDonald, Jr., Senior Project Manager
Project Directorate I-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket Nos. 50-317
and 50-318

- Enclosures: 1. Amendment No. 213 to DPR-53
2. Amendment No. 190 to DPR-69
3. Safety Evaluation

cc w/encls: See next page

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