UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA ST., N.W.
ATLANTA, GEORGIA 30323

Report Nos.: 50-338/85-02 and 50-339/85-02

Licensee: Virginia Electric and Power Company
Richmond, VA 23261

Docket Nos.: 50-338 and 50-339 License Nos.: NPF-4 and NPF-7

Facility Name: North Anna 1 and 2

Inspection Conducted: January 22 - 25, 1985

Inspector: N. Economos 2/7/85
Date Signed

Approved by: for J. J. Blake, Section Chief 2/7/85
Engineering Branch
Division of Reactor Safety
Date Signed

SUMMARY

Scope: This routine, unannounced inspection involved 25 inspector-hours on site in the areas of service water pipe mechanical cleaning and pipe replacement; licensee action on previous open items; Pump and Valve Program, evaluation of performance test results, Units 1 and 2.

Results: No violations or deviations were identified.

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REPORT DETAILS

1. Licensee Employees Contacted

*E. W. Harrell, Station Manager
M. L. Bowling, Assistant Station Manager
*T. Bennett, Superintendent, Projects Engineering and Construction
*J. A. Adams, Senior Staff Engineer
G. Seay, Senior QC Inspector
B. C. Davis, Senior Construction Specialist
M. Morgan, Associate Engineer, Performance and Testing

Other licensee employees contacted included technicians and office personnel.

NRC Resident Inspector

*J. G. Luehman, Resident Inspector

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on January 25, 1985, with those persons indicated in paragraph 1 above. The licensee did not identify as proprietary any of the materials provided to or reviewed by the inspector during this inspection.

3. Licensee Action on Previous Enforcement Matters (92702)

(Open) Unresolved Item (UNR) 339/83-10-02, U/T Procedure ISI-205 Calibration Provisions and Examination of Accumulator Tank B Weld #3. By memorandum dated August 31, 1984, NRR informed Virginia Electric and Power Company (VEPCO) that the requested relief from Code required examinations of certain welds on the accumulator and boron injection tanks has been denied. The licensee has been granted relief from performing the code required volumetric examination of these welds during the fourth and third refueling outages for Units 1 and 2 respectively. The Code required volumetric examinations must be performed on the next scheduled refueling outage, however. Therefore, this item remains open pending a review and evaluation of examination results.

(Closed) UNR 339/83-10-01, Verification of Calibration Following Inspection System Changes. Field changes have been issued to applicable procedures which were reviewed and approved for implementation during future Inservice Inspection (ISI).

4. Unresolved Items

Unresolved items were not identified during this inspection.

5. Inspector Followup Items (IFI) (92701)

(Closed) IFI 338/81-04-05, Section XI Weld Repair Program. The licensee has issued ADM 9.9 dated August 16, 1984, "ASME Section XI Repair and Replacement Program". The scope/purpose of this document is to maintain design integrity of ASME Class 1, 2 and 3 pressure retaining boundaries with respect to repairs and replacement. It references Section XI (80W81) subsections IWA, B, C and D-4000 (74575). Modifications to original design of system require engineering approval and documentation changes. Major modifications and installation of new systems are controlled by the Design Change Program described in Section 3 of the Nuclear Power Station QA Manual (NPSQAM). Examples of work activities covered by this document as well as responsibilities and steps/procedures to be followed are specified.

6. Service Water System Piping Corrosion - Pipe Replacement and Mechanical Cleaning Program Units 1 and 2 (92706)

a. Background

The phenomenon involving corrosive attack which led to pinhole leaks in the service water supply and return headers to the charging pump lube oil coolers, and the air compressors was first reported in April 1981 . The cause of this problem has been attributed to a combination of "aggressive water" and bacteria found in Lake Anna water. A study of the phenomenon conducted by Lehigh University has disclosed that approximately 80% of the corrosive attack can be attributed to the "aggressive water" and 20% to bacterial reduction of the mild carbon steel piping. A more detailed chronology of licensee activity, submitted Licensee Event Reports (LERs), and a discussion of the subject matter is documented in AEOD technical review report T341, December 19, 1983. A copy of this report is provided as Attachment 1. Also, in a recent meeting that was held at the NRC Headquarters, Bethesda, Maryland on October 2, 1984, to discuss the subject matter, VEPCO presented an update on the corrosion problem and submitted their plan for removing the rust and silt accumulation from the internal surfaces of service water system (SWS) piping by hydrolazing. A copy of this report is provided as Attachment 2.

