VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

October 18, 2002

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

Serial No. 02-491A
NL&OS/GDM R5
Docket Nos. 50-338/339
License Nos. NPF-4/7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2
NRC BULLETIN 2002-02 – REACTOR PRESSURE VESSEL HEAD AND VESSEL HEAD PENETRATION NOZZLE INSPECTION PROGRAMS
30-DAY RESPONSE FOR NORTH ANNA UNIT 2 INSPECTION RESULTS AND RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

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.

30-Day Bulletin Response for North Anna Unit 2 (NRC Bulletin Item 2)

North Anna Unit 2 is currently in a refueling outage and has recently performed extensive RVH and RVHP nozzle examinations. The status of North Anna 2 inspection activities and findings were discussed with the NRC on an ongoing basis during several conference calls and have also been provided, in part, in a 10 CFR 50.72 report dated September 14, 2002, which was subsequently updated on October 7, 2002. Consistent with Item 2.A of NRC Bulletin 2002-02, the inspection scope and results of the RVH and the RVHP nozzle inspections to identify the presence of any degradation are provided in Enclosure 1. It should be noted that the inspection results provided herein are still being evaluated internally; however, this information is being provided in response to the NRC's expressed interest in receiving the information in a timely manner. If any of the inspection results in Enclosure 1 are subsequently revised, we will provide a supplemental response to the NRC documenting the changes. It should also be noted that the extent of the inspection scope originally identified in the September 12, 2002 bulletin response was subsequently modified (i.e., inspections were suspended before

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completing all sixty-five penetrations) for North Anna Unit 2 based on the inspection results obtained, the difficulty encountered in removing thermal sleeves, and the decision to replace the RVH during the current outage. Due to the identification of two confirmed and four suspected leaking penetrations and the additional indications identified in the J-groove welds and the RVHP nozzles for these and other penetrations, Dominion has decided to replace the RVH during the current outage. The decision to replace the RVH this outage rather than repair the RVHPs was based on 1) consideration of the extensiveness and difficulty of removing and reinstalling thermal sleeves, 2) the significant amount of personnel radiation exposure required to perform the repairs, 3) the fact that Dominion had previously decided to replace the RVH during the Spring 2004 North Anna Unit 2 refueling outage, and 4) the availability of a replacement RVH suitable for use on North Anna Unit 2. Additional information regarding the specifics of the RVH replacement will be provided in separate correspondence.

Although indication of leaking penetrations and J-groove weld flaws were observed, none of these observations were indicative of a significant safety issue nor was any observed indication outside of the existing safety analyses. Specifically, no reactor vessel head wastage was observed nor were any through-wall cracks identified above the J-groove weld in any of the inspected RVHP nozzles, thus precluding the possibility of tube separation. Consistent with bulletin Item 2.B, a root cause evaluation is also being performed to better understand the specific causal factors associated with the RVHP cracking that was observed on North Anna Unit 2. The results of this evaluation will be provided upon completion.

NRC Request for Additional Information – North Anna Unit 1

Due to the similarities in design, construction and operating parameters of the North Anna Units 1 and 2 reactor vessel heads, the NRC requested additional information in a letter dated October 11, 2002 regarding our bases for concluding that North Anna Unit 1 reactor coolant pressure boundary integrity 1) has not experienced cracking that could jeopardize reactor coolant pressure boundary integrity, and 2) is in conformance with regulatory requirements. Dominion's response to the NRC's request for additional information is provided in Enclosure 2.

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

Very truly yours,

Leslie N. Hartz
Vice President – Nuclear Engineering

Enclosures

Commitments made in this letter:

1. If any of the inspection results in Enclosure 1 are subsequently revised, we will provide a supplemental response to the NRC documenting the changes.

2. Consistent with Bulletin Item 2.B, a root cause evaluation is being performed to better understand the specific causal factors associated with the RVHP cracking that was observed on North Anna Unit 2. The results of this evaluation will be provided upon completion.

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SN: 02-491A
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Subject: 30-Day Response to NRC Bulletin 2002-02
Inspection Results for NAPS U2 and
Response to Request for Additional Information

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 18th day of October, 2002.

My Commission Expires: March 31, 2004.

Maggie McClure
Notary Public

(SEAL)

Enclosure 1

30 Day Response of Inspection Scope and Results
NRC Bulletin 2002-02 - Item 2.A

North Anna Power Station Unit 2

Virginia Electric and Power Company
(Dominion)

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1.0 INTRODUCTION

During the 2R15 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 tubes and J-groove welds at North Anna Unit 2. The purpose of the reactor vessel head bare-metal visual inspection was to look for evidence of head penetration leakage and any resulting reactor vessel head wastage, and the purpose of the NDE inspection program was to identify the presence of primary water stress corrosion cracking (PWSCC) on the accessible OD and ID surfaces of the head penetration tubes and the partial penetration J-groove welds attaching the penetrations to the reactor vessel head.

The reactor vessel head at North Anna Unit 2 contains 65 alloy 600 penetration tubes that are shrunk fit in the reactor vessel head and attached with alloy 182 partial penetration J-groove welds. The reactor vessel head was manufactured by Rotterdam Dry Dock.

There are a variety of configurations for the 65 penetration tubes, each configuration requiring special consideration for examination. The penetration tube configurations are as follows:

- 56 penetration tubes with thermal sleeves installed
- 5 penetration tubes with part length drive shafts removed
- 4 penetration tube thermocouple columns without thermal sleeves

The vessel head penetrations were dispositioned based on an assessment of results from visual examinations performed from the top of the reactor vessel head and results from the nondestructive examinations presented herein.

The nondestructive examinations performed by Westinghouse were conducted in accordance with the following field service procedures and field change notices (FCNs):

WDI-ET-002, Rev. 1 and FCN-001 – IntraSpect Eddy Current Inspection of J-Groove Welds in Vessel Head Penetrations

WDI-ET-003, Rev. 3 and FCN-001 – IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations

WDI-ET-004, Rev. 1 and FCN-001 – IntraSpect Eddy Current Analysis Guidelines Inspection of Reactor Vessel Head Penetrations

WDI-ET-008, Rev. 0 and FCN-001 – IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations With Gap Scanner

WDI-UT-010, Rev. 3 and FCN-001 - "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic & Longitudinal Wave"

WDI-UT-013, Rev. 1 and FCN-001 – "CRDM/ICI UT Analysis Guidelines"

A discussion of the procedure demonstrations that were performed and personnel qualifications is provided in Attachment 1.

2.0 SCOPE OF WORK

The reactor vessel head and penetration examination scope at North Anna Unit 2 was based on a "best effort" plan to perform:

1) a 100% bare-metal visual inspection on the top of the reactor vessel head, clean the head and re-inspect for any evidence of wastage,

2) eddy current examinations of 100% of the accessible J-groove welds and penetration tube OD surfaces using the Grooveman manipulator, and

3) eddy current and/or ultrasonic examinations from the penetration tube ID surfaces to the extent practical using the Westinghouse 7010 Open Housing Scanner and the Eddy Current Gapscanner.

The approved protocol required removal of thermal sleeves for full tube interrogation above the centering ring if the tube was rejected or masked by the bare-metal visual inspection or if rejectable indications were found in the J-groove weld. The thermal sleeve design at North Anna is somewhat unique in that there are solid centering rings at elevations near the uppermost elevation of the J-groove welds on the uphill side of the penetrations which restrict access to the tube in the area of interest.

Thermal sleeves were removed from thirty-one penetration locations (the four thermocouple locations do not have thermal sleeves) and thirty-five inspections of the penetration ID surfaces were conducted with the Westinghouse 7010 Open Housing Scanner. Six penetration tubes were inspected using the Westinghouse Gapscanner.

For this inspection, the overall approach for the detection of PWSCC includes a combination of ultrasonic and eddy current techniques. For ID initiated PWSCC, the primary detection method is eddy current, supplemented by ultrasonic testing for confirmation and sizing (depth and length). The data analysis logic for determination of ID PWSCC is presented in the flow chart in Figure (1).

For OD initiated PWSCC, the detection methods are volumetric ultrasonic testing using time-of-flight diffraction (TOFD) techniques and eddy current examinations of the J-groove welds and accessible penetration OD surfaces. Since the J-groove weld fabrication process, including welding, grinding and repair, can produce a variety of false positive ultrasonic indications, these results are not considered conclusive. Many of these signals can be evaluated as non-relevant in the data analysis process. However, a confirmatory OD surface examination is performed to determine if the indication initiates on a wetted surface. For these confirmatory inspections, an eddy current technique is performed on the J-groove and/or the nozzle OD below the weld. In instances where meaningful eddy current results are not possible due to geometric constraints, for example, at the thermocouple column locations (#51, #53, #55, and #57), supplementary penetrant tests are performed. The data analysis logic for evaluation of OD indications is presented in the flow chart in Figure (2).

The Grooveman manipulator is designed to deliver eddy current probes for examination of the surface of the J-groove weld and the penetration tube OD surfaces. The eddy current probe holders are designed to conform to the geometry of the J-groove welds and penetration OD surfaces and allow the probes to follow the contour of the assembly. Continuous positional and video feedback is provided to the operator to assist in achieving coverage of the weld and the penetration tube. Scanning of the penetration tube OD surface is conducted in a vertical direction and the probes are indexed in the circumferential direction. For scanning of the J-groove welds, scanning is conducted in the circumferential direction, along the weld, and the index is in a direction perpendicular to the weld.

The Westinghouse 7010 Open Housing Scanner delivers an end effector containing ultrasonic and eddy current probes to the ID surface of open reactor vessel head penetration tubes. The scanning motion is in the axial direction and the probe is indexed in the circumferential direction. With the open housing scanner, five examinations are conducted simultaneously. These include:

- eddy current inspection for identification of circumferential and axial degradation on the ID surfaces of the penetration tubes,
- time-of-flight diffraction ultrasonic inspection optimized for identification of circumferentially oriented degradation on the penetration tube OD surfaces,
- time-of-flight diffraction ultrasonic inspection optimized for identification of axially oriented degradation on the penetration tube OD surfaces,
- high frequency straight beam ultrasonic inspection to identify variations in the tube-to-reactor vessel head shrink fit area that might indicate a leak path, and
- low frequency straight beam ultrasonic inspection for identification of degradation in the weld, parallel to the tube-to-weld interface.

