Virginia Electric and Power Company
Richmond, Virginia 23261

W. L. Stewart
Vice President
Nuclear Operations

March 8, 1988

United States Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Serial No. 86-477D
NO/RMK:jmj
Docket Nos. 50-338
50-339
License Nos. NPF-4
NPF-7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2
PROPOSED LICENSE AMENDMENT GDC4
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Virginia Electric and Power Company requested an amendment to Operating License Nos. NPF-4 and NPF-7 for the North Anna Power Station Units 1 and 2 by letter dated November 6, 1986 (Serial No. 86-477A). The proposed amendment would add a license condition stating that the design of the reactor coolant pump and steam generator supports may be revised in accordance with our November 6, 1986 submittal. Discussions were then held between members of our respective staffs during telephone conferences on January 23, 1987 and February 5, 1987. In response to NRC questions raised during these discussions, we submitted additional information in our letters dated February 25, 1987 (Serial No. 86-477B) and March 12, 1987 (Serial No. 86-477C).

The NRC subsequently requested additional information by letter dated July 17, 1987. Attachment 1 to this letter provides the specific responses to the questions in the July 17, 1987 NRC letter. Supporting analyses are provided in the proprietary Westinghouse report provided in Attachment 2, WCAP-11163, Supplement 1, "Additional Information in Support of the Technical Justification for Eliminating Large Primary Loop Pipe Rupture as the Structural Design Basis for North Anna Units 1 and 2." A non-proprietary version of this report, WCAP-11164, Supplement 1, is also provided in Attachment 3. The results of these additional analyses confirm the original conclusions that the dynamic effects of postulated ruptures of reactor coolant loop piping can be eliminated from the design basis. The primary loop component support design can be revised while retaining a margin of 10 for the leak rate, a margin of 2 for the crack size, and a margin of 1.4 on the combined applied loads. These margins are consistent with the guidelines of NUREG-1061, Volume 3.

Change: LPDR ltr Encl
NRC PDR ; NP
; NP

A001
1/1 Prop
1 Non Prop

As regards constraints on our schedule, please note the following. NRC approval of revisions to the design of primary loop component supports based on the elimination of postulated primary loop ruptures from the design basis for North Anna Units 1 and 2, in accordance with our original request, will allow the substitution of rigid restraints for certain existing large bore snubbers. Given the fabrication lead times for these restraints, NRC approval is needed by early April, 1988 in order to support the current outage date of November 4, 1988 for Unit 2.

Since WCAP-11163, Supplement 1 contains information proprietary to Westinghouse Electric Corporation, an affidavit signed by a representative of Westinghouse is provided in Attachment 4 along with an Application for Withholding. The affidavit sets forth the basis on which the information may be withheld from public disclosure and addresses with specificity the considerations listed in 10CFR2.790(b)(4). Accordingly, we request that the information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10CFR2.790. Correspondence with respect to the proprietary aspects of the Application for Withholding or the supporting affidavit should reference CAW-88-014 and should be addressed to R. A. Wiesemann, Manager, Regulatory and Legislative Affairs, Westinghouse Electric Corporation, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Should you have any further questions, please contact us.

Very truly yours,

W L Stewart

W. L. Stewart

cc: U. S. Nuclear Regulatory Commission
101 Marietta Street, N.W.
Suite 2900
Atlanta, GA 30323

Mr. J. L. Caldwell
NRC Senior Resident Inspector
North Anna Power Station

VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

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Change: LPDR 4r Encl
NRC PDR ; 1 NP
; 1 NP

A001
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101 Marietta Street, N.W.
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Mr. J. L. Caldwell
NRC Senior Resident Inspector
North Anna Power Station

ATTACHMENT 1

REQUEST FOR ADDITIONAL INFORMATION
ON ELIMINATION OF DYNAMIC EFFECTS OF POSTULATED
PRIMARY LOOP RUPTURES FROM DESIGN BASIS OF
NORTH ANNA POWER STATION UNITS 1 AND 2
DOCKET NOS 50-338 AND 50-339

Virginia Electric and Power Company requested an amendment to operating license Nos. NPF-4 and NPF-7 for the North Anna Power Station Units 1 and 2 by letter dated November 6, 1986 (Serial No. 86-477A). Later discussions were held between the members of the NRC staff and Virginia Electric and Power Company staff during telephone conferences on January 23, 1987 and February 5, 1987. The staff requested additional information during these discussions. The requested information was transmitted by letters dated February 25, 1987 (Serial No. 86-477B) and dated March 12, 1987 (Serial No 86-477C).

The NRC requested additional information by letter dated July 17, 1987. Item by item responses have been prepared and are presented in this attachment. The requested additional confirmatory analyses were performed using the criteria and recommendations provided by the NRC, and are presented in Supplement 1 to the previously submitted Westinghouse report WCAP-11163. The results of these additional confirmatory analyses verify the margins of 10 for leakage rate, 2 on the crack size and 1.4 on the applied load. The margins are consistent with the guidelines of NUREG-1061, Volume 3.

