



North Anna 2 RPV Head Non Destructive and Destructive examinations

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North Anna 2 RPV Head

General Configuration

- 65 Alloy 600 penetration Tubes
 - 56 tubes with thermal sleeves
 - 5 tubes with part length drive shafts removed
 - 4 tubes thermocouple columns without thermal sleeves
 - Shrunk fit into reactor vessel head
 - Attached with alloy 182 partial penetration J-groove weld
- RVH manufactured by Rotterdam Dry Dock



North Anna 2 RPV Head Inspections

- Fall 2001 - Bare metal visual of the upper head surface.
 - 3 nozzles were leaking; subsequently repaired
- Fall 2002 – Bare metal visual, ECT / PT of all J-groove welds, and ultrasonic of 35 nozzles
 - 6 potential leakers from BMV
 - 63 of 65 J-groove welds had indications
 - 42 J-groove welds would require repair
 - 6 nozzles with OD circumferential indications
 - BMV – negative or masked
- Utility decided to replace the Reactor Vessel Head
 - Agreed to allow MRP to remove samples from head



North Anna 2 RPV Head 2001 Inspections and Repairs

- Nozzle 51, 62, and 63 were leaking
- Tested welds with Dye Penetrant
 - several indications on each weld
- Removed the thermal sleeves
- Performed UT and ECT on the ID of the nozzles
- Ground indications on Nozzles 51 and 63 welds
 - Nozzle 63 was extensive ($\frac{3}{4}$ " deep)
 - Some light grinding on Nozzle 62 weld
- Removed boat sample from Nozzle 51
- Filled divots in Nozzle 51 and 63 with Alloy 52 weld material
- Overlayed all three welds with Alloy 52 welds
- Dye Penetrant tested all welds after repairs were completed
- Returned Head to Service



North Anna 2 RPV Head 2002 Inspections

- Bare Metal Visual
 - 2 leakers: Nozzle 21 and 31
 - 4 Potential: Nozzle 10, 35, 51, and 57
 - 21 masked: 14 masked by conoseal leak at Nozzle 53
- ECT of J-groove weld and OD of nozzle
 - Numerous welds with indications
- ECT and UT of ID Nozzles with weld indications
 - Thermal sleeves were cut
 - Either Mechanical or EDM process
- 6 nozzles (including the 3 previously repaired nozzles) were Dye Penetrant tested
 - Some grinding on all three welds
 - Boat sample from outer weld area (overlay and original butter) in Nozzle 51



Table 1: Summary of Leaking or Degraded Nozzles at NA-2

Penetration	UT Result (Circ Extent, Depth)	BMV Result
10	Weld interface indications, lack of fusion	Leaking
15	OD circumferential (5 deg, 0.226")	No discernable leakage
21	Potential leak path	Leaking
31	Potential leak path	Leaking
35	OD axial	Leaking
41	OD circumferential (46 deg, 0.097")	Masked
46	ECT circ by toe	Masked
51	Potential leak path	Leaking
54	OD circumferential (32 deg, 0.156") (79 deg, 0.226")	No discernable leakage
57	No detectable degradation	Leaking
59	OD circumferential (76 deg, 0.149") (50 deg, 0.149")	Masked
63	Potential leak path	Masked
65	OD circumferential (72 deg, 0.152") (30 deg, 0.078")	Masked
67	OD circumferential (44 deg, 0.094")	No discernable leakage



