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Byron Station Unit 2
Facility Operating License No. NPF-66
NRC Docket No. STN 50-455

Subject: Byron Station, Unit 2, 60-Day Response to First Revised NRC Order EA-03-009, "Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors"

Reference: Letter from NRC, "Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated February 20, 2004.

The purpose of this letter is to provide the results of examinations performed at Byron Station, Unit 2, in accordance with the requirements of the referenced NRC Order.

During the Spring 2007 refueling outage (B2R13), Byron Station Unit 2, completed visual, surface, and volumetric nondestructive examinations in accordance with the NRC Order. Section IV. E. of the Order requires that the results of this examination be submitted to the NRC within 60 days after returning the plant to operation.

The detailed report of the examination results is provided in the attachment to this letter. In summary, one indication of cracking was found in Penetration 68. All other penetrations examined, had no indications noted. All penetrations did not show any evidence of a leakage path along the reactor vessel head penetration shrink-fit regions. Sixteen penetrations (#s 33, 34, 39, 42, 44, 45, 51, 52, 53, 55, 56, 58, 63, 68, 69 and 71) had limited inspection coverage that will require the submittal of a relaxation request. As discussed in an April 25, 2007 telephone conversation between an Exelon Generation Company, LLC Licensing representative and the NRC Byron Station Project Manager, this relaxation request was not required to be submitted prior to restart from the Spring 2007 refueling outage. The request will be submitted under separate letter.

Penetration 68 was repaired using the embedded flaw technique, which was verbally approved by the NRC on April 16, 2007, for Byron Station Unit 2 with Inservice Inspection Relief Request I3R-14 "Alternative Requirements for the Repair of a Reactor Vessel Head Penetration In Accordance with 10 CFR 50.55a(a)(3)(i)." Written approval from the NRC was received on May 23, 2007.

With the presence of primary water stress corrosion cracking (PWSCC) identified, the order stipulates that the Byron Unit 2 RPV Head be considered in the "High Susceptibility" category. This re-categorization required that a bare metal examination be completed during B2R13.

<u>60-Day Reporting Required by NRC Order Section IV.E Concerning Section IV.C Examinations</u>

Paragraph C, Item 1 of this Order requires the following inspections:

(1) For those plants in the High category, RPV head and head penetration nozzle inspections shall be performed using the techniques of paragraph IV.C.(5)(a) and paragraph IV.C.(5)(b) every refueling outage.

(a) Bare metal visual examination of 100 percent of the RPV head surface (including 360° around each RPV head penetration nozzle).

(b) Either:

(i) Ultrasonic testing of each RPV head penetration nozzle (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-1]); OR ... In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel,

(ii) Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-3]); OR....

(iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii).

A remote bare metal visual inspection of the Unit 2 RPV head was performed during B2R13, to meet the requirements of Item 5(a). The inspection included an examination around the full circumference of each RPV head penetration nozzle (i.e., 78 control rod drive mechanism (CRDM) nozzles and the RPV head vent line) and the RPV head surface to provide 100% coverage of the RPV head. No evidence of CRDM or RPV head vent line boric acid leakage and no evidence of any wastage was observed.

The inspection was performed in accordance with procedure ER-AP-335-1012, "Visual Examination of PWR Reactor Vessel Head Penetrations." The inspection, performed by VT-2 certified personnel, used a pole-mounted camera connected to a video recorder/monitor that provided the examiner with immediate access to the examination surfaces. The inspection used remote equipment capable of resolving the appropriate detail (i.e., VT-1/1C character height in accordance with 1992 ASME Boiler and Pressure Vessel Code Section XI, Table IWA-2210-1) at two feet. The actual distances viewed were less than two feet, which gave close views of the nozzle to interface region, thereby ensuring any boric acid leakage would be easily identified.

<u>60-Day Reporting Required by NRC Order Section IV.E Concerning Section IV.D Examinations</u>

Section IV.D required the following inspections:

D. During each refueling outage, visual inspections shall be performed to identify potential boric acid leaks from pressure-retaining components above the RPV head. For any plant with boron deposits on the surface of the RPV head or related insulation, discovered either during the inspections required by this Order or otherwise and regardless of the source of the deposit, before returning the plant to operation the Licensee shall perform inspections of the affected RPV head surface and penetrations appropriate to the conditions found to verify the integrity of the affected area and penetrations.

VT-2 certified examiners performed a visual inspection to identify potential boric acid leaks from pressure-retaining components above the RPV head. This inspection was performed during the B2R13 shutdown as part of the Mode 3 walkdown. Each of the doors on the integrated RPV head package was opened and the areas of the head insulation around the CRDMs and potential sources of leakage above the head were examined. No evidence of any leakage from sources above was found.

Should you have any questions or desire additional information regarding this letter, please contact William Grundmann, Regulatory Assurance Manager, at (815) 406-2800.

