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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 for 2R12

During the recent Beaver Valley Power Station (BVPS) Unit No. 2 Refueling Outage (2R12), inspections of the reactor pressure vessel (RPV) head and associated penetration nozzles were performed in accordance with Nuclear Regulatory Commission First Revised Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors (the Order).

In accordance with the Order, Section IV.E, a report entitled "Evaluation Report for 2R12: Beaver Valley Power Station Unit 2 Reactor Vessel Head Penetration Inspections" is attached.

There are no regulatory commitments contained in this letter. If there are any questions or if additional information is required, please contact Mr. Henry L. Hegrat, Supervisor - FENOC Fleet Licensing, at (330) 315-6944.

Sincerely,

James H. Lash

Attachment:
Evaluation Report for 2R12: Beaver Valley Power Station Unit 2 Reactor Vessel Head Penetration Inspections

A101

cc: Ms. N. Morgan, NRR Senior Project Manager
Mr. P. C. Cataldo, NRC Senior Resident Inspector
Mr. S. J. Collins, NRC Region I Administrator
Mr. D. A. Allard, Director BRP/DEP
Mr. L. E. Ryan (BRP/DEP)

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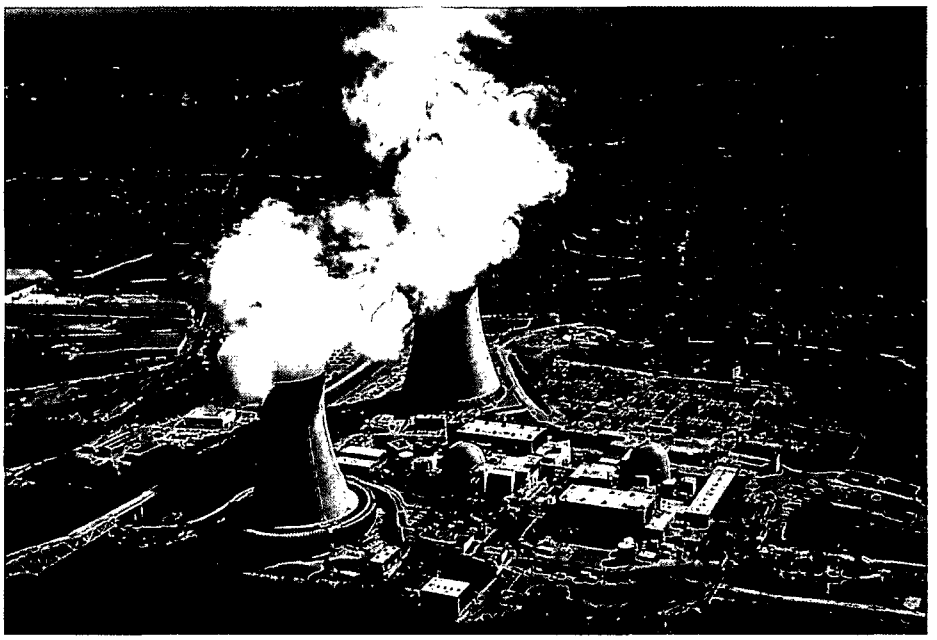

Evaluation Report for

2R12

Beaver Valley Power Station Unit 2

Reactor Vessel Head Penetration

Inspections

(Ref: First Revised Order EA-03-009)

Introduction:

Reactor Pressure Vessel (RPV) Head Inspections were performed at Beaver Valley Power Station (BVPS) Unit 2 during the 2R12 Refueling Outage in accordance with the First Revised Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors (the Order, Reference 1). The Order establishes criteria by which licensees must perform periodic inspections of the reactor vessel head. FirstEnergy Nuclear Operating Company (FENOC) provided a response to the Order for BVPS via letter L-04-030, dated March 5, 2004 (Reference 2).

