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December 9, 2003
L-03-190

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Subject: Beaver Valley Power Station, Unit No. 2
BV-2 Docket No. 50-412, License No. NFP-73
Reactor Head Inspection 60-Day Report

Reference:
1) NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors, dated February 11, 2003

During the recent BVPS Unit 2 2R10 Refueling Outage, inspections of the reactor pressure vessel (RPV) head and associated penetration nozzles were performed. In accordance with NRC Order EA-03-009 (Reference 1) Section IV.E, the 60-day report, detailing the inspection results is being provided. The BVPS Unit 2 2R10 report is enclosed with this letter.

There are no new regulatory commitments contained in this letter. If there are any questions concerning this matter, please contact Mr. Larry R. Freeland, Manager, Regulatory Affairs/Performance Improvement at 724-682-5284.

Sincerely,

L. William Pearce

Enclosure

c: Mr. T. G. Colburn, NRR Senior Project Manager
Mr. P. C. Cataldo, NRC Sr. Resident Inspector
Mr. H. J. Miller, NRC Region I Administrator

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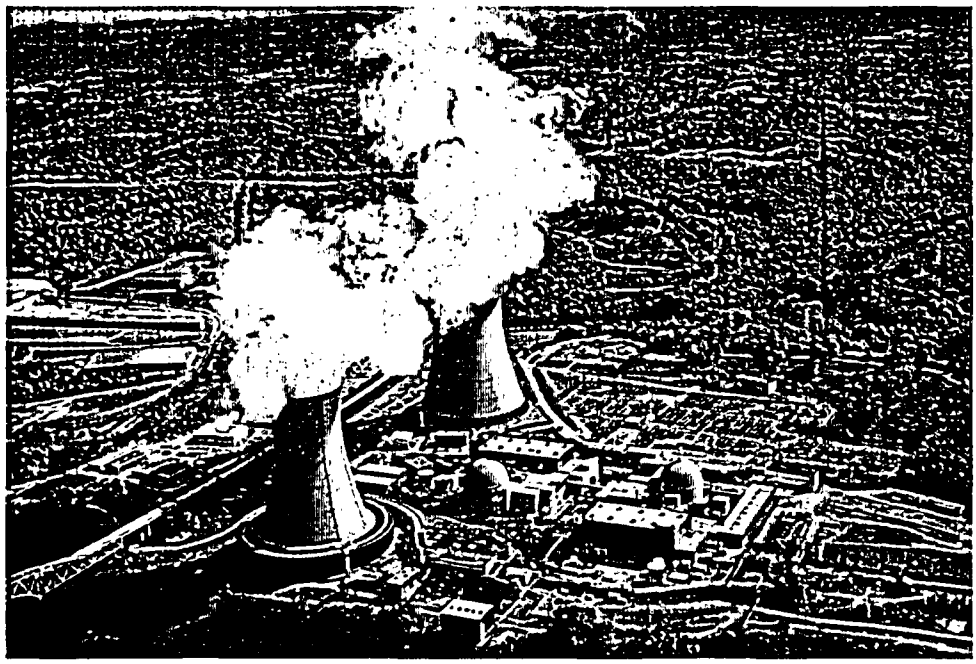

Evaluation Report for 2R10

Visual and Under-head Inspections

of

Beaver Valley Unit 2

Reactor Vessel Head Penetrations

(Ref: Order EA-03-009)

November 2003

Introduction

Reactor Pressure Vessel (RPV) head inspections were performed at Beaver Valley Power Station (BVPS) Unit 2 during the 2R10 Refueling Outage in accordance with NRC Order EA-03-009. The Order establishes criteria by which licensees must perform periodic inspections of the reactor vessel head.

Purpose and Scope

The purpose of the inspections performed was 1) to identify any evidence of leakage from the CRDM penetrations or Head Vent piping penetration onto the surface of the RPV head, and 2) to identify any relevant indications in the RPV head penetration base material or evidence of any leak path in the interference fit zones.

The susceptibility of the BVPS Unit 2 RPV head to primary water stress corrosion cracking (PWSCC)-related degradation was calculated using the formula provided in Section IV.A of the Order. Using best estimate values for each parameter, the Unit 2 RPV head susceptibility was calculated to be 10.28 Effective Degradation Years (EDY) at the conclusion of Operating Cycle 10. This value places the Unit 2 RPV head at greater than 8 EDY but less than 12 EDY, the "Moderate Susceptibility" category as outlined in the Order.

The required inspection techniques for Moderate Susceptibility plants are outlined in Section IV.C.(2) of the Order:

(2) For those plants in the Moderate category, RPV head and head penetration inspection shall be performed such that at least the requirements of 2(a) or 2(b) are performed each refueling outage. In addition the requirements of 2(a) and 2(b) shall each be performed at least once over the course of every two (2) refueling outages.

(a) Bare metal visual examination of 100% 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 two (2) inches above the J-groove weld to the bottom of the nozzle and an assessment to determine if leakage has occurred into the interference fit zone, OR

(ii) *Eddy current testing or dye penetrant testing of the wetted surface of each J-Groove weld and RPV head penetration nozzle base material to at least two (2) inches above the J-Groove weld.*

A visual examination of the Unit 2 RPV head was performed in accordance with Section IV.C.(2)(a), fulfilling the minimum inspection requirement for the 2R10 refueling outage.

Non-destructive under-head examinations were also performed during 2R10 using a combination of the techniques specified in Sections IV.C.(2)(b)(i) and IV.C.(2)(b)(ii) of the Order. On July 29, 2003, FENOC issued Letter L-03-088 to the NRC requesting relaxation of two requirements of the Order pertaining to Section IV.C.(2)(b). A forthcoming submittal will provide supplemental information to this relaxation request, based on actual field data, to provide the basis for the utilization of the non-destructive examinations performed during 2R10 as fulfillment of the requirements of Section IV.C.(2)(b) of the Order.