The eddy current Gapscanner is designed to position and guide eddy current "sword" probes into the annulus between the ID surface of the reactor vessel head penetration tube and the OD surface of the thermal sleeve and to manipulate the probe to provide the desired coverage. The nominal annulus size is 0.125". The sword probe design utilizes a flexible metal "sword" on which a pair of eddy current probes are mounted in a spring configuration that enables the probes to ride on the ID surface of the penetration tubes. The scanning motion is in a vertical direction moving from a specified height above the weld toward the lower end of the penetration and the probes are indexed in the circumferential direction. The Gapscanners consist of a probe tilt and drive unit to advance and reverse the probe in the tube/thermal sleeve annulus, a turntable to rotate the probe drive around the axis of the penetration, a lifting cylinder to raise and lower the tilt and drive unit and a centering device consisting of two clamping arms.

Before the inspection program was suspended, fifty-nine head penetration J-groove welds and the outer diameter (OD) surfaces of forty-seven penetration tubes were examined using eddy current techniques with the Grooveman manipulator. Thirty-five reactor vessel head penetrations were examined with ultrasonic and eddy current techniques from the inner diameter (ID) surface using the 7010 Open Housing Scanner. Six reactor vessel head penetrations were examined from the ID surface using eddy current techniques with the Westinghouse Eddy Current Gapscanner. Finally, the six vessel head penetration J-groove welds not examined by eddy current were examined by Dominion using liquid dye penetrant techniques.

2.1 J-Groove Weld and Penetration Tube OD Surface Eddy Current Examinations

Grooveman eddy current examinations were conducted on fifty-nine CRDM penetration J-groove welds and on the outside diameter surfaces of forty-seven penetration tubes. These examinations were performed to identify the presence of primary water stress corrosion cracking on the outside diameter surfaces of the penetrations and on the surface of the J-groove welds attaching the penetrations to the reactor vessel head. Examinations were conducted in accordance with WDI-ET-002, Rev. 1 and FCN-001 – "IntraSpect Eddy Current Inspection of J-Groove Welds in Vessel Head Penetrations".

2.2 7010 Open Housing Scanner Ultrasonic and Eddy Current Examinations

Rotating probe examinations were conducted on thirty-five reactor vessel head penetration tubes. These examinations included:

1) TOFD ultrasonic techniques demonstrated capable of detecting axial and circumferential reflectors on the penetration tube OD surfaces with UT probes (PCS24) in accordance with WDI-UT-010, Rev. 3 and FCN-001 – "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic & Longitudinal Wave",

2) straight beam ultrasonic techniques at 2.25 MHz, to interrogate the J-groove weld zone, and at 5.0 MHz to identify possible leak paths in the shrink fit region between the head penetrations and the reactor vessel head, and

3) eddy current examinations demonstrated capable of detecting axial and circumferential degradation on the penetration tube ID surfaces in accordance with and WDI-ET-003, Rev. 3 and FCN-001- "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations."

2.3 Gapscanner Penetration Tube ID Surface Eddy Current Examinations

Gapscanner eddy current examinations were conducted on the ID surfaces of six reactor vessel head penetration tubes. These examinations are capable of identifying the presence of primary water stress corrosion cracking (PWSCC) on the inside diameter surfaces of the penetration tubes. Examinations were conducted in accordance with WDI-ET-008, Rev. 0 and FCN-001 – "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations With Gap Scanner."

3.0 EXAMINATION RESULTS

3.1 Reactor Vessel Head Bare-Metal Visual Inspection Results

A bare-metal visual inspection was performed on the reactor vessel head. Evidence of leakage was identified on two penetrations, Penetrations #21 and 31. Potential leakage was identified on four other penetrations, Penetrations #10, 35, 51 and 57. Penetration #51 was repaired during the Fall 2001 outage, and it was determined that the repair was improperly installed. An additional twenty-one visually inspected penetrations were masked, of which fourteen were masked due to a conoseal leak at Penetration #53.

No discernable head wastage was identified during the initial head inspection. The head was subsequently cleaned and re-inspected and the head was determined to be in good condition with no evidence of head wastage identified.

3.2 J-Groove Weld and Penetration Tube OD Surface Eddy Current Examinations

The following table provides a summary of all Grooveman eddy current reactor vessel head penetration nondestructive inspections performed at North Anna Unit 2 during the 2R15 refueling outage.

Penetration #	Eddy Current J-Groove Weld	J-Groove Weld Coverage	Eddy Current Penetration Tube OD
1 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
2 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
3 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
4 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
5 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
6 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
7 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
8 CRDM	Reportable (RI)	360°	Recordable (NRI)
9 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
10 CRDM	Recordable (NRI)	360°	Not Inspected
11 CRDM	Recordable (NRI)	360°	Recordable (NRI)
12 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)

Penetration #	Eddy Current J-Groove Weld	J-Groove Weld Coverage	Eddy Current Penetration Tube OD
13 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
15 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
17 CRDM	No Detectable Indications (NDI)	360°	No Detectable Indications (NDI)
19 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
21 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
22 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
23 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
24 CRDM	No Detectable Indications (NDI)	360°	Not Inspected
25 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
26 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
27 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
28 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
29 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
30 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
31 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
32 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
33 CRDM	Recordable (NRI)	360°	Not Inspected
34 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
35 CRDM	Reportable (RI)	360°	Not Inspected
36 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
37 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
38 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
39 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
40 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
41 CRDM	Reportable (RI)	360°	Not Inspected
42 CRDM	Reportable (RI)	360°	Not Inspected
43 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
44 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
45 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
46 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
47 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
48 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
49 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
50 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
51 CRDM	PT		Not Inspected
52 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
53 CRDM	PT		Not Inspected

Penetration #	Eddy Current J-Groove Weld	J-Groove Weld Coverage	Eddy Current Penetration Tube OD
54 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
55 CRDM	PT		Not Inspected
56 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
57 CRDM	PT		Not Inspected
58 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
59 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
60 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
61 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
62 CRDM	PT		Not Inspected
63 CRDM	PT		Not Inspected
64 CRDM	Recordable (NRI)	360°	No Detectable Indications (NDI)
65 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
66 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
67 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
68 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)
69 CRDM	Reportable (RI)	360°	No Detectable Indications (NDI)

Forty-two J-groove welds were found to contain reportable indications (RI), fifteen contained recordable indications (NRI) and two contained no detectable indications (NDI). Two penetration tubes contained recordable indications (NRI) and forty-five contained no detectable indications.

RI – Reportable Indication (≥ 9 mm in length)

NRI – Recordable Indication (≥ 6 mm and < 9mm in length)

NDI – No Detectable Indication (<6 mm in length)

All fifteen of the NRIs were considered crack-like in nature. Seven of the NRIs were actually < 6 mm in length, but since they were crack-like in nature, they were conservatively classified as NRIs.

3.3 7010 Open Housing Scanner Ultrasonic and Eddy Current Examinations

The following table provides a summary of all 7010 open housing scanner RVHP nondestructive inspections performed at North Anna Unit 2 during the 2R15 September 2002 refueling outage.

	Tube (volumetric)		J-Groove Weld Zone	Shrinkfit Region	Tube ID Surface
Penetration #	Axial TOFD Channel 1	Circ TOFD Channel 2	2.25 Mhz 0°	5.0 Mhz 0°	ECT Results
10 CRDM	NDD	WII	LOF	LOF	NDD
12 CRDM	PTI - ID	NDD	NDD	NDD	3 Axial
15 CRDM	PTI/BBP/NDD	NDD	NDD	NDD	NDD
19 CRDM	PTI/IPA/NDD	NDD	NDD	NDD	1 Axial
21 CRDM	NDD	NDD	PLP	PLP	NDD
31 CRDM	NDD	PTI/IPA/NDD	PLP	PLP	NDD
35 CRDM	PTI	PTI	WVI	WVI	1 Axial
38 CRDM	NDD	WII/IPA/NDD	NDD	NDD	NDD
40 CRDM	NDD	WII/IPA/NDD	NDD	NDD	2 Axial
41 CRDM	PTI - ID	PTI	LOF	LOF	6 Axial
43 CRDM	NDD	WII/IPA/NDD	NDD	NDD	NDD
44 CRDM	LCG	PTI/WII/NDD	LOF	LOF	3 Axial
46 CRDM	NDD	WII/BBP/NDD	NDD	NDD	NDD
47 CRDM	NDD	WII/IPA/NDD	NDD	LOF	NDD
48 CRDM	LCG	WII/IPA/NDD	NDD	LOF	NDD
49 CRDM	NDD	NDD	NDD	NDD	NDD
50 CRDM	PTI/IPA/NDD	PTI/IPA/NDD	NDD	NDD	6 Axial
51 T/C	PTI - ID	WII/IPA/NDD	NDD	PLP	9 Axial
52 CRDM	PTI/IPA/NDD	PTI/IPA/NDD	LOF	LOF	3 Axial
53 T/C	PTI - ID	NDD	LOF	NDD	3 Axial
54 CRDM	NDD	PTI	NDD	NDD	1 Axial
55 T/C	PTI - ID	WII/IPA/NDD	NDD	NDD	3 Axial
56 CRDM	NDD	WII/IPA/NDD	NDD	NDD	NDD
57 T/C	NDD	NDD	NDD	NDD	NDD
58 CRDM	WII/IPA/NDD	WPI/IPA/NDD	NDD	NDD	NDD
59 CRDM	PTI	PTI	NDD	NDD	1 Axial
60 CRDM	WII/IPA/NDD	WII/IPA/NDD	NDD	NDD	NDD
61 CRDM	PTI - ID	WII/IPA/NDD	NDD	NDD	5 Axial
62 CRDM	PTI/IPA/NDD	WII/IPA/NDD	NDD	NDD	19 Axial
63 CRDM	PTI - ID	NDD	PLP	PLP	2 Axial
64 CRDM	NDD	WII/IPA/NDD	NDD	NDD	14 Axial
65 CRDM	PTI - ID	WII/PTI	NDD	NDD	9 Axial
66 CRDM	PTI - ID	PTI/IPA/NDD	NDD	NDD	9 Axial
67 CRDM	PTI - ID	PTI/WII	LOF	NDD	1 Axial
68 CRDM	NDD	NDD	LOF	LOF	NDD

Legend:

NDD – No Detectable Defect
IPA – Indication Profile Analysis Resolution of Indication
WII – Weld Interface Indication
WVI – Weld Volume Indication
PTI – Parent Tube Indication

LCS – Loss of Coupling-Scanner
LCG – Loss of Coupling-Geometry
LIF – Loss of Interference Fit
LOF – Lack of fusion at the tube to weld interface
BBP – B and B Prime Analysis Resolution
VOL – Volumetric Indication
PLP – Possible Leak Path

The final disposition of these results is presented in Section 4.0.