For each inspection required in Paragraph IV.C and IV.D, Paragraph IV.E of the Order requires licensees to submit a report detailing the inspection results within sixty (60) days after returning the plant to operation. This report fulfills this requirement for the examinations required by IV.C. Visual inspections performed to identify potential boric acid leaks from pressure-retaining components above the RPV head required by Paragraph IV.D did not identify any evidence of leakage.

RPV Head Configuration:

The BVPS Unit 2 RPV head contains sixty-five (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 line that is clearance fit in the reactor vessel head and attached with an Alloy 182/82 partial penetration J-groove weld.

The 65 Control Rod Drive Mechanism (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 has a nominal OD dimension of 1.0" and a nominal ID dimension of 0.770". (NOTE: The bottom of the RPV head vent line is flush with the attachment weld and inner head surface, thus, no OD wetted surface exists.)

Susceptibility Ranking:

The cumulative Effective Degradation Years (EDY) of the BVPS Unit 2 reactor head were calculated at the conclusion of Cycle 12 in accordance with Paragraph IV.A of the Order. The Unit 2 RPV head has maintained one consistent bulk head temperature of 595°F for its operating history, as reported in Table 2-1 of EPRI MRP-48 and validated by a BVPS/Westinghouse study using external thermocouple measurements obtained from the BVPS Unit 1 RPV head surface (the Units 1 and 2 RPV head configurations are equivalent). The cumulative EFPY (Effective Full Power Years) for the Unit 2 RPV head through Cycle 12 was calculated to be 15.42. These plant-specific inputs were used to calculate EDY_{2R12} per the equation provided in Paragraph IV.A of the Order:

$$EDY_{2R12} = \sum_{j=1}^{n} \left\{ \Delta EFPY_j \exp\left[-\frac{Q_i}{R}\left(\frac{1}{T_{head,j}} - \frac{1}{T_{ref}} \right) \right] \right\}$$

$$EDY_{2R12} = \sum_{j=1}^{1}\left\{(15.42 years)\exp\left[-\frac{(50 kcal/mole)}{(1.103x10^{-3} kcal/mole°R)}\left(\frac{1}{(1054.67°R)}-\frac{1}{(1059.67°R)}\right)\right]\right\}$$

$$EDY_{2R12} = 12.59$$

The calculated EDY of 12.59 places the BVPS Unit 2 RPV Head in "High" susceptibility per the table in Paragraph IV.B of the Order.

Required Inspections:

As a "High" susceptibility plant, the inspection requirements of Paragraph IV.C.(1) of the Order apply to the BVPS Unit 2 RPV head. The inspection requirements of Paragraph IV.C.(1) were met during the BVPS 2R12 refuel outage by the successful completion of RPV head inspections in accordance with the requirements detailed in Paragraphs IV.C.(5)(a) and IV.C.(5)(b) of the Order.

Specifically, a visual inspection of the RPV head was performed, including bare metal visual examination of the RPV head surface and 360° around each RPV head penetration, in accordance with Paragraph IV.C.(5)(a) of the Order. Remote visual examinations were performed by Westinghouse/R. Brooks Associates and Wesdyne/FENOC VT-2 qualified personnel.

Under-head NDE examinations were performed in accordance with the requirements of Paragraph IV.C.(5)(b)(i) or (ii). (Note: The required examinations of each of the 65 CRDM penetrations were completed using a Time-of-Flight-Diffraction (TOFD) ultrasonic technique combined with 0-degree leak-path detection capability. Examinations of the RV head vent penetration and weld were completed using eddy current examination techniques. Examination techniques were not combined on any one penetration, therefore, the requirements of Paragraphs IV.C.(5)(b)(iii) do not apply.)