BVPS Unit 2 RPV Head Configuration

The BVPS Unit 2 RPV is a Westinghouse design and manufactured by Combustion Engineering (CE). The head contains 65 Alloy 600 penetration tubes that are interference 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.

The 65 CRDM penetration tubes measure 4.0" on the outside diameter (OD) and have an inside diameter (ID) dimension of 2.75". The wall thickness is 0.625". The RPV head vent line is a 1.0" schedule 160 pipe.

All 65 CRDM penetration tubes are threaded on the OD surface from approximately 1.25" from the bottom of the nozzle. The ID surface of each penetration exhibits a 20° chamfer beginning at a distance of approximately 0.75" from the bottom of the nozzle. This configuration is shown in Figure 1. The distance from the top of the thread relief to the bottom of the fillet of the J-groove weld (identified as "A" in the figure) varies based on the location of the penetration in the head. Four of the 65 CRDM penetrations have a guide funnel threaded onto the OD threaded surface of the penetration.

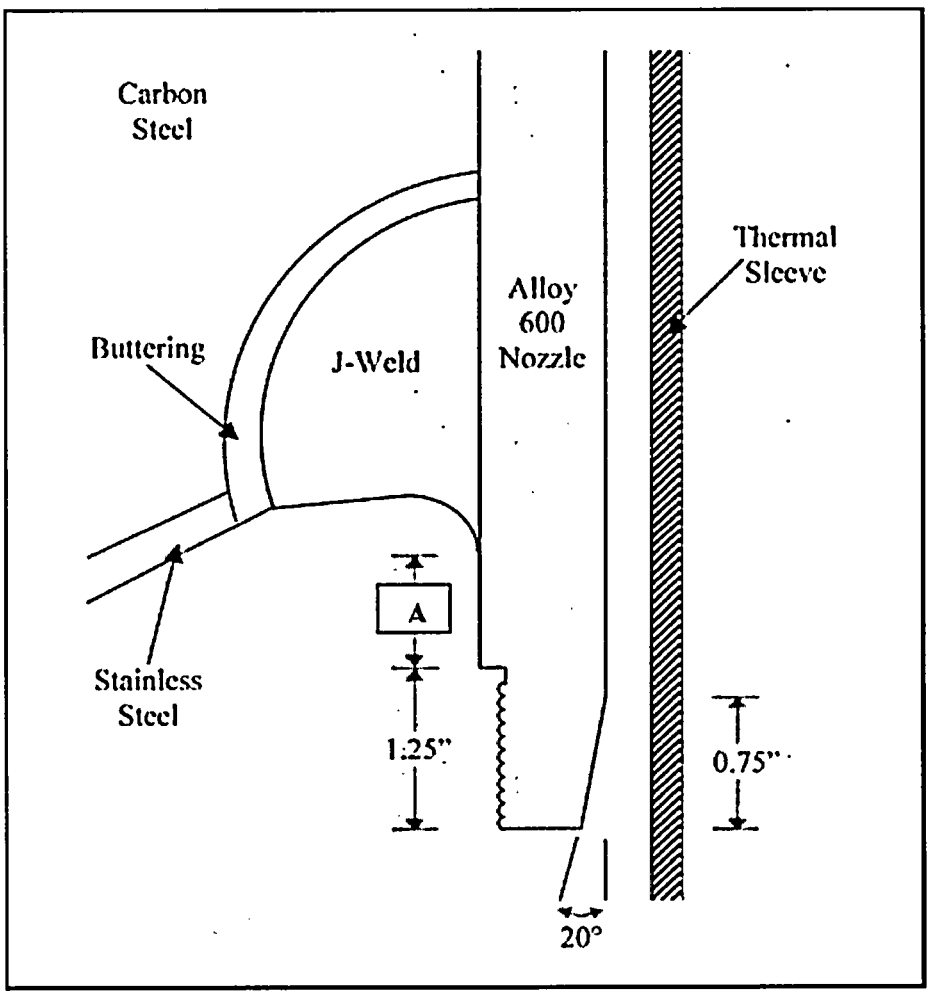

Figure 1: BVPS Unit 2 CRDM Penetration Configuration.

Inspection Techniques

Visual Inspection

Qualified contractor personnel using high-resolution remote visual inspection equipment performed visual inspection of the top of the RPV head. Qualified contractor personnel, with BVPS Site Non-Destructive Examination (NDE) personnel providing concurrence, performed VT-2 inspection of the RPV head penetrations and base metal. Qualified visual examination was completed on 360° around each CRDM penetration and the Head Vent, as well as a complete assessment of the carbon steel base metal inside the ventilation shroud where the RPV head penetrations are located.

Under-Head Inspection

The nondestructive examinations performed were conducted in accordance with site-specific field service procedures. With the exception of the vent line examination procedures, all have been demonstrated through the Electric Power Research Institute / Materials Reliability Program (EPRI/MRP) protocol. In the absence of an EPRI/MRP protocol for the vent line applications, the examination procedures and techniques followed the basic requirement outlined in ASME B&PVC (2000 edition) Sec. XI, Appendix IV, Supplement 2 - "Qualification Requirements for Surface Examination of Piping and Vessels". The technique used is further outlined in Westinghouse Technical Justification WDI-TJ-011-03. Under-head inspections of the RPV head penetration base material and J-groove welds were performed by qualified Level II/III NDE personnel.

Non-destructive examinations were performed using the techniques defined in Order EA-03-009, Section IV.C.(2)(b) with those exceptions identified in the BVPS Unit 2 Relaxation Request (L-03-088, July 29, 2003). Relaxation Item (a) requested that ultrasonic and eddy current testing be required to extend to as close as practical to the bottom of the nozzle. Relaxation Item (b) requested the combination of the inspection techniques described in sections IV.C.(2)(b)(i) and IV.C.(2)(b)(ii) of the Order to match the appropriate inspection technique to the specific physical configuration of each individual nozzle. A separate forthcoming submittal will provide supplemental information, based on actual field data, in support of the preceding relaxation requests.