Respectfully,

David M. Hoots
Site Vice President
Byron Nuclear Generating Station

Attachment Westinghouse Report WDI-PJF-1303451-FSR-001

DMH/DJS/rah

ATTACHMENT

Westinghouse Report WDI-PJF-1303451-FSR-001

"Byron Generating Station Outage – B2R13 Reactor Vessel Head Penetration Examination"

Byron Generating Station
Outage – B2R13
Reactor Vessel Head
Penetration Examination

April 2007

Final NDE Report

WDI-PJF-1303451-FSR-001

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1.0 INTRODUCTION

During the Byron Unit B2R13 outage in April 2007, Westinghouse performed nondestructive examinations (NDE) of the reactor vessel head CRDM penetration tubes, the reactor vessel head vent tube and the vent line j-weld.

The purpose of the examination program was to identify evidence of primary water stress corrosion cracking (PWSCC) that might be present on the OD and ID surfaces of the head penetration tubes, the ID surface of the vent line tube, and the surface of the vent line J-groove weld. Examinations of the CRDM penetration tubes also included the application of techniques to identify evidence of CRDM leakage in the shrink-fit region at the tube-to-head interface. Examinations were performed using procedures and techniques demonstrated through the EPRI/MRP protocol, and/or Westinghouse internal demonstration programs, and applied in a manner acceptable within the context of the February 20, 2004, USNRC Order EA-03-009, Rev. 1, "Establishing Interim Inspection Requirements for Reactor Vessel Heads at Pressurized Water Reactors".

The reactor vessel head at Byron 2 is a Westinghouse design and manufactured by Babcock & Wilcox (B&W). The head contains seventy eight alloy 600 penetration tubes that are shrunk fit in the reactor vessel head and attached with alloy 182/82 partial penetration J-groove welds. The head also contains one alloy 600 vent tube, attached to the vessel head with an alloy 182/82 partial penetration J-groove weld.

There are a variety of configurations for the seventy eight penetration tubes, each configuration requiring special consideration for examination. The penetration tubes measure 4.04" on the OD and have an ID dimension of 2.75". The nominal wall thickness is 0.645". The penetration tube configurations are as follows:

- 55 penetration tubes with thermal sleeves installed
- 5 open thermocouple column penetration tubes
- 18 open penetration tubes
- One (1) 1.00" - schedule 160, ID vent tube

As per, Section IV.C. (5) of the USNRC Order EA-03-009 revision 1 ,The Byron Unit 2 reactor vessel head is in the "low susceptibility" category. For a reactor vessel head in the low category, the requirements of paragraph IV.C. (5)(b), specify for each penetration:

"Either

i Ultrasonic testing of the RPV head penetration nozzle volume (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches; OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater. In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

ii Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater.

iii. A combination of (i) and (ii) to cover equivalent volumes, surfaces and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric examination may be performed with the following requirements:

1. *On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.*
2. *On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed*

The examination program selected for Byron 2 included ultrasonic examinations of the seventy eight CRDM penetration nozzles with leakage assessment in accordance with Section IV.C.(5) (b) (i) of the Order, and eddy current examinations of the wetted surfaces of the vent tube and vent tube J-groove weld in accordance with Section IV.C.(5) (b) (ii) of the Order.

In anticipation that a combination of volumetric and surface examination techniques might be necessary to complete the reactor vessel head penetration inspection program, the following Westinghouse field service procedures and any associated field change requests (FCRs) were approved for use at Byron 2. With the exception of the vent line examination procedures, WDI-STD-101, Rev. 6 and WDI-STD-114, Rev. 5, all have been demonstrated through the EPRI/MRP protocol. In the absence of an EPRI/MRP protocol for the vent line applications, the examination procedures and techniques are based on processes demonstrated for examinations of steam generator tubes and demonstrated Westinghouse experience with these techniques.

- WDI-ET-003, Rev. 11
  "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations"
- WDI-ET-004, Rev. 11
  "IntraSpect Eddy Current Analysis Guidelines "
- WDI-ET-008, Rev. 8
  "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations With Gap Scanner"
- WDI-UT-010, Rev 13
  "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic & Longitudinal Wave & Shear Wave"
- WDI-UT-013, Rev. 12
  "IntraSpect UT Analysis Guidelines"
- WDI-STD-101, Rev. 6
  "RVHI Vent Tube J-Weld Eddy Current Examination"
- WDI-STD-114, Rev. 5
  "RVHI Vent Tube ID & CS Wastage Eddy Current Examination"
- WCAL-002, Rev. 7
  "Pulser/Receiver Linearity Procedure"
- WDI-STD-151, Rev.1.
  "Reactor Vessel Head Inspection for Byron Units 1&2 CEA/CBE and Braidwood Units 1&2 CCE/CDE"

The vessel head penetrations data results were dispositioned based on an assessment of results from the nondestructive examinations presented herein.

Due to thermal sleeve wear identified in other plants a visual inspection of the thermal sleeves was conducted in conjunction of the above mentioned inspection and is documented in a separate report.