For the CRDM examinations, the minimum examination coverage extended from 2 inches above the highest point of the root of the J-groove weld to 1 inch below the lowest point at the toe of the J-groove weld, or to the distances identified in the Supplement to the Order Relaxation Request for Beaver Valley Unit 2 (Reference 4), which was approved by NRC (Reference 5). As in the examination coverage determinations provided as part of that request, the extent of ultrasonic examination coverage was verified for each penetration by confirming that tube entry signals were evident in the eddy current and ultrasonic data, and that scan coverage elevations were in excess of 2.0" above the uppermost elevation of each weld.

All of the nondestructive examinations performed during 2R12 were conducted in accordance with site-specific field service procedures. All CRDM ultrasonic and eddy current examination techniques 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 were demonstrated as identified in Westinghouse Technical Justifications WDI-TJ-011-03 and WDI-TJ-044-04.

Inspection Results:

Visual Inspections (Paragraph IV.C.(5)(a))

VT-2 visual inspection of 360° around each of the 65 CRDM Penetrations and the vent line showed no indication of penetration leakage characteristic of a through-wall leak. 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.

Ultrasonic Examinations (Paragraph IV.C.(5)(b)(i))

Ultrasonic examination with leak-path detection capability was performed on the sixty-five CRDM Penetrations in accordance with Paragraph IV.C.(5)(b)(i) of the Order. These examinations were performed using the Westinghouse 7010 Open-housing Scanner (5) or Gapscanner Trinity Probes (60). Each examination technique simultaneously performs Time-of-Flight-Diffraction (TOFD) ultrasonic testing for the detection of axial or circumferential degradation in the tube material, 0° ultrasonic testing to identify potential leak paths, and eddy current surface examinations (supplemental to Paragraph IV.C.(5)(b)(i) requirements).

The TOFD ultrasonic examinations of the sixty-five CRDM Penetrations identified three Penetrations as "special interest" requiring further evaluation, Penetrations 16, 56, and 61:

Penetration 16

Trinity Probe ultrasonic examination of CRDM Penetration 16 identified a reflector approximately 0.192 inches from the outside surface of tube at a radial position of 348°. The reflector measured approximately 0.5" in the circumferential orientation.

Penetration 56

Trinity Probe ultrasonic examination of CRDM Penetration 56 identified a reflector approximately 0.162 inches from the outside surface of tube at a radial position of 12°. The reflector measured approximately 0.5" in the circumferential direction and 0.25" in the axial direction.

Penetration 61

Trinity Probe ultrasonic examination of CRDM Penetration 56 identified a reflector approximately 0.349 inches from the outside surface of tube at a radial position of 315°. The reflector measured approximately 0.7" in the circumferential direction and 0.3" in the axial direction.

The reflectors observed in Penetrations 16, 56, and 61 prompted a focused, independent review of the 2R10 (Fall 2003) ultrasonic examination data in the areas of interest. During the course of this review, the indications identified in Penetrations 16 and 61 were discovered to be present in the Fall 2003 results, but neither was reported as Primary Water Stress Corrosion Cracking (PWSCC). When compared to the 2006 results, the indication in Penetration 16 showed no appreciable growth (i.e. any growth observed was within the tolerance of the measurement

technique). The indication in Penetration 61 was approximately 0.080" deeper than shown in the 2003 data. The indication in Penetration 56 was a new reflector, not apparent in the 2003 data.

Ultrasonic leak-path assessments on all 65 CRDM Penetrations identified no leak paths.

Supplementary eddy current examinations of the ID surface of all 65 CRDM Penetrations identified No Detectable Degradation (NDD).

Eddy Current Examinations (Paragraph IV.C.(5)(b)(ii))

The head vent tube eddy current inspection was performed using an array of 16 plus-Point probes and a low frequency bobbin coil. The head vent weld eddy current examination was performed with an array of 28 plus-Point coils. Eddy current examinations of the head vent tube and weld identified no detectable degradation characteristic of Primary Water Stress Corrosion Cracking.

