September 20, 2002

Mr. Ted C. Feigenbaum
Executive Vice President and
Chief Nuclear Officer
North Atlantic Energy Service Corporation
c/o Mr. James M. Peschel
P.O. Box 300
Seabrook, NH 03874

SUBJECT: SUMMARY OF CONFERENCE CALL WITH NORTH ATLANTIC ENERGY SERVICE CORPORATION REGARDING THE 2002 STEAM GENERATOR INSPECTION RESULTS AT SEABROOK STATION, UNIT NO. 1 (TAC NO. MB5299)

Dear Mr. Feigenbaum:

On August 27, 2002, the Nuclear Regulatory Commission staff participated in a conference call with North Atlantic Energy Service Corporation representatives regarding the ongoing steam generator tube inspection activities at Seabrook Station. Enclosed please find a summary of that conference call.

Sincerely,

/RA/

Robert D. Starkey, Project Manager, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-443

Enclosure: As stated

cc w/encl: See next page

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SUMMARY OF CONFERENCE CALL

WITH

NORTH ATLANTIC ENERGY SERVICE CORPORATION

REGARDING THE SEABROOK STEAM GENERATOR TUBE

LABORATORY EXAMINATION RESULTS

Background

The Nuclear Regulatory Commission (NRC) staff participated in conference calls on May 20 and May 23, 2002, with North Atlantic Energy Service Corporation (the licensee) representatives regarding the steam generator tube inspection findings at Seabrook during its eighth refueling outage (RFO8). During these calls, the licensee discussed the identification of axial outside diameter (OD) indications detected in the "D" steam generator. The NRC staff issued a summary of these two calls (Accession number: ML021800003) and an NRC Information Notice (IN2002-21), "Axial Outside-Diameter Cracking Affecting Thermally Treated Alloy 600 Steam Generator Tubing", dated June 25, 2002, on this issue.

As described in the previous call summary, the licensee detected 42 locations in 15 tubes containing OD axial indications. The indications were found at tube to tube support plate (TSP) intersections from TSP 2 through TSP 6 on the hot leg side and from TSP 3 through TSP 5 on the cold leg side. The indications were confined to the intersection locations within the thickness of the TSPs. The tubes were within the first 10 rows in steam generator D. Tubes in the first 10 rows were subjected to a stress relief process through a special heat treatment before the installation of the tubes in the steam generator. The licensee pulled two of these tubes for metallurgical examinations and root cause analysis.

The NRC staff participated in a follow-up call with the licensee on August 27, 2002 to discuss information gathered from the ongoing examination of the pulled tubes. A summary of this call is documented below.

Discussion of Examination Results

The licensee stated that the root cause analysis was performed by the North Atlantic Root Cause Team, Westinghouse Laboratory, and Altran Inc. A professor from the Massachusetts Institute of Technology performed the third party oversight of the activities.

The licensee has determined that the 15 tubes with flaws were from three different Heat numbers. Specifically, 13 tubes were from one specific Heat number - No. 1374. The remaining two tubes were from two different Heat numbers, No. 1456 and No. 1457. The licensee previously indicated that these tubes were from eleven different Heat numbers, but later discovered that the tube identification map had been improperly oriented.

Enclosure

The licensee obtained archived tube material from Heat No. 1456 and Heat No. 1457. The archived tubes were taken from products after the alloy 600 thermal treatment process. The degraded tubes were from the same process but were subjected to an additional heat treating process intended to relieve the residual stress at the tube u-bend location. The two pulled tubes, portions of the hot leg from tube Row 5 Column 62 (R5C62) and portions of the cold leg from tube Row 9 Column 63 (R9C63), were from Heat No. - 1374. The licensee has not yet determined if they have archived tube material from Heat No. 1374.

Detailed results from the laboratory examination are discussed below.

1. Flaw Assessment Using Non-Destructive Examinations (NDE)

The licensee performed laboratory NDE tests on the pulled tube specimens. The eddy current tests (ECT) performed in the laboratory utilized bobbin probes, plus point probes, RG 34 probes and X-probes. The laboratory tests, including destructive examinations, resulted in flaw estimates very close to those from the field tests in regard to flaw length, depth and voltage. The laboratory results confirmed average flaw depths of 35-40%, which agree with the field test results.

The licensee discussed the test results of the flaws located at TSP 4 of the tube from R5C62 which contained the deepest flaw according to field eddy current data. Laboratory ECT indicated a flaw 65% through-wall (TW) and 1.15 volts, as compared to the field test result of 65% TW and 1.3 volts. The axial length of the indication was estimated to be 0.6 inches which was confined within the thickness of the TSP which is 0.75 inches thick. The laboratory eddy current test identified a small indication which the field test did not identify. This indication is located at TSP 2 of R5C62 with a voltage of 0.12 volts by the bobbin probe.

The ultrasonic test (UT) results from the laboratory agreed with the field test results, which confirmed the presence of OD cracks. However, no depth results were assessed in either the laboratory or field tests.

The licensee also performed a radiography test (RT) in the laboratory. The test results also confirmed the presence of cracks.