The non-destructive examinations performed during 2R10 were performed using a combination of the acceptable techniques described in Section IV.C.(2)(b) of the Order:

Section IV.C.(2)(b)(i): The nozzle base material of the 65 CRDM penetrations was examined using ultrasonic testing from two inches above the J-groove weld to the uppermost elevation of the chamfer on the ID surface (~0.75") and to slightly above the elevation of the thread relief on the OD surface (~1.45") (see Figure 1). In addition ultrasonic leak-path examinations were performed on all 65 CRDM penetrations to determine if leakage had occurred into the interference fit zone.

Section IV.C.(2)(b)(ii): The one RPV head vent line was examined using eddy current testing of the wetted surface of the J-groove weld and penetration nozzle base material to at least two inches above the J-groove weld.

Inspection Results: Visual Inspection

VT-2 visual examinations 360° around the circumference of each of the 65 CRDM penetrations and the head vent line in the BVPS Unit 2 RPV head showed no indication of penetration leakage. Figure 2 shows the typical condition found around each penetration during the penetration exam during 2R10.

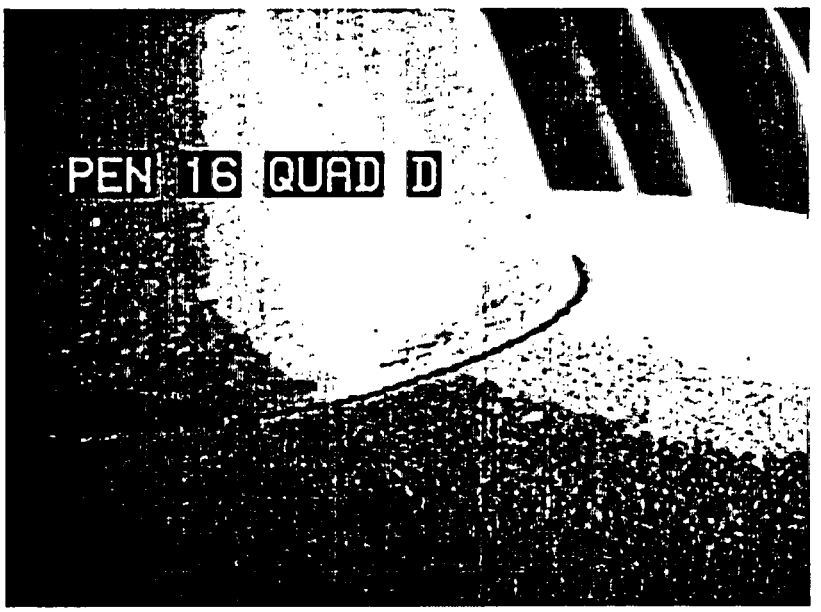

Figure 2: Typical 2R10 RPV Head Penetration Condition

The carbon steel assessment performed on 100% of the RPV head carbon steel base metal inside the ventilation shroud found no degraded conditions on the RPV head surface. Figure 3 shows the typical condition of the RPV head base metal.

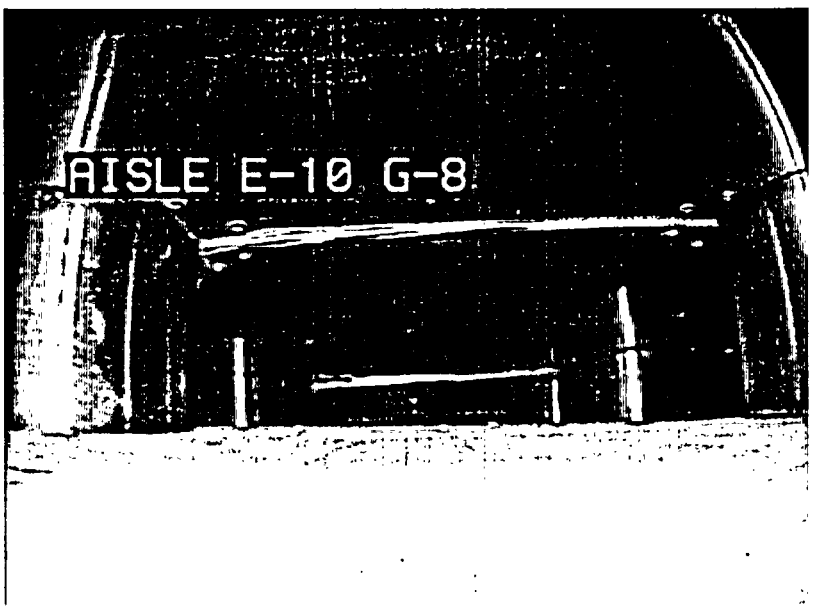

Figure 3: Typical 2R10 RPV Head Carbon Steel Condition

Evaluation of Results: Visual Inspection

The visual examinations 360° around each penetration and the 100% carbon steel assessment performed during 2R10 found no indication of RPV head penetration leakage or degradation of the carbon steel base metal.

Inspection Results: Under-Head Inspection

Time-of-flight diffraction ultrasonic data was obtained for each of the 65 CRDM penetrations in the BVPS Unit 2 RPV head from at least two inches above the J-groove weld to the uppermost elevation of the chamfer on the ID surface (~0.75") and to slightly above the elevation of the thread relief on the OD surface (~1.45"). Exact examination coverage distances on the bottoms of the nozzles will be provided in the aforementioned supplement to the BVPS Unit 2 Relaxation Request, Letter L-03-088.

Straight beam ultrasonic data for the identification of leak paths in the interference fit area was obtained for each of the 65 CRDM penetrations from at least two inches above the J-groove weld to the top of the chamfer on the ID surface.