Evaluation of "Special Interest" Penetrations 16, 56, and 61

In an effort to better characterize the ultrasonic indications observed, Penetrations 16, 56, and 61 were subjected to a series of supplemental non-destructive examinations. Eddy current examinations of the tube OD and J-groove weld were performed on Penetrations 16, 56, and 61 to attempt to identify any surface breaking indications that could be associated with the tube anomalies observed during the TOFD ultrasonic examinations. The eddy current exams identified No Detectable Degradation.

In addition, Penetrations 56 and 61 were examined from the ID with circumferentially oriented TOFD Ultrasonic Testing (UT) to better ascertain the axial extent of the indications seen with the axially oriented TOFD. These exams produced essentially the same disposition of the tube anomalies in terms of approximate size and orientation as the axial TOFD.

Finally, dye penetrant inspections were performed in the area of interest of the tube OD and J-groove weld on Penetrations 16, 56, and 61. In all three cases, these exams identified small, rounded indications in the J-groove weld in the same general circumferential orientations as the UT-identified tube reflectors. A summary of the examination results for Penetrations 16, 56, and 61 are shown in Table 1.

Table 1: Penetrations 16, 56, and 61 Examination Summary

Pen #	Axial-UT	Circ-UT	ID ECT	OD ECT	J-weld ECT	Leak Path Assessment	LPT
16	- Previous reflector (seen in re-review of 2R10 data) - (~0.5" C) - Growth within measurement tolerance (0.40 vs. 0.43) - Tube OD (~348°) - At or above J-weld toe		NDD	NDD	NDD	NDD	Small rounded indication near J-weld/Tube OD interface @ ~348°
56	- New reflector (not seen in 2R10 data) - (~0.5" C x 0.25" A) - Tube OD (~12°) - Above J-weld toe	Validates Axial-UT	NDD	NDD	NDD	NDD	- Tube OD, NDD - J-weld, 1/16" Rounded @ ~10-15°
61	- Previous reflector (seen in re-review of 2R10 data) - (~0.7" C x 0.3" A) - ~0.080" growth - Tube OD (~315°) - Above J-weld toe	Validates Axial-UT	NDD	NDD	NDD	NDD	- Tube OD, NDD - J-weld, Two aligned rounded indications, 3/32" x 3/16" @ ~315°

Notes:
ECT (Eddy Current Testing)
LPT (Liquid Penetrant Testing)
NDD (No Detectable Degradation)
OD (Outside Diameter)

The J-groove weld dye penetrant examination results on Penetrations 16, 56, and 61, while acceptable per the Construction Code, prompted FENOC to further interrogate these locations via minor excavation. A burring tool was used to perform minor metal removal on the J-groove weld indications on all three "special interest" locations, in conjunction with iterative dye penetrant exams. Following removal of between 30 and 60 mils of material, the subsequent dye penetrant exams revealed linear indications at all three locations.

Following the unsatisfactory dye penetrant results on Penetrations 16, 56, and 61, an independent UT Level-III review was conducted on the ultrasonic examination results to identify any conditions similar to the UT reflectors observed on 16, 56, and 61. During the course of this review, Penetration 45 was identified as having a shallow signal at ~95°, similar to that observed on Penetration 56. However, a follow-up dye penetrant examination of the tube OD and J-groove weld in the area of interest for Penetration 45 identified no indications (PT white).

The results of the excavation and dye penetrant exams on Penetrations 16, 45, 56, and 61 are provided in Table 2. Graphical representations of the ultrasonic reflectors and corresponding dye penetrant indications for Penetrations 16, 56, and 61 are shown in Figures 1, 2 and 3, respectively.

