VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

February 27, 2003

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Serial No. 03-101
NL&OS/GDM R0
Docket No. 50-339
License No. NPF-7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNIT 2
NRC BULLETIN 2002-02 – REACTOR PRESSURE VESSEL HEAD AND VESSEL HEAD PENETRATION NOZZLE INSPECTION PROGRAM
ROOT CAUSE EVALUATION AND REVISED INSPECTION RESULTS

On August 9, 2002, the NRC issued Bulletin 2002-02, "Reactor Pressure Vessel Head and Vessel Head Penetration Nozzle Inspection Programs," requesting information from all PWR addressees concerning their subject inspection programs to ensure compliance with applicable regulatory requirements. In a letter dated September 12, 2002 (Serial No. 02-491), Virginia Electric and Power Company (Dominion) provided a response to the bulletin for North Anna and Surry Power Stations. Item 2 of the bulletin requires licensees to provide a supplemental response within 30 days after plant startup following the next inspection of the reactor vessel head (RVH) and reactor vessel head penetration (RVHP) nozzles to identify the presence of any degradation. Item 2.A requests the submittal of the inspection scope and results, details of the NDE used, and the criteria used for determining acceptable/rejectable indications, shadows or backwall anomalies, and Item 2.B requests provision of the corrective actions taken and the root cause determinations for any degradation found.

Dominion's response to Bulletin Item 2 was provided for North Anna Unit 2 in a letter dated October 18, 2002 (Serial No. 02-491A). The letter was provided at the NRC's request well before North Anna Unit 2 restart since 1) the NRC desired timely receipt of the North Anna Unit 2 RVHP nozzle inspection results to facilitate their overall review of industry RVH and RVHP nozzle inspection results, and 2) Dominion had decided to replace the North Anna Unit 2 RVH during the ongoing outage which would potentially delay submittal of the inspection results for an extended period of time. We noted in that letter that the inspection results provided therein were still being evaluated internally, and if any of the inspection results were subsequently revised, we would provide a supplemental response to the NRC documenting the changes. Receipt and review of the final inspection data has been completed and indicated that certain data previously provided in the October 18, 2002 letter required revision. The revised information is provided below. We also noted that a root cause evaluation was underway to better understand the causal factors associated with the RVHP cracking observed on North Anna Unit 2, and that the results of the root cause evaluation would

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be provided to the NRC upon completion. This information is discussed further below and in the attachment.

Revised Inspection Results (Bulletin Item 2.A)

The North Anna Unit 2 RVH and RVHP inspection data previously provided in Dominion's October 18, 2002 letter that requires revision is provided as follows:

- Section 3.3 of Attachment 1, page 8 of 10, "7010 Open Housing Scanner Ultrasonic and Eddy Current Examinations" is revised as follows for five penetrations:

CRDM	Column	Reported	Changed to
15	Axial TOFD Channel 1	PTI/BBP/NDD	NDD
19	Axial TOFD Channel 1	PTI/IPA/NDD	PTI-ID
50	Axial TOFD Channel 1	PTI/IPA/NDD	PTI-ID
52	Axial TOFD Channel 1	PTI/IPA/NDD	PTI-ID
64	Axial TOFD Channel 1	NDD	PTI-ID

- Section 4.0 of Attachment 1, page 10 of 10, "Discussion of Results" included a Table of penetration tubes with inspection results indicative of degradation. Penetration #46 was included in this Table as exhibiting characteristics consistent with an OD circumferential indication. However, upon further review of the inspection data for this penetration, it was determined that these results were reported in error. The inspection results for Penetration #46 actually indicate no detectable defects (NDD). Deletion of Penetration #46 from this Table was previously reflected in Table 2 of our letter dated December 20, 2002 (Serial No. 02-491B) in response to an NRC request for additional information.

The above revised data does not alter any of the conclusions provided in Dominion's October 18, 2002 letter.

Root Cause Evaluation Results (Bulletin Item 2.B)

Consistent with Bulletin Item 2.B, a root cause evaluation has been performed to better understand the specific causal factors associated with the RVHP cracking that was observed on North Anna Unit 2. The root cause of the indications on the reactor vessel head was determined to be hot short cracking. It was determined that the presence of hot cracks just below the surface of the welds likely contributed to localized high stresses, and because of their tendency to appear as stress risers to the material, led to the onset of primary water stress corrosion cracking (PWSCC) from the weld surface. Once cracking progressed through the J-groove welds, PWSCC began to affect the penetration tubes.