3.4 Gapscanner Penetration Tube ID Surface Eddy Current Examinations

The following table provides a summary of all Gapscanner eddy current examinations performed at North Anna Unit 2 during the 2R15 September 2002 refueling outage.

Penetration #	ECT Results
1 P/L	NDD
17 CRDM	NDD
22 P/L	2 Axial
23 P/L	NDD
24 P/L	2 Axial
25 P/L	5 Axial

Of the six penetrations inspected with the Gapscanner eddy current system, three showed axial indications on the ID surfaces and three showed no detectable degradation.

4.0 DISCUSSION OF RESULTS

The bare-metal visual inspection performed on the reactor vessel head identified evidence of leakage or potential leakage on six penetrations. An additional twenty-one visually inspected penetrations were masked, of which fourteen were masked due to a conoseal leak. No discernable head wastage was identified during the initial visual head inspection, nor was any identified head wastage identified during the re-inspection following head cleaning.

Results from the Grooveman eddy current examinations of fifty-nine J-groove welds and forty-seven penetration tube OD surfaces showed forty-two J-groove welds with reportable indications (RI), fifteen with recordable indications (NRI) and two with no detectable indications (NDI). Indication orientations were found to be axial and circumferential with respect to the welding direction and ranged in length from 0.12" to about 7.0". In some cases, the longer flaws that are reported are actually a series of small flaws with very short distances in between. A table of results from the Grooveman eddy current examinations is provided as Attachment 2.

Eddy current results from tube inside diameter surface examinations with the Westinghouse 7010 Open Housing Scanner examinations showed twenty of thirty-five penetration tubes had axial indications. These indications are believed to be less than 0.12" (3.0 mm) deep based on the PCS24 axial TOFD results. More accurate sizing would require additional time-of-flight interrogation with probes with smaller PCS spacings. Therefore, refined depth sizing was not performed.

Time-of-flight ultrasonic examinations with the Westinghouse 7010 Open Housing Scanner showed a number of penetration tubes with indications. Indication profile analyses and "B and B-Prime" resolution analyses were performed in order to assess the significance of these reflectors. Four penetrations (#21, #31, #51, and #63) also showed evidence of a leak path in the shrink fit area between the vessel head and the tube. Penetrations #51 and 63 were identified as leaking in Fall 2001. Repairs were determined to have been improperly applied.

The six penetration welds inspected by LP had rejectable (greater than 1/16" linear) indications.

Penetration tubes with results indicative of degradation are summarized below.

Penetration	Characteristics	Length	Depth
#15	OD Circumferential	7.5 deg. to 12 deg.	0.226"
#21	Potential Leak Path	220 deg.	N/A
#35	OD Axial	0.80"	0.223"
#41	OD Circumferential	357 deg. to 43 deg.	0.097"
#46	OD Circumferential	4 deg. To 20.deg.	0.072
#51	Potential Leak Path	210 deg. to 260 deg.	N/A
#54	OD Circumferential	119 deg. to 198 deg.	0.226"
"	OD Circumferential	344 deg. to 16 deg.	0.156"
#59	OD Circumferential	347 deg. to 63 deg.	0.149"
"	OD Circumferential	156 deg. to 206 deg.	0.149"
#63	Potential Leak Path	320 deg. to 0 deg.	N/A
#65	OD Circumferential	330 deg. to 42 deg.	0.152"
"	OD Circumferential	160 deg. to190 deg.	0.078"
#67	OD Circumferential	343 deg. to 27 deg.	0.094"

Eddy current results from tube inside diameter surface examinations with the Gapscanner showed three of six penetration tubes had axial indications. More accurate sizing would require additional time-of-flight interrogation with probes with smaller PCS spacings. A root cause evaluation is being performed to better understand the phenomena/conditions that resulted in the cracking identified in the inspections discussed above and will be provided to the NRC upon completion.

FIGURE 1 - PENETRATION TUBE ID FLAW EVALUATION

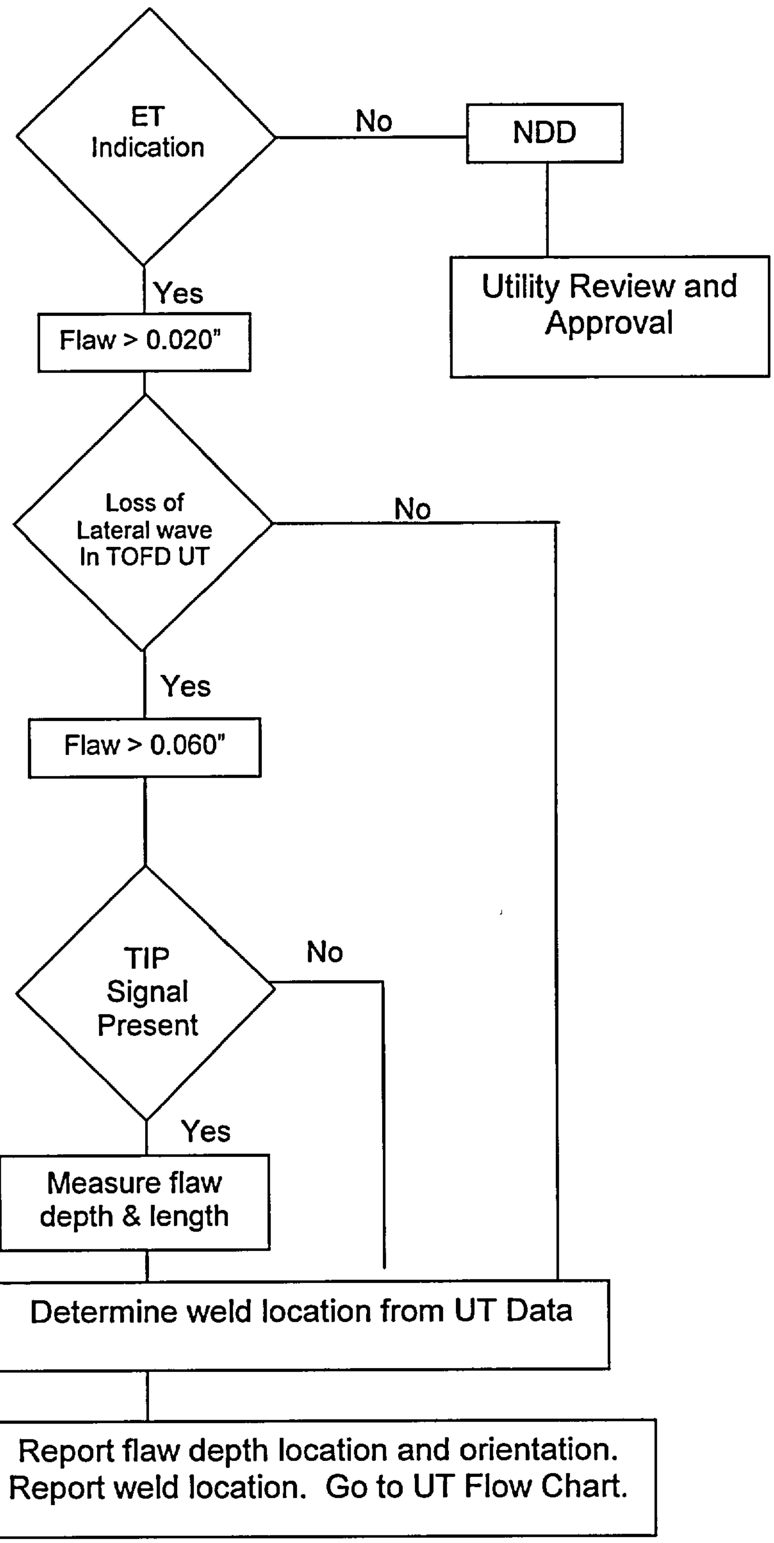
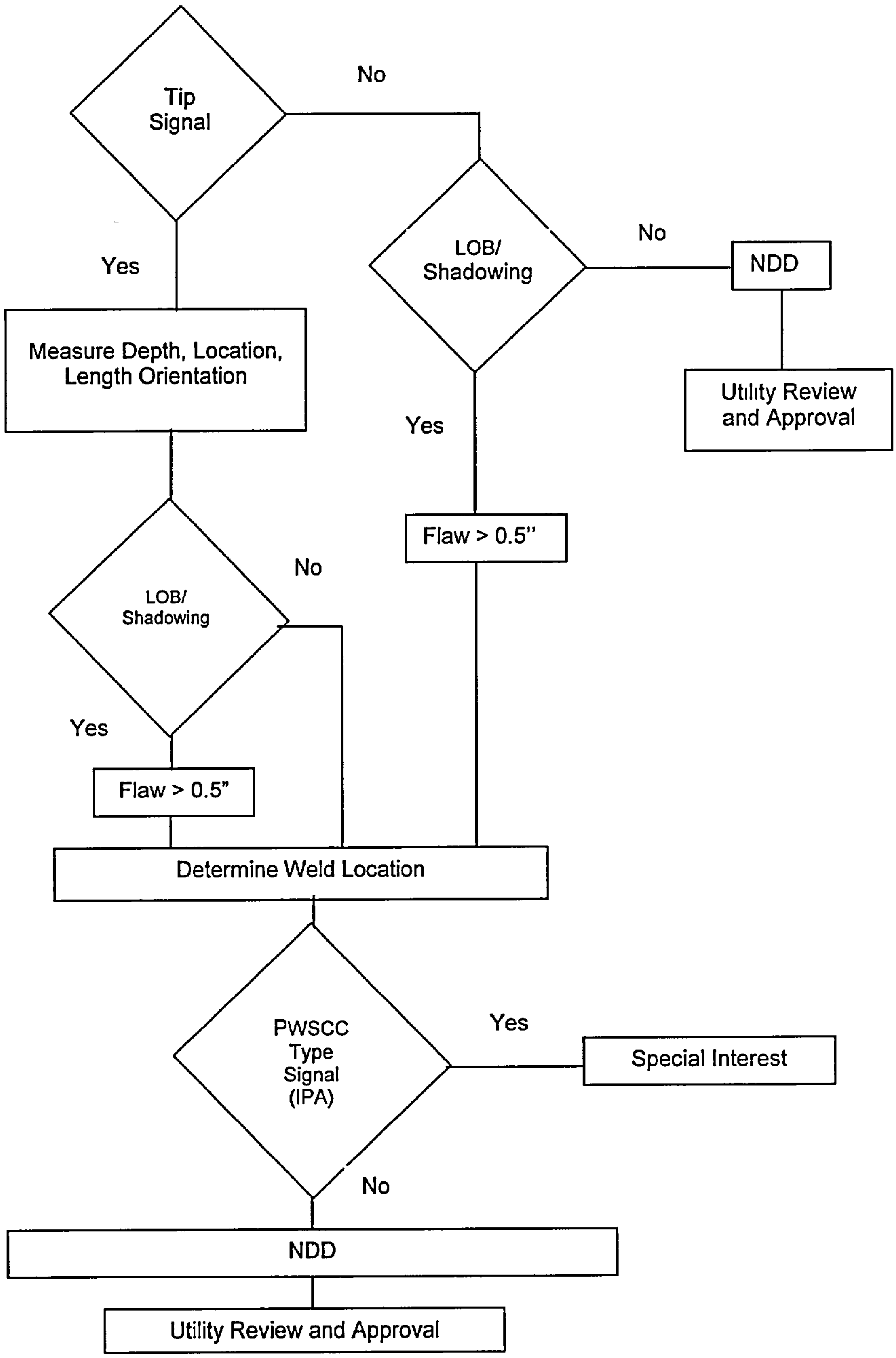