The nondestructive examination identified minor variations in tube thickness at the end of the tube in twenty of the penetrations inspected and is documented in section 3.4 of this report.

2.0 SCOPE OF WORK

The reactor vessel head penetration nondestructive examination scope at Byron Unit 2 included all seventy eight CRDM penetration tubes and the reactor vessel head vent.

- Examinations of the CRDM penetration tubes were performed from the inside diameter (ID) surfaces using two examination systems. The system selected for each penetration was dependent upon the penetration tube configuration and penetration-specific conditions:

    1) Eighteen (18) open penetration tubes and five (5) open thermocouple column penetration tubes were examined from the ID using the Westinghouse 7010 Open Housing Scanner which perform; 1) TOFD ultrasonic examinations, 2) 0° straight beam examination to identify evidence of a leak path in the shrink fit area, and 3) supplementary eddy current examination.

    2) Fifty-five (55) penetration tubes containing thermal sleeves were inspected from the ID using the Westinghouse Gap Scanner and "Trinity" blade probes which perform 1) TOFD ultrasonic examination, 2) 0° straight beam examination to identify evidence of a leak path in the shrink fit area, and 3) supplementary eddy current examination.

- The vent line tube ID surface and the vent line J-groove weld were examined using eddy current techniques with multiple coil arrays.

The delivery system used for the CRDM examinations at Byron Unit 2 was the Westinghouse DERI 700 manipulator.

The DERI 700 is a multi-purpose robot that can access all head penetrations and provides a common platform for all CRDM examination end effectors. The manipulator consists of a central leg, mounted on a carriage, which in turn is mounted onto a guide rail. The manipulator arm, with elbow and removable wrist, is mounted onto the carriage, which travels vertically along the manipulator leg.

The DERI 700 was used to deliver 1) the Westinghouse 7010 Open Housing Scanner for ultrasonic and supplementary eddy current examinations of penetration locations without thermal sleeves, 2) the Westinghouse Gap Scanner end effector for ultrasonic and supplementary eddy current examinations of penetration locations containing thermal sleeves, and 3) special interest probe.

The Westinghouse 7010 Open Housing Scanner delivers an examination wand containing ultrasonic and eddy current probes to the ID surface of open reactor vessel head penetrations. The scanning motion is in a vertical direction moving from a specified height above the weld, in this case at least 2.0", to the ID chamfer at the bottom of each penetration. The probe is indexed in the circumferential direction. With the Open Housing Scanner, four examinations are conducted simultaneously. These include:

1) Time-of-flight diffraction ultrasonic examination optimized for identification of axially oriented degradation on the penetration tube OD surfaces
2) Time-of-flight diffraction ultrasonic examination optimized for identification of circumferentially oriented degradation on the penetration tube OD surfaces
3) Straight beam ultrasonic examination to identify variations in the penetration tube-to-reactor vessel head shrink fit area that might indicate a leak path
4) Supplementary eddy current examination for identification of circumferential and axial degradation on the ID surfaces of the penetration tubes

The Gap Scanner end effector delivers "Trinity" blade probes which include a crosswound eddy current coil, a TOFD UT transducer pair and a 0°ultrasonic transducer into the annulus between the ID surface of the reactor vessel head penetration tube and the OD surface of the thermal sleeve. The typical annulus gap size is 0.125". The blade probe design utilizes a flexible metal "blade" on which ultrasonic and/or 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, in this case at least 2.0", to the ID chamfer at the bottom of each penetration. The probes are indexed in the circumferential direction. The Gap Scanner end effector also has 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. With the Gap Scanner, three examinations are conducted simultaneously. These include:

1) Time-of-flight diffraction ultrasonic examination optimized for identification of circumferentially oriented degradation on the penetration tube OD surfaces
2) Straight beam ultrasonic examination to identify variations in the penetration tube-to-reactor vessel head shrink fit area that might indicate a leak path
3) Supplementary eddy current examination for identification of circumferential and axial degradation on the ID surfaces of the penetration tubes

The vent line weld scanner is delivered manually beneath the head and applies an array of plus-Point eddy current coils to the vent tube J-weld surface. The entire weld is examined with two 360 degree scans.

The vent line tube scanner is also delivered manually beneath the head and applies an array of plus-Point eddy current coils and a low frequency bobbin probe to the inside diameter surface of the vent tube.

2.1 7010 Open Housing Scanner Ultrasonic and Eddy Current Examinations

7010 Open Housing Scanner examinations were conducted on eighteen (18) reactor vessel head penetrations without thermal sleeves and five (5) open thermocouple column penetration tubes.

Examinations of these vessel head penetrations included:

1) TOFD ultrasonic techniques demonstrated capable of detecting axial and circumferential reflectors on the penetration tube OD surfaces with PCS24 probes in accordance with WDI-UT-010, Rev. 13 – "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic, Longitudinal Wave & Shear Wave.

