VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

October 13, 1997

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

Serial No. 97-553
NL&OS/ETS R0
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**
**ASME SECTION XI RELIEF REQUESTS NDE-44 AND NDE-39**
**SERVICE WATER SYSTEM LEAKS**

On September 9, 1997 during a system walkdown, ten locations with evidence of possible previous leakage i.e., stains, were identified in four ASME Class 3 Service Water lines in North Anna Units 1 and 2. In order to reduce the number of entries into action statements and service water manipulations, a repair plan was developed and implemented for the affected service water lines. Pursuant to 10 CFR 50.55a(3)(ii), Virginia Electric and Power Company requests relief of ASME Code requirements, paragraph IWA-5250(a)(2) (Unit 1 - 1983 Edition with Summer 1983 Addenda) and paragraph IWA-5250(a)(3) (Unit 2 - 1986 Edition) for the period of September 9, 1997 through September 25, 1997, when the last weld was repaired. Relief Requests NDE-44 and NDE-39 for the leaking welds in Units 1 and 2, respectively, and the basis for the relief requests are provided in the attachment to this letter.

Where meaningful results could be obtained, the areas of leakage were examined by radiography and an evaluation was performed for continued operation in accordance with the Generic Letter 90-05, "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping." The evaluation determined the operability and continued safe operation of the examined service water lines until the necessary ASME Code repairs could be made. The leaking locations were identified during a recurring system visual inspection which involves all of the stainless steel piping associated with the service water system. Additionally, in accordance with GL 90-05, radiographic assessment was performed on an additional sample of five welds. Each of these welds were found acceptable by radiography and structural integrity analysis. The indications of possible leakage were in the welds or the adjacent base material. Based on previous laboratory assessments of the repaired leaking indications the cause of leakage was determined to be microbiological influenced corrosion (MIC).

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The condition of the Service Water System was monitored during the period corresponding to the relief request. The monitoring program included walkdowns of the affected welds to identify and quantify any leakage. No significant changes were noted in the condition of the affected piping during this period.

This relief request has been reviewed and approved by the Station Nuclear Safety and Operating Committee.

If you have any additional questions concerning this request, please contact us.

Very truly yours,

RF Saunders

R. F. Saunders
Vice President - Nuclear Engineering and Services

Attachment

Commitments made in this letter:

None.

cc: U. S. Nuclear Regulatory Commission
Region II
Atlanta Federal Center
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Mr. M. J. Morgan
NRC Senior Resident Inspector
North Anna Power Station

**ASME Section XI Relief Requests**
**NDE-44 and 39**

**North Anna Power Station Units 1 and 2**
**Virginia Electric and Power Company**

Virginia Electric & Power Company
North Anna Power Station Units 1 and 2
Second 10 Year Interval
Request for Relief Number NDE-44 (Unit 1)
Request for Relief Number NDE-39 (Unit 2)

I. IDENTIFICATION OF COMPONENTS

| Mark/Weld# | Line# | Drawing# | Joint |
|---|---|---|---|
| 14W | 2"-WS-775-163-Q3 | 11715-CBM-78C-2 SH. 2<br>12050-WS-2485E | SW |
| 53W | 2"-WS-776-163-Q3 | 11715-CBM-78G-2 SH. 2<br>12050-WS-2482C | SW |
| FW55 | 4"-WS-F65-163-Q3 | 11715-CBM-78A-2 SH. 1<br>11715-WS-2D89B | BW |
| FW67 | 4"-WS-47-163-Q3 | 11715-CBM-78C-2 SH. 2<br>11715-WS-17F | BW |
| FW83 | 3"-WS-75-163-Q3 | 11715-CBM-78C-2 SH. 2<br>11715-WS-1075A | BW |
| FW65 | 4"-WS-56-163-Q3 | 11715-CBM-78C-2 SH. 2<br>11715-WS-18E | BW |
| FW61 | 4"-WS-56-163-Q3 | 11715-CBM-78A-2 SH. 2<br>11715-WS-18D | BW |
| FW66 | 4"-WS-56-163-Q3 | 11715-CBM-78A-2 SH. 2<br>11715-WS-18D | BW |
| 8 | 4"-WS-H48-163-Q3 | 11715-CBM-78A-2 SH. 4<br>12050-WS-2H48A | BW |
| 11A | 4"-WS-H48-163-Q3 | 11715-CBM-78A-2 SH. 4<br>12050-WS-2H48A | BW |