FIGURE 2 - PENETRATION TUBE OD FLAW EVALUATION



ATTACHMENT 1

PROCEDURE DEMONSTRATIONS AND PERSONNEL QUALIFICATIONS

I. Procedure Demonstrations

The Materials Reliability Program (MRP) has conducted inspection demonstrations in two phases. Phase 1 demonstrations were conducted in the fall of 2001 to support Fall 2001 and Spring 2002 inspection activities. The mock-ups addressed flaw detection in the reactor vessel head penetration (RVHP) tube material only. Phase II WesDyne demonstration activities began on August 28, 2002. WesDyne finalized analysis of data collected on the Entergy/MRP practice mock-up. This data was reviewed as part of the readiness review process established by the MRP demonstration protocol. Preliminary results for the WesDyne Phase II demonstration have been provided to Dominion and are included in this discussion.

Phase I Demonstrations

Mock-ups for the first phase (base metal inspection only) included field-removed tube specimens and a full-scale mock-up of the tube, weld and vessel head. The field-removed tube specimens from Oconee Unit 3 contained a variety of pressurized water stress corrosion cracks (PWSCC) ranging from shallow flaws initiating at the OD surface of the tube to through-wall flaws. The full-scale mock-up contained electro-discharge machined (EDM) notches and was used to evaluate the influence of component geometry since defect detection and sizing capabilities are influenced by the presence of the attachment weld and the configuration of the component.

Framatome-ANP, WesDyne, and Tecnatom conducted demonstrations of inspection equipment and procedures. All three vendors demonstrated blade-probe UT equipment for inspection with thermal sleeves in place and open-tube UT equipment for inspection with thermal sleeves removed. All vendors demonstrated the ability to detect 2-3 mm OD-initiated PWSCC and determined flaw position with an accuracy of 6 mm.

Phase II Demonstrations

Demonstration of WesDyne equipment and procedures was conducted at their Windsor, CT facility during the period of August 26 to September 11, 2002. Three WesDyne personnel were at North Anna and performed the initial analysis of CRDM UT data.

Open-tube and blade probe UT and ET equipment and procedures were demonstrated. WesDyne procedures addressed inspection of the RVHP tube and weld-to-tube interface from the inside surface of the tube only during this phase of the demonstration. WesDyne did not demonstrate ET equipment for inspection of the wetted surface of the J-groove weld (procedure WDI-ET-002) during the initial demonstration. This portion of the demonstration has recently been demonstrated but to date the results have not been released.

WesDyne used UT procedure WDI-UT-010, Revision 3, for the demonstration with an additional UT analysis guide (WDI-UT-013, Revision 1). WesDyne used two ET procedures (WDI-ET-003, Revision 3 and WDI-ET-008, Revision 0) with an additional ET analysis guide (WDI-ET-004, Revision 1). These Wesdyne procedures are the same procedures used for the North Anna Unit 2 CRDM examinations except that the procedures used at North Anna included modifications that were recommended during the demonstration process.

The WesDyne demonstration results are summarized in the following table and sketch showing the flaw type/location designations for the mockups used.

II. Personnel Qualifications

Personnel involved in the acquisition of nondestructive examination data for the North Anna Unit 2 reactor vessel head penetration inspection program were certified as Level I in ultrasonic testing and/or eddy current testing, and worked under the supervision of an individual certified as a Level II or Level III in eddy current or ultrasonic testing. Personnel involved in the analysis of nondestructive examination data were certified as Level II or Level III in eddy current and/or ultrasonic testing. Personnel certifications were in accordance with written practices satisfying SNT-TC-1A, 1984 Edition, and CP-189. As stated earlier, certified UT individuals who participated in the MRP performance demonstration performed the initial analysis of CRDM UT data.

Nondestructive examination personnel also had prior experience with, or received training in, the operation of the automated data acquisition and analysis system applied for the North Anna Unit 2 reactor vessel head penetration program. In addition, all nondestructive examination acquisition and analysis personnel participated in a site-specific training program.

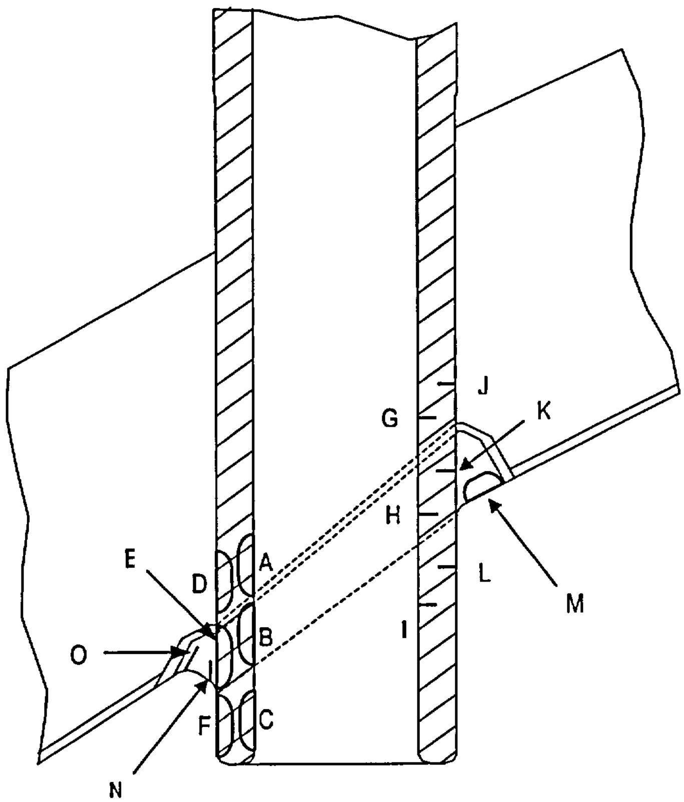
EPRI/MRP Demonstration Results Table

Intermediate Review of WesDyne Detection Results

The following table summarizes detection results after incorporation of procedure revisions that were subsequently incorporated into the procedures used at North Anna.

	WesDyne Detection Results Including Missed Flaws and False Calls See flaw table and drawing for description of flaw types "A" through "O"					
WesDyne UT Techniques	A, B, & C ID Axial Flaws	G, H, & I ID Circumferential Flaws	D, E, & F OD Axial Flaws	J, K, & L OD Circumferential Flaws	M, N, & O Weld Flaws (Note 4)	Cluster Flaws OD Flaws under shallow (< 3 mm deep) ID Cluster Flaws
"Circ Blade" (PCS24 TOFD UT AOCF /ET) (Note 1) **1.5 degree scan increment**	5%-86% TWE detected (Note 3)	11%-49% TWE detected	12%-100% TWE detected 2 flaws < 10% TWE missed 1-D type flaw, 1-EF type flaw	15%-100% TWE detected	No implanted flaws detected 4 false calls. MN type flaws (Note 5)	100% detection of ID & OD
"Circ Blade" (PCS24 TOFD UT AOCF /ET) (Note 1) **1.0 degree scan increment**	5%-86% TWE detected	11%-49% TWE detected	12%-100% TWE detected 2 flaws < 10% TWE missed 1-D type flaw, 1-EF type flaw	15%-100% TWE detected	Data not reviewed	100% detection of ID & OD
"Rotating Probe" (PCS24 TOFD UT AOCF/COAF/ 0 Deg/ET) (Note 2) **2 degree scan increment**	5%-86% TWE detected	11%-49% TWE detected	10%-100% TWE detected Orientation of flaws < 40% TWE inconsistent 1 D type flaw <8% TWE missed	15%-100% TWE detected 2 false calls 16% TWE KL type flaws	1 M type flaw, 100% to triple-point detected 2 M type flaws < 75% to triple-point missed 2 false calls M type flaws (Note 5)	100% detection of ID & OD
Notes:	(1) PCS24 TOFD UT AOCF/ET (Axially Oriented for Circumferential Flaws) used for detection and sizing of flaws. PCS24 UT COAF (Circumferentially Oriented for Axial Flaws), PCS18 UT COAF/AOCF, & Zero degree probes used for sizing only. (2) PCS24 UT AOCF/COAF/0 deg/ET open-tube probe used for detection and sizing of flaws PCS18 UT AOCF/COAF open-tube probe used for sizing only. (3) Through-wall-extent (TWE) of flaw depth in the tube thickness (4) WesDyne only interrogated the first 0 1" of the tube-to-weld-interface for detection of flaws (5) Appears to be a welding defect at the tube-to-weld-interface.					