2) Straight beam ultrasonic techniques at 2.25 MHz to identify possible leak paths in the shrink fit region between the head penetrations and the reactor vessel head, and

3) Supplementary 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. 11 - "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations".

2.2 Gap Scanner Penetration Tube Examinations using Trinity Blade Probe

Examinations were performed with the Gap Scanner end effector from the penetration ID surfaces on fifty five penetration tubes containing thermal sleeves. These fifty five penetration tubes were inspected from the ID using "Trinity" blade probes capable of performing TOFD ultrasonic examinations, leak path assessment, and supplementary eddy current examinations simultaneously. These examinations were performed in accordance with:

1) WDI-UT-010, Rev. 13 – "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic Longitudinal Wave & Shear Wave

2) WDI-ET-008, Rev. 8 – "Intraspect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations with Gap Scanner".

2.3 Vent Line and Vent Line J-Weld Eddy Current Examination

The vent line tube eddy current examination was performed with and array of 16 plus-Point probes and a low frequency bobbin coil in accordance with WDI-STD-114, Rev. 5 - "RVHI Vent Tube ID & CS Wastage Eddy Current Examination". The vent line J-groove weld eddy current examination was performed with an array of 28 plus-Point coils in accordance with WDI-STD-101, Rev. 6, and "RVHI Vent Tube J-Weld Eddy Current Examination".

3.0 EXAMINATION RESULTS

3.1 7010 Open Housing Scanner Ultrasonic and Eddy Current Examinations

The following table provides a summary of all 7010 Open Housing Scanner RVHP nondestructive examinations performed at Byron Unit 2 during the B2R13 Spring 2007 refueling outage.

A total of twenty-three (23) open penetrations; #10, #11, #12, #13, #18, #19, #20, #21, #22, #23, #24, #25, #26, #27, #28, #29, #62, #64, #74, #75, #76, #77 and #78, were inspected from the ID using the Westinghouse Open Housing Scanner. The final disposition of the examination results is provided in the table 3.1.1 below.

Table 3.1.1 Open Housing Scanner Penetrations

Penetration #	Axial TOFD Channel 1	Circ TOFD Channel 2	0°(2.25 Mhz) Channel 3	Tube ID ECT (Supplement)	Exam Extent	
					Lower	Upper
10	NDD	PTI/BBP/NDD	NDD	NDD	2.00	4.00
11	NDD	NDD	SI/NDD	NDD	1.96	3.52
12	NDD	PTI/BBP/NDD	NDD	NDD	1.92	3.52
13	NDD	NDD	NDD	NDD	2.00	5.04
18	PTI/BBP/NDD	NDD	NDD	NDD	1.88	3.96
19	NDD	PTI/BBP/NDD	NDD	NDD	1.76	3.40
20	NDD	NDD	NDD	NDD	1.90	3.44
21	NDD	NDD	NDD	NDD	1.92	4.80
22	NDD	NDD	NDD	NDD	2.04	3.20
23	NDD	NDD	NDD	NDD	2.00	4.48
24	NDD	NDD	NDD	NDD	1.56	3.36
25	NDD	PTI/BBP/NDD	NDD	NDD	1.56	3.40
26	NDD	NDD	NDD	NDD	2.00	3.00
27	NDD	NDD	NDD	NDD	1.96	2.88
28	PTI/BBP/NDD	PTI/BBP/NDD	NDD	NDD	1.80	4.96
29	NDD	NDD	NDD	NDD	1.72	4.84
62	NDD	NDD	NDD	NDD	1.20	5.32
64	NDD	NDD	NDD	NDD	1.40	2.68
74	NDD	NDD	NDD	PCI/NDD SGI/NDD	1.12	3.88
75	NDD	LOL/NDD	NDD	SGI/NDD	1.04	5.52
76	WVI/NDD	WVI/NDD	NDD	NDD	1.24	5.40
77	SSS/NDD	SSS/NDD	NDD	NDD	1.12	2.24
78	NDD	NDD	NDD	NDD	1.08	5.04

Legend: (for Table 3.1.1)

NDD	No Detectable Defect	LOL	Loss of Lateral Wave
PTI	Penetration Tube Indication	WVI	Weld Volume Indication
IPA	Indication Profile Analysis	SGI	Surface Geometry Indication
BBP	B and B Prime	PCI	Probe Chatter Indication
SSS	Shallow Surface Scratch	SI	Special Interest

There was no detectable degradation in the twenty-three penetrations inspected with the 7010 Open Housing Scanner System.

There were no indications of leak paths identified in the shrink fit areas with the 0° UT probes.

Of the twenty-three penetrations inspected with the 7010 Open Housing Scanner System, none showed indications characteristic of primary water stress corrosion cracking on the ID surface and no penetrations showed any detectable degradation. Although some of the Eddy Current indications were detectable with the TOFD inspection, all indicated a depth less or equal to 0.040".