Table 2: Penetrations 16, 56, and 61 Excavation and Dye Penetrant Summary

Pen #	LPT (As-found)	LPT (after 1st grind)	LPT (after 2nd grind)
16	- Small rounded indication near J-weld/Tube OD interface @ ~348°	- ~1/4-3/8" linear indication, circ., near J-weld/Tube OD interface @ ~348°	
45	OD, J-weld @ 95° - PT White - SAT		
56	- Tube OD, NDD - J-weld, 1/16" Rounded @ ~10-15°	- Tube OD, NDD - J-weld, 1/16" Rounded @ ~10-15°	- Tube OD, NDD - J-weld, ~1/2" Linear, circ. @ ~10-15°
61	- Tube OD, NDD - J-weld, Two aligned, rounded indications, 3/32" x 3/16" @ ~315°	- Tube OD, NDD - J-weld, Single rounded indication with linear branching @ ~315° - New 1/16" rounded indication	- Tube OD, NDD - J-weld, Intersecting linear indications, ~0.75" circ x ~0.5" axial @ ~315°

Penetration Repairs:

Following the examinations, weld overlay repairs were performed on Penetrations 16, 56, and 61 in accordance with Beaver Valley Relief Request BV3-RV-04 (Reference Letter L-03-065), which was approved by the NRC (SER dated May 13, 2003) and remains in effect for the current BV-2 In-Service Inspection interval. The repairs were performed using the embedded flaw repair technique, consisting of a three-pass Alloy 52 weld overlay of the J-groove weld and a two-pass overlay of the penetration tube OD for each of the three penetrations. Post-repair dye penetrant examinations of all repaired regions identified no indications (PT white).

Upon completion of the repairs, ultrasonic and eddy current examinations were performed from the tube ID to verify that the repair process did not introduce any new flaws or adversely change the size or characteristics of the previously reported flaws. Analysis of the post-repair TOFD ultrasonic examination results revealed no new indications. Furthermore, the TOFD sizing results indicate the through-wall dimensions and lengths of the reflectors did not change as a result of the repair process. The conclusion can be made that the applied repair process had no detrimental effect on the tubes, did not result in any crack growth and did not result in the initiation of any additional cracking in the tubes.

Summary:

Visual and under-head Inspections of all RPV Head Penetrations were completed in accordance with the First Revised NRC Order EA-03-009 (Reference 1) and the relaxation to the Order approved by the NRC (Reference 5). Visual Inspection of the RPV head surface showed no evidence of a through-wall RPV head penetration leak or RPV head degradation. Under-head ultrasonic inspections of RPV head penetrations, and subsequent "special interest" examinations revealed relevant indications in the penetration tube and J-groove welds of three CRDM Penetrations.

Repairs were made to Penetrations 16, 56, and 61 using the embedded flaw repair technique per BVPS Relief Request BV3-RV-04 (Reference 7). A three layer Alloy 52 weld overlay was applied to each J-groove weld, and a two-pass weld overlay was applied to the OD of each of the affected Penetrations. Post-repair dye penetrant examinations of all repaired regions were satisfactory. Furthermore, post-repair eddy current and ultrasonic examination of each

penetration confirmed no new flaws were created nor did the size and characteristics of the existing flaws change as a result of the repair process.

References:

1. "Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors", February 20, 2004
2. L-04-030, BVPS Response to First Revised Order (EA-03-009), March 5, 2004
3. L-03-088, BVPS Unit 2 Order (EA-03-009) Relaxation Request, July 29, 2003
4. L-03-198, BVPS Unit 2 Supplement to Order (EA-03-009) Relaxation Request, December 19, 2003
5. NRC Safety Evaluation Report, BVPS Unit 2 Order (EA-03-009) Relaxation Request, August 2, 2004
6. L-03-065, Proposed Alternative Repair Methods for Reactor Vessel Head Penetrations (Relief Request No. BV3-RV-04), March 28, 2003
7. NRC Safety Evaluation Report, BVPS Relief Request No. BV3-RV-04, May 14, 2003