Eddy current data was obtained for the wetted surface of the vent line J-groove weld and the vent line tube to at least two inches above the weld.

No detectable degradation was reported in any of the 65 CRDM penetration tubes examined using time-of-flight diffraction ultrasonic testing. There were no indications of leak paths identified in the interference fit areas of any of the penetrations examined using straight beam ultrasonic testing. No detectable degradation was identified during the eddy current examination of the vent line J-groove weld or vent line tube.

Evaluation of Results: Under-Head Inspection

No detectable degradation was identified during any of the non-destructive examinations of the 66 RPV head penetrations (65 CRDMs and 1 Head Vent) during 2R10. The Examination Summary of the Westinghouse Final Report #1302505-03, Rev. 1 "Beaver Valley Unit 2-2R10 Reactor Vessel Head Penetration Examination, September 2003" is included as Appendix A to this submittal.

Summary

RPV head inspections were completed during 2R10 in accordance with the requirements of Order EA-03-009. Visual inspection of the top of the RPV head in accordance with Section IV.C.(2)(a) showed no indication of RPV head penetration leakage or degradation of the carbon steel surface. Under-head examinations performed using a combination of the techniques specified in Sections IV.C.(2)(b)(i) and IV.C.(2)(b)(ii) reported no detectable degradation of the RPV head penetration base material and no indications of leak paths in the interference fit areas. Supplemental information for the pending BVPS Unit 2 relaxation request (L-03-088) will be submitted to provide the basis for the utilization of the non-destructive examinations performed during 2R10 as fulfillment of the requirements of Section IV.C.(2)(b) of the Order.

Appendix A

Beaver Valley Unit 2

2R10 Reactor Vessel Head

Penetration Examination

September 2003

Final Report

1302505-03, Rev. 1

November 24, 2003

Beaver Valley Unit 2–2R10 Reactor Vessel Head Penetration Examination

September 2003

Final Report

1302505-03, Rev. 1

November 24, 2003

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Table of Contents

Volume 1

Examination Summary

1.0 Introduction

2.0 Scope of Work

- 2.1 7010 Open Housing Scanner Ultrasonic and Eddy Current Examinations
- 2.2 Gapscanner Penetration Tube ID Surface Eddy Current and Combination Probe Examinations
- 2.3 Vent Line and Vent Line Weld Eddy Current Examination

3.0 Examination Results

- 3.1 7010 Open Housing Scanner Ultrasonic and Eddy Current Examinations
- 3.2 Gapscanner Penetration Tube ID Surface Eddy Current and Combination Probe Examinations
- 3.3 Vent Line and Vent Line Weld Eddy Current Examination

4.0 Examination Coverage

5.0 Discussion of Results

Procedures

Personnel Certifications

Volume 2

Gapscanner and Open Housing Scanner Examination Results

Volume 3

Calibration Data

Data Disks

7010 Open Housing Scanner Ultrasonic and Eddy Current Examinations

1. Beaver Valley Unit 2 7010 OHS Data, Disk 1 of 2 – Penetrations #21,47
2. Beaver Valley Unit 2 7010 OHS Data, Disk 2 of 2 – Penetrations #49,51,53

Gapscanner Penetration Tube ID Surface Combination Probe Examinations

1. Beaver Valley Unit 2 Combo Probe, Disk 1 of 7 – Penetrations #1-10

2. Beaver Valley Unit 2 Combo Probe, Disk 2 of 7 – Penetrations #11-20
3. Beaver Valley Unit 2 Combo Probe, Disk 3 of 7 – Penetrations #22-30
4. Beaver Valley Unit 2 Combo Probe, Disk 4 of 7 – Penetrations #31-40
5. Beaver Valley Unit 2 Combo Probe, Disk 5 of 7 – Penetrations #41-46,48,50
6. Beaver Valley Unit 2 Combo Probe, Disk 6 of 7 – Penetrations #52,54-60
7. Beaver Valley Unit 2 Combo Probe, Disk 6 of 7 – Penetrations #61-65

Calibration Data

1. Calibration Data 7010 Probe, Disk 1 of 1
2. Calibration Data Trinity Probe, Disk 1 of 1

Vent Line and Vent Line Weld Eddy Current Examinations

1. FENOC; Beaver Valley 2; 9/26/03; "Reactor Vessel Head Inspection Vent Tube and J-Weld Inspection"; VTBVHCAL00001, VTBVHCAL00002

1.0 INTRODUCTION

During the Beaver Valley Unit 2 2R10 outage in September 2003, Westinghouse performed nondestructive examinations (NDE) of the reactor vessel head penetration tubes, the reactor vessel head vent tube and the vent line 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 11, 2003, USNRC Order EA-03-009, "Establishing Interim Inspection Requirements for Reactor Vessel Heads at Pressurized Water Reactors" and relaxation requests submitted via letter number L-03-088, "Beaver Valley Power Station, Unit No.2, BV-2 Docket No. 50-412, License No. NPF-73, Order (EA-03-009) Relaxation Request".

The reactor vessel head at Beaver Valley Unit 2 is a Westinghouse design and manufactured by Combustion Engineering (CE). The head contains 65 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.

All penetration tubes in the Beaver Valley Unit 2 reactor vessel head are manufactured from heats of material supplied by Huntington Alloys. These heats of material are not present in any other reactor vessel heads, thus there is no prior service history for these heats.

Heats of Huntington material in the Beaver Valley Unit 2 head are identified below.