By discussions with cognizant personnel and document review, the inspector understood that presently the corrosion rate is approximately 0.010" per year. Two types of corrosive attack is evident in this piping i.e., general or uniform corrosion which has caused a general wall thickness reduction over the entire supply side of the pipe system in contact with Lake Anna water, and extensive pitting corrosion which has resulted in pinhole leaks. The corrosion rate in the pits is several orders of magnitude greater than that observed in locations where only uniform corrosion was experienced. In order to remedy this

situation, the licensee introduced the use of a molybdate-base (Mo04) chemical, a corrosion inhibitor, by additions to the reservoir. This program was implemented on or about July 13, 1984. The licensee representative stated that the inhibitor addition has been effective in significantly reducing the aggressiveness of the Lake Anna and/or service water. To illustrate this point, the licensee provided the inspector with carbon steel test coupons which had been exposed to inhibitor treated service water for periods of up to 60 days. Results of subsequent measurements show that the coupons experienced a corrosion rate of less than 0.001" per year.

b. Mechanical Cleaning

Because the inhibitor is most effective when the carbon steel surface is free of corrosion product buildup, the licensee is making preparations to clean the internal pipe surfaces down to bare metal by hydrolazing. The licensee, VEPCO's Engineering and Construction (E&C) Planning Department is in charge of the project, has divided the work into five categories which involve components and/or pipe line sections identified as "Tech Spec" and "Non-Tech Spec". These categories are identified as follows:

| | |
|---|---|
| Category A | Non-Tech Spec Hydrolazing |
| Category B | Tech Spec Hydrolazing Requiring Main Header Isolation |
| Category C | Tech Spec Hydrolazing Requiring Branch Line Isolation |
| Category D | Maintenance Outage Hydrolazing |
| Category E | Refueling Outage Hydrolazing |

This work effort is planned to be performed over an 18-month period, beginning with January 1985 and continuing to June 1986. Five proposed work schedule plans have been drawn. They take into consideration North Anna's 72-hour Technical Specification Action Statement, and a proposed 168-hour Action Statement which is presently under NRR review. The licensee plans to begin hydrolazing the N-TS Category A items, including the control room A/C condensers, the auxiliary service water pump, and the coating of auxiliary service water pump components. This work is expected to begin shortly and will continue through March 1985.

c. Administrative Controls - Document Review

At the time of this inspection, the replacement of existing carbon steel pipe with stainless steel type 316-L schedule 40 pipe material was complete. Certain phases of this activity were observed and documented in RII Reports 50-338, 339/83-24 and 84-33.

During this work effort, the inspector reviewed the following documents:

- Proposed Methodology for Implementating Mechanical Cleaning of Service Water Piping and Repair of Service Water Isolation Valves
- Mechanical Cleaning of Service Water Piping Air Conditioning System Piping - DCP #84-75 (Final Draft)
- Pipe Preservation Section 12, Auxiliary Service Water Branch, DCP #84-83
- Service Water System Upgrade DCP #82-S08B
- Replacement of 4" Charging Pump Service Water Headers DC-83-13
- Redundant 2" Supply Header Installation DC-82-S08B
- Dwg. #MFSK-5455-WS-48-2, Pipe Lugs to Pipe Supports H48A to D Modifications
- North Anna UFSAR Section 9.2.1
- NAS-1009, Revision 5, Installation of Piping and Mechanical Equipment

The service water line where carbon steel pipe was replaced with stainless 316-L type material was identified as Seismic Category 1, Class 3 per ANSI B31.7 Nuclear Power Piping Code, 1969 Edition.

d. Work Observation - Completed Welds

Welds in the newly installed lines were fabricated in accordance with ANSI B31.7 code requirements. Weld procedures and welder performance qualifications were governed by ASME Section IX.