Based upon the results of analyses, material properties and material behavior presented in WCAP-11163 and Supplement 1 to WCAP-11163 the following summary is presented.

Normal operating loads including pressure, dead weight and thermal expansion, were used to determine leak rate and leakage size flaws. The flaw stability analyses performed to assess margins against pipe rupture were based on normal plus Safe Shutdown Earthquake (SSE) loads. In the stability analysis, the individual normal load components were summed algebraically and the seismic loads were then added absolutely. In the leak rate analysis, the individual normal load components were summed algebraically. Loads and material properties for the entire primary loop piping were reviewed and five potentially critical locations were indentified. Leak-before-break calculations were performed at those five different locations in the piping including the limiting location.

For Westinghouse facilities, including North Anna Units 1 and 2, there is no history of cracking failures in reactor coolant system (RCS) primary loop piping. The RCS primary loop has an operating history which demonstrates its inherent stability. This includes a low susceptibility to cracking failure from the effects of corrosion (e.g., intergranular stress corrosion cracking), water hammer, or fatigue (low and high cycle). This operating history totals over 450 reactor years, including 5 plants each having over 16 years of operation and 15 other plants each with 11 years of operation.

The material tensile and toughness properties are provided in WCAP-11163 and its Supplement 1. Because there are cast stainless steel piping and fittings and associated welds in North Anna Units 1 and 2 primary loop (which are subjected to thermal aging), the predicted end of life toughness properties of cast stainless steel materials were estimated according to procedures previously accepted by the NRC. The material tensile properties at operating temperatures were estimated using generic procedures. For flaw stability evaluations, the lower-bound stress-strain properties were used. For leakage rate evaluation average stress strain properties were used.

North Anna Unit 1 and 2 has RCS pressure boundary leak detection system which meets the intent of the guidelines of Regulatory Guide 1.45 such that a leakage of 1 gpm can be detected. The calculated leak rate through the postulated flaw is large relative to the required sensitivity of the plant's leak detection systems; the margin is at least a factor of 10 on leakage and is consistent with the guidelines of NUREG-1061, Volume 3.

The margin between the leakage size flaw (i.e. the flaw size using 10 gpm leak rate) and the critical size flaw was evaluated in the flaw stability analysis. The margin in terms of flaw size is at least equal to 2 and is consistent with guidelines of NUREG-1061, Volume 3.

In the flaw stability analyses, the margin in terms of load for the leakage-size flaw under normal plus SSE loads exceeds 1.4 and also is consistent with the guidelines of NUREG-1061, Volume 3.

On the basis of these evaluations, it is concluded that the North Anna Units 1 and 2 primary loop piping complies with the revised GDC-4 according to the criteria in NUREG-1061, Volume 3. Thus the probability or likelihood of large pipe breaks occurring in the primary coolant loops of North Anna Units 1 and 2 is sufficiently low such that dynamic effects associated with postulated pipe breaks need not be a design basis.

Question 1

The primary loop piping and fittings were fabricated from cast stainless steel. Describe whether the piping and fittings are centrifugally cast stainless steel or statically cast stainless steel. Also, identify the welding process of the primary loop and indicate if solution annealing was performed.

Response 1

The primary loop piping of North Anna Units 1 and 2 are made of SA351 CF8A cast stainless steel. The elbows are made of SA351 CF8M cast stainless steel. The piping is centrifugally cast while the fittings are statically cast. The field welds feature a gas tungsten arc weld (GTAW or TIG) root pass followed by shielded metal arc welding (SMAW) to completion. The shop welds are either SMAW or submerged arc (SAW) with a GTAW root pass. Weld repairs on shop welds would be either SMAW or GTAW. The welds have TP 308 stainless steel chemistry. No solution annealing was performed.

Question 2

The material properties were presented in tables 3-1 through 3-3 in WCAP-11163. Describe whether the properties are plant specific data from certified material test reports (CMTRs) or Section III Code-minimum values, at room temperature or operating temperature. Provide the elastic modulus, yield strength, ultimate strength, and stress-strain curve, at the limiting location and at the operating temperature.

Response 2

The material properties presented in tables 3-1 through 3-3 of WCAP-11163 are the ASME Boiler and Pressure Vessel Code Section III minimum properties at the operating temperatures. These values were used in the analysis of WCAP-11163.

The enclosed Supplement 1 to WCAP-11163 provides the other requested properties based on material certifications. The additional confirmatory analyses provided in Supplement 1 use these properties. Table S3-1 of Supplement 1 to WCAP-11163 shows tensile properties at 70°F for SA351 CF8A and SA351 CF8M materials. Table S3-2 of Supplement 1 to WCAP-11163 shows the tensile properties at 650°F as taken from the material certifications. The properties at 650°F were used to obtain the representative minimum and average tensile properties. The properties at plant operating temperatures were obtained by linearly ratioing the above values using the ASME Section III code minimum properties at various temperatures. The moduli of elasticity were obtained from the Nuclear Systems Materials Handbook (reference S3.1) of Supplement 1 to WCAP-11163.

