VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

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

Serial No. 96-571
NL&OS/ETSR7
Docket No. 50-338
50-339
License No. NPF-4
NPF-7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2
ASME SECTION XI RELIEF REQUEST NDE-31
SERVICE WATER SYSTEM LEAKS

On October 31, 1996, a pin hole leak was identified in a four inch line of the ASME Class 3 Service Water System of North Anna Unit 1. During further inspection and evaluation of the Service Water System, additional pin hole leaks and locations with possible evidence of previous leakage were identified in the Service Water System. At the time the initial leak was identified, the Service Water System was in an extended Action Statement, with the "B" SW header drained for repair and restoration. Therefore, the affected portions of the operating Service Water System could not be immediately isolated and repaired in accordance with ASME Code requirement without requiring a unit shutdown. Upon exiting the extended action statement on November 23, 1996, repair activities for the affected welds began. Each confirmed or suspected leaking weld was repaired per the requirements of the ASME Code by December 14,1996. 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 October 31, 1996 through December 14, 1996. Relief Request NDE-31 for the leaking welds and the basis for the relief request are provided in Attachment 1 to this letter.

In accordance with Generic Letter 90-05, "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping," an evaluation of the Service Water System was performed to determine operability and continued safe operation until the necessary ASME Code repairs could be made. When meaningful radiographic examination data could be obtained, the evaluation included an assessment of the structural integrity of the flawed service water piping using a "through-wall flaw" evaluation technique. An assessment of the overall degradation of the system using augmented radiographic and visual inspection was also performed. The pin hole leaks were in the welds or the adjacent heat affected zone of the stainless steel service water piping. Based on radiographic examination and subsequent laboratory assessment,

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the failure mechanism was determined to be microbiological influenced corrosion (MIC). These evaluations concluded that the extent of MIC related corrosion did not affect the structural integrity of the Service Water System. During the expanded inspections, two butt welds were determined to be inoperable due to a combination of MIC, construction flaws and the conservative assumption that any indication identified by radiography was considered through-wall. Both of the service water lines associated with the inoperable welds were isolated immediately, repaired, and returned to service within the applicable Technical Specification action statement.

During the period of continued operation and repair, the condition of the Service Water System was monitored. The monitoring program included walkdowns of the affected welds and the accessible portions of the stainless steel Service Water System piping to monitor 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,

James P. O'Hanlon

James P. O'Hanlon
Senior Vice President - Nuclear

Attachment

cc: U. S. Nuclear Regulatory Commission
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Mr. R. D. McWhorter
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North Anna Power Station Unit 1
ASME Section XI Relief Request

NDE-31

Virginia Electric & Power Company
North Anna Power Station Unit 1 and Unit 2
Second 10 Year Interval
Request for Relief Number NDE-31 Revision 1

I. IDENTIFICATION OF COMPONENTS

Mark/Weld#	Line#	Drawing#	Joint
FW-18W, 71	4"-WS-46-163-Q3	11715-CBM-78A-2 SHT. 4 11715-WS-19E	BW
87, 91	4"-WS-46-163-Q3	11715-CBM-78C-2 SHT. 2 11715-WS-19F	BW
89, 59	4"-WS-56-163-Q3	11715-CBM-78C-2 SHT. 4 11715-WS-18F	BW
85	4"-WS-56-163-Q3	11715-CBM-78A-2 SHT. 4 11715-WS-18F	BW
89	4"-WS-57-163-Q3	11715-CBM-78A-2 SHT. 4 11715-WS-16E	BW
58	2"-WS-60-163-Q3	11715-CBM-78G-2 SHT. 1 11715-WS-1060B	BW
76	2"-WS-61-163-Q3	11715-CBM-78G-2 SHT. 1 11715-WS-16B	BW
66*	2"-WS-62-163-Q3	11715-CBM-78G-2 SHT. 1 11715-WS-1062B	BW
67	2"-WS-62-163-Q3	11715-CBM-78G-2 SHT. 1 11715-WS-1062B	SW
91	2"-WS-65-163-Q3	11715-CBM-78G-2 SHT. 1 11715-WS-1064B	BW
9W	3"-WS-74-163-Q3	11715-CBM-78G-2 SHT. 1 11715-WS-1074A	BW
71*	3"-WS-75-163-Q3	11715-CBM-78G-2 SHT. 1 11715-WS-1075A	BW
46*, 59	3"-WS-76-163-Q3	11715-CBM-78G-2 SHT. 1 11715-WS-1076A	BW
73	2"-WS-450-163-Q3	11715-CBM-78G-2 SHT. 2 11715-WS-2450B	SW
86	2"-WS-451-163-Q3	11715-CBM-78G-2 SHT. 2 11715-WS-2450B	SW
97	2"-WS-461-163-Q3	11715-CBM-78G-2 SHT. 2 11715-WS-16B	BW
10	2"-WS-775-163-Q3	11715-CBM-78C-2 SHT. 2	SW
20	2"-WS-945-153A-Q3	11715-CBM-78G-2 SHT. 2 11715-WS-2951A	SW
40	2"-WS-954-153A-Q3	11715-CBM-78G-2 SHT. 2 11715-WS-2951A	SW
7	2"-WS-954-153A-Q3	11715-CBM-78G-2 SHT. 2 11715-WS-2954A	SW
43	4"-WS-H48-163-Q3	11715-CBM-78A-2 SHT. 4 12050-WS-2H48A	BW