Completed field fabricated welds were selected at random and inspected to ascertain whether the following characteristics complied with applicable code and procedural requirements:

1. Weld surface finish and appearance.
2. Transitions between components of different diameters and wall thickness.
3. Weld reinforcement.
4. Removal of temporary attachments, arc strikes and weld spatter.

5. Absence of surface defects including cracks, laps, lack of penetration, lack of fusion, porosity, slag, oxide film and undercut exceeding prescribed limits.

Welds selected for the above work effort were as follows:

| Unit 2 Weld | Size | Return Iso | Line to "A" Header Type |
|---|---|---|---|
| FW-65 | 4" sch. 40 | WS16D Rev. 1 | Pipe to Flange |
| FW-66 | 4" sch. 40 | WS16D Rev. 1 | Pipe to 45° Ell |
| FW-67 | 4" sch. 40 | WS16D Rev. 1 | 45° Ell to Pipe |
| FW-68 | 4" sch. 40 | WS16D Rev. 1 | Pipe to Flange |
| FW-74 | 4" sch. 40 | WS-17F | Pipe to Reducer 4"x3" |
| FW-79 | 4"x3" Red. sch.40 | WS-160 | 4" Gate Valve |

e. Record Review and Evaluation

(1) Welding

- Records of the above welds were reviewed to ascertain whether the prescribed QA/QC inspections and nondestructive examinations had been performed and documented at the appropriate times. Areas of specific interest included pipe cleanliness, fitup and weld complete inspections, identification of welder, welding technique, filler metal, component identification, and final acceptance by appropriate, QA/QC personnel.

  Quality records for the aforementioned materials were reviewed for code and procedure compliance including conformance with specification, storage conditions, identification and issue control requirements.

  Quality records of pipe, valves and fittings joined by the aforementioned welds were reviewed to verify receipt inspection, retrievability and compliance with specification as applicable. Items selected for this review were as follows:

| Component | Purchase Order No. | Item No. |
|---|---|---|
| Flange | 61331 | 3 |
| Elbow 45° | 61331 | 26 |
| Valve VGW-15X | 61470 | 1 |
| Pipe | 61462 | 1 |

(2) Material Identification and Control

- Filler metal used on the aforementioned welds included:

| | | |
|---|---|---|
| ER-308 | 3/32" | C2277R308 |
| ER-308 | 1/8" | B923 |

(3) Nondestructive Examination:

- Completed welds were liquid penetrant (PT) inspected per NDE PT-1 Revision 2 requirements. The inspector reviewed PT reports for the aforementioned welds and found them satisfactory. PT material certifications were reviewed for halogen and sulfur content and found acceptable.

Within the areas inspected, no violations or deviations were identified.

7. Inservice Testing and Pumps and Valves - Units 1 and 2 (92706)

Review of Inservice Testing Program Implementation

Selected aspects of the licensee's implementation of inservice testing (IST) requirements for pumps and valves were reviewed to verify compliance with regulatory requirements and licensee commitments. The applicable code for IST, as identified through 4.0.5 of the Technical Specifications and 10 CFR 50.55(a)(g) is ASME Section XI (74S75). The inspector discussed the scheduling, performance, and documentation of pump/valve testing with cognizant on-site personnel. In addition, the inspector reviewed the documentation of previously performed pump/valve performance tests (PT) for Units 1 and 2 to determine accuracy, completeness and Code compliance. The PTs reviewed were as follows:

Unit 1

| | | | |
|---|---|---|---|
| 1-PT-133.7 | Sample Valves | 3 mos. | 1/20/85 |
| 1-PT-78.1 | Residual Heat Removal | monthly | 1/23/85 |
| 1-PT-34.6 | Turbine Generator Motor Driven Oil Pump | monthly | 1/23/85 |
| 1-PT-71.3 | Auxiliary Feedwater Pump | monthly | 1/23/85 |

