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

January 24, 1997

Mr. David Modeen, Director
Engineering
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, DC 20006-3708

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION REGARDING NP 7480-L, ADDENDUM 1, "STEAM GENERATOR TUBING OUTSIDE DIAMETER STRESS CORROSION CRACKING AT TUBE SUPPORT PLATES, DATABASE FOR ALTERNATE REPAIR LIMITS," 1996 DATABASE UPDATE, NOVEMBER 1996

Dear Mr. Modeen:

In a letter dated September 18, 1996, the Nuclear Energy Institute (NEI) submitted the Electric Power Research Institute (EPRI) report, "Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates, Database for Alternate Repair Limits," NP 7480-L, Addendum 1, 1996 Database Update, August 1996, for Nuclear Regulatory Commission (NRC) staff review and approval. EPRI subsequently updated the August 1996 report with EPRI report NP-7480-L, Addendum 1, 1996 Database Update, November 1996. All page and paragraph numbers in the attached request for additional information are based on the November 1996 report.

The report presents the latest burst pressure and leakage data taken from the destructive examination of defective tubes removed from domestic and European steam generators. Compilation of this data is a part of the industry effort in response to NRC) Generic Letter 95-05, "Voltage-Based Repair Criteria fcr Westinghouse Steam Generator Tubes Affected By Outside Diameter Stress Corrosion Cracking," which relies on burst pressure and leakage data from defective tubes for the application of the voltage-based alternate tube repair criteria. The report also contains industry proposals regarding exclusion of the French data from the database and voltage-dependent probability of detection criteria. In the report, the industry also presented limited data for a correlation between axial tensile rupture and bobbin volts. In order to complete its review, the staff requests additional information as discussed in the enclosure. We also request that you inform us of your schedule to respond to these questions.

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In accordance with the provisions of 10 CFR Part 170, the staff intends to recover the costs of this review by billing NEI for the staff's review effort.

Sincerely,

Stewart L. Magruder

Stewart L. Magruder, Project Manager
Generic Issues and Environmental
Projects Branch
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Project No. 689

Enclosure: Request for Additional
Information

cc w/ encl: See next page

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Original Signed By:

Stewart L. Magruder, Project Manager
Generic Issues and Environmental
Projects Branch
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

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Enclosure: Request for Additional Information

cc w/ encl: See next page

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REQUEST FOR ADDITIONAL INFORMATION

REVIEW OF EPRI REPORT "STEAM GENERATOR TUBING OUTSIDE DIAMETER STRESS CORROSION CRACKING AT TUBE SUPPORT PLATES DATABASE FOR ALTERNATE REPAIR LIMITS" NP 7480-L, ADDENDUM 1, 1996 DATABASE UPDATE NOVEMBER 1996

In a letter dated September 18, 1996, Nuclear Energy Institute submitted for staff review the EPRI report, "Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates, Database for Alternate Repair Limits," NP 7480-L, Addendum 1, 1996 Database Update, August 1996. EPRI subsequently updated the August 1996 report with EPRI report NP-7480-L, Addendum 1, 1996 Database Update, November 1996. All page and paragraph numbers in the attached request for additional information are based on the November 1996 report.

The report presents the latest burst pressure and leakage data taken from the destructive examination of defective tubes removed from domestic and European steam generators. Compilation of this data is a part of the industry effort in response to NRC Generic Letter 95-05 which relies on burst pressure and leakage data from defective tubes for the application of the voltage-based alternate tube repair criteria. The report also contains industry proposals regarding exclusion of the French data from the database and voltage-dependent probability of detection criteria. In the report, the industry also presented limited data for a correlation between axial tensile rupture and bobbin volts. In order to complete its review, the staff requests additional information as discussed below:

Comments and Questions:

Q1 EPRI and NEI state that the correlation for the axial tensile rupture force with bobbin voltage is considered preliminary due to limited data. The staff will review this topic when the correlation is finalized.

Q2 In the report, EPRI refers to the database as the alternate repair criteria (ARC) database. The name should be modified to distinguish it from other ARC databases that may be developed.

Q3 It would be beneficial in monitoring the database if EPRI would include a separate table that contains those data that have not been included in the ARC database.

Q4 The statistical analysis presented in the report did not show convincing physical or statistical evidence that the French pulled tube data are of different population from the U. S. pulled tube data. Pending additional statistical analysis and physical explanation to show that the French data are different from the U. S. data, the NRC approved database is the data with inclusion of the French data remaining after applying the NRC agreed upon exclusion criteria. When, and if, additional statistical and physical evidence exists that would support removing the French data, the following areas should be addressed:

(1) On Page 2-2, fourth paragraph, EPRI states that the differences in the French data relative to the voltage-based correlations in the ARC database may be due to differences in crack morphology between the U.S. data and French data. EPRI also states that the French pulled tubes appear to have a higher crack density, higher voltages for a given maximum depth and short through wall lengths than that of the U.S. pulled tubes. Explain why the French data would show different crack morphology than that of the U.S. data even though tubes in the French and U.S. steam generators were fabricated with the same material.