Figure 1: Penetration 16

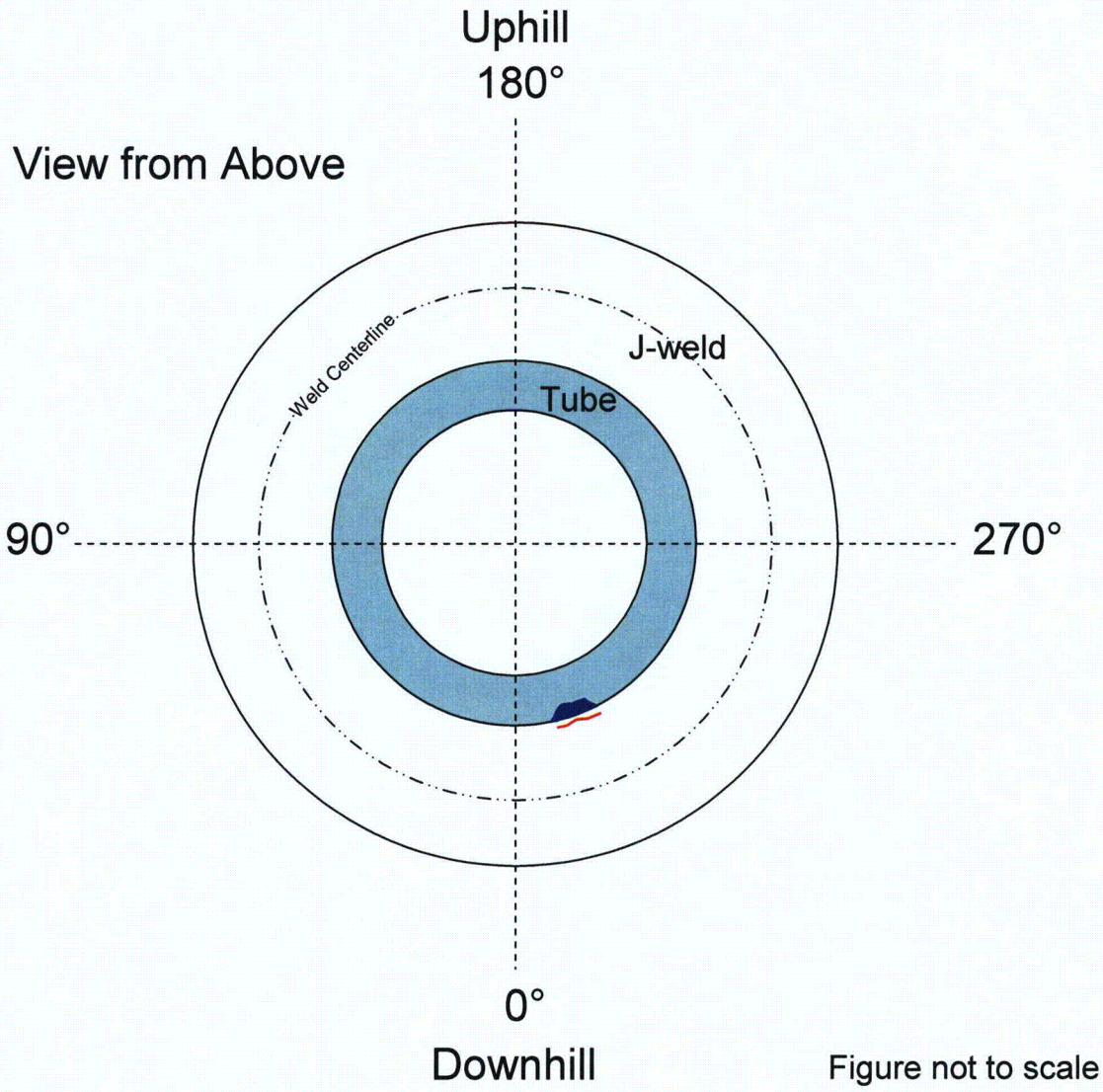

Figure not to scale

Figure 2: Penetration 56