Unit 2

| | | | |
|---|---|---|---|
| 2-PT-82.3A | Diesel Generator Test | weekly | 1/20/85 |
| 2-PT-212.6 | Accumulator Isolation MOVs | 3 mos. | 1/20/85 |
| 2-PT-213.2 | Charging Pump MOVs | 3 mos. | 1/21/85 |
| 2-PT-82.3B | Diesel Generator Test | weekly staggered | 1/21/85 |
| 2-PT-133.7 | Sample Trip Valve | 3 mos. | 1/24/85 |
| 2-PT-132 | Safety Injection Valve | 3 mos. | 1/23/85 |
| 2-PT-57.1B | L. Head S. Injection Pump | 3 mos. | 1/16/85 |

Within the areas inspected, no violations or deviations were identified.

Attachments
1. AEOD Technical Review Report T341
2. Proposed Methodology for Implementing Mechanical Cleaning of Service Water Piping and Repair of Service Water Isolation Valves

ATTACHMENT 1

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

DEC 19 1983

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MEMORANDUM FOR: Karl V. Seyfrit, Chief
Reactor Operations Analysis Branch
Office for Analysis and Evaluation
of Operational Data

AEOD/T341

FROM: Earl J. Brown, Lead Engineer
Engineering Systems
Reactor Operations Analysis Branch

SUBJECT: CORROSION OF CARBON STEEL PIPE IN SERVICE WATER HEADERS

The enclosed Technical Review Report is forwarded for your consideration. Based on the nature of the corrosive attack and the long term aspects of the proposed solution, we should anticipate similar reports in the future. However, it does not appear that additional AEOD effort is needed at this time.

Earl J. Brown

Earl J. Brown, Lead Engineer
Engineering Systems
Reactor Operations Analysis Branch

Enclosure:
As stated

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# AEOD TECHNICAL REVIEW REPORT*

UNIT: North Anna Power Station, Unit 1
DOCKET NO.: 50-339
LICENSEE: Virginia Electric and Power Co.
NSSS/AE: Westinghouse/Stone and Webster

TR REPORT NO. AEOD/T341
DATE: December 19, 1983
EVALUATOR/CONTACT: E. J. Brown

SUBJECT: CORROSION OF CARBON STEEL PIPE IN SERVICE WATER HEADERS

EVENT DATES: January 13, 1983; January 18, 1983; January 25, 1983; (LER 83-014/03-L)


## SUMMARY

A total of seven LERs since 1981 refer to 12 events involving corrosive attack with pinhole leaks in the service water supply and return headers to the charging pump lube oil coolers and the air compressors. The corrosive action was found to be a combination of two mechanisms that are generic to both units. One relates to the lake water having a very low dissolved solid content with a high affinity to dissolve whatever it contacts and the second involves bacteria such as sulfate reducers, ensheathed iron and filamentous iron. The corrosion appears as localized pinholes rather than general wall thinning. Although corrective actions have been identified to slow the attack, additional events should be expected until the piping is eventually replaced. There does not appear to be a need for additional AEOD effort at this time.



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* This document supports ongoing AEOD and NRC activities and does not represent the position or requirements of the responsible NRC program office.

DISCUSSION

On three separate occasions in January 1983 with Unit 2 in Mode 1 and Unit 1 in Mode 5, it was necessary to isolate a service water supply header to the charging pump lube oil coolers and the air compressors for both units to repair pinhole leaks caused by corrosion. The specific dates and headers affected on Unit 1 were as follows (LER 83-014):

January 13, 1983 - "A" Service Water Supply Header (line 4"-WS-46-151-Q3), two leaks.

January 18, 1983 - "B" Service Water Supply Header (line 4"-WS-47-151-Q3), one leak.

January 25, 1983 - "A" Service Water Supply Header (line 4"-WS-47-151-Q3), one leak.

The redundant service water supply header to the charging pump lube oil coolers and air compressors remained in service while the opposite header was isolated for repairs.