A root cause evaluation of the cause of the leakage identified on Penetration #51 during the Fall 2002 North Anna Unit 2 refueling outage was also performed as this penetration had been previously identified as leaking during the Fall 2001 North Anna Unit 2 outage and repaired at that time. The leakage was determined to be due to an improper weld repair overlay. The root cause of the inadequate repair was determined to be a training/qualification issue in that the individual performing the repair had insufficient

practice and understanding (i.e., hands-on experience) in performing such repairs. Further discussion of the root cause evaluation is provided in the attachment.

In addition, the replaced North Anna Unit 2 reactor vessel head has been made available to the EPRI MRP Alloy 600 Issue Task Group for research and investigation. A complete scope of examination activities is currently being developed. However, the intent is to remove material from the head to: 1) investigate a previously repaired nozzle, 2) determine the effectiveness of flaw characterization by NDE, 3) establish the cause and extent of identified flaws, 4) determine the path of flaws through the penetration tubing and welds, 5) assess the nozzle-annulus operating environment, and 6) support future crack growth rate studies on tubing and weld material.

If you have any further questions or require additional information, please contact us.

Very truly yours,

Leslie N. Hartz
Vice President – Nuclear Engineering

Commitments made in this letter: None.

Attachment

cc: U.S. Nuclear Regulatory Commission
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SN: 03-101
Docket No.: 50-339
Subject: NRC Bulletin 2002-02
30 Day Response After Plant Startup

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Leslie N. Hartz, who is Vice President - Nuclear Engineering, of Virginia Electric and Power Company. She has affirmed before me that she is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of her knowledge and belief.

Acknowledged before me this 27th day of February, 2003.

My Commission Expires: March 31, 2004.

Maggie McClure
Notary Public

(SEAL)

Attachment

NRC Bulletin 2002-02

Root Cause Evaluation Results
North Anna Power Station Unit 2

Virginia Electric and Power Company
(Dominion)

North Anna Power Station Unit 2

ATTACHMENT

NRC BULLETIN 2002-02
ROOT CAUSE EVALUATION RESULTS
NORTH ANNA POWER STATION UNIT 2

I. Root Cause(s)

A. North Anna Unit 2 RVH and RVHP Inspection Results – Fall 2002 Refueling Outage

During the Unit 2 Cycle 15 refueling outage in September 2002, Dominion performed a reactor vessel head bare-metal visual inspection, and Westinghouse performed nondestructive examinations (NDE) of reactor vessel head penetration (RVHP) tubes and J-groove welds at North Anna Unit 2. The visual inspection identified evidence of potential leakage on six penetrations, while the eddy current and ultrasonic examinations revealed multiple indications.

A Category 1 Root Cause Evaluation was conducted to determine the root cause(s) associated with the RVHP cracking that was observed on North Anna Unit 2. The root cause of the reportable NDE indications was determined to be Equipment Specification, Manufacture and Construction – Fabrication Deficiency. Specifically, the indications were due to hot short cracking, which occurred during original fabrication of the reactor vessel head. Hot short cracking in a weldment is caused by the segregation at grain boundaries of low melting point constituents in the weld metal. The low melting point constituents can be the result of the effects of weld/base metal dilution when welding dissimilar materials or the presence of low melting point contaminants in the weld metal.

Definition of Hot-Short Cracking

"Hot-short cracking is the microfissuring which occurs under tensile stress at elevated temperatures (as when welding under constraint), due to low-melting constituents at the grain boundaries. When a metal is hot-worked or welded, these low-melting constituents separate (even though the metal itself is well below its melting range) and leave a network of microfissures. These usually develop quickly into visually detectable macrocracks as well. Hot-short cracking bears a distinct resemblance, upon microscopic examination, to environmental cracking in an intergranular mode. However, it is usually detectable immediately after occurrence by such methods as dye-penetrant or ultrasonic inspection."
(Reference: Dillon, C. P., Corrosion Control in the Chemical Process Industries, NY: McGraw-Hill Book Company, 1986, page 60)

A boat sample was obtained from Penetration 62 during the Unit 2 Fall 2001 outage. Analysis of this boat sample confirmed that the indications were most likely associated with original fabrication hot short cracking.