Heat	Vendor	Service History
NX 4530	Huntington	No Prior History
NX 4536	Huntington	No Prior History
NX 4504	Huntington	No Prior History
NX 4544	Huntington	No Prior History
NX 4912	Huntington	No Prior History

There are a variety of configurations for the 65 penetration tubes, each configuration requiring special consideration for examination. The penetration tubes measure 4.0" on the OD and have an ID dimension of 2.75". The wall thickness is 0.625". The penetration tube configurations are as follows:

- 60 penetration tubes with thermal sleeves installed
- 4 open thermocouple column penetration tubes
- 1 penetration tube with part length drive shaft removed
- One 1.0" schedule 160 head vent tube

The Beaver Valley Unit 2 reactor vessel head is in the "moderate susceptibility" category. For a reactor vessel head in the moderate category, Section IV.C. (2) of USNRC Order EA-03-009 specifies:

a) *"Bare metal visual examination of 100% of the RPV head surface (including 360^{o} around each RPV head penetration nozzle), AND*

b) *Either:*

i. *Ultrasonic testing of each RPV head penetration nozzle (i.e., nozzle base material) from two (2) inches above the J-groove weld to the bottom of the nozzle and an assessment to determine if leakage has occurred in the interference fit zone, OR*

ii. *Eddy current or dye penetrant testing of the wetted surface of each J-groove weld and RPV head penetration nozzle base material to at least two (2) inches above the J-groove weld.*

...shall be performed at least once over the course of every two (2) refueling outages. "

The examination program selected for Beaver Valley Unit 2 included ultrasonic examinations of the 65 CRDM penetration nozzles with leakage assessment in accordance with Section IV.C.(2) (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.(2) (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 associated field change notices (FCNs) were approved for use at Beaver Valley Unit 2. With the exception of the vent line examination procedures; WDI-STD-101, Rev. 1 and WDI-STD-114, Rev. 0; 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-002, Rev. 3 and FCN-01 – "Eddy Current Inspection of J-Groove Welds in Vessel Head Penetrations"
- WDI-ET-003, Rev. 5 – "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations"
- WDI-ET-004, Rev. 3 – "IntraSpect Eddy Current Analysis Guidelines Inspection of Reactor Vessel Head Penetrations"
- WDI-ET-008, Rev. 2 and FCN-01 – "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations With Gap Scanner"
- WDI-UT-010, Rev 5 and FCN-01 - "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic & Longitudinal Wave"
- WDI-UT-013, Rev. 3 – "CRDM/ICI UT Analysis Guidelines"

- WDI-STD-101, Rev. 1 and FCNs 01 and 02 – "RPHI Vent Tube J-Weld Eddy Current Examination"
- WDI-STD-114, Rev. 0 and FCNs 01 and 02 – "Head Vent ID Eddy Current Inspection"
- WCAL-002, Rev. 2 – "Pulser/Receiver Linearity Procedure"

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

2.0 SCOPE OF WORK

The reactor vessel head penetration nondestructive examination scope at Beaver Valley Unit 2 included all 65 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) Five penetration tubes without thermal sleeves were examined from the ID using the Westinghouse 7010 Open Housing Scanner which performs; 1) TOFD ultrasonic examinations, 2) 0^{o} straight beam examinations to identify evidence of a leak path in the shrink fit area, and 3) supplementary eddy current examinations.

  2) Sixty penetration tubes containing thermal sleeves were inspected from the ID using the Westinghouse Gapscanner and "combination" blade probes which perform 1) TOFD ultrasonic examinations, 2) 0^{o} straight beam examinations to identify evidence of a leak path in the shrink fit area, and 3) supplementary eddy current examinations.

- 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 Beaver Valley 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 and 2) the Westinghouse Gapscanner end effector for ultrasonic and supplementary eddy current examinations of penetration locations containing thermal sleeves.

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 circumferentially oriented degradation on the penetration tube OD surfaces

2) Time-of-flight diffraction ultrasonic examination optimized for identification of axially 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 Gapscanner end effector delivers "combination 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. All three examinations are performed simultaneously. The typical annulus 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 Gapscanner 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.

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 five reactor vessel head penetrations without thermal sleeves.

Examinations of the 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. 5 and FCN 01 – "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 and 5.0 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. 5 - "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations".

2.2 Gapscanner Penetration Tube ID Surface Eddy Current and Combination Probe Examinations

Examinations were performed with the Gapscanner end effector on 60 penetration tubes containing thermal sleeves from the penetration ID surfaces. These 60 penetration tubes containing thermal sleeves were inspected from the ID using "combination" blade probes capable of performing TOFD ultrasonic examinations, leak path assessment, and supplementary eddy current examinations simultaneously. These examinations were performed in accordance with WDI-UT-010, Rev. 5 and FCN 01 – "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic Longitudinal Wave" & Shear Wave" and WDI-ET-008, Rev. 2 and FCN 01 – "Intraspect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations With Gapscanner".

2.3 Vent Line and Vent Line Weld 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. 0 and FCNs 01 and 02 - "Head Vent ID Eddy Current Inspection". The vent line J-groove weld eddy current examination was performed with an array of 24 plus-Point coils in accordance with WDI-STD-101, Rev. 1 and FCNs 01 and 02, "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 Beaver Valley Unit 2 during the 2R10 September 2003 refueling outage.

Five penetrations without thermal sleeves; #21, #47, #49, #51 and #53, were inspected from the ID using the Westinghouse Open Housing Scanner. The final disposition of the examination results is provided in the table below.

Penetration #	Axial TOFD Channel 1	Circ TOFD Channel 2	2.25 Mhz 0°	5.0 Mhz 0°	Supplementary Tube ID ECT
21	NDD	NDD	NDD	NDD	NDD
47	NDD	NDD	NDD	NDD	NDD
49	NDD	NDD	NDD	NDD	NDD
51	NDD	NDD	NDD	NDD	NDD
53	NDD	NDD	NDD	NDD	NDD

No detectable degradation was reported in any of the five penetration tubes examined with the 7010 Open Housing Scanner. There were no indications of leak paths identified in the shrink fit areas.