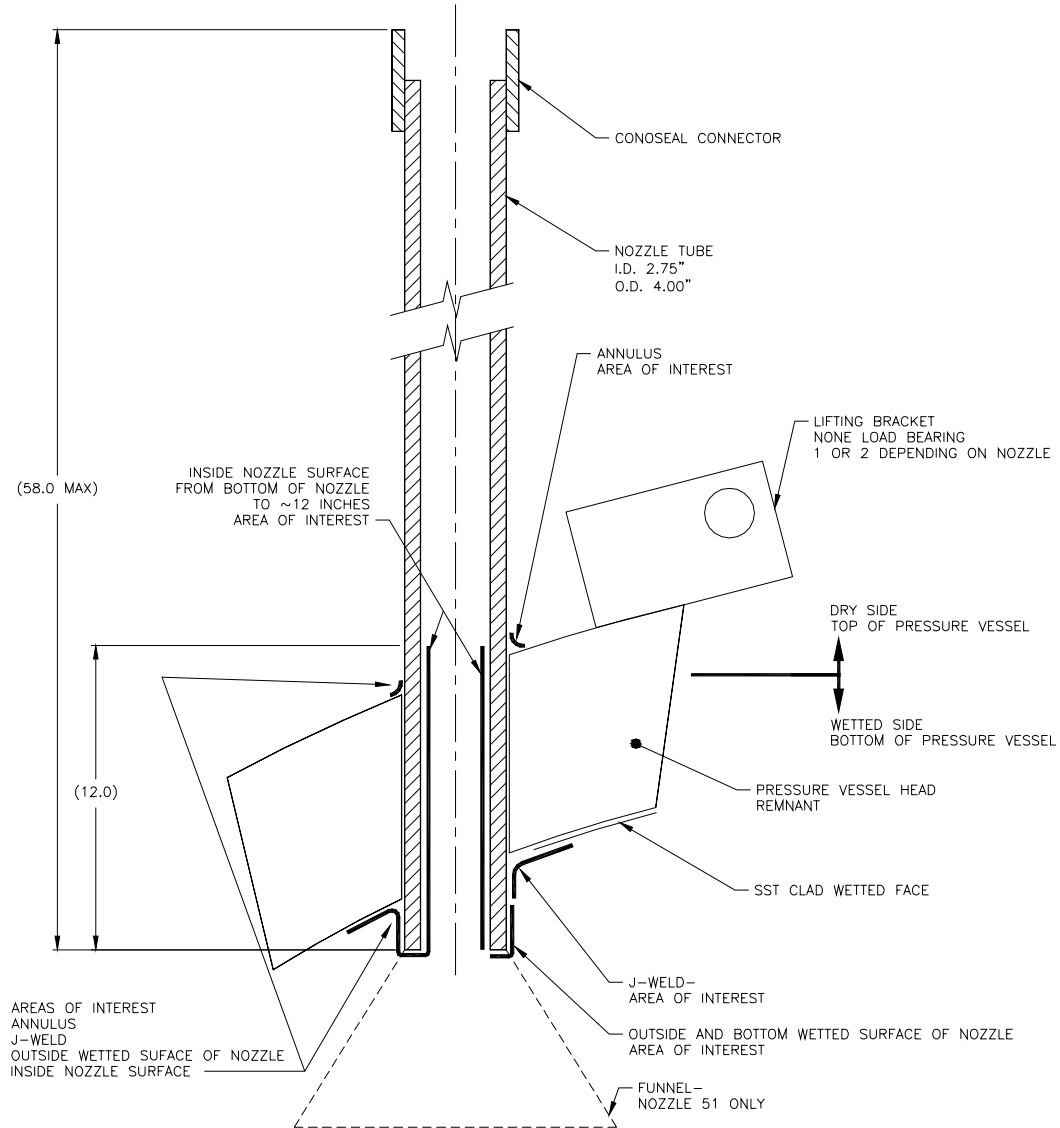
North Anna 2 RPV Head Candidate Penetrations for NDE/DE

- Group 1: penetrations 31, 51 & 54 => priority 1
- Group 2: penetrations 10, 63 & 59 => priority 2
- Penetrations 10, 63 and 59 are sister penetrations for penetrations 31, 51 and 54, respectively



CRDM Penetrations Preparations

Areas of Interest



CRDM Inspection Stands



Field NDE Results

Penetration 54:

Visual : no leak

UT 1: circumferential indication at the nozzle OD, near the top of the weld, 119/198°