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

(b) Provide cooling water from the service water to instrument air compressors and charging pump lube oil coolers for both units and return service water back to the return headers. Normal flow is 20 to 100 gpm at an operating pressure of 100 psig. The design pressure is 150 psig and design temperature is 150°F.

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

* These welds were repaired before radiographic examination could be performed.

II. IMPRACTICABLE CODE REQUIREMENTS

Five (5) of the above welds had external evidence of through-wall leakage, i.e. external moisture. The remaining welds were stained. Virginia Electric and Power Company decided to proceed under the assumption all of the above welds contain through-wall flaws. Although this evidence of leakage was not detected during the conduct of a system pressure test, the requirements of IWA-5250 of the 1983 Edition and Summer 1983 Addenda and the 1986 Edition are applicable to Unit 1 and Unit 2 respectively. The specific Code requirement for which relief is requested is IWA-5250(a)(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) 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.

When the first through-wall leak, FW-18W on line 4"-WS-46-163-Q3, was identified, Code repairs were considered impractical to perform. In order to perform Code repairs the "A" service water header would have required removal from service. The "B" service water header was already out of service during this time for piping upgrades. Taking both service water headers out of service to perform Code repairs would have required both units to be shut down.

Subsequent to the detection of the initial through-wall leak, additional areas were identified as having evidence of through-wall leaks. Virginia Electric and Power Company decided to replace all welds having evidence of through-wall leakage in a planned evolution to reduce the number of action statements and service water system manipulations.

III. BASIS FOR RELIEF REQUEST

This relief request is submitted in accordance with NRC Generic Letter 90-05, "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping". The following information and justification is 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 listed above in piping with evidence of possible through-wall leaks in the Service Water system at the North Anna Power Station Unit 1 and Unit 2. The material of the piping is stainless steel ASME SA-312 type 316L with 316 or inconel weld filler metal for pipe class 163 and ASME SA-312 type 304 with 304 filler metal for pipe class 153A.

Limitations

Based on radiographic examinations and examination of removed portions of piping from replacements, Microbiological Influence Corrosion (MIC) is the cause. The MIC caused 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 with the identified through-wall flaws until repair could be accomplished without a forced shutdown by following the guidance of NRC Generic Letter 90-05 to the extent practical. This period extended from detection of the first leaking weld on October 31, 1996 to the repair of all welds suspected of having through-wall flaws was completed on December 14, 1996.

Specific Considerations

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

The structural integrity of the butt welds were evaluated based on radiographic examination results for the required design loading conditions, including dead weight, pressure, thermal expansion and seismic (DBE) 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 butt welds analyzed were found to be acceptable except for two, weld 58 on line 2"-WS-60-163-Q3 and weld 9W on line 3"-WS-74-163-Q3. These two welds were found to be unacceptable due to the extent of the indication identified by radiographic examination. Almost all of the identified defects were conservatively identified as MIC. The welds were removed and cut open for analysis. The analysis determined that a large amount of the areas reported as MIC by radiography were actually construction defects, slag and lack of penetration, etc.