3.2 Gapscanner Penetration Tube ID Combination Probe Examinations

The following table provides a summary of all Gapscanner examinations performed at Beaver Valley Unit 2 during the 2R10 September 2003 refueling outage.

Sixty penetration tubes containing thermal sleeves; penetrations #1 through #20, 22-46, 48, 50 52, and 54 through 65 were inspected from the ID using the Westinghouse Gapscanner and "combination" blade probes. Due to occasional eddy current probe malfunctions; supplementary eddy current examinations of penetrations #27, 36, 45, 57-62, and 65 achieved only partial ID coverage and no data were collected on penetration #52.

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

Penetration #	PCS24 TOFD	0° Leak Path	Supplementary Eddy Current Tube ID
1	NDD	NDD	NDD
2	NDD	NDD	NDD
3	NDD	NDD	NDD
4	NDD	NDD	NDD
5	NDD	NDD	NDD

Penetration #	PCS24 TOFD	0° Leak Path	Supplementary Eddy Current Tube ID
6	NDD	NDD	NDD
7	NDD	NDD	NDD
8	NDD	NDD	NDD
9	NDD	NDD	NDD
10	NDD	NDD	NDD
11	NDD	NDD	NDD
12	NDD	NDD	NDD
13	NDD	NDD	NDD
14	NDD	NDD	NDD
15	NDD	NDD	NDD
16	NDD	NDD	NDD
17	NDD	NDD	NDD
18	NDD	NDD	NDD
19	NDD	NDD	NDD
20	NDD	NDD	NDD
21	----	----	----
22	NDD	NDD	NDD
23	NDD	NDD	NDD
24	NDD	NDD	NDD
25	NDD	NDD	NDD
26	NDD	NDD	NDD
27	NDD	NDD	PARTIAL/NDD
28	NDD	NDD	NDD
29	NDD	NDD	NDD
30	NDD	NDD	NDD
31	NDD	NDD	NDD
32	NDD	NDD	NDD
33	NDD	NDD	NDD
34	NDD	NDD	NDD
35	NDD	NDD	NDD
36	NDD	NDD	PARTIAL/NDD
37	NDD	NDD	NDD
38	NDD	NDD	NDD
39	NDD	NDD	NDD
40	NDD	NDD	NDD
41	NDD	NDD	NDD
42	NDD	NDD	NDD
43	NDD	NDD	NDD
44	NDD	NDD	NDD
45	NDD	NDD	PARTIAL/NDD
46	NDD	NDD	NDD

Penetration #	PCS24 TOFD	0° Leak Path	Supplementary Eddy Current Tube ID
47	----	----	----
48	NDD	NDD	NDD
49	----	----	----
50	NDD	NDD	NDD
51	----	----	----
52	NDD	NDD	NO DATA
53	----	----	----
54	NDD	NDD	NDD
55	NDD	NDD	NDD
56	NDD	NDD	NDD
57	NDD	NDD	PARTIAL/NDD
58	NDD	NDD	PARTIAL/NDD
59	NDD	NDD	PARTIAL/NDD
60	NDD	NDD	PARTIAL/NDD
61	NDD	NDD	PARTIAL/NDD
62	NDD	NDD	PARTIAL/NDD
63	NDD	NDD	NDD
64	NDD	NDD	NDD
65	NDD	NDD	PARTIAL/NDD

No detectable degradation was reported in any of the sixty penetration tubes examined with the Gapscanner. There were no indications of leak paths identified in the shrink fit areas.

3.3 Vent Line and Vent Line Weld Eddy Current Examination

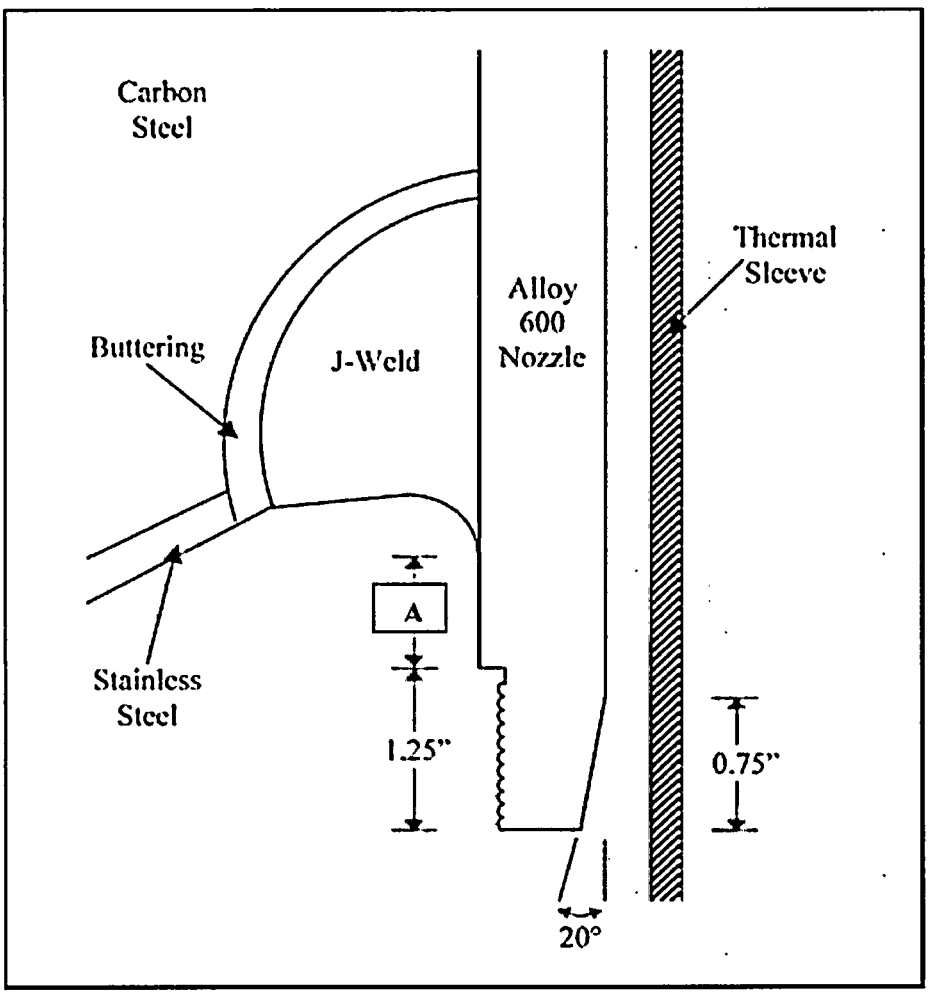
Eddy current examinations were conducted on the vent line J-groove weld and on the ID of the vent line tube. These examinations are designed to identify the presence of primary water stress corrosion cracking on the surfaces of the weld and tube that are exposed to primary coolant. Results of these examinations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