Sketch - *Flaw Type/Location Designations*



Flaw Designation	Flaw Description	Contained in Mockups
A	ID Axial Above the Weld	Yes
B	ID Axial Over the Weld	Yes
C	ID Axial Below the Weld	Yes
D	OD Axial Above the Weld	Yes
E	OD Axial Over the Weld	Yes
F	OD Axial Below the Weld	Yes
G	ID Circumferential Above the Weld	N/A (Note 1)
H	ID Circumferential Over the Weld	N/A (Note 1)
I	ID Circumferential Below the Weld	Yes
J	OD Circumferential Above the Weld	Yes
K	OD Circumferential Over the Weld	Yes
L	OD Circumferential Below the Weld	Yes
M	Axial/Radial @ Wetted Surface of the J-Groove Weld	Yes
N	Circumferential/Radial @ Wetted Surface @ Head/J-Groove Weld	Yes
O	Circumferential/Radial @ Wetted Surface @ Tube/J-Groove Weld	Yes
Notes:	(1) Presence of back-wall does not influence detection and analysis of ID surface initiated flaws to the degree that it affects OD surface initiated flaws	

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 01

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	90	96	0.44	0.44	346	354	N/A	0.49	Crc.
2	109	98	0.44	0.56	350	350	0.12	N/A	Axi
3	57	91	0.60	0.60	346	353	N/A	0.43	Crc.
4	31	94	0.56	0.56	352	356	N/A	0.12	Crc.
5	23	83	0.48	0.48	168	195	N/A	1.65	M Crc

Weld Surface Inspection – Indications in CRDM No. 02

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	100	88	0.44	0.72	90	114	0.28	1.46	M-Crc/A

Weld Surface Inspection – Indications in CRDM No. 03

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	43	84	0.20	0.20	327	330	N/A	0.18	Crc
2	74	88	0.44	0.76	347	347	0.30	N/A	Axi
3	115	97	0.16	0.88	38	38	0.72	N/A	Axi
4	136	94	0.44	0.76	87	87	0.32	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 04

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	92	101	0.52	0.52	116	160	N/A	2.8	M Crc.
2	56	100	0.44	1.28	15	15	0.84	N/A	Axi
3	80	103	0.44	1.10	216	240	0.2	N/A	M Axi/Cr

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 05

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	78	72	0.32	0.64	298	298	0.32	N/A	Axi
2	31	106	0.24	0.48	357	357	0.24	N/A	Axi
3	31	110	0.52	0.52	145	122	0.20	N/A	M Axi
4	99	99	0.28	0.28	144	160	N/A	0.98	Crc.
5	111	93	0.84	0.84	152	164	N/A	0.73	Crc.
6	106	95	0.76	1.64	20	20	0.88	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 06

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	83	77	0.36	0.36	92	101	N/A	0.55	Crc
2	92	91	0.36	0.36	193	214	N/A	1.28	Crc

Weld Surface Inspection – Indications in CRDM No. 07

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	59	86	0.20	0.20	70	88	N/A	0.30	Crc
2	100	107	0.56	0.88	59	59	0.32	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 08

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	71	70	0.0	0.24	315	315	0.24	N/A	Axi
2	61	95	0.48	0.48	6	27	N/A	1.30	Crc

Weld Surface Inspection – Indications in CRDM No. 09

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	129	95	0.56	1.40	189	189	0.84	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 10

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	110	94	0.24	0.52	256	256	0.28	N/A	Axi
2	68	89	0.28	0.60	284	284	0.32	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 11

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	36	98	0.20	0.20	79	82	N/A	0.18	Crc

Weld Surface Inspection – Indications in CRDM No. 12

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	112	62	0.48	0.48	120	125	N/A	0.30	Crc
2	72	86	0.28	0.36	124	124	0.10	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 13

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	81`	94	0.04	0.04	63	76	N/a	0.79	Crc
2	72	89	0.24	0.24	44	53	N/A	0.54	Crc
3	168	102	0.52	0.52	184	217	N/A	2.01	Crc
4	127	94	0.64	0.64	113	360	N/A	1.20	M Crc
5	83	106	0.24	0.48	275	275	0.24	N/A	Axi

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 15

Indication NO.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	124	96	0.48	0.48	12	50	N/A	2.30	Crc
2	108	88	0.60	1.00	330	330	0.40	N/A	Axi
3	109	92	0.80	0.80	140	155	N/A	0.90	Crc

Weld Surface Inspection – Indications in CRDM No. 17

Indication NO.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
N/A									NDI

Weld Surface Inspection – Indications in CRDM No. 19

Indication NO.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	91	82	0.20	0.60	5	5	0.40	N/A	Axi
2	82	105	0.08	0.60	57	57	0.52	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 21

Indication NO.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	82	97	0.0	0.32	260	260	0.32	N/A	Axi
2	75	91	0.0	0.0	282	292	N/A	0.5	Crc

Weld Surface Inspection – Indications in CRDM No. 22

Indication NO.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	80	84	0.12	0.32	60	60	0.20	N/A	Axi
2	50	103	0.16	0.16	48	52	N/A	0.20	Crc
3	76	78	0.36	0.36	272	279	N/A	0.30	Crc
4	106	106	0.96	1.4	32	32	0.44	N/A	Axi

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 23

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	66	79	0.0	0.12	178	178	0.12	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 24

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
N/A									NDI

Weld Surface Inspection – Indications in CRDM No. 25

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	70	70	0.12	0.12	237	247	N/A	0.61	Crc

Weld Surface Inspection – Indications in CRDM No. 26

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	39	76	0.64	0.64	201	204	N/A	0.25	Crc
2	57	77	0.84	1.04	220	220	0.25	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 27

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	141	102	0.16	0.56	27	70	0.40	N/A	M Axi

Weld Surface Inspection – Indications in CRDM No. 28

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	91	85	0.24	0.24	256	258	n/a	0.12	Crc

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 29

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	80	88	0.08	0.48	38	38	0.40	N/A	Axi
2	100	84	0.32	0.32	33	39	N/A	0.36	Crc
3	116	91	0.0	0.32	70	70	0.32	N/A	Axi
4	143	88	0.04	0.36	125	125	0.32	N/A	Axi
5	151	83	0.08	0.24	138.5	152	0.16	0.82	Crc
6	136	97	0.24	0.40	191	191	0.16	N/A	Axi
7	98	90	0.24	0.24	195	203	N/A	0.48	Crc
8	155	93	0.16	0.52	318	318	0.36	N/a	Axi

Weld Surface Inspection – Indications in CRDM No. 30

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	56	88	0.36	0.56	160	160	0.20	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 31

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	100	96	0.0	0.20	235	235	0.20	N/A	Axi
2	105	104	0.0	0.20	209	209	0.20	N/A	Axi
3	76	82	0.0	0.24	154	154	0.24	N/A	Axi
4	72	113	0.0	0.16	265	265	0.16	N/A	Axi
5	87	96	0.0	0.08	264	264	0.08	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 32

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	85	80	0.04	0.24	137	137	0.20	N/A	Axi

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 33

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	66	83	0.20	0.40	126	126	0.20	N/A	Axi
2	70	95	0.26	0.56	332	332	0.30	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 34

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	81	99	0.32	0.48	313	313	0.16	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 35

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	88	80	0.24	0.52	193	193	0.28	N/A	Axi
2	157	91	0.32	1.60	190	190	1.28	N/A	Axi
3	97	80	0.84	0.84	233	244	N/A	1.16	Crc

Weld Surface Inspection – Indications in CRDM No. 36

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	68	94	0.16	0.44	306	306	0.28	N/A	Axi
2	135	97	0.16	0.56	320	320	0.40	N/A	Axi
3	90	88	0.16	0.36	333	333	0.20	N/A	Axi
4	116	99	0.16	0.44	342	342	0.28	N/A	Axi
5	119	95	0.36	0.36	341	350	N/A	0.55	Crc
6	60	108	0.12	0.28	236	236	0.16	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 37

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	63	79	0.0	0.20	126	126	0.20	N/A	Axi

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 38

Indication NO.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	71	94	0.20	0.52	20	20	0.32	N/A	Axi
2	84	89	0.32	0.44	5	5	0.12	N/A	Axi
3	73	107	0.44	0.76	355	355	0.32	N/A	Axi
4	155	109	0.44	1.28	312	312	0.84	N/A	Axi
5	130	99	0.28	1.20	132	132	0.92	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 39

Indication NO.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	67	81	0.0	0.06	319	319	0.06	N/A	Axi
2	80	79	0.0	0.12	349	349	0.12	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 40

Indication NO.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	202	92	0.16	0.44	177	293	0.28	7.10	Crc
2	121	96	0.12	0.28	225	225	0.16	N/A	Axi
3	101	87	0.12	0.36	14	14	0.24	N/A	Axi
4	101	99	0.16	0.16	54	98	N/A	2.70	Crc

Weld Surface Inspection – Indications in CRDM No. 41

Indication NO.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	108	93	0.44	0.44	150	178	N/A	1.70	Crc
2	144	93	0.32	0.68	340	340	0.36	N/A	Axi
3	208	84	0.32	0.32	30	77	N/A	2.75	Crc
4	176	90	0.32	0.32	84	141	N/A	3.50	Crc