The welds that were found to be unacceptable were declared inoperable and repaired within the limiting conditions of operation as defined in the plant's Technical Specifications.

Radiography of the socket welds was attempted but did not yield meaningful results. Since the flaws could not be characterized for socket welds a structural analysis was not performed. The socket welds were monitored for leakage until replaced. All socket welds were replaced or removed from service within 15 days from the date of discovery.

Three (3) butt welds, weld 66 on line 2"-WS-62-163-Q3, weld 71 on 3"-WS-75-163-Q3, and weld 46 on 3"-WS-76-163-Q3, were adjacent to planned replacements and were replaced before radiography was performed.

The structural integrity for all welds identified with evidence of through-wall leakage were monitored by the following methods:

- Weekly visual monitoring of through-wall flaw and leakage.
- Walkdown of the accessible portions of the service water system. This walkdown was performed on November 25, 1996 and November 26, 1996. All subject welds were replaced before the next scheduled monthly system walkdown.
- Radiographic examination of all but three (3) butt weld locations was performed. This examination was not repeated since the subject welds were replaced before the next three (3) month RT surveillance was due. Socket welds were not radiographed.

The temporary non-code repair was to leave the welds as they are found, subject to monitoring and meeting the criteria for consequences and for structural integrity as described above.

Evaluation

Flaw Detection During Plant Operation and Impracticality Determination

The flaws were detected when Unit 1 was in service. When the initial flaw on the "A" train of the Service Water System was detected, October 31, 1996, service water piping on the "B" train associated with the component cooling heat exchangers was being refurbished. This work required one train of service water to be isolated for a length of time that would exceed the seven (7) day action statement of Tech. Spec. 3.7.4.1.d. By letter dated October 11, 1995, the NRC issued Technical Specification Amendment Nos. 194 and 175 for North Anna Power Station, Units 1 and 2 respectively. These amendments allowed one train of service water to be isolated for 49 days. The "B" train of service water was taken out of service on October 21, 1996 for piping upgrades. Performing an immediate Code repair would have required the "A" train to be taken out of service which would require Unit 1 to be shut down.

Augmented inspections and a walkdown of the accessible portion of the Service Water System were performed to assess the integrity of the system. This resulted in additional welds being identified as having evidence of possible leakage. Virginia Electric and Power Company decided it was impractical to immediately replace all of the subject welds. Code repairs were performed within 44 days from the date of discovery under controlled conditions by use of limited scheduled service water outages.

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 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. Additionally, examinations performed by a Virginia Electric and Power Company staff metallurgist of a sample of the piping segments removed to repair the leaking welds confirmed the presence of MIC.

Flaw Evaluation

Flaw evaluation for butt welds subjected to radiographic examination was performed as described in Attachment 1. The flaws were evaluated by three types of analyses, area reinforcement, limit load analyses, 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, the structural assessment considered each indication to be through wall. Additionally, the radiography is not conclusive in differentiating purely MIC conditions from conditions such as slag and incomplete root penetration, which has been aggravated by corrosion during service. Therefore, these areas were also considered fully degraded for the structural assessments. This resulted in two welds being rejected by the structural acceptance criteria weld 58 on line 2"-WS-60-163-Q3 and weld 9W on line 3"-WS-74-163-Q3. The lines containing these two welds were declared inoperable and the action was taken per the plant's Technical Specifications. Supplemental examinations of weld 58 and weld 9W, after removal from the piping system, determined MIC as only part of the problem. Pre-existing conditions from the time of installation were also a major contributor.

The analysis determine each butt weld listed in the scope was capable of maintaining their structural integrity until it was repaired. This is based on the results from the analysis.

1. Ductile tearing will not occur at a postulated two (2) inch hole when the piping is subjected to the design pressure. This applies to each pipe size under the scope of this relief request.

2. The limit load analysis shows that there is at least a margin of 5 against a ductile rupture for the most limiting case analyzed.

3. 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 brittle fracture is unlikely.