All penetrations were inspected from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to the chamfer at the bottom end of the tube. All penetrations have UT data collected at least 1 inch below the lowest point at the toe of the J-groove weld to the chamfer.

3.2 Gap Scanner Penetration Tube Trinity Blade Probe Examinations

The following table provides a summary of all Gap Scanner examinations performed at Byron Unit 2 during the B2R13 Spring 2007 refueling outage.

Fifty-five penetration tubes containing thermal sleeves; penetrations #1 through #9, #14 through #17, #30 through #61, #63, #65, and #66 through #73 were inspected from the ID using the Westinghouse Gap Scanner and "Trinity" blade probes.

The final disposition of the examination results is provided in the table 3.2.1 below.

Table 3.2.1 Thermal Sleeve Penetrations

Penetration #	PCS 23.5 TOFD	0° Leak Path	Supplementary ECT Tube ID	Exam Extent	
				Lower	Upper
1	NDD	NDD	NDD	1.16	3.04
2	NDD	NDD	NDD	1.40	3.12
3	NDD	NDD	NDD	1.28	2.80
4	NDD	NDD	NDD	1.28	3.20
5	NDD	NDD	NDD	1.20	2.60
6	PTI/BBP/NDD	SSS/NDD	NDD	1.16	2.76
7	PTI/BBP/NDD	NDD	NDD	1.12	2.72
8	NDD	NDD	NDD	1.16	2.52
9	PTI/BBP/NDD	SSS/NDD	NDD	1.20	4.24
14	PTI/IPA/NDD	NDD	NDD	1.16	4.88
15	NDD	NDD	NDD	1.16	3.56
16	NDD	NDD	NDD	1.44	3.80
17	PTI/BBP/NDD	NDD	NDD	1.24	3.24
30	NDD	NDD	NDD	1.12	4.80
31	PTI/BBP/NDD	NDD	NDD	1.20	4.00
32	PTI/BBP/NDD	NDD	NDD	1.08	4.08
33	NDD	NDD	NDD	0.92	3.88
34	PTI/BBP/NDD	NDD	NDD	0.88	4.32

Penetration #	PCS 23.5 TOFD	0° Leak Path	Supplementary ECT Tube ID	Exam Extent	
				Lower	Upper
35	PTI/BBP/NDD	NDD	NDD	1.28	4.60
36	PTI/IPA/NDD	NDD	NDD	1.16	4.16
37	PTI/IPA/NDD	NDD	NDD	1.48	4.60
38	PTI/IPA/NDD	NDD	NDD	1.16	4.24
39	PTI/IPA/NDD	NDD	NDD	0.80	3.84
40	PTI/BBP/NDD	NDD	NDD	1.04	4.08
41	PTI/IPA/NDD	NDD	NDD	1.20	3.92
42	PTI/IPA/NDD	NDD	NDD	0.88	5.00
43	NDD	NDD	NDD	1.08	4.12
44	PTI/BBP/NDD	NDD	NDD	0.84	4.44
45	NDD	NDD	NDD	0.80	4.16
46	PTI/BBP/NDD	NDD	NDD	1.00	4.08
47	NDD	NDD	NDD	1.12	4.48
48	PTI/BBP/NDD	NDD	NDD	1.16	3.64
49	PTI/IPA/NDD	NDD	SGI/NDD	1.12	4.60
50	PTI/IPA/NDD	NDD	NDD	1.00	4.56
51	PTI/BBP/NDD	NDD	NDD	0.96	4.40
52	NDD	NDD	NDD	0.88	4.60
53	PTI/BBP/NDD	NDD	NDD	0.88	4.44
54	PTI/IPA/NDD	NDD	NDD	1.20	4.68
55	PTI/BBP/NDD	NDD	NDD	0.92	4.32
56	PTI/BBP/NDD	NDD	NDD	0.64	4.52
57	NDD	NDD	NDD	1.08	4.32
58	PTI/BBP/NDD	NDD	NDD	0.84	4.20
59	VOL/NDD PTI/IPA/NDD	NDD	NDD	1.60	4.12
60	PTI/IPA/NDD	NDD	NDD	1.20	4.20
61	PTI/BBP/NDD	NDD	NDD	1.00	4.44
63	NDD	NDD	NDD	0.76	4.28
65	NDD	NDD	NDD	1.52	4.64
66	NDD	NDD	NDD	1.28	4.36
67	PTI/IPA/NDD	NDD	NDD	1.00	4.28
68	PTI	NDD	NDD	0.80	4.24
69	NDD	NDD	NDD	0.80	4.48
70	PTI/BBP/NDD	NDD	NDD	1.08	4.32
71	PTI/BBP/NDD	NDD	SGI/NDD	0.96	4.12
72	NDD	NDD	NDD	1.0	3.68
73	NDD	NDD	NDD	1.24	4.56

Legend for Table 3.2.1:

NDD No Detectable Defect
PTI Penetration Tube Indication
IPA Indication Profile Analysis
BBP B and B Prime
VOL Volumetric
SGI Surface Geometry Indication
SSS Shallow Surface Scratch

Of the fifty-five penetrations inspected with the Gap Scanner System, one (penetration 68) showed indications characteristic of primary water stress corrosion cracking connected to the OD. This was later confirmed by PT from the J-groove weld.