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 42

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	181	98	0.12	0.12	358	16	N/A	1.10	Crc
2	109	101	0.08	0.08	53	72	N/A	1.16	Crc
3	104	76	0.20	0.52	357	357	0.32	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 43

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	140	97	0.04	0.32	62	62	0.28	N/A	Axi
2	120	95	0.08	0.36	72	102	0.25	0.25	M Ax/Cr
3	81	106	0.08	0.28	302	347	0.20	0.20	M Ax/Cr
4	107	88	0.0	0.18	122	154	0.18	0.18	M Ax/Cr
5	101	100	0.34	0.64	52	52	0.30	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 44

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	113	104	0.0	0.36	207	207	0.36	N/A	Axi
2	75	99	0.08	0.48	287	327	0.32	N/A	M Axi
3	114	107	0.20	0.48	27	87	0.28	N/A	M Axi

Weld Surface Inspection – Indications in CRDM No. 45

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	122	102	0.44	1.20	108	108	0.76	N/A	Axi
2	91	92	0.28	1.00	355	25	.72	N/A	M Axi
3	73	83	0.24	0.80	219	240	0.25	N/A	M Axi

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 46

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	127	101	0.08	0.24	120	171	N/a	3.10	M Crc
2	157	104	0.0	0.32	145	169	N/a	1.46	M Crc
3	116	92	0.32	0.32	215	222	N/a	0.49	Crc
4	142	90	0.08	0.44	275	305	N/A	1.80	M Crc
5	153	96	0.08	0.48	293	328	N/A	2.14	M Crc

Weld Surface Inspection – Indications in CRDM No. 47

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	148	99	0.24	0.56	200	236	0.32	N/A	M Axi
2	79	95	0.24	0.52	130	165	0.28	N/A	M Axi
3	73	90	0.28	0.44	305	325	0.16	N/a	M Axi

Weld Surface Inspection – Indications in CRDM No. 48

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	181	93	0.20	0.44	60	125	N/A	4.00	M Crc
2	181	105	0.36	0.64	302	337	N/A	2.10	MM Crc
3	237	105	0.12	0.40	146	184	N/A	2.30	Crc

Weld Surface Inspection – Indications in CRDM No. 49

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	75	94	0.0	0.24	233	233	0.24	N/A	Axi
2	130	95	0.0	0.40	170	170	0.40	N/A	Axi
3	61	92	0.04	0.36	148	342	0.32	N/A	M Axi

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 50

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	138	86	0.24	0.68	185	185	0.44	N/A	Axi
2	111	98	0.24	0.68	160	215	0.30	N/A	M Axi

Weld Surface Inspection – Indications in CRDM No. 52

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	129	100	0.20	0.52	131	211	0.32	3.23	M Crc/Ax
2	133	112	0.32	0.64	90	130	0.32	2.4	M Crc/Ax

Weld Surface Inspection – Indications in CRDM No. 54

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	303	94	0.40	0.60	115	140	0.20	1.5	Crc/Axi
2	105	92	0.32	0.64	245	245	0.32	N/A	Axi
3	79	89	0.24	0.16	333	353	0.08	1.22	Crc

Weld Surface Inspection – Indications in CRDM No. 56

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	135	96	0.32	0.56	115	147	0.24	1.95	M Crc
2	112	99	0.12	0.56	188	188	0.44	N/A	Axi
3	163	84	0.36	0.68	219	219	0.32	N/A	Axi
4	53	95	0.40	0.68	200	218	0.28	N/A	M Axi
5	174	109	0.36	0.72	274	315	0.36	1.40	Crc

Weld Surface Inspection – Indications in CRDM No. 58

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	145	100	0.12	0.32	55	102	0.20	2.87	Crc
2	108	89	0.16	0.44	182	220	0.32	N/A	M Axi

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 59

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	153	108	0.0	0.44	49	136	0.44	5.31	M Crc
2	162	94	0.08	0.36	256	306	0.28	3.05	M Crc

Weld Surface Inspection – Indications in CRDM No. 60

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	77	102	0.68	0.92	30	30	0.24	N/A	Axi
2	101	96	1.00	1.00	326	350	N/A	1.46	Crc

Weld Surface Inspection – Indications in CRDM No. 61

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	82	80	0.12	0.32	80	110	0.20	N/A	M Axi
2	119	102	0.48	0.48	7	47	N/A	2.40	M Crc
3	58	96	0.40	0.40	331	334	N/a	0.18	Crc

Weld Surface Inspection – Indications in CRDM No. 64

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	37	105	0.0	0.0	36	41	N/A	0.30	Crc

Weld Surface Inspection – Indications in CRDM No. 65

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	104	100	0.0	0.32	290	314	0.32	1.46	M Crc/Ax
2	49	101	0.04	0.04	153	160	N/A	0.43	Crc
3	75	92	0.76	1.32	287	287	0.56	N/A	M Axi

Attachment 2
J-Groove Weld Examination Results

Weld Surface Inspection – Indications in CRDM No. 66

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	116	90	0.0	0.40	253	253	0.40	N/A	Axi
2	120	96	0.24	0.72	170	187	0.40	N/A	M Axi
3	125	95	0.24	0.64	211	231	0.40	n/a	M Axi
4	112	91	0.24	1.20	80	80	0.96	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 67

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	67	97	0.44	0.56	277	320	0.12	2.60	M Crc
2	134	97	0.48	1.12	28	28	0.64	N/A	Axi
3	100	89	0.24	0.48	201	201	0.24	N/A	Axi

Weld Surface Inspection – Indications in CRDM No. 68

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	106	88	0.0	0.48	72	72	0.48	N/A	Axi
2	60	92	0.04	0.24	153	153	0.20	N/A	Axi
3	127	100	0.36	0.36	28	60	N/A	1.95	Crc

Weld Surface Inspection – Indications in CRDM No. 69

Indication N0.	Amplitude 400kHz [ECU]	Phase 400kHz [Dgr.]	Axial Start [inch]	Axial End [inch]	Circ. Start [Dgr.]	Circ. End [Dgr.]	Axial Length [inch]	Circ. Length [inch]	Comment
1	114	99	0.40	0.40	158	168	N/A	0.61	Crc
2	117	100	0.20	0.64	94	125	0.44	N/A	M Axi
3	105	80	0.16	0.88	45	45	0.72	N/A	Axi

Enclosure 2

Response to NRC Request for Additional Information

NRC Bulletin 2002-02
Reactor Pressure Vessel Head and Vessel Head Penetration
Nozzle Inspection Program

North Anna Power Station Unit 1

Virginia Electric and Power Company
(Dominion)

Response to NRC Request for Additional Information

NRC Bulletin 2002-02 Reactor Pressure Vessel Head and Vessel Head Penetration Nozzle Inspection Program

The underlying safety philosophy for preventing catastrophic pressure boundary breach is multi-tiered. This regulatory framework specifically includes quality standards in design and construction; monitoring performance and condition of critical parameters and equipment at predetermined frequencies, with augmented inspection for emergent issues if applicable; and appropriate and timely corrective action to address defects or degrading conditions. Prevention of catastrophic failure is the basis for the specific criterion which precludes continued operation with known through-wall leakage of the reactor coolant pressure boundary.

The following discussion in response to the NRC Request for Additional Information establishes our determination of reasonable assurance that the intent of these provisions continues to be met and that the public health and safety is being protected. Specifically, the previous inspection of the Unit 1 reactor vessel head (RVH) thirteen months ago included a significant sample of penetrations. Although recordable indications were identified, consistent with the criteria of the time, no through-wall indication was determined. Following the outage, the system was visually inspected and verified to be leak-tight per the ASME Code before its return to power. Since the outage, the system has performed with no measurable unidentified leakage. Finally, consistent with the philosophy to address emerging conditions in an effective and timely manner, we are committed to replace the RVH at the next refueling outage following head availability. From this perspective, we conclude with reasonable assurance that we are meeting regulatory requirements consistent with the terms of our license and, more importantly, are maintaining a proper perspective regarding reactor safety.

NRC Question No. 1

Describe the bases for concluding that the VHP nozzles and welds at North Anna, Unit 1 do not have cracking that could jeopardize reactor coolant pressure boundary integrity.

Dominion Response

Background

In accordance with our September 12, 2002 response to NRC Bulletin 2002-02, the North Anna Unit 2 reactor vessel head penetrations (RVHPs) were inspected during the current 2R15 refueling outage for evidence of degradation. The results of the North Anna Unit 2 inspection effort are provided in Enclosure 1. The bare-metal visual inspection identified six (6) confirmed or potentially leaking RVHPs, and an additional twenty-one (21) penetrations that were visually obscured (i.e., masked). Sixty-three (63) of sixty-five (65) CRDM penetration attachment welds were identified with surface indications based on eddy current testing (ECT) or liquid penetrant tests (PT). Ultrasonic testing (UT) and ECT were performed on thirty-five (35) RVHP tubes, which identified axial and circumferential inner diameter (ID) and outer diameter (OD) indications. Most of the OD indications exist in the penetration tube below the annulus between the toe and the root of the penetration weld.

The North Anna Units 1 and 2 reactor vessel heads are of similar construction with similar Effective Degradation Years (EDY). ECT inspections were performed previously on twenty-six (26) of sixty-five (65) North Anna Unit 1 penetration welds and only five reportable indications were identified. These indications were identified to be outside of the weld in the cladding material, and therefore not to present a challenge to pressure boundary integrity. Indications in the tubes of eight penetrations were also identified and were evaluated by fracture mechanics. This evaluation determined that these indications would not compromise structural integrity. As part of its return to service for this cycle, Unit 1 was examined per ASME Code requirements for indication of reactor coolant pressure boundary leakage and none was observed. Furthermore, reactor coolant system leakage monitoring has revealed no measurable unidentified leakage to date. There is no plant performance indicator that would suggest anything other than reactor coolant pressure boundary integrity is being maintained. Nevertheless, the potential for RVHP attachment weld cracking similar to that found at North Anna Unit 2 is at least credible and has been evaluated for North Anna Unit 1.