The elastic modulus, yield strength, ultimate strength and poisson's ratio at operating temperatures are summarized in Table S3-3 of Supplement 1 to WCAP-11163 for the critical locations 1 through 5 discussed in WCAP-11163.

The lower bound stress-strain curves used in the stability evaluations are given in figures S3-1 through S3-3 and are obtained using the methodology of reference S3-1 of Supplement 1 to WCAP-11163.

Question 3

It appears that the same stress-strain relationship was used in the fracture stability and leakage calculations. The licensee should use the lower-bound stress-strain relationship for the stability evaluation and the average stress-strain relationship for the leakage evaluation.

Response 3

In response to this question, analyses were redone using lower-bound stress-strain relationships in the stability evaluations and the average stress-strain relationships for the leakage evaluations. The results are presented in Section 4 and 5 of the Supplement 1 to the WCAP-11163. The table S4-1 shows the leakage size flaws at critical locations, which yield leak rate of 10 gpm. The table S5-1 presents the results of elasto-plastic crack stability analyses and clearly indicates a margin greater than 2 on leakage size flaw and a margin greater than 1.4 on the applied load. Although the results of these reanalyses are somewhat different, they do not in any way change the basic conclusions of WCAP-11163.

Question 4

Linear elastic fracture mechanics (LEFM) were used for the fracture stability analysis. However, from the calculated "J_{app}", it appears that the associated Irwin plane-stress plastic zone sizes are not small compared with the half-crack length "a". The license should use elastic-plastic fracture mechanics instead of LEFM procedures.

Response 4

In response to this question, additional confirmatory stability analyses were performed. Elastic plastic fracture mechanics was used for determining both J_{app} and T_{app} in the stability analyses. The lower-bound stress-strain relationships were used for the stability evaluations. These reanalyses are presented in Section 5 of Supplement 1 to WCAP-11163; table S5-1 summarizes the results of these reanalyses. The results demonstrate margins equal to or greater than those required in NUREG-1061, Volume 3.

Question 5

Limit load analysis was used to estimate the size of a stable crack. However, limit load analysis does not account for material toughness limitations. In particular, low toughness thermally-aged cast stainless steel is involved in the present evaluation. The licensee should use a fracture stability analysis which accounts for material toughness.

Response 5

Limit load analyses were presented in WCAP-11163 for reference only and to indicate margin against a ductile rupture. It is shown in WCAP-11163 that the limit load analyses do not produce limiting conditions. Limiting conditions are established by fracture stability analyses which account for material toughness. Fracture stability analyses which account for material toughness are presented both in WCAP-11163 and its Supplement 1. Those analyses are used to establish the required margins of safety.

Question 6

Load critical and toughness critical locations were discussed. However, the leak-before-break (LBB) evaluation margins should be demonstrated for the limiting location having the least favorable combination of stress and material properties. The limiting location may be defined from a fracture stability evaluation of the load critical and toughness critical locations. Since the primary loop piping is of a similar size, the location with the smallest stable crack size (independent of leakage) is the limiting location for LBB evaluations.

Response 6

The results presented in table S5-1 of the Supplement 1 to WCAP-11163 indicate that the limiting location is location 1, because it is associated with the smallest stable crack size. The required leak-before-break margins on leakage rate crack size and loading are presented at this location as well as the other four locations identified as potentially critical locations in WCAP-11163.

Question 7

The limiting location as discussed in item 6 above should be evaluated to demonstrate that the LBB margins are satisfied. Specifically, the margins are 10 on the leakage rate, 2 on the crack size, and 1.4 on the applied load, as discussed in detail in NUREG-1061, Volume 3. (Note that in the submittal, the licensee did not discuss the margin of 1.4 on the applied load. The licensee should include this margin of 1.4 on the applied load in the LBB evaluations.)

Response 7

As discussed in the response to question 6 there are five locations which were identified as potentially critical locations, with location 1 considered as the most limiting. The desired margins are presented at all five locations to establish margins.

The table S4-1 in Supplement 1 to WCAP-11163 provides the leakage size cracks which yield leak rate of 10 gpm when subjected to normal operating loads; these crack sizes provide a margin of 10 on detectable leak rate. The table S5-1 in Supplement 1 to WCAP-11163 establishes that, based upon elastic plastic fracture mechanics, flaws twice the leakage size flaws remain stable when subjected to normal plus SSE loadings. This demonstrates a margin of at least 2 on the crack size. The same table also establishes that leakage size flaws remain stable when subjected to 1.4 times the normal plus SSE loads. Thus the margins of 10 on the leakage rate, 2 on crack size and 1.4 on the applied load as required in NUREG-1061, Volume 3 have been demonstrated.