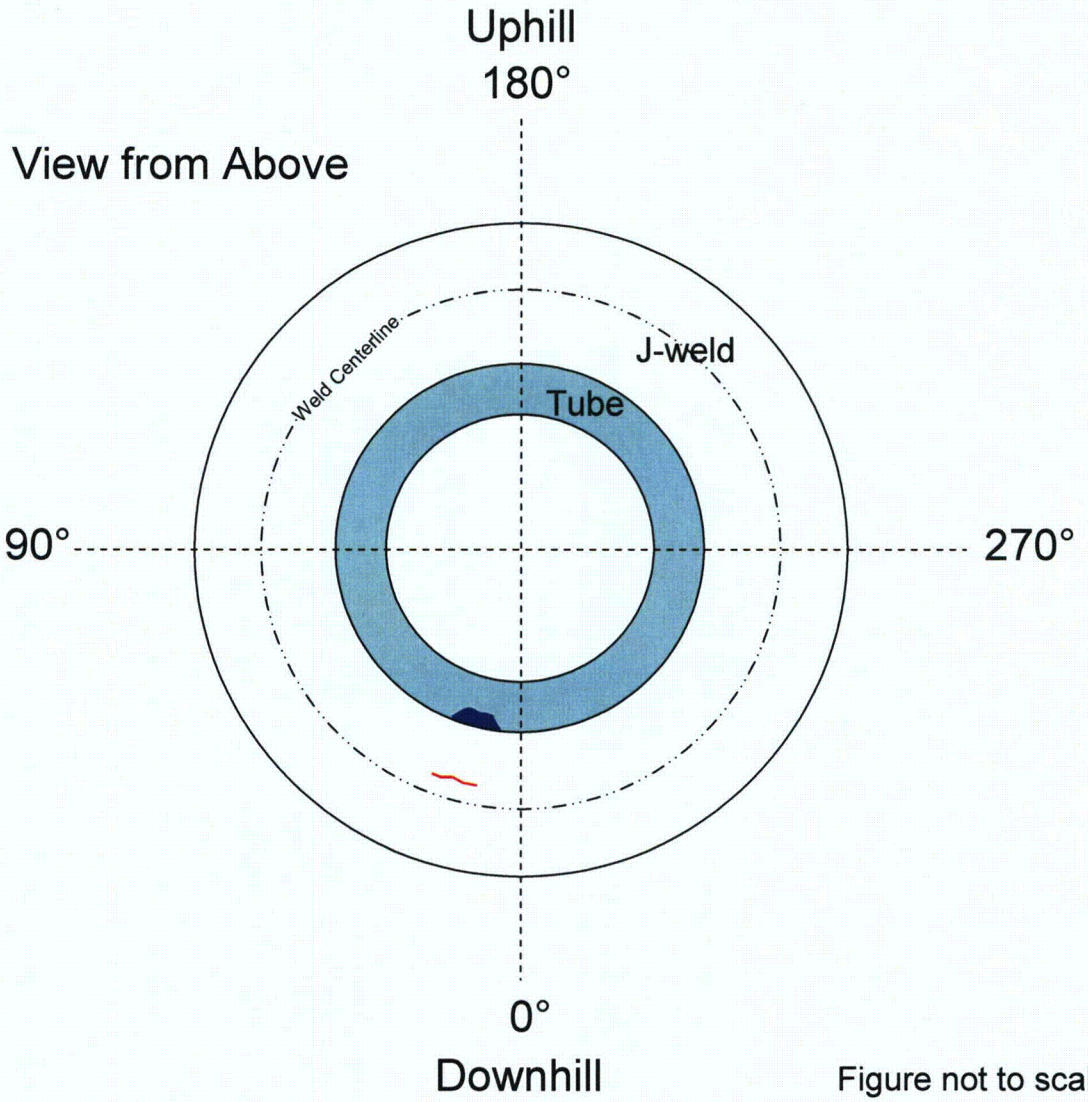

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