VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

August 8, 1997

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

Serial No. 97-453
NL&OS/ETS R0
Docket Nos. 50-338
License Nos. NPF-4

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNIT 1
ASME SECTION XI RELIEF REQUEST NDE-42
SERVICE WATER SYSTEM LEAKS

On June 25, 1997 during a system walkdown, three locations with evidence of possible previous leakage i.e., stains, were identified in three ASME Class 3 Service Water lines in North Anna Unit 1. In order to reduce the number of entries into action statements and service water manipulations, a repair plan was developed and implemented for the three affected service water lines. Pursuant to 10 CFR 50.55a(g)(6)(i), Virginia Electric and Power Company requests relief of ASME Code requirements, paragraph IWA-5250(a)(2) for the period of June 25, 1997 through July 9, 1997, when the last weld was repaired. Relief Request NDE-42 for the leaking welds for Unit 1, 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 three 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 welds. The three indications of possible leakage were in the welds or the adjacent base material. Based on subsequent laboratory assessments of two of the repaired leaking indications, the cause of leakage was determined to be microbiological influenced corrosion (MIC).

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.

A047/1

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,

R F Saunders

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

Attachment

Commitments made in this letter:

None

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

ASME Section XI Relief Request
NDE-42

North Anna Power Station Unit 1
Virginia Electric and Power Company

Virginia Electric & Power Company
North Anna Power Station Unit 1
Second 10 Year Interval
Request for Relief Number NDE-42

I. IDENTIFICATION OF COMPONENTS

Mark/Weld#	Line#	Drawing#	Joint
9W	2"-WS-84-163-Q3	11715-CBM-78C-2 SHT. 2 11715-WS-1087E	SW
16W	4"-WS-46-163-Q3	11715-CBM-78C-2 SHT. 2 11715-WS-19F	BW
84	4"-WS-57-163-Q3	11715-CBM-78C-2 SHT. 2 11715-WS-16E	BW
19W	3"-WS-75-163-Q3	11715-CBM-78C-2 SHT. 2 11715-WS-1075A	BW

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

(b) Line 4"-WS-46-163-Q3 provides cooling water to the Unit 1 charging pump lube oil coolers and instrument air compressors. Line 2"-WS-84-163-Q3 is the return from the 1-IA-E-1A heat exchanger. Lines 4"-WS-57-163-Q3 is the return from instrument air compressors and charging pump lube oil coolers. Line 3"-WS-75-163-Q3 is the return line from the charging pump lube oil coolers. 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 is applicable.

"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) 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 effected 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).

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 Unit 1. The material of the piping, for all welds except 19W, is stainless steel ASME SA-312 type 316L with 316 weld filler metal. The material of the piping for weld 19W is ASME SA-312 type 316L with inconnel filler metal.

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. Additionally, laboratory examinations of welds 9W and 19W shows evidence of MIC. Welds 16W and 84 have not yet been subjected to laboratory examinations, however MIC was seen on radiographs of these welds. 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

June 25, 1997 to 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 July 9, 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 analyses. 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 provided in Attachment 1. All welds were analyzed and found acceptable, except welds 84, and 9W.

Radiography of socket weld 9W on line 2"-WS-84-163-Q3 was 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. Line 2"-WS-84-163-Q3 was removed from service upon detection of leakage. The socket weld was replaced two (2) days after the evidence of leakage was detected. Weld 84 on line 2"-WS-57-163-Q3 was removed from service after the weld was radiographed. Because of the inability of both RT and UT to give reliable through-wall depth for MIC indications, all MIC indications was considered through-wall. This conservative assumption caused the weld to fail the assessment requirements of GL 90-05. The weld was replaced on July 3, 1997 two (2) days after the weld was radiographed and removed from service.

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 June 25, 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 for welds 16W and 19W.

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.

The analyses determined that welds 16W and 19W were capable of maintaining their structural integrity until they were repaired. The following is based on the results from the analyses:

1. Ductile tearing will not occur at the flaw locations when the piping is subjected to the design pressure from the area reinforcement calculation.

2. The limit load analysis shows that there is enough margin against a ductile rupture for the most limiting case analyzed.

3. For the subject welds a linear elastic fracture mechanics analysis shows that the applied stress intensity factor at the analyzed flaws is below the allowable stress intensity factor per the guidance of NRC Generic Letter 90-05. Therefore, a failure by brittle fracture is unlikely to occur.

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. Four (4) of the five (5) welds had evidence of MIC, without showing evidence of through-wall leakage, i.e. stains. All augmented weld locations were found structurally acceptable by structural integrity evaluation. However, all five (5) of the welds selected for augmented inspection were replaced. The one weld which did not show evidence of MIC on the radiographs was replaced because it is located on a reducer on the opposite side of a weld containing MIC.

VI. ALTERNATE PROVISIONS

As an alternative to performing Code repairs in accordance with IWA-5250(a)(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 June 25, 1997 to the repair of each weld suspected of having a through-wall flaw. All through-wall flaws have been repaired by July 9, 1997. The through-wall flaws were evaluated to assure they met the criteria for flooding and spraying consequences and for structural integrity and were visually monitored as described above until code repaired.

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 effected welds were completed by July, 9, 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

σ_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)
θ = half angle of the crack (radians) = $\frac{\text{crack length}}{2 \cdot R_m}$

MR = Resultant Moment from the above mentioned loading conditions

$$MR=\sqrt{{}'Y^2+MZ^2+T^2}$$

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:

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

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 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. Resulting Moment MR ft-lbs	Allowable Limit Load M_a ft-lbf	Factor of Safety[1]	Applied K_I $ksi\sqrt{in}$	Allowable K_{IC} $ksi\sqrt{in}$
16W	4"-WS-46-163-Q3	2.12	1.9	184	0	236	212	317	11960	37.71	62.24	135
84	4"-WS-57-163-Q3	2.12	3.75	Note 2	-	-	-	-	-	-	-	-
19W	3"-WS-75-163-Q3	1.66	.200	64	30	37	76	89.69	6439	71.79	52.65	135

Notes:

1. Limit load factor of safety is Allowable Limit Load/Resulting Moment.
2. Weld 84 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.