(2) On Page 4-11, EPRI states that five of the EdF tests were conducted with putty and then pressurized with water until the tube either burst or developed a leak. This description is unclear. Provide a descriptive summary of how the EdF tests were conducted.

(3) On page 4-14, EPRI states that most of the EdF burst tests were conducted without the use of foil and putty and were terminated if a leak was developed. Describe how these EdF burst tests, which did not use the foil and putty, were conducted, and compare how these EdF tests were conducted with those of U.S. tests. Provide an assessment of the differences in the methods, techniques, and setup in the French and U.S. tests that could have caused the differences in the burst pressure and leakage results in the French data and U.S. data.

(4) On Page 4-17 and in Table 4-14, Comparison 1 shows that model 4 fits the data about as well as model 1, and in one sense it shows that there is no statistically significant difference between them. Because model 1 has 4 free parameters (2 intercepts and 2 slopes of the regression line) and model 4 has only 2 free parameters (1 intercept and 1 slope), model 1 will fit the data better than model 4, i.e. the more the parameters the better the fit. However, because model 2 has 3 free parameters (2 intercepts and 1 slope), model 2 will fit the data better than model 4, but not as well as model 1. Furthermore, if there is no significant difference between model 4 and model 1, we would expect that there should also be no significant difference between model 4 and model 2, because model 2 lies "between" model 4 and model 1. Justify the conclusion on page 4-17 that model 4 and model 2 are different in view of the argument above, especially when the p-value of 6.6% is larger than the usual p-value criterion of 5%? In addition, the F Statistic values calculated for Comparisons 1 and 2 are different from the values that were presented by Westinghouse in the NEI/NRC meeting in the NRC headquarters on July 25, 1996. Clarify why the F statistic values have been changed.

Q5 Page 2-1, first paragraph
EPRI states that the data from plant AD were not included in the ARC database because the field-reported bobbin voltages for the indications appear to be high for the depths found for the indications. On page 3-10, EPRI states that the bobbin voltages were not cross-calibrated to the reference laboratory standard. If the latter is true, it is appropriate to exclude the plant AD data from the database until the cross calibration can be completed since the

voltages for these indications would not be appropriate. However, if the data were removed because the field-reported bobbin voltages appeared high for the depths of the indications, the staff believes that the data should not be excluded from the database (since excluding data that does not meet expectations is not appropriate unless the data can be shown to be invalid). Clarify the reason why the plant AD data was excluded from the database. If the voltages were not cross-calibrated to the reference laboratory standard, provide a schedule for completing the cross calibration.

Q6 Page 3-3, bottom of the page
It appears, as is stated, that exclusion criterion 2b allows any indication greater than 20 volts be excluded. This is contrary to the original exclusion criterion 2b stated in a letter from David Modeen of NEI to Brian Sheron of NRC, dated June 9, 1994. The original criterion allows exclusion of data points only if they had a voltage measurement which is at least 20 volts higher than the next adjacent point located at the outer boundary of the data. Clarify the intent of the statement in this paragraph.

Q7 Page 3-4, Section 3.2
(1) The staff believes that specimen R20C7-5 from plant AB-1 should be deleted from the database per EPRI exclusion criterion 2a. Criterion 2a specifies that specimens with $\leq$ 2 uncorroded ligaments between cracks and a crack depth less than 60% be excluded from the database. This data point satisfies criterion 2a and should be excluded, but EPRI did not exclude it from the database because EPRI states that the burst pressure is not "high" compared to the remainder of the data. The staff believes that this interpretation and modification to criterion 2a are inconsistent with GL 95-05. If this interpretation is valid, it essentially allows high outlying data points to be excluded but include only the "normal" data points. The staff believes that including the favorable data points and excluding the outliers would reduce the uncertainty in the correlation. The exclusion criteria should be applied consistently. If criterion 2a were applied consistently, specimen R26C63-2 from plant AC-1 as discussed in Section 3.3 should also be removed from the database because the number of uncorroded ligaments has not been reported.

(2) Similarly, EPRI excludes specimen R27C54 TSP 3 of plant A-2 from the database for the 7/8 inch diameter tubes on the basis of exclusion criterion 2a (page 4-7). For specimen R27C54, EPRI states that "EPRI Criterion 2a applies to atypical ligament morphology for indications having high burst pressures relative to the burst/voltage correlation and states that high burst pressure indications with $\leq$ 2 uncorroded ligaments in shallow cracks less than 60% deep should be excluded from the database." Again, this interpretation and modification to criterion 2a are inconsistent with GL 95-05. Specimen R27C54 TSP 3 should be excluded from the database by the mere fact that it had less than 2 ligaments between cracks and its depth was less than 60% through wall. The burst pressure should not be brought into the exclusion discussion.