(a) The above welds are Class 3, moderate energy piping in the Service Water (SW) system;

(b) Line 2"-WS-775-163-Q3 is the cross-connection between instrument air heat exchangers 2-IA-E-1B and 2-IA-E-1C. Line 2"-WS-776-163-Q3 is the cross-connection between instrument air heat exchangers 2-IA-E-1A and 2-IA-E-1B. Line 4"-WS-F65-163-Q3 is the return from the Unit 1 air conditioning condenser. Line 4"-WS-47-163-Q3 provides cooling water to the Unit 1 charging pump lube oil coolers and instrument air heat exchangers. Line 3"-WS-75-163-Q3 is the return line from the charging pump lube oil coolers. Line 4"-WS-56-163-Q3 is the return from the Unit 1 charging pump lube oil coolers and instrument air compressors. Line 4"-WS-H48-163-Q3 provides cooling water to the Unit 2 air conditioning condensers. The nominal operating pressure and temperature is 75 psig and 95°F, respectively; and

(c) Joint type - butt weld (BW), and socket weld (SW).

II. CODE REQUIREMENTS

The above welds had external evidence of through-wall leakage, i.e., active leaks or stains. Virginia Electric and Power Company decided to proceed under the assumption that each of the above welds contain through-wall flaws. Although this evidence of leakage was not detected during the conduct of a system pressure test, it is being treated as such, and the requirements of IWA-5250 of the 1983 Edition and Summer 1983 Addenda are applicable to Unit 1. The requirements of IWA-5250 of the 1986 Edition are applicable to Unit 2.

"IWA-5250 Corrective Measures:

(a) The source of leakage detected during the conduct of a system pressure test shall be located and evaluated by the Owner for corrective measures as follows:...
(2 or 3) repairs or replacements of components shall be performed in accordance with IWA-4000 or IWA-7000, respectively."

Articles IWA-4000 and IWD-4000 of ASME Section XI Code repair requirements would require removal of the flaw and subsequent weld repair.

III. CODE REQUIREMENT FROM WHICH RELIEF IS REQUESTED

Relief is requested from performing the above Code required repair of the above identified welds until the affected piping system can be taken out of service. The specific Code requirement for which relief is requested is the 1983 Edition and Summer 1983 Addenda, IWA-5250(a)(2) for Unit 1, and the 1986 Edition, IWA-5250(a)(3) for Unit 2.

IV. BASIS FOR RELIEF REQUEST

This relief request is submitted in accordance with NRC Generic Letter 90-05 (GL 90-05), "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping." The following information and justification are provided in accordance with the guidelines of Part B and C of Enclosure 1 to GL 90-05.

Scope, Limitations and Specific Considerations

Scope

The scope consists of the welds identified in Section I with evidence of possible through-wall leaks in the service water system for North Anna Power Station Units 1 and 2. The material of the piping is stainless steel ASME SA-312 type

316L.

Limitations

Based on radiographic examinations and laboratory examinations of removed portions of piping from previous replacements, Microbiological Influence Corrosion (MIC) was determined to be the cause of the flaws. Radiographs of welds FW67, FW83, FW65, FW61, FW66, 8, and 11A show indications of MIC. The MIC induced flaws originated on the inner diameter of the pipe and were detected during plant operation. The intent of this request is to obtain relief for the period of operation from the identification of a through-wall flaw until repair was accomplished. To the extent practical, the repair was accomplished in accordance with the guidance of NRC Generic Letter 90-05. This period extends from identification of the first leaking weld on **September 9, 1997** to when the repair of each weld (suspected of having through-wall flaws) was completed. All identified welds suspected of having through-wall flaws were repaired by September 25, 1997.

Specific Considerations

System interactions, i.e., consequences of flooding and spray on equipment were evaluated. The identified flaws were located on the piping such that potential through-wall leakage would not affect plant equipment.

The structural integrity of the butt welds was evaluated based on radiographic examination results, the required design loading conditions, including dead weight, pressure, thermal expansion and seismic loads. The methods used in the structural integrity analysis consisted of an area reinforcement, fracture mechanics, and limit load analysis. Each indication was considered to be through-wall due to the inability of either radiography or ultrasonics to determine indication depth. A summary of the flaw evaluation is pr vided in Attachment 1. All welds were analyzed and found acceptable, except welds FW65 and 8.