All penetrations were inspected from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to the start of the thread relief shadow effect at the bottom end of the tube. All penetrations, but #33, #34, #39, #42, #44, #45, #51, #52, #53, #55, #56, #58, #63, #68, #69 and #71, have UT data collected at least 1 inch below the lowest point at the toe of the J-groove weld to the chamfer. The shortest coverage measured was penetration 56 measuring 0.640".

3.3 Vent Line ID and Vent Line J-Weld Eddy Current Examination

Eddy current examinations were conducted on the vent line J-groove weld and on the ID of the vent line tube. These examinations are designed to identify the presence of primary water stress corrosion cracking on the surfaces of the weld and tube that are exposed to primary coolant. Results of these examinations are summarized in the table below.

Table 3.3.1

Penetration #	Array ECT Results
Vent Line Weld	**NDD**
Vent Line Tube	**NDD**

Legend:
NDD No detectable Defect

No detectable degradation was identified during the eddy current examination of the vent line J-groove vent line weld or the vent line tube.

3.4 Penetration Tube Thickness Variations

During the original scope of inspection a variation of thickness in the chamfer region of some tubes was noted. This reduction of wall thickness originates from changes in the ID, however the cause is unknown. It shall be noted that the changes only appear in sleeved penetrations. In table 3.4.1 the measurements made are presented and will function as a base line in order to monitor future changes

Pen	Type	Circ Start	Circ Stop	Axial Upper	ΔT (at "Start")
1	Sleeve	N/A	N/A	N/A	None
2	Sleeve	N/A	N/A	N/A	None
3	Sleeve	N/A	N/A	N/A	None
4	Sleeve	N/A	N/A	N/A	None
5	Sleeve	N/A	N/A	N/A	None
6	Sleeve	N/A	N/A	N/A	None
7	Sleeve	N/A	N/A	N/A	None
8	Sleeve	N/A	N/A	N/A	None
9	Sleeve	N/A	N/A	N/A	None
10	OH	N/A	N/A	N/A	None

Pen	Type	Circ Start	Circ Stop	Axial Upper	ΔT (at "Start")
11	OH	N/A	N/A	N/A	None
12	OH	N/A	N/A	N/A	None
13	OH	N/A	N/A	N/A	None
14	Sleeve	N/A	N/A	N/A	None
15	Sleeve	N/A	N/A	N/A	None
16	Sleeve	N/A	N/A	N/A	None
17	Sleeve	N/A	N/A	N/A	None
18	OH	N/A	N/A	N/A	None
19	OH	N/A	N/A	N/A	None
20	OH	N/A	N/A	N/A	None
21	OH	N/A	N/A	N/A	None
22	OH	N/A	N/A	N/A	None
23	OH	N/A	N/A	N/A	None
24	OH	N/A	N/A	N/A	None
25	OH	N/A	N/A	N/A	None
26	OH	N/A	N/A	N/A	None
27	OH	N/A	N/A	N/A	None
28	OH	N/A	N/A	N/A	None
29	OH	N/A	N/A	N/A	None
30	Sleeve	N/A	N/A	N/A	None
31	Sleeve	N/A	N/A	N/A	None
32	Sleeve	N/A	N/A	N/A	None
33	Sleeve	148.5	294	4.47	0.026
34	Sleeve	N/A	N/A	N/A	None
35	Sleeve	N/A	N/A	N/A	None
36	Sleeve	111	273	4.59	0.026
37	Sleeve	111	255	5.35	0.038
38	Sleeve	N/A	N/A	N/A	None
39	Sleeve	93	231	4.35	0.029
40	Sleeve	N/A	N/A	N/A	None
41	Sleeve	N/A	N/A	N/A	None
42	Sleeve	N/A	N/A	N/A	None
43	Sleeve	121.5	244.5	5.51	0.032
44	Sleeve	N/A	N/A	N/A	None
45	Sleeve	N/A	N/A	N/A	None
46	Sleeve	N/A	N/A	N/A	None
47	Sleeve	141	274.5	5.59	0.038
48	Sleeve	N/A	N/A	N/A	None
49	Sleeve	129	255	5,59	0.047
50	Sleeve	N/A	N/A	N/A	None
51	Sleeve	99	228	3.43	0.029
52	Sleeve	94.5	300	4.07	0.020
53	Sleeve	108	234	5.59	0.023
54	Sleeve	108	238.5	5.95	0.056
55	Sleeve	N/A	N/A	N/A	None