Safety Assessment

10CFR50, Appendix A – General Design Criteria 14, requires that "the reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture." Based on the results of the Fall 2002 North Anna Unit 2 RVHP inspection effort, the potential for RVHP cracking in Unit 1 has been evaluated. It is concluded that there is an extremely low probability of a nozzle separation event, abnormal leakage or extensive head wastage.

As discussed in References 2 and 3, weld metal cracking by itself does not result in an immediate safety issue since cracking that is contained entirely within the weld metal will not lead directly to nozzle ejection. Nozzle ejection is not considered credible because the portion of the weld that is attached to the outside surface of the nozzle will not be able to pass through the tight annular fit. Additionally, the outward distortion in the penetration from weld shrinkage would further prevent the nozzle from passing through the tight annular fit (i.e., the nozzle maintains its circumference, but becomes oval in shape at the weld, thus resisting ejection through the round penetration). Through-weld cracking to the annulus has the same consequence as a leaking nozzle.

Leakage observed at other plants and at North Anna Unit 2 from Alloy 600 RVHPs due to primary water stress corrosion cracking (PWSCC) has been well below the sensitivity of on-line leakage detection systems. Accordingly, personnel sensitivity to the unidentified leak rate has been increased by issuance of an Operations Standing Order which requires rigorous monitoring of RCS leakage trends. To provide further assurance that RCS pressure boundary integrity is maintained and that any potential leakage would be quickly identified, additional contingency measures have been implemented for North Anna Unit 1 including the following:

- Action levels significantly below Technical Specifications limits (e.g., increase in the RCS unidentified leakrate greater than 0.2 gpm) have been established for the detection and evaluation of unidentified leakage that requires prompt management notification and assessment.

- Containment-cooler thermal performance is being monitored on a daily basis to detect any possible fouling that may be indicative of RVH wastage.

- Filter paper from the containment and process vent radiation monitors is being visually inspected and, if the visual inspection results so warrant, the filter paper will be analyzed for the presence of iron oxide and/or boric acid to determine if RVH degradation may be occurring.

Ultrasonic Testing (UT) of the RVHP nozzle material has been performed to address safety issues associated with ejection of a RVHP by detecting circumferential cracking above the weld. As identified in Reference 3, even a circumferential crack in a nozzle above the weld takes many years to grow before nozzle separation becomes a concern. To date, UT inspection of the RVHP nozzle material at North Anna Units 1 and 2 have not revealed any OD circumferential cracking initiating above the weld, whether initiated by through-wall weld cracking or nozzle cracking.

Also, a through-wall circumferential crack growth curve (Attachment 1) was developed using the same bases as those contained in Reference 1 except that the latest (i.e., more conservative) crack growth model recommended by the EPRI Material Reliability Program (Reference 4) and stress intensities as developed by the NRC (Reference 5) were used. The curve shows that a circumferential, through-wall crack, if initiated at the beginning life of the plant, would not grow to 270 degrees (3/4 of the circumference), the criteria for determining instability of the tube, until the unit has operated for 37.5 years. Since North Anna Unit 1 will only have 21.2 Effective Degradation Years usage by the 2003 refueling outage when the next inspection would be performed, no circumferential through-wall crack is expected that would approach this criterion. The maximum circumferential flaw size found in North Anna Unit 2 was contained within a central angle of 79 degrees and was part through-wall. However, it is estimated that this flaw would grow to through-wall in 1.8 years, and would require another 24.2 years to reach the 270 degree stability limit. Therefore, the tube would remain stable for approximately an additional 26 operating years.

Also, the likelihood of extensive head wastage occurring prior to the next North Anna Unit 1 refueling outage has been evaluated as extremely remote. A leak rate of 10^{-3} gpm will result in the release of about 500 in^3 of boric acid in an 18-month operating cycle, which would be easily observed by a bare metal visual head inspection. The time for a crack to grow from a length that will produce a leak rate of 10^{-3} gpm to a leak rate of 0.1 gpm has been estimated by deterministic analyses to be 1.7 years for plants with 602°F head temperatures (Reference 3). Furthermore, the North Anna Unit 1 RVH was visually inspected, cleaned and re-inspected thirteen months ago with no head wastage observed. Therefore, head wastage is not considered a current safety concern for North Anna Unit 1.

Conclusion

UT inspection of the North Anna RVHP nozzles to date have only found circumferential flaws that originated in the attachment weld material and are contained within the welded area of the tube (Unit 2). The North Anna flaws identified by the recent inspections will not lead directly to nozzle ejection. Even if a crack were to develop, the projected crack growth would not be expected to result in a through-wall crack that would penetrate a RVHP tube, nor would it cause tube instability due to crack propagation for the remainder of the operating cycle. (Reference 1) Furthermore, the through-wall circumferential crack growth curve provided in Attachment 1 shows that a circumferential, through-wall crack, if initiated early in the life of the plant, would not result in tube instability until the unit has operated for 37.5 years. Additionally, we are aware of no evidence that a significant amount of RVH wastage could be created due to a postulated through-wall crack initiated immediately following startup from the Fall 2001 refueling outage twelve months ago that would challenge reactor vessel head structural integrity. This is based on the extremely small leak rates that result from cracks that just reach the annulus through base or weld metal. In summary, the above assessment provides our bases for concluding that there is reasonable assurance that the observed cracking will not cause a nozzle separation event, abnormal leakage or extensive head wastage.

The as-left condition of the North Anna Unit 1 RVHPs following the September 2001 refueling outage indicated that there was no RCS pressure boundary leakage and no through-wall leakage identified in any of the twenty-six penetrations previously examined. Furthermore, the current North Anna Unit 1 reactor coolant system leak rate is 0.0 gpm. Based on our assessment, we conclude that there is reasonable assurance that North Anna Unit 1 RVHP nozzles and welds do not have cracking that could jeopardize reactor coolant pressure boundary integrity.

NRC Question No. 2

Provide the bases for assurance of reactor coolant pressure boundary integrity and conformance with all regulatory requirements consistent with the terms of your operating license.

Dominion Response

The applicable regulatory requirements for providing reasonable assurance of reactor coolant pressure boundary integrity for North Anna Unit 1 include the following:

- Appendix A to 10 CFR Part 50, "General design criteria for nuclear power plants"

  Criteria 14 - "Reactor coolant pressure boundary"

  Criteria 30 – "Quality of reactor coolant pressure boundary"

Criteria 31 - "Fracture prevention of reactor coolant pressure boundary", and

Criteria 32 - "Inspection of reactor coolant pressure boundary"

- North Anna Unit 1 Technical Specifications
- 10 CFR 50.55a, Codes and Standards, which incorporates by reference Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components, of the ASME Boiler and Pressure Vessel Code"
- Appendix B of 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," Criteria V, IX, and XVI

The following discussion provides the basis that there is reasonable assurance of reactor coolant pressure boundary (RCPB) integrity and conformance with regulatory requirements consistent with the terms of the North Anna Unit 1 Operating License.

<u>10 CFR 50, Appendix A, General Design Criteria</u>

The principal design criteria to provide reasonable assurance that a given plant can be operated without undue risk to the health and safety of the public is given in 10 CFR 50, Appendix A.

10 CFR 50, Appendix A, specifies four General Design Criteria that are applicable to RCS pressure boundary integrity. The applicable GDC include GDC 14 (Reactor coolant pressure boundary), GDC 30 (Quality of reactor coolant pressure boundary), GDC 31 (Fracture prevention of reactor coolant pressure boundary), and GDC 32 (Inspection of reactor coolant pressure boundary).

The four GDCs specify the following requirements:

Criteria 14 - Reactor coolant pressure boundary. The reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

Criterion 30 - Quality of reactor coolant pressure boundary. Components which are part of the reactor coolant pressure boundary shall be designed, fabricated, erected, and tested to the highest quality standards practical. Means shall be provided for detecting and, to the extent practical, identifying the location of the source of reactor coolant leakage.

Criterion 31 - Fracture prevention of reactor coolant pressure boundary. The reactor coolant pressure boundary shall be designed with sufficient margin to assure that when stressed under operating, maintenance, testing, and postulated accident conditions (1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The design shall reflect consideration of service temperatures and other conditions of the boundary material under operating, maintenance, testing, and postulated accident conditions and the uncertainties in determining (1) material properties, (2) the effects of irradiation on material properties, (3) residual, steady state and transient stresses, and (4) size of flaws.

Criterion 32 - Inspection of reactor coolant pressure boundary. Components which are part of the reactor coolant pressure boundary shall be designed to permit (1) periodic inspection and testing of important areas and features to assess their structural and leaktight integrity, and (2) an appropriate material surveillance program for the reactor pressure vessel.

During the initial plant licensing of North Anna Power Station Units 1 and 2, it was demonstrated that the design of the reactor coolant pressure boundary met the regulatory requirements in place at that time. The GDC included in Appendix A to 10 CFR Part 50 did not become effective until May 21, 1971. The Construction Permits for North Anna Units 1 and 2 were issued prior to May 21, 1971; consequently, these units were not subject to GDC requirements. (Reference SECY-92-223 dated September 18, 1992.) However, the following information demonstrates compliance with the design criteria relative to the cracking of reactor vessel head nozzles and the potential for subsequent wastage of the reactor vessel head:

- Pressurized water reactors licensed both before and after issuance of Appendix A to 10 CFR Part 50 (1971) complied with these criteria in part by: 1) selecting Alloy 600 or other austenitic materials with excellent corrosion resistance and extremely high fracture toughness, for reactor coolant pressure boundary materials, and 2) following ASME Codes and Standards and other applicable requirements for fabrication, erection, and testing of the pressure boundary parts. NRC reviews of operating license submittals subsequent to issuance of Appendix A included evaluating designs for compliance with the General Design Criteria. The standard review plans (SRPs) in effect at the time of licensing did not address the selection of Alloy 600. They only required that ASME code requirements be satisfied.
- Although stress corrosion cracking of primary coolant system penetrations was not originally anticipated during plant design, it has occurred in the RPV top head nozzles at North Anna and other plants. However, given the inherently high fracture toughness and flaw tolerance of the Alloy 600 material, there is in fact an extremely low probability of a rapidly propagating failure and gross rupture. It should also be noted that earlier versions of the GDCs were specified in terms of design to extremely low probability of gross rupture or significant leakage throughout service life.
- As discussed in response to NRC Question No. 1 above, our assessment of observed cracking in North Anna RVHP weld material indicates that it does not create a potential for a nozzle separation event, abnormal leakage, or extensive head wastage inconsistent with GDC-14.
- Leakage observed at other plants and at North Anna Unit 2 from Alloy 600 RVHPs due to PWSCC has been well below the sensitivity of on-line leakage detection systems. If an unidentifiable through-wall pressure boundary leak were to develop at a North Anna Unit 1 RVHP while the unit was at power and increase to the point that the leakage is detected by the on-line leakage detection system, the leak will be

evaluated per the applicable plant Technical Specification (TS) Limiting Condition for Operation. (The leakage limit per the North Anna Unit 1 TS for unidentified leakage is 1 gpm.) Contingent actions have been put into place to provide greater plant staff sensitivity to this issue including specifying an action level below the TS limit that requires management assessment/intervention.