Radiography of socket weld 14W on line 2"-WS-775-163-Q3, and weld 53W on line 2"-WS-776-163-Q3 were not attempted because radiographs of socket welds do not yield meaningful results. Additionally, flaws cannot be characterized for socket welds. Therefore, complete structural integrity analysis was not performed. Lines 2"-WS-775-163-Q3, and 2"-WS-776-163-Q3 were removed from service and the socket welds were replaced by September 25, 1997, sixteen (16) days after the evidence of leakage was detected.

Because of the inability of both RT and UT to give reliable through-wall depth for MIC indications, all MIC indications were considered through-wall. This conservative assumption caused weld 8 on line 4"-WS-H48-163-Q3 and weld FW65 on line 4"-WS-56-163-Q3 to fail the assessment requirements of GL 90-05. Weld 8 was replaced on September 23, 1997 two (2) days after the weld was radiographed and removed from service. Weld 11A on line 4"-WS-H48-163-Q3 was replaced at the same time as weld 8. Weld FW65 on line 4"-WS-56-163-Q3 was replaced on September 16, 1997. Weld FW55 on line 4"-WS-F65-163-Q3 did not show evidence of MIC on the radiographs. Therefore, no structural integrity analysis was performed on weld FW55. However, weld FW55 was replaced as a conservative measure on September 23, 1997 two (2) days after the weld was radiographed and removed from service. Welds FW67 (on line 4"-WS-47-163-Q3), FW83 (on line 3"-WS-75-163-Q3), FW61 (on line 4"-WS-56-163-Q3), and FW66 (on line 4"-WS-56-163-Q3) showed evidence of acceptable MIC as determined by radiography and structural integrity analysis. However, these welds were replaced as a conservative measure on September 16, 1997.

The structural integrity for each weld identified with evidence of through-wall leakage (and remaining in service) was monitored weekly by visual monitoring of through-wall flaws to determine any degradation of structural integrity.

Generic Letter 90-05 allows two options for temporary non-code repairs of Class 3 piping in moderate energy systems, (1) non-welded repairs, and (2) leaving the piping as-is if there is no leakage and the flaw is found acceptable by the "through-wall flaw" approach discussed in Section C.3.a. The temporary non-code repair approach selected was to leave the welds as they were found, subject to monitoring and meeting the criteria for consequences and for structural integrity as described above until replaced.

Evaluation

Flaw Detection During Plant Operation and Impracticality Determination

The subject welds were identified as having evidence of through-wall leakage during a Service Water System walkdown conducted on September 9, 1997, when both Units were operating. During the past several months Virginia Electric and Power Company has been monitoring, evaluating, and replacing through-wall leaks in the Service Water System caused by MIC. Removing portions of the Service Water System, prior to performing a structural integrity analysis, due to MIC can unnecessarily reduce the margin of safety by isolating portions of the Service Water System that are structurally sound and capable of performing their intended safety function. Therefore, performing Code repairs immediately was considered impractical.

Root Cause Determination and Flaw Characterization

The Service Water System at North Anna Power Station has previously experienced MIC. The radiograph examinations of the service water welds with indications of through-wall leaks revealed small voids surrounded by exfoliation, which is typical of MIC. No other type of operationally caused defects were identified by the radiographs.

Flaw Evaluation

Flaw evaluation for the welds was performed as described in Attachment 1. The flaws were evaluated by three types of analyses, area reinforcement, limit load analysis, and fracture mechanics evaluation using the guidance from NRC Generic Letter 90-05. Because of the inability for either radiography or ultrasonic techniques to determine the extent of wall degradation, at the identified location, the structural assessment considered each indication to be through-wall.

V. AUGMENTED INSPECTION

To assess the overall degradation of the service water system augmented radiographic examinations were performed. After the initial through-wall flaws were identified, five (5) additional locations on lines having the same function were examined using radiography. One (1) of the five (5) welds (weld FW74 on line 4"-WS-F65-163-Q3) had evidence of MIC, without showing evidence of through-wall leakage, i.e. stains. Weld FW74 was found structurally acceptable by radiography and structural integrity evaluation, and not replaced. Weld FW56 on line 4"-WS-F65-163-Q3 was replaced for ease of construction, i.e., it is on the same elbow as FW55. The remaining three welds which did not show evidence of MIC on the radiographs were not replaced, (welds FW59, FW60 and FW73 on line 4"-WS-F65-163-Q3).