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

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

4.0 EXAMINATION COVERAGE

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



The threads on the OD surfaces extend from the bottom of the tube to an elevation of approximately 1.1" where there a thread relief is machined. The top of the thread relief is 1.25" above the bottom of the tube. The distance from the top of the thread relief to the bottom of the fillet of the J-groove weld (identified as "A" in the figure) varies based on location of the penetration in the head. These distances are longer for penetrations at "inboard" locations and become progressively shorter for penetrations located further away from the center of the head.

The ID surfaces of the penetration tubes are chamfered at a 20° angle from the bottom of the tube to an elevation of ¾".

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.

For ID examinations of all 65 penetration tubes, the supplementary eddy current and the TOFD PCS24 examination coverage extended from the uppermost elevation of the chamfer, ¾" 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 in the eddy current and ultrasonic data and 2) scan coverage elevations were in excess of 2.0" above the uppermost elevation of each weld.

For OD examinations of all 65 penetration tubes, the TOFD PCS24 transducer coverage extended from 0.2" above the elevation of the thread relief, 1.45" from the bottom of the tube, to elevations at least 2.0" above the welds. Due to the geometry of the thread relief, approximately 0.2" of the tube OD surfaces just above the thread relief were not inspectable due to masking. The extent of coverage was verified for each examination of each penetration by confirmation that 1) TOFD ultrasonic signals from the thread relief were evident ultrasonic data and 2) scan coverage elevations were in excess of 2.0" above the uppermost elevation of each weld.

5.0 DISCUSSION OF RESULTS

All penetration tube ultrasonic examination data were analyzed in accordance with WDI-UT-013, Rev. 3 – "CRDM/ICI UT Analysis Guidelines". The penetration tube eddy current data were analyzed in accordance with WDI-ET-004, Rev. 3 – "IntraSpect Eddy Current Analysis Guidelines Inspection of Reactor Vessel Head Penetrations". The disposition process for ID indications is summarized in the logic chart in figure 1 and the process for OD indications is summarized in the logic chart in figure 2.

Data from the eddy current examinations of the vent line and vent line weld were analyzed in accordance with WDI-STD-114, Rev. 0 and FCNs 01 and 02 – "Head Vent ID Eddy Current Inspection" and WDI-STD-101, Rev. 1 and FCNs 01 and 02 – "RPHI 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.

Results from the TOFD ultrasonic and eddy current examinations of the sixty-five reactor vessel head penetrations, and the eddy current examinations of the vent line tube and vent line weld identified no indications characteristic of PWSCC. The straight beam ultrasonic examinations of the shrink-fit regions of the sixty-five penetration tubes showed no evidence of leak paths.