Pen	Type	Circ Start	Circ Stop	Axial Upper	ΔT (at "Start")
56	Sleeve	N/A	N/A	N/A	None
57	Sleeve	145.5	271.5	3.75	0.012
58	Sleeve	130.5	235.5	5.87	0.020
59	Sleeve	N/A	N/A	N/A	None
60	Sleeve	N/A	N/A	N/A	None
61	Sleeve	109.5	264	5.27	0.026
62	OH	N/A	N/A	N/A	None
63	Sleeve	103.5	288	>12.67	0.059
64	OH	N/A	N/A	N/A	None
65	Sleeve	N/A	N/A	N/A	None
66	Sleeve	91.5	252	5.15	0.032
67	Sleeve	88.5	237	4.07	0.017
68	Sleeve	N/A	N/A	N/A	None
69	Sleeve	N/A	N/A	N/A	None
70	Sleeve	N/A	N/A	N/A	None
71	Sleeve	168	240	5.68	0.044
72	Sleeve	135	264	4,15	0.029
73	Sleeve	136.5	258	6.83	0.023
74	OH	N/A	N/A	N/A	None
75	OH	N/A	N/A	N/A	None
76	OH	N/A	N/A	N/A	None
77	OH	N/A	N/A	N/A	None
78	OH	N/A	N/A	N/A	None

4.0 EXAMINATION COVERAGE

The configuration of the Byron Unit 2 CRDM penetration tubes is shown in the figure 4.1 below. This figure represents the tube-to-head geometry on the "downhill" side of the tube (0° location of the penetration). The bottom ends of all seventy-eight penetration tubes are threaded on the OD surface and have a 20° chamfer on the ID surface.

The ID surfaces of the penetration tubes are chamfered at a 20° angle from the bottom of the tube to an elevation of 0.756". The threads on the tube OD surfaces and chamfer on the ID surfaces represent geometric conditions which limit examination coverage near the bottoms of the tubes.

The threads on the OD surfaces extend from the bottom of the tube to an elevation of approximately 1.0" where a thread relief is machined. The top of the thread relief is 1.13" above the bottom of the tube.

The lowest possible starting point for the Gap scanner inspection is 1.28" from the bottom of the tube, due to the Trinity's axial shooting TOFD technique, refer to Figure 4.1. For the Open Housing inspection the lowest starting point is at the chamfer, based on the fact that the Open Housing inspection includes the circumferential shooting TOFD technique in combination with axial shooting TOFD.

The distance from inspection start to the bottom of the fillet of the J-groove weld varies based on location of the penetration in the head and the amount of weld material applied during the welding process. These distances are longer for penetrations at inner locations and become progressively shorter for penetrations located further away from the center of the head.

For ID examinations of all seventy eight penetration tubes, the supplementary eddy current examination coverage extended from the uppermost elevation of the chamfer, 0.756" from the bottom of the tube, to elevations at least 2.0" above the welds. The extent of coverage was verified for each examination of each penetration by confirmation that 1) tube entry signals were evident and 2) scan coverage elevations were in excess of 2.0" above the uppermost elevation of each weld.

For OD and ID examinations of all fifty five sleeved penetration tubes, the TOFD PCS 23.5 transducer coverage extended from approximately 1.3" from the bottom of the tube, to elevations at least 2.0" above the welds. The extent of coverage was verified for each examination of each penetration by confirmation that 1) back wall shadowing of TOFD ultrasonic signals from thread relief and 2) scan coverage elevations were in excess of 2.0" above the uppermost elevation of each weld.

For OD and ID examinations of all twenty three open penetration tubes, the TOFD PCS24 transducer coverage extended from approximately 0.75" from the bottom of the tube, to elevations at least 2.0" above the welds. The extent of coverage was verified for each examination of each penetration by confirmation that 1) loss of lateral wave of TOFD ultrasonic signals from the chamfer and 2) scan coverage elevations were in excess of 2.0" above the uppermost elevation of each weld.

The measured coverage below and above the weld per penetration is presented in table 3.1.1 and 3.2.1.