Q8 Tables 5-1 and 5-2
In a letter dated March 4, 1996, TVA submitted an ARC database as a part of implementing the voltage-based ARC in the Sequoyah Unit 2 technical specifications. In a letter dated March 27, 1996, Duquesne Power also

submitted an ARC database for the same type of technical specification amendment for Beaver Valley Unit 1. The two ARC databases are identical and they include the destructive test data of steam generator tubes removed from nuclear plants in 1995. As a matter of reference, the staff used the TVA database and the 1993 EPRI database (as presented in EPRI report, NP-7480-L, 1993) to compare the database in Tables 5-1 and 5-2 in the 1996 EPRI report. The staff found the following differences:

(1) Although excluded from the 3/4 inch tube database, it appears that the burst pressure for model boiler specimen 591-3 was improperly calculated, if the data in the 1993 EPRI database report is assumed to be correct and consistent with the other model boiler data; (2) For specimen R05C28 TSP 2 of plant J-1 in the 7/8 inch tube database, the bobbin volt recorded (4.4 volts) in the TVA database is different from the recorded value (4.58 volts) in the 1996 EPRI database. The yield stress for specimen R05C28 TSP 2 also is different between the TVA database and 1996 EPRI database; and (3) the yield and ultimate stresses of specimen R22C26 of plant J-1 in the 7/8 inch tube database are different between the TVA database and 1996 EPRI database. Explain these differences.

Q9 Page 7-1
The probability of detection (POD) adjustment procedure cited in Generic Letter 95-05 is used, in part, to conservatively project the number and size of the indications that will be present in the steam generator tubes in the next inspection. The conservative projection in the number and size of indications ensures conservative estimates for the probability of burst and the primary-to-secondary leakage under postulated accident conditions. The proposed approach (i.e., the probability of prior cycle detection (POPCD) approach) differs from the POD approach in GL 95-05 and differs from a traditional POD approach. The POD approach in GL 95-05 accounts not only for indications not detected during the inspection but also for new indications which may develop during the course of the operating cycle. A traditional POD approach, on the other hand, would only account for indications not detected during an inspection. Since the POD approach in GL 95-05 may provide overly conservative results (as discussed above), an alternative to the GL 95-05 POD approach may be justified provided the alternative ensures conservative results (i.e., the projection of the end-of-cycle voltage distribution is conservative which ensures that the estimates for the probability of burst and the primary-to-secondary leakage under postulated accident conditions are conservative). The ability to conservatively project the end-of-cycle voltage distribution may be plant-specific, steam generator-specific, and/or cycle-specific since detection capability and the initiation of new indications depend, in part, on generator- and cycle-specific conditions (e.g., nature of interfering signals, temperature of tube, tube microstructure, etc.).

As a result of the above, the staff requests the following information to continue its review of the proposed POPCD approach:

(1) Discuss if indications not detected with the bobbin coil and which would be detected with the rotating pancake coil (RPC), if they were inspected, could be considered significant flaws. Discuss whether the

pulled tube data support the statement that significant indications (in terms of leakage or burst probability) can be expected to be detected by the bobbin coil and confirmed by RPC inspection. In addition, discuss whether the pulled tube data support the observation that indications detected by the bobbin coil and not confirmed through RPC inspection are insignificant. For example, discuss whether the population of bobbin indications confirmed through RPC inspection is different from the population of bobbin indications not confirmed by RPC in terms of their leakage and burst potential.

(2) Provide an assessment of the POPCD approach at conservatively projecting the EOC voltage distribution. Perform this assessment for at least 20 steam generators. The steam generators should be chosen arbitrarily from the entire population of plants which implement (or have implemented) the GL 95-05 repair criteria. The assessment should include data from steam generators where the results from the inspection were not included in the POPCD determination. It is intended that this assessment will determine whether or not the POPCD should be plant-specific, generator-specific, and/or cycle-specific and/or a more conservative POPCD adjustment procedure should be used.

In performing the above assessment, take into consideration that calculations of the EOC voltage distribution may be generated in a variety of ways (e.g., using a steam generator specific growth rate distribution and/or a bounding growth rate distribution), and use the most limiting assumptions in demonstrating the conservatism of the proposed approach.

Provide the criteria used in assessing the conservatism of the projected EOC voltage distribution (e.g., by comparing the projected probability of burst and leakage under postulated accident conditions using the POPCD approach to the results from the as-found condition).

(3) If the POPCD approach were to be implemented, discuss any assessment that would be performed at the end of each plant outage to confirm the adequacy of the POPCD approach. Discuss any reporting criteria to be implemented based on the assumptions in the proposed POPCD methodology.

Q.0 Page 8-1, References section
The staff requests the following reference documents:

1. NP-7480-L, volume 1, Revision 2, June 1996
2. NP-7480-L, volume 2, Revision 1, June 1996
3. NSD-EPRI-0823 (SG-96-02-007), "EPRI Agreement WOS 550-17 entitled, "Database Maintenance of ODSCC at TSP Intersections ARC" Revised database for 7/8 inch and 3/4 inch diameter tubes" Westinghouse February 14, 1996
4. EdF report D.5716/CTT/RS 94 6124, August 94.
5. EdF Report D. 5716/CTT/RB 94.6129, July 1994.

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