VI. ALTERNATE PROVISIONS

As an alternative to performing Code repairs in accordance with IWA-5250(a)(2) for Unit 1 and IWA-5250 (a) (3) for Unit 2 on through-wall flaws in the Service Water System, it is proposed to allow the through-wall flaws to remain in service until a scheduled code repair, unless the structural integrity has been determined to be unacceptable. This alternate provision applies to the subject welds from identification of the first leaking weld on September 9, 1997 to the repair of each weld suspected of having a through-wall flaw. All through-wall flaws had been repaired by September 25, 1997.

The proposed alternative stated above ensures that the overall levels of plant quality and safety will not be compromised.

VII. IMPLEMENTATION SCHEDULE

Repairs of the affected welds were completed by September 25, 1997.

References:

1. USAS B31.1 Power Piping Code - 1967 Edition

2. EPRI Report NP-6301-D, "Ductile Fracture Handbook"

3. Nuclear Regulatory Commission Generic Letter 90-05 "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping"

Attachment 1

Flaw Evaluation Methods and Results

Introduction

Butt welds identified by radiography as having MIC were analyzed for structural integrity by three methods, area reinforcement, limit load analysis, and linear elastic fracture mechanics evaluation.

**Area Reinforcement Analysis**

The area reinforcement analysis is used to determine if adequate reinforcing exists such that ductile tearing would not occur. The guidelines of ANSI B31.1 paragraph 104.3.(d) 2 (reference 1) are used to determine the Code required reinforcing area. The actual reinforcing area is calculated and is checked against the required reinforcement area.

The Code required reinforcement area in square inches is defined as:

$$1.07(t_m)(d_1)$$

Where $t_m$ is the code minimum wall, and $d_1$ is the outside diameter

The Code required reinforcement area is provided by the available material around the flaw in the reinforcing zone.

The results of this analysis determined that for the subject four inch (4") and three inch (3") pipes, a hole size of 2.2" and 1.7" respectively will be contained by the reinforcement provided by the excess material in the near vicinity.

**Limit Load Analysis**

The structural integrity of the piping in the degraded condition was established by calculating the minimum margin of safety based upon a Limit Load Analysis. These methods are documented in EPRI report NP-6301-D (Ductile Fracture Handbook) (reference 2).

The limit load analysis of the postulated flawed sections were performed with a material flow stress representing the midpoint of the ultimate strength and yield point stress for the SA312-TP316L stainless steel material at the design temperature of 150°F.

The flawed sections were subjected to deadweight, thermal, and seismic DBE loading.

The allowable limit load is given by,

$M_a = 2 \cdot \sigma_f \cdot R_m^2 \cdot t \cdot (2\cos(\beta) - \sin(\theta))$ in-lbf

$\sigma_f$ = flow stress = 0.5 ($S_y$ + $S_u$), psi
$S_y$ = yield stress, psi
$S_u$ = ultimate stress, psi

$R_m$ = mean radius of the pipe (inches)

$$\beta = \frac{\Theta}{2} + \frac{\Pi \cdot (R_i^2 \cdot P) + F}{4 \cdot \sigma_f \cdot R_m \cdot t}$$

$R_i$ = internal radius of the pipe (inches)
P = pressure (psig)
F = axial load (lbs)
D = Outside diameter (inches)
t = pipe thickness (inches)
$\theta$ = half angle of the crack (radians) = $\frac{\text{crack length}}{2 \cdot R_m}$

MR = Resultant Moment from the above mentioned loading conditions

$$MR = \sqrt{MY^2 + MZ^2 + T^2}$$

MY = Bending Moment
MZ = Bending Moment
T = Torsion

The calculated factor of safety is,

$$FS = \frac{M_a}{(MR)}$$

The minimum factor of safety of 1.4 is required to be qualified for continued operation.

A summary of the results is listed in Table 1.