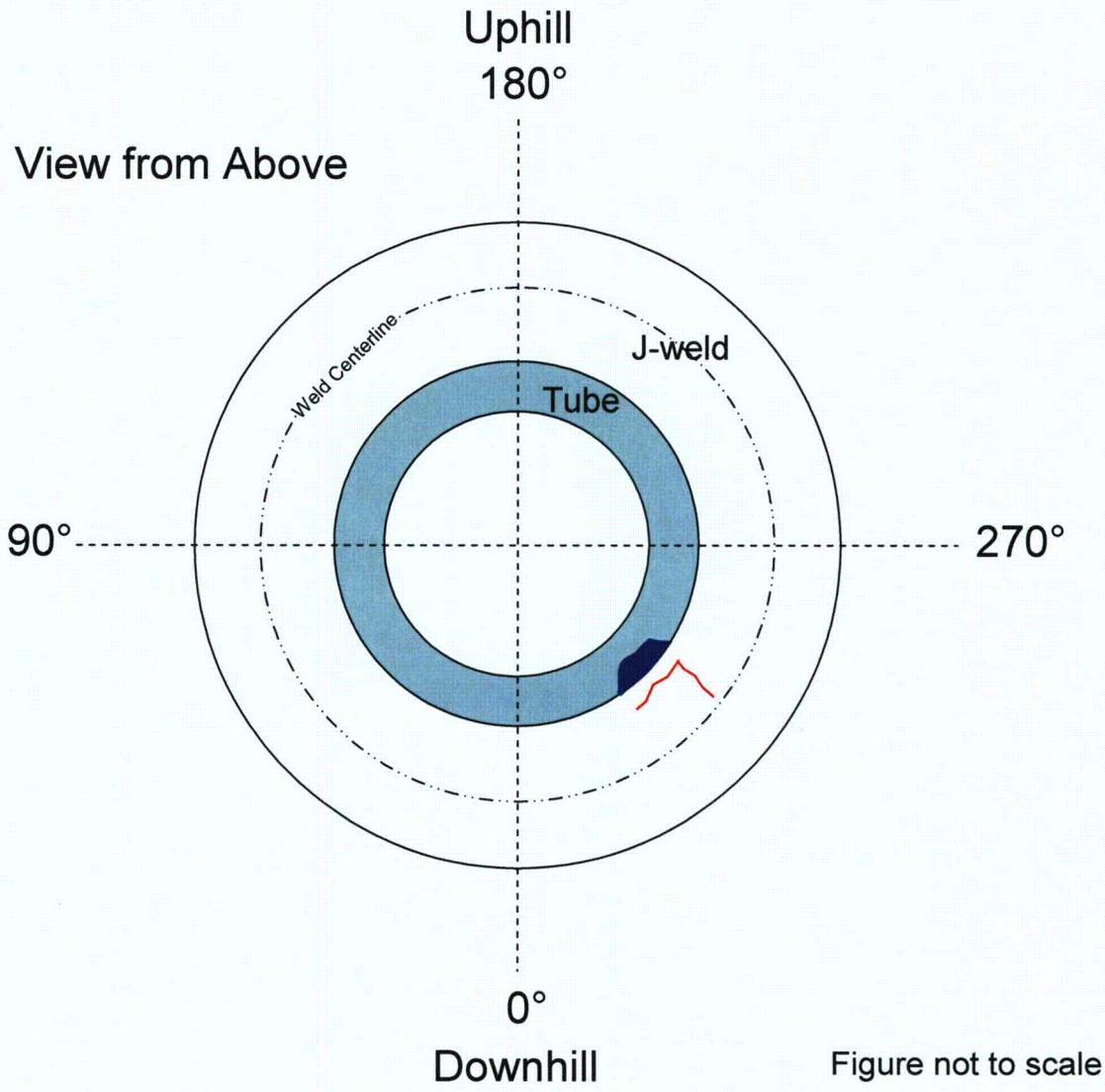
Figure 3: Penetration 61



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