FIGURE 1 - PENETRATION TUBE ID FLAW EVALUATION

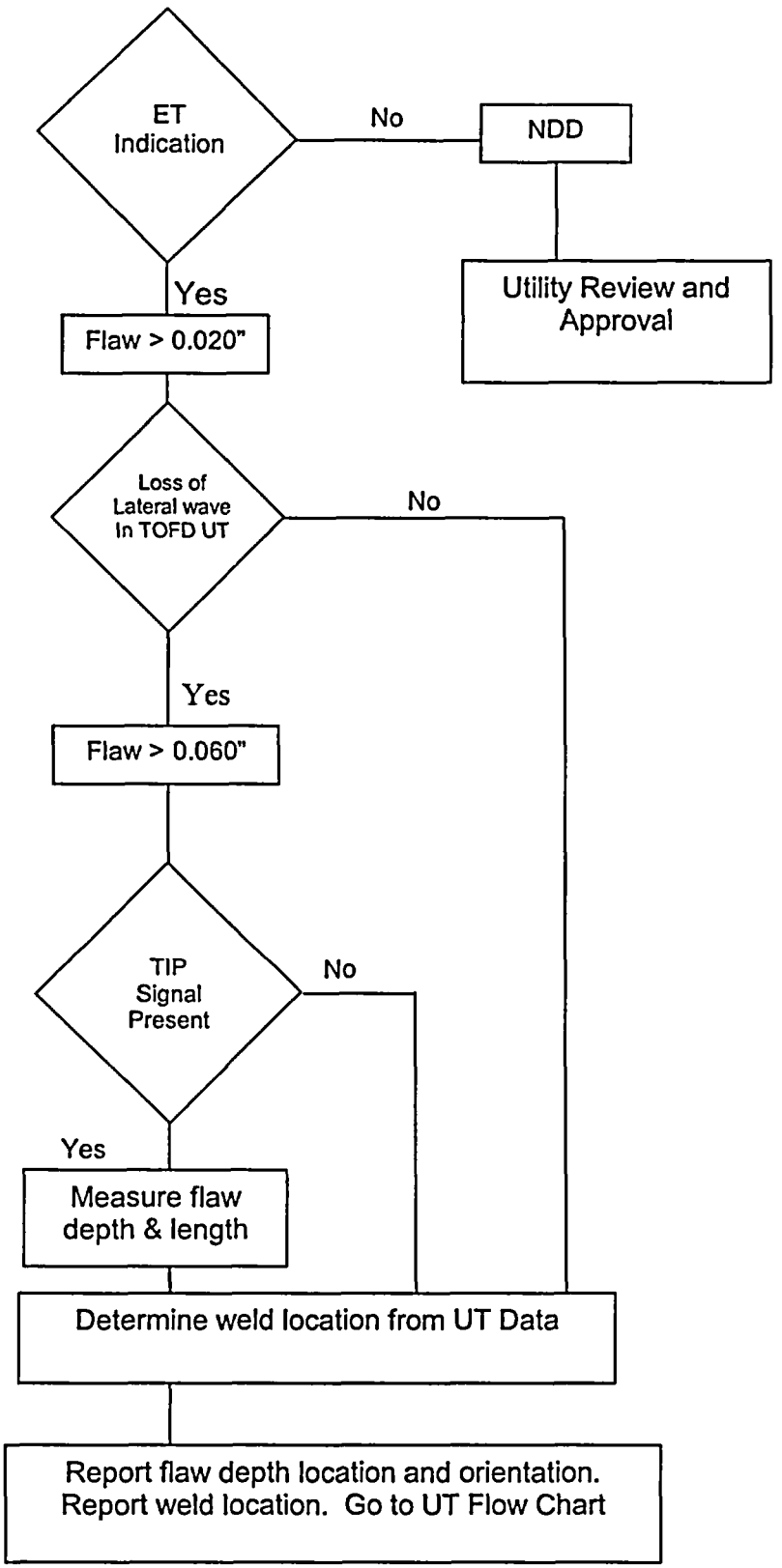
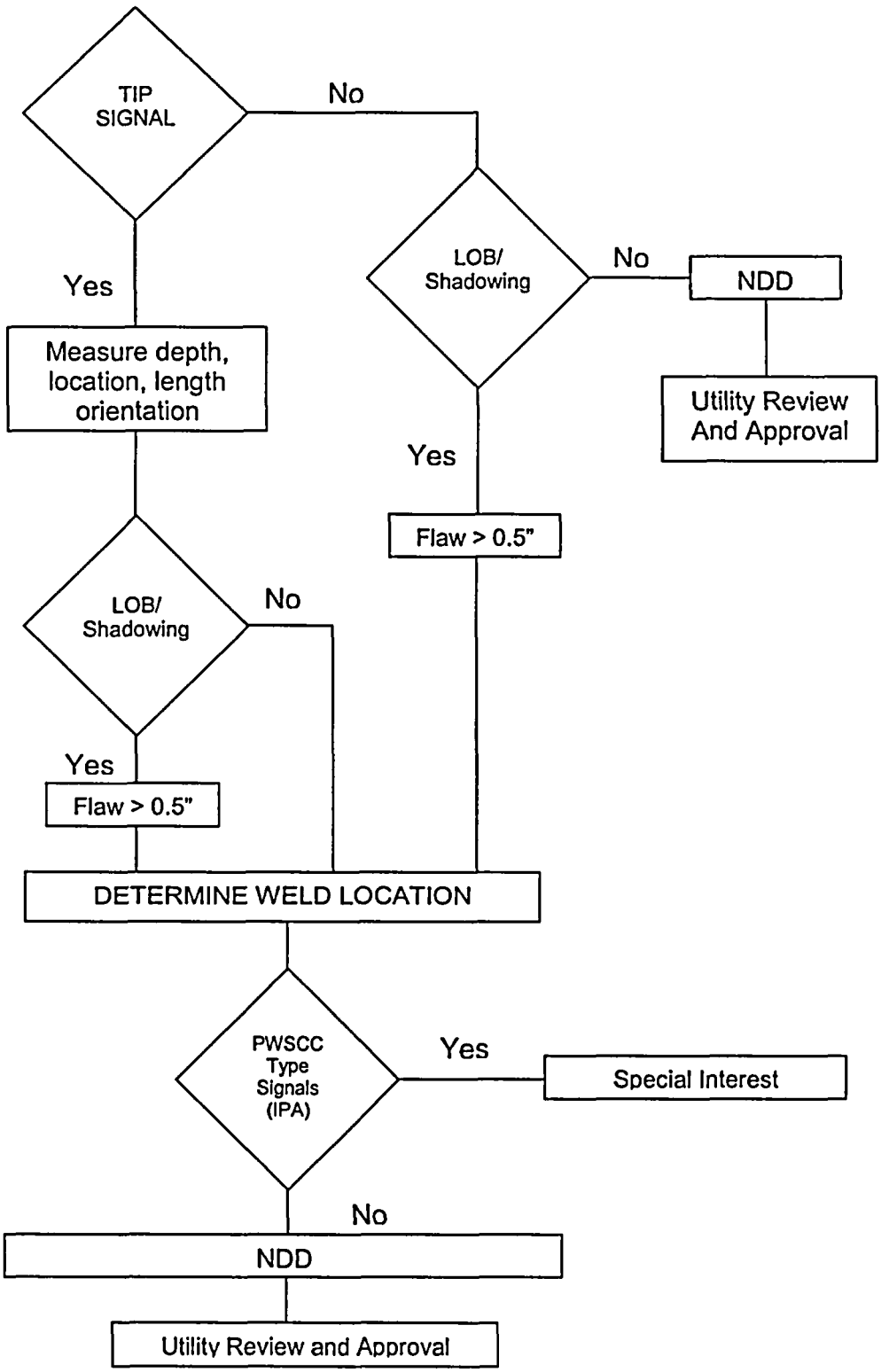



FIGURE 2 - PENETRATION TUBE OD FLAW EVALUATION