**Fracture Mechanics Evaluation**

A linear elastic fracture mechanics analysis was performed for circumferential through-wall crack using the guidance provided in NRC Generic Letter 90-05. The structural integrity of the piping in the degraded condition was established by calculating the stress intensity factor ratio based upon a Fracture Mechanics evaluation. This method is documented in EPRI report NP-6301-D (Ductile Fracture Handbook) (reference 2).

A through-wall circumferential crack was postulated for every area containing MIC. The cracks were subjected to a design pressure loading of 150 psig in addition to the deadweight, normal operating thermal and seismic DBE loadings. For the purpose of this evaluation a generic allowable stress intensity factor of $K_{IC}$ = 135 ksi√in was used for the material per NRC GL 90-05.

The applied stress intensity factor for bending, $K_{IB}$, is found by:

$$K_{IB} = \sigma_b \cdot (\pi \cdot R_m \cdot \theta)^{0.5} \cdot F_b$$

The applied stress intensity factor for internal pressure, $K_{IP}$, is found by:

$$K_{IP} = \sigma_m \cdot (\pi \cdot R_m \cdot \theta)^{0.5} \cdot F_m$$

The applied stress intensity factor for axial tension, $K_{IT}$ is found by:

$$K_{IT} = \sigma_t \cdot (\pi \cdot R_m \cdot \theta)^{0.5} \cdot F_t$$

The stress intensity factor for residual stresses, $K_{IR}$ is found by:

$$K_{IR} = S \cdot (\pi \cdot R_m \cdot \theta)^{0.5} \cdot F_t$$

Total applied stress intensity factor $K_T$ includes a 1.4 safety factor and is calculated by:

$$K_T = 1.4 \cdot (K_{IB} + K_{IP} + K_{IT}) + K_{IR}$$

The allowable stress intensity factor is taken from Generic Letter 90-05.

$K_{ALL}$ = 135 ksi√in for stainless steel.

Stress Intensity Factor Ratio is defined as:

$$SR = \frac{K_T}{K_{ALL}}$$

The stress intensity factor ratio shall be less than 1.0 for continued operation.

A summary of the results are listed in Table 1.

## Table 1
## SUMMARY OF FLAW EVALUATION RESULTS FOR SERVICE WATER WELDS

| Weld Nos. | Line Nos. | Flaw Length Analyzed Length in | Actual Flaw Length in | Max. Axial Load lbs | Max. Torsion T ft-lbs | Max. Bending Moment MY ft-lbs | Max. Bending Moment MZ ft-lbs | Max. Resulant Moment MR ft-lbs | Allowable Limit Load $M_a$ ft-lbf | Factor of Safety[1] | Applied $K_I$ ksi$\sqrt{in}$ | Allowable $K_{IC}$ ksi$\sqrt{in}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FW65 | 4"-WS-56-163-Q3 | 2.12 | 3.25 | Note 2 | - | - | - | - | - | - | - | - |
| 8 | 4"-WS-H48-163-Q3 | 2.12 | 2.25 | Note 2 | - | - | - | - | - | - | - | - |
| FW67 | 4"-WS-47-163-Q3 | 2.12 | 1.936 | 117 | 18 | 57 | 319 | 324.55 | $1.197\times10^4$ | 36.8 | 62.24 | 135 |
| FW83 | 3"-WS-75-163-Q3 | 1.65 | 0.937 | 122 | 7 | 62 | 189 | 199.03 | $6.452\times10^3$ | 32.4 | 54.54 | 135 |
| FW61 | 4"-WS-56-163-Q3 | 2.12 | 0.437 | 151 | 152 | 140 | 454 | 498.82 | $1.196\times10^4$ | 23.98 | 63.99 | 135 |
| FW66 | 4"-WS-56-163-Q3 | 1.125 | 1.125 | 138 | 418 | 102 | 506 | 664.80 | $1.094\times10^4$ | 16.46 | 42.26 | 135 |
| 11A | 4"-WS-H48-163-Q3 | 2.12 | 1.125 | 293 | 674 | 240 | 666 | 977.46 | $1.196\times10^4$ | 12.23 | 66.82 | 135 |

Notes:
1. Limit load factor of safety is Allowable Limit Load/Resultant Moment.
2. Weld FW65 and 8 failed the structural integrity evaluation because the actual flaw length was greater than the analyzed flaw length. The analyzed flaw length was bounded by the 15% circumferential length as maximum thru-wall flaw lengths permitted by NRC Generic Letter GL 90-05.