The reactor vessel head may not have been sufficiently cleaned prior to welding, allowing the incorporation of unintended species in the welds, which would indicate a lapse in process control; or welding on the combination of low alloy steel base metal and stainless steel cladding may have contributed to very localized compositional anomalies that resulted in hot short cracking. The presence of hot cracks just below the surface of the welds probably contributed to localized high stresses, because of their tendency to appear as stress risers to the material, leading to the onset of primary water stress corrosion cracking (PWSCC) from the weld surface. Once cracking progressed through the J-groove welds, PWSCC affected the penetration tubes.

B. Penetration #51 (and 62 and 63) - Improper Weld Repair Overlay

A root cause evaluation of the cause of the leakage identified on Penetration #51 during the Fall 2002 North Anna Unit 2 refueling outage was also performed, as this penetration had been previously identified as leaking during the Fall 2001 North Anna Unit 2 outage and had been repaired at that time. (Penetrations 62 and 63 were also repaired during the Fall 2001 outage.) A boat sample from Penetration 51 was obtained during the Unit 2 Fall 2002 refueling outage and sent to Westinghouse for laboratory analysis. The boat sample was analyzed to 1) characterize the penetrant indications, 2) determine whether the indications could constitute a leak path, and 3) determine the extent of the repair weld with respect to the original J-groove weld. Analysis of the boat sample indicated that the weld overlay repair did not extend out far enough to cover all of the PWSCC susceptible Alloy 82 or 182 weld material. The Westinghouse on-site repair team had assumed the interface of the crack susceptible J-groove weld/butter region with the crack resistant stainless steel cladding could be accurately gauged by using fabrication drawings coupled with visual inspections of the J-groove weld toe. A subsequent review of manufacturing records revealed the location of the interface could vary considerably from penetration to penetration. The root cause for the improper weld repair overlay was determined to be Training/Qualification – Insufficient Practice or Hands-on Experience.

Contributing Cause(s)

A contributing cause for the improper weld repair overlay on Penetrations 51, 62, and 63 was determined to be Communications – Pertinent Information not Transmitted. The Westinghouse on-site repair team incorrectly identified the interface between the J-groove weld/butter region and the stainless steel cladding which led to the undersized weld repair overlay. Westinghouse corporate staff did not adequately communicate to the Westinghouse on-site repair team that certain non-visual assessment techniques, such as the use of acid etchants, must be utilized to determine the interface, particularly if the toe of the weld was ground smooth during fabrication. Since this information was not communicated to the Westinghouse repair team on-site, they relied solely on visual inspections and fabrication drawings to size the weld overlay.

II. Corrective Actions

A. Immediate

(1) Based on the qualified, visual barehead inspection results, additional NDE examinations were initiated to characterize the nature of the indications.

(2) An evaluation using methodology obtained from WCAP-14552, (with supplemental stress intensity and crack growth rate curves) was performed of the NDE indications to determine the additional service life allowable before repair. The results indicated that 1.5 years of service could be achieved prior to the indication growing to 75% through-wall, 1.8 years before becoming completely through-wall, and 26.0 years remained before the flaw would become unstable.

(3) A boat sample from the previous weld overlay repair of penetration 51 was removed and sent to Westinghouse for laboratory analysis. Analysis of the boat sample indicated that the weld overlay repair did not extend out far enough to cover all of the PWSCC susceptible Alloy 82 or 182 weld material.

(4) Additional information related to the structural integrity of the RVHP nozzles, including the extent of the leakage and indications, and the inspections and repairs undertaken to satisfy regulatory requirements were provided to the NRC. [Reference Virginia Electric and Power Company letters to the USNRC dated October 18, 2002 (Serial No. 02-491A) and December 20, 2002 (Serial No. 02-491B).]

B. Long Term

(1) A new North Anna Unit 2 reactor vessel head constructed of materials that are more resistant to cracking was installed during the recently completed outage. In addition, the North Anna Unit 1 and Surry Units 1 and 2 reactor vessel heads will be replaced in 2003. [Reference Virginia Electric and Power Company letter to the USNRC dated January 23, 2003 (Serial No. 03-041).]

(2) The station boric acid corrosion control program is being revised and enhanced to provide better protection from, and response to, potential boric acid leakage and/or corrosion. [Reference Virginia Electric and Power Company letter to the USNRC dated January 31, 2003 (Serial No. 02-689).]