Subsequent to the preceding event, Unit 2 (Docket 339) had a similar occurrence reported in LER 83-007. Similar events were also reported by LERs 338/81-024, 81-046, 81-071, 82-006, and 82-081. The event dates and affected piping headers are as follows:

Unit 2 (339)

LER 83-007

February 1, 1983 - "B" Service Water Supply Header (line 4"-WS-47-151-Q3)

February 8, 1983 - "B" Service Water Supply Header (line 3"-WS-74-151-Q3)

Unit 1 (338)

LER 82-081

December 3, 1982 - "A" Service Water Supply Header (line 3"-WS-73-151-Q3)

December 8, 1982 - "A" Service Water Supply Header (line 3"-WS-73-151-Q3)

LER 82-006

March 5, 1982 - "A" Service Water Return Header
(line 4"-WS-57-151-Q3)

LER 81-071

August 27, 1981 - "B" Service Water Supply Header
(line 3"-WS-74-151-Q3)

September 5, 1981 - "B" Service Water Supply Header
(line 3"-WS-74-151-Q3)

LER 81-046

May 27, 1981 - "B" Service Water Supply Header
(line 3"-WS-74-151-Q3)

LER 81-024

April 21, 1981 - "B" Service Water Supply Header
(line 3"-WS-74-151-Q3)

It appears that the first reported corrosion event occurred on April 21, 1981 and the LER indicates a study was initiated to determine the cause of corrosion. The cause was first reported in LER 81-071 after completion of the study at Lehigh University. The cause was attributed to a combination of "aggressive water" and bacterial reduction of the mild steel piping. Analysis of Lake Anna water showed it has a very low dissolved solid content and the water has a high affinity to dissolve whatever it contacts. The total alkalinity and hardness levels are also low. The service water system operation also includes aeration through the spray system which also adds oxygen. Thus, the conclusion was that this set of circumstances contributes to the water being very aggressive or corrosive to mild steel piping. The LER indicates that approximately 80% of the corrosion present in the service water system can be attributed to the aggressive water process.

Similarly, the bacterial investigation indicates that 20% of the corrosion can be attributed to three types of bacteria found in the service water. The bacteria are sulfate reducers (sulfide producers), ensheathed iron bacteria, and filamentous iron bacteria.

The corrosion is in the form of localized, random pinhole corrosive attack. There does not appear to be any evidence of generalized wall thinning connected with this type of corrosion. However, the corrosive attack is generic to both North Anna Units.

The usual corrective action has been to cut out and replace the pipe where the pinhole leaks occur. Long term actions include chemical treatment to inhibit or slow corrosion attack that could lead to further degradation of the service water piping. Reports also indicate that equipment and piping which has degraded beyond acceptable limits will be replaced during major plant outages. The most recent LER indicates that plans are being formulated to consider replacement of damaged material. Also, during discussions with the resident inspector it was revealed there are long term plans that involve replacement of the carbon steel pipe.

FINDINGS

These seven LERs have resulted in 12 events involving pinhole leaks in service water supply and return headers to the charging pump lube oil coolers and the air compressors. It appears that the licensee immediately recognized the generic aspects and took steps to identify the cause of the corrosion. The corrosive attack is generic to both units and although the entire service water system could be affected, the only reported leaks have been in the small piping (3" and 4") headers. The damage appears restricted to localized attack with small pinholes through the wall. There was no reported evidence of wall thinning and hence little expectation of pipe rupture. The licensee has implemented chemical cleaning procedures to slow the attack and is considering replacement of the affected pipe on a long term basis.

CONCLUSIONS

Failure of this piping is a potentially serious event in that loss of lube oil cooling would eventually lead to loss of the charging pump and high head injection cooling to the reactor. Although the cause has been identified, the current corrective actions will only slow the attack rather than prevent the attack. Therefore, it should be anticipated that similar events will occur in the future until the piping is replaced. It does not appear that additional AEOD effort is needed at this time.