2. Structural Analysis

Pressurized burst tests were performed in the laboratory using methods recommended by the Electric Power Research Institute (EPRI) Guidelines. The two pulled tubes were divided into 14 sections, four of which contained indications. The section containing the deepest flaw from TSP 4 of tube R5C62 was tested to 7000 psi with no burst or leakage. This pressure is well above the three times normal operating pressure differential (approximately 3750 psi) which is required to meet structural integrity performance criteria. The section of TSP 2 of Tube R5C62 containing a minor indication detected by the laboratory ECT was tested to 11,500 psi before burst. The remaining twelve sections were tested, ten of which did not contain any flaws. These sections all bursted at approximately 13,000 psi with no leakage. No foil or bladder were used in these burst tests. The licensee concluded, based on the pressurized burst tests, that the indications did not compromise the structural or leakage integrity performance criteria.

3. Chemical Analysis

Deposits were noticed on the tube samples in the crevices formed by the TSPs, however, the deposits were very thin. No heavy crust was observed in any of the samples examined. Chemical analysis of the deposits indicated that there were no detrimental species detected, such as chloride or sulfate species, in the specimens or in the crack tips. Tests performed by an independent laboratory detected a trace amount of copper and lead. However, the amount was within the margin of error and was so minute that it was not detectable in the tests performed in the Westinghouse laboratory. Overall, the licensee stated that chemical analysis did not provide any evidence to indicate environmental factors as the root cause.

4. Metallurgical Analysis

The licensee performed metallurgical analysis on samples from the two pulled tubes as well as samples from archived alloy 600 thermally treated (TT) tube material.

Chemistry analysis of the pulled tube specimens showed that the material contains a carbon content of 0.047%C, which the licensee believes is higher than the average carbon content typically found in alloy 600 TT steam generator tubing currently in service at Seabrook (~0.03%C). The archived material contained a carbon content of 0.033%C.

The licensee indicated, based on the metallurgical analysis, that all indications in the pulled tubes are axial OD cracks. All cracks are intergranular in nature and are classified as intergranular attack (IGA) and/or intergranular stress corrosion cracking (IGSCC) (i.e., the indications contained IGA 1-2 grains deep and contained IGSCC for the remainder of the depth). No transgranular cracks were observed. The destructive examination generally confirmed the results from the NDE tests in terms of size and type of indication.

The metallurgical analysis showed that the overall microstructure in the pulled tube specimens is not “ideal” as compared to typical alloy 600 TT material. In comparison, the archived tube specimens appeared to be of typical alloy 600 TT microstructure. The licensee discussed specific findings from the metallurgical analysis as follows:

1) Mechanical tests showed the pulled tube material has a yield strength of 70 ksi, as compared to 60 ksi reported for this material in the certified material test report.

2) Metallography showed that the pulled tube material contains grain-sizes from ASTM Size 9 through Size 11, which is finer than typical alloy 600 TT material. It also contains duplex grains - two different sizes of grains instead of a uniform size. A significant amount of banding (a segregated structure consisting of alternating nearly parallel bands of different composition) was observed in the pulled tube material, which is unusual for alloy 600 TT material.

3) The microstructure in the pulled tube material contains a significant amount of intragranular carbides and very few intergranular carbides. Alloy 600 TT material typically contains more intergranular carbides and very few intragranular carbides.

4) The licensee modified a standard American Society for Testing and Materials (ASTM) test, ASTM A262 Practice C, "Nitric Acid Test for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels", to determine the pulled tube and archived tube's susceptibility to stress corrosion cracking. The test results suggested that the pulled tube material may have been more sensitized than the archived tube material. However, the licensee indicated that these test results are not quantitative in nature and are typically inconclusive.

To further examine the degree of sensitization of the pulled tube material, electrochemical potentiokinetic reactivation (EPR) tests, as well as a modified version of the EPR tests, were performed on both materials. No conclusive results have been obtained yet and the tests are still ongoing.

It was noted that crack indications were detected in tubes from Heat No. 1456 and Heat No. 1457. Yet, based on metallurgical examinations performed so far, specimens from the archived tubes from these heat numbers appeared to have normal microstructure, a lower yield strength and lower susceptibility by sensitization tests, compared to the pulled degraded tubes of Heat No. 1374. The archived tubes were taken from products after the alloy 600 thermal treatment process. The degraded tubes were from the same process but were subjected to an additional heat treating process intended to relieve the residual stress at the tube u-bend location. The licensee has not determined whether the stress relief process impacted the corrosion resistance properties.

The licensee also plans to perform residual stress tests to identify the extent of residual stresses in the pulled tube material.

Generic Implications

Seabrook steam generators contain a total of 194 tubes from Heat No. 1374, 340 tubes from Heat No. 1456 and 472 from Heat No. 1457. All active tubes with these heats were inspected with an eddy current bobbin probe. Only the 15 tubes previously discussed contain axial OD indications. All tubes with indications were plugged.

Other tubes from the same three heats may exist in other domestic steam generators. However, there is no conclusive evidence at this time to relate the cause of degradation at Seabrook to the heat of material (and therefore to other domestic steam generators).

The licensee has evaluated all the currently available information in an effort to determine the root cause. The licensee stated that, based on the examinations performed so far, no conclusive root cause has been identified. The root cause analysis is still ongoing. The licensee indicated that they have shared the eddy current data with the industry and also notified the industry that the presence of axial OD indications was confirmed by laboratory testing. The licensee stated that the final report will be completed in 3-4 weeks. Additional information will be communicated to the NRC staff at that time.