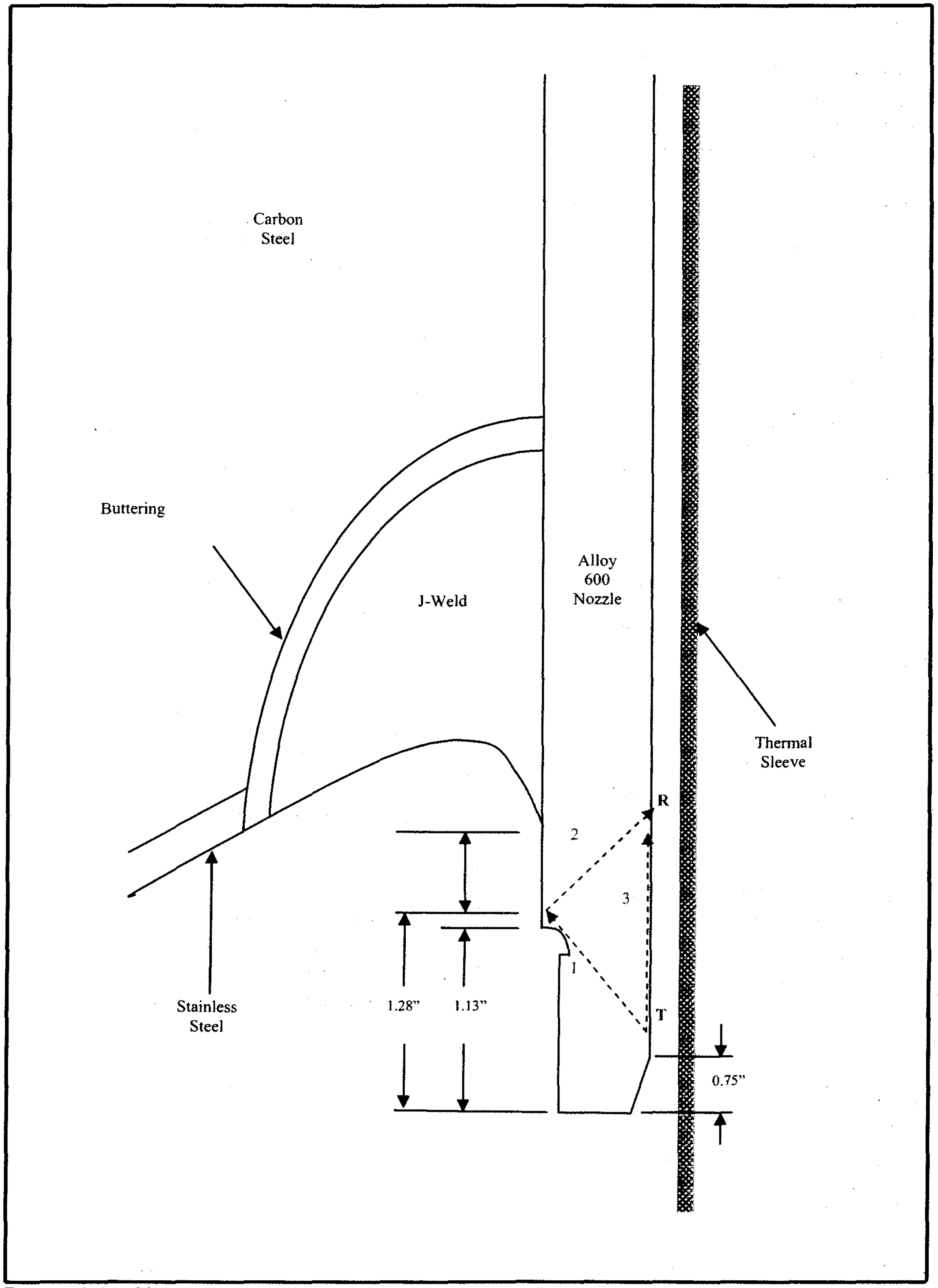

Figure 4.1 – Not to scale

5.0 DISCUSSION OF RESULTS

All penetration tube ultrasonic examination data were analyzed in accordance with WDI-UT-013, Rev. 12 – "IntraSpect UT Analysis Guidelines". The penetration tube eddy current data were analyzed in accordance with WDI-ET-004, Rev. 11 – "IntraSpect Eddy Current Analysis Guidelines Inspection of Reactor Vessel Head Penetrations". The extent below the weld in penetrations inspected with the Open housing scanner was measured using technique demonstrated for EPRI in May 2005.

Data from the eddy current examinations of the vent line and vent line weld were analyzed in accordance with WDI-STD-114, Rev. 5, – "RVHI Vent Tube ID & CS Wastage Eddy Current Examination" and WDI-STD-101, Rev. 6 – "RVHI Vent Tube J-Weld Eddy Current Examination", respectively.

Data sheets and printouts of the results of each examination performed on each penetration are found in Volume 2 and Volume 3.

Eddy Current tube ID surface examinations showed no penetration tubes with indications characteristic of cracking. Some of the ID surface examinations did show shallow surface indications that were detectable with the TOFD inspection; however, all indicated a depth equal to or less than 0.040".

Eddy current examinations of the vent line tube and vent line weld showed no evidence of cracking.

The straight beam ultrasonic examinations of the shrink-fit regions of the seventy-eight penetration tubes showed no evidence of leak paths.

Results from the TOFD ultrasonic examinations of the seventy-eight reactor vessel head penetrations identified one indication in penetration 68 characteristic of PWSCC. Special Interest examinations were performed on penetration 68 to further characterize the indications detected. These examinations included circumferentially oriented TOFD UT from the ID of the penetration tube, radiography, and Liquid Dye Penetrant Testing (PT) at the J-groove weld to penetration tube interface on the outside surface of the downhill side of the penetration in the area of interest. The penetration was repaired using the embedded flaw methodology to isolate flaw from the primary water. A summary report of this can be found in WDI-PJF-1303833-FSR-001.