IV. AUGMENTED INSPECTION

To assess the overall degradation of the service water system augmented radiographic and visual inspections were performed. After the initial through-wall flaw was identified six (6) additional locations on lines having the same size and function were examined using radiography. This sample group

also identified welds degraded by MIC. An additional sample of five (5) welds was examined using radiography and four (4) out of the five (5) welds were identified as having MIC. Any indication of MIC was treated as a through-wall defect and analyzed for structural stability as described in Attachment 1. All augmented weld locations were found to be structurally acceptable.

In addition, a walkdown of the accessible portions of the service water system was performed and identified 17 welds with evidence of leakage. Radiography was used to determine the extent of MIC for butt welds. Butt welds identified with MIC were evaluated for structural integrity as described in Attachment 1. As stated previously, all but two (2) butt welds were found to be acceptable. Socket weld flaws could not be characterized by radiography or ultrasonics. Therefore, an analysis could not be performed.

V. ALTERNATE PROVISIONS

It is proposed that the operation of the Service Water System from October 31, 1996 through December 14, 1996 with the identified possible through-wall flaws, subject to monitoring and meeting the criteria for consequences and for structural integrity as described above be accepted as an alternative to IWA 5250(a)(2). Operation in this mode continued until the subject welds were replaced. Each subject weld was replaced by December 14, 1996.

During the above period, structural integrity of the Service Water System was continuously monitored by the following methods until the repairs required by IWA 5250(a)(2) are completed.

- Weekly visual monitoring of all areas with possible evidence of leakage.
- Walkdown of the accessible portion of the service water system at least monthly.

The proposed alternative stated above ensured that the overall level of plant quality and safety were not compromised.

Attachment:

1. Flaw Evaluation Methods and Results

References:

1. USAS B31.1 Power Piping 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 reinforcement area required is provided by the available material around the flaw in the reinforcing zone.

The results of this analysis determined that for the subject piping, a two (2) inch diameter hole would have acceptable reinforcement.

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 of 45.98 ksi 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 = $\frac{D - t}{2}$

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

R_i = internal radius = $\frac{D - 2 \cdot t}{2}$ inches

P = pressure = 150 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

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

MY = Bending Moment
MZ = Bending Moment
T = Torsion

The calculated factor of safety is,

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

A summary of the results are 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$\sqrt{\text{in}}$ 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 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.

$$K_{ALL} = 135 \text{ ksi}\sqrt{\text{in}}$$

Stress Intensity Factor Ratio is defined as:

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

A summary of the results are listed in Table 1.

Table 1
SUMMARY OF FLAW EVALUATION RESULTS FOR SERVICE WATER WELDS

Weld Nos.[1]	Line Nos.	Crack Length	Axial Load lbs	Torsion T ft-lbs	Bending Moment MY ft-lbs	Bending Moment MZ ft-lbs	Resulting Moment MR ft-lbs	Allowable Limit Load M_a ft-lbf	Factor of Safety[2]	Applied K_T ksi$\sqrt{in}$	Allowable K_{IC} ksi$\sqrt{in}$
89	4"-WS-56-163-Q3	4.0	98	27	313	51	318.275	7899	24.818	123.8	135
Enveloping Calc 1		3.376	1155	539	942	995	1472.0	9133	6.204	120.6	135
43	4"-WS-H48-163-Q3	1.6	519	813	1076	561	1461.0	13100	8.969	58.02	135
59	3"-WS-76-163-Q3	2.876	783	21	55	97	113.468	4542.5	40.032	96.06	135
Enveloping Calc 2		2.25	96	140	149	144	250.074	1283.33	5.13	109.70	135
76	2"-WS-61-163-Q3	1.25	240	30	44	102	115.065	1564.17	13.597	55.65	135

Notes:

1. Enveloping Calc. 1 includes welds FW-18W, 71, 87, and 91 on line 4"-WS-46-163-Q3, welds 59 and 85 on line 4"-WS-56-163-Q3, and weld 89 on line 4"-WS-57-163-Q3. Enveloping Calc. 2 includes welds 91 on line 2"-WS-65-163-Q3 and weld 97 on line 2"-WS-461-163-Q3.
2. Limit load factor of safety is Allowable Limit Load/Resulting Moment