- The ASME requirement for the J-groove RVHP nozzle welds is for a visual examination of 25% of the penetrations for leakage during pressure testing. The component was designed for that inspection. That examination requirement was satisfied by the 100% bare-metal visual reactor vessel head inspection that was performed during the North Anna Unit 1 Fall 2001 refueling outage thirteen months ago. That inspection did not identify any leaking reactor vessel head penetrations.
- Recent industry events, including one with significant head wastage, have demonstrated that the design of the reactor vessel head is robust, and that it can tolerate significant degradation without rapidly propagating failure or gross rupture. The only example of significant head wastage in the industry required several years to progress. The North Anna Unit 1 RVH was inspected during the Fall 2001 refueling outage thirteen months ago with no head wastage and no RVHP through-wall leakage identified. Furthermore, Dominion is committed to replacing the North Anna Unit 1 RVH during the first refueling outage following the availability of a suitable replacement.

As described above, the requirements established for design, quality and leak detection, fracture toughness, and inspectability in GDC 14, 30, 31, and 32, respectively, were satisfied during each plant's initial licensing review and continue to be satisfied during operation, even in the presence of a potential for PWSCC of the reactor vessel head penetrations and/or subsequent wastage of the reactor vessel head. Therefore, there continues to be reasonable assurance that regulatory design requirements are currently being met.

ASME Section XI Requirements

NRC regulations in 10 CFR 50.55a state that American Society of Mechanical Engineers (ASME) Class 1 components (which includes the reactor coolant pressure boundary) must meet the requirements of Section XI of the ASME Boiler and Pressure Vessel Code. For example, Table IWB-2500-1 of Section XI of the ASME Code provides examination requirements for reactor vessel head nozzles and references IWB-3522 for acceptance standards. IWB-3522.1(c) and (d) specify that conditions requiring correction include the detection of leakage from insulated components and discoloration or accumulated residues on the surfaces of components, insulation, or floor areas which may reveal evidence of borated water leakage, with leakage defined as the "through-wall leakage that penetrates the pressure retaining membrane."

For through-wall leakage identified by visual examinations in accordance with the ASME Code, acceptance standards for the identified degradation are provided in IWB-3142. Specifically, supplemental examination (by surface or volumetric examination), corrective measures or repairs, analytical evaluation, and replacement provide methods for determining the acceptability of degraded components.

Title 10 of the Code of Federal Regulations, Part 50.55a requires that inservice inspection and testing be performed per the requirements of the ASME Boiler and Pressure Vessel Code, Section XI, "Inservice Inspection of Nuclear Plant Components." Section XI contains applicable rules for examination, evaluation and repair of code class components, including the reactor coolant pressure boundary.

Requirements for partial penetration welds attaching CRDM housings to the reactor vessel head are contained in Table IWB-2500-1, Examination Category B-E, "Pressure Retaining Partial Penetration Welds in Vessels," Item Numbers: B4.10, "Partial Penetration Welds;" B4.11, "Vessel Nozzles;" B4.12, "CRDM Nozzles;" and B4.13, "Instrumentation Nozzles." The Code requires a VT-2 visual examination of 25% of the CRDM nozzles from the external surface. Since the reactor vessel head is insulated, and the nozzles do not represent a bolted flange, paragraph IWA-5242(b) permits these inspections to be performed with the insulation left in place.

The acceptance standard for the visual examination is found in paragraphs IWA-5250, "Corrective Measures" and IWB 3522, "Standards for Examination Category B-E, Pressure Retaining Partial Penetration Welds in Vessels, and Examination Category B-P, All Pressure Retaining Components." Paragraph IWA-5250 requires repair or replacement of the affected part if a through-wall leak is found and requires an assessment of damage, if any, associated with corrosion of steel components by boric acid. Plants may not return to service after finding a leak from a reactor vessel head nozzle without first having repaired the nozzle and having assessed any wastage of the reactor vessel head the leakage may have caused.

Flaws identified by NDE methods, which are not addressed by specific ASME Section XI acceptance criteria are evaluated in accordance with the flaw evaluation rules for piping contained in Section XI of the ASME Code. The NRC has accepted this approach. Any identified flaw not meeting requirements for the intended service period would be repaired before returning it to service.

North Anna Unit 1 was shutdown for refueling in September 2001, and visual examination of the reactor vessel head penetrations was performed. Several penetrations obscured by boric acid and other debris were examined from under the head. No circumferential cracking or through-wall flaws were identified in the welds or in the tubes of any of the reactor vessel penetrations; however, indications were identified on nine penetrations. One non-service induced flaw (crater crack) and four indications in the cladding at the J-groove weld were discovered on one penetration (Penetration 50). The non-service induced flaw was successfully excavated, and since the other four indications were considered non-relevant, they did not require repair. The tube indications (which were not through-wall and were on the penetrations' inside diameters) associated with the remaining eight penetrations (i.e., Penetration Nos. 3, 11, 31, 33, 52, 57, 60, 66) were evaluated by fracture mechanics, and it was determined that these indications would not compromise structural integrity. Following the refueling outage, a pressure test of the reactor coolant system (RCS) pressure boundary was performed, and no RCS pressure boundary integrity concerns were identified.

North Anna Unit 1 is in compliance with ASME Section XI Code requirements through implementation of its inservice inspection program. When a VT-2 examination detected the conditions described by IWB-3522.1(c) and (d), corrective actions per IWB-3142 were performed in accordance with the plant's corrective action program. Disposition of indications in the North Anna Unit 1 reactor vessel head nozzles was performed in accordance with Section XI requirements, NRC-approved ASME Code Case requirements, or an alternative repair or replacement method approved by the NRC.

North Anna Unit 1 Technical Specifications Requirements

The reactor coolant pressure boundary is one of the three physical barriers to the release of radioactivity to the environment. Therefore, our plant Technical Specifications (TS) include a requirement and associated action statements addressing reactor coolant pressure boundary (RCPB) leakage. The limits for reactor coolant pressure boundary leakage in the North Anna Technical Specifications is 1 gallon per minute (gpm) for unidentified leakage, 10 gpm for identified leakage, and no leakage from a non-isolable fault in the reactor coolant system pressure boundary (i.e., component body, pipe well, vessel wall, or pipe weld). Currently, Unit 1's unidentified leakage rate is 0.0 gpm.

As noted above, leaks observed in other plants and at North Anna Unit 2 from Alloy 600 reactor vessel head penetrations due to PWSCC have been well below the sensitivity of on-line leakage detection systems. These plants have evaluated the condition and we have evaluated the condition for North Anna Unit 2 and determined that appropriate inspections are bare-metal visual inspections of the reactor vessel head for boric acid deposits during plant shutdowns and NDE examinations of the RVHPs where indicated by the visual results. If leakage or unacceptable indications are found, then the defects must be repaired before the plant returns to power operation. If RCPB leakage is identified during power operation, the unit will be shut down as directed by Technical Specifications.

Quality Assurance Requirements: 10 C.F.R. § 50, Appendix B

All of the work undertaken to inspect and evaluate the North Anna Unit 1 reactor vessel head penetrations has been conducted and documented in accordance with existing or new procedures which comply with the Company's Quality Assurance (QA) Topical Report, the QA program, and Appendix B to 10 CFR Part 50. Measures have been taken to assure that conditions adverse to quality were promptly identified and corrected, in that the North Anna Unit 1 RVH and RVHPs were inspected and any identified flaws were either repaired or dispositioned in accordance with ASME requirements and pursuant to the station's corrective action program. These actions and measures meet the requirements of 10 CFR 50, Appendix B.

Conclusion

Since 1) the North Anna Unit 1 RVH and RVHPs were inspected during the previous outage, 2) RVHP flaws were identified, evaluated and dispositioned pursuant to regulatory requirements, 3) the "as-left" condition of the RVH and RVHPs was "no RCPB leaks," 4) the current TS RCS unidentified leak rate is 0.0 gpm, and finally 5) plans are underway to replace the RVH with an improved design, it is our assessment that there is reasonable assurance that RCS pressure boundary structural integrity has been, and will continue to be, maintained in conformance with regulatory requirements and consistent with the terms of the North Anna Unit 1 Operating License.

References:

1. WCAP-14552, "Structural Integrity of Reactor Vessel Upper Head Penetrations to Support Continued Operation: North Anna and Surry Units."

2. NRC memorandum to Gary Holahan, Director - Division of Systems Safety and Analysis from Walton Jensen, Reactor Systems Branch - Division of Systems Safety and Analysis, "Sensitivity Study of PWR Reactor Vessel Breaks," dated May 10, 2002.

3. EPRI Report 1007337, "PWR Reactor Pressure Vessel (RPV) Upper Head Penetrations Inspection Plan (MRP-75)," Revision 1, 2002.

4. EPRI MRP-55, "Materials Reliability Program (MRP), Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick-Wall Alloy 600 Material," dated July 18, 2002.

5. Hiser, Allen, "Deterministic and Probabilistic Assessments," presentation at NRC/Industry/ACRS meeting, November 8, 2001.

Attachment 1

Stress Corrosion Crack Growth Prediction for Circumferential Through-wall Crack Near the Top of the Attachment Weld