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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 180 TO FACILITY OPERATING LICENSE NO. DPR-26

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

INDIAN POINT NUCLEAR GENERATING UNIT NO. 2

DOCKET NO. 50-247

1.0 INTRODUCTION

By letter dated April 13, 1994, as supplemented by letters dated December 20, 1994, January 12, 1995, and January 31, 1995, the Consolidated Edison Company of New York (the licensee) submitted a request for changes to the Indian Point Nuclear Generating Unit No. 2 (IP2) Technical Specifications (TSs). The requested changes would revise TSs Sections 3.1.F and 4.13 to allow the repair of steam generator tubes via the implementation of an F* criteria. This would allow tubes that are degraded in a location not affecting structural integrity of the tube to remain in service as an alternative to removal from service through the use of tube plugs. The requested changes related to tube sleeving will be addressed in a separate amendment. The December 20, 1994, submittal provided responses to an NRC staff Request for Additional Information (RAI). The January 12, 1995, submittal clarified one of the RAI responses and the January 31, 1995, submittal requested that the part of the proposed request dealing with steam generator tube sleeving be separated from the original request to allow additional review of current sleeving issues and to permit processing of the F* part of the request. The December 20, 1994, January 12, 1995, and January 31, 1995, letters provided clarifying information which did not change the initial proposed no significant hazards consideration and that was within the scope of the original *Federal Register* notice.

The licensee proposed an alternative repair criteria for defects found in the tube expansion region within the tubesheet. Steam generator tubes with degradation in excess of the current plugging limits could remain inservice without repair provided the indications existed below a specified distance, F* (F-star), from the bottom of the roll transition region. To support the licensee's request, Babcock & Wilcox Nuclear Technologies (BWNT) completed a test program to demonstrate that the proposed F* distance satisfies the necessary structural and leakage integrity requirements of Appendix A to 10 CFR Part 50 and the IP2 TSs.

Surveillance requirements within the plant TSs require a periodic inspection of steam generator tubes for the detection of potential degradation (i.e., cracks, dents, corrosion, etc.), which could diminish the structural margins and leakage integrity of the tubes. For IP2, detection of tube degradation in

excess of the TSs limits requires removal of the tube from service. The licensee has proposed a revised repair criteria that would allow steam generator tube defects to remain in place without repair provided the defects reside a specified distance below the roll transition region. This distance is called F*. Degradation identified in a steam generator tube below the F* length would be allowed to remain in service without repair. This is based on the results of the testing which determined the minimum interference fit engagement length necessary to retain steam generator tubes within the tubesheet.

The NRC staff requested additional information by letter sent to the licensee dated November 21, 1994. In addition, a phone call was held on January 11, 1995, between the NRC staff and the licensee to clarify several answers in the licensee's response to this request. The NRC staff has reviewed the information supplied by the licensee and completed an evaluation of the licensee's request to amend the IP2 TSs with the F* criteria.

The licensee also included in their submittal dated April 13, 1994, a proposed amendment to permit steam generator tube sleeving as an alternative to removing defective tubes from service through plugging. This safety evaluation only addresses the proposed changes associated with F*. Steam generator tube sleeving will be evaluated in a separate safety evaluation.

2.0 BACKGROUND

Steam generator tubes comprise a significant portion of the reactor coolant pressure boundary. Maintenance of this barrier is provided by the integrity of the steam generator tube wall and the tube to tubesheet connection. The connection between the tube and tubesheet is an interference fit made by roll expanding the tube into a bore through the tubesheet. The inelastically deformed steam generator tube is held in place by the elastic springback of the tubesheet. The IP2 steam generator tubes are roll expanded from the bottom of the tubesheet and welded at the tubesheet primary face. Undegraded, this joint provides sufficient strength to maintain adequate structural and pressure boundary (leakage) integrity.

General Design Criteria 14, "Reactor Coolant Pressure Boundary," and 31, "Fracture Prevention of Reactor Coolant Pressure Boundary," of Appendix A to 10 CFR Part 50 state the requirements applicable to maintaining adequate structural and leakage integrity for steam generator tubes. Regulatory Guide (RG) 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes," describes an acceptable method to the NRC staff for establishing the limiting safe conditions of tube degradation of steam generator tubing. Although RG 1.121 conservatively focuses on tube degradation in the freespan regions, the methods described apply to other tube regions, such as the roll expansion length.

In order to demonstrate adequate structural margin for steam generator tube degradation, the bases must address the limiting conditions during normal operation, anticipated operational occurrences, and postulated accident

conditions. The margin to failure under normal operating conditions, as recommended in RG 1.121 should not be less than 3 at any tube location. Subsection NB-3225 of Section III of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) specifies the margins of safety under postulated accident conditions.

Structural loads imposed on the steam generator tube-to-tubesheet connections primarily result from the differential pressure between the primary and secondary sides of the tubes. The peak postulated loading occurs during a steam line break due to a lowering of the secondary side pressure. However, normal operating loads, cyclic joint loading from major plant transients (i.e., startup/shutdown), and potential thermal expansion loads can also be significant. The analysis (BAW-10195P) supporting the licensee's proposed modification to the IP2 TSs addressed the limiting conditions necessary to maintain adequate integrity of the tube-to-tubesheet interference fit. Specifically, the tube must not experience excessive displacement relative to the tubesheet.

Leakage through steam generator tubes is limited by plant TSs. For IP2, the limits for the allowable primary to secondary leakage are stated in TS 3.1.F. The total primary to secondary leakage must be less than 0.3 gpm in any steam generator.

The elastic preload between the tube and tubesheet not only prevents pullout of the tube from the tubesheet, but also provides a leaktight barrier minimizing the potential for primary to secondary coolant leakage. With sufficient length of hardroll, the tube-to-tubesheet connection will not allow any leakage under normal and faulted conditions. Steam generator tube through-wall degradation within the roll expanded joint would decrease the path length necessary for primary to secondary leakage. The licensee's proposed amendment would permit such degradation to remain in service provided there exists a sufficient length of undegraded hardroll below the bottom of the roll transition region. Therefore, an acceptable F* distance must be such that leakage integrity is not jeopardized during all analyzed conditions.

3.0 TESTING TO DETERMINE F*

The licensee completed a test program to determine the F* distance. Two failure criteria were considered for testing -- pullout of the tube from the tubesheet and primary to secondary leakage requirements. The following describes the methodology used for the tests.

3.1 Fabrication of Test Specimens

Mockup blocks were fabricated to simulate the actual installed rolled expansion fabrication variations and loading conditions with the IP2 Steam Generators. Lengths of steam generator tubing were roll expanded into holes drilled through the mockup blocks. Several peripheral tubes were roll expanded in the test block to simulate additional constraint by surrounding tubes. The interior tubes were used for testing. In order to simulate tube

wall degradation, tubes were severed at a certain distance below the bottom of the roll transition region. This configuration is representative of a 360° through-wall crack present in the tube.

Several mockup blocks were fabricated for testing. After the tubes were expanded into the blocks and the hardroll length was verified by nondestructive evaluation methods, each block was thermally soaked to simulate the effects of actual steam generator service temperature. Heating the test block would theoretically lead to thermal stress relaxation in the roll expansion joint.

To account for potential factors, which might affect the calculated F* length, several variables were changed within the test matrix. For example, tubing with high and low yield strengths were tested. In addition, tubesheet bore surface roughness, as well as tubesheet bore diameter were varied in the test matrix. The results from the tests revealed the effects from these variables.

In the qualification test program the effects of boric acid corrosion and post-weld heat treatment on the integrity of the tube-to-tubesheet joint were considered. BWNT postulated that if primary coolant penetrated through the steam generator tube wall and came in contact with the carbon steel tubesheet the potential exists for initiating stress corrosion cracking in the tubesheet. Based on previous studies, the likelihood of developing significant corrosion of the tubesheet bore due to boric acid corrosion is low.

After the roll expansion process to secure steam generator tubes into the tubesheet, the channel head to tubesheet weld attachment was stress relieved via heat treatment. BWNT assessed the effects of this fabrication step on the tube-to-tubesheet joint by exposing several test specimens to temperatures similar to that experienced by the tubes during the original fabrication process. Any stress relaxation due to creep would theoretically lower the pullout strength of the tube from the tubesheet. Based on ultimate load testing, it was concluded that the post-weld heat treatment did not adversely affect the strength of the joint retaining the tube within the tubesheet.

3.2 Testing for F* Determination

To determine the necessary roll expansion joint engagement length the licensee completed a series of mechanical tests on the simulated steam generator tubes. The testing involved subjecting tubes to combined internal pressure and axial loading to determine the F* distance. Under actual service conditions, the differential pressure acting over the cross section of the tube provides an axial force tending to force the tube out of the tubesheet. This axial load is counterbalanced by the frictional force between the tube and tubesheet due to the roll expanded interference fit. The primary to secondary differential pressure also increases radial force between the tube and tubesheet by slightly expanding the tube and bowing the tubesheet. The increased radial forces due to these effects will increase the frictional force between the tube and tubesheet resisting pullout. The use of both internal pressure and

axial loading during testing simulates actual loading on the roll expanded joint.

Three different mechanical tests were conducted to determine F*: a locked tube test, pressure cycling, and an ultimate load test. All tests were conducted at ambient temperatures. The locked tube test simulated the loading applied to a steam generator tube during cooldown of the plant assuming the tube was locked at a tube support plate location. The unequal coefficients of thermal expansion of the tube wrapper and the tube would lead to an applied tensile load on the tube. For the pressure cycling test, several tubes were subjected to pressure cycling between low and normal operating pressures. Motion of the tube was monitored during the cyclic loading. Finally, tubes were subjected to an ultimate load test. Tubes were internally pressurized and subjected to an increasing axial tensile load until failure. Failure was defined as a relative movement of a specified distance between the tube and tubesheet.

As part of the test program to provide the basis for the proposed F* length, steam generator tubes were subject to leak rate testing. Tubes were internally pressurized to simulate differential pressures during normal operating and faulted conditions. The acceptance criteria for these tests specified an allowable leakage limit. Tube displacements were also monitored during the tests.

3.3 F* Test Results

Based on the results of the leakage rate and mechanical testing the licensee determined a nominal engagement length necessary to ensure adequate margins of safety. Accounting for limited sample size, statistical scatter in the data, and NDE inspection error this value was increased appropriately. The licensee has proposed that steam generator tubes with degradation in the roll expanded portion of the tube can remain in service if all degradation lies below the F* distance. The F* distance is equal to the 1.25 inches and is measured down from the bottom of the roll transition.

4.0 EVALUATION OF PROPOSED TECHNICAL SPECIFICATION AMENDMENT

The licensee proposed a revision to the IP2 TS to implement the F* criterion by letter dated April 13, 1994. The following summarizes the proposed changes:

1. The TSs define the F* distance as the distance of expanded portion of a tube which is sufficient to resist pullout of the tube from the tubesheet. This distance is equal to 1.25 inches.

2. The revised TSs include a definition of an F* tube, which is a tube with degradation of 40% through-wall or greater below the F* distance, has no degradation within the F* distance, and remains in service.

3. In addition to the minimum sample size for steam generator tube inspection, all F* tubes will be inspected within the pertinent tubesheet region at every outage.

As a bases for the proposed amendment to the IP2 TSs, tests were completed to determine an acceptable F* distance. The testing utilized specimens which reflect the actual tube-to-tubesheet joint configuration within the IP2 Steam Generators. Unknown variables, which could potentially affect the calculated F* distance were taken into consideration in developing the test matrix. Applied loads for structural assessment and leakage rate testing were specified in accordance with staff recommendations in RG 1.121 and the ASME Code. The licensee's proposed changes to the IP2 TSs are consistent with the conclusions from the test program to determine F*.

To ensure continued integrity of F* tubes, the licensee has included a requirement in the plant TSs to reinspect F* tubes during each steam generator examination. Although F* tubes are specified as part of the Basic Sample Selection for examination, F* steam generator tubes are not considered as part of the 12 percent Minimum Size specified for examination in Table 4.13-1 of the IP2 TSs. The inclusion of a requirement in the proposed TSs to reexamine F* tubes during each examination should ensure that no degradation exists within the F* distance of all F* tubes.

One issue not discussed in the licensee's original request to amend the IP2 TSs, was the option of rerolling a degraded steam generator tube so that it would then be acceptable by the F* criterion, pending approval of this amendment. The licensee indicated during a phone call on January 11, 1995, that rerolling has been considered and was evaluated using the same methodology as that described previously in Section 3 of this Safety Evaluation. However, the licensee stated that the test program addressed potential impurities, which could become trapped between the outer tube surface and the tubesheet bore during the rerolling process. Results from these tests concluded that the proposed F* distance is acceptable for rerolled tubes as well. Based on one assumption made in the qualification test program the licensee could only reroll a steam generator tube up to one-half the tubesheet thickness. Additional rerolling beyond this height would be considered an unanalyzed condition.

The NRC staff has reviewed the TSs change related to the implementation of the F* criterion proposed by the licensee in their submittal dated April 13, 1994. Based on information provided in the submittal, additional information provided by letter dated December 20, 1994, and during a phone conversation on January 11, 1995, the NRC staff finds the licensee's proposed changes acceptable.

5.0 STATE CONSULTATION

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

6.0 ENVIRONMENTAL CONSIDERATION

The amendment changes 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 amendment involves 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 amendment involves no significant hazards consideration, and there has been no public comment on such finding (59 FR 27051). Accordingly, the 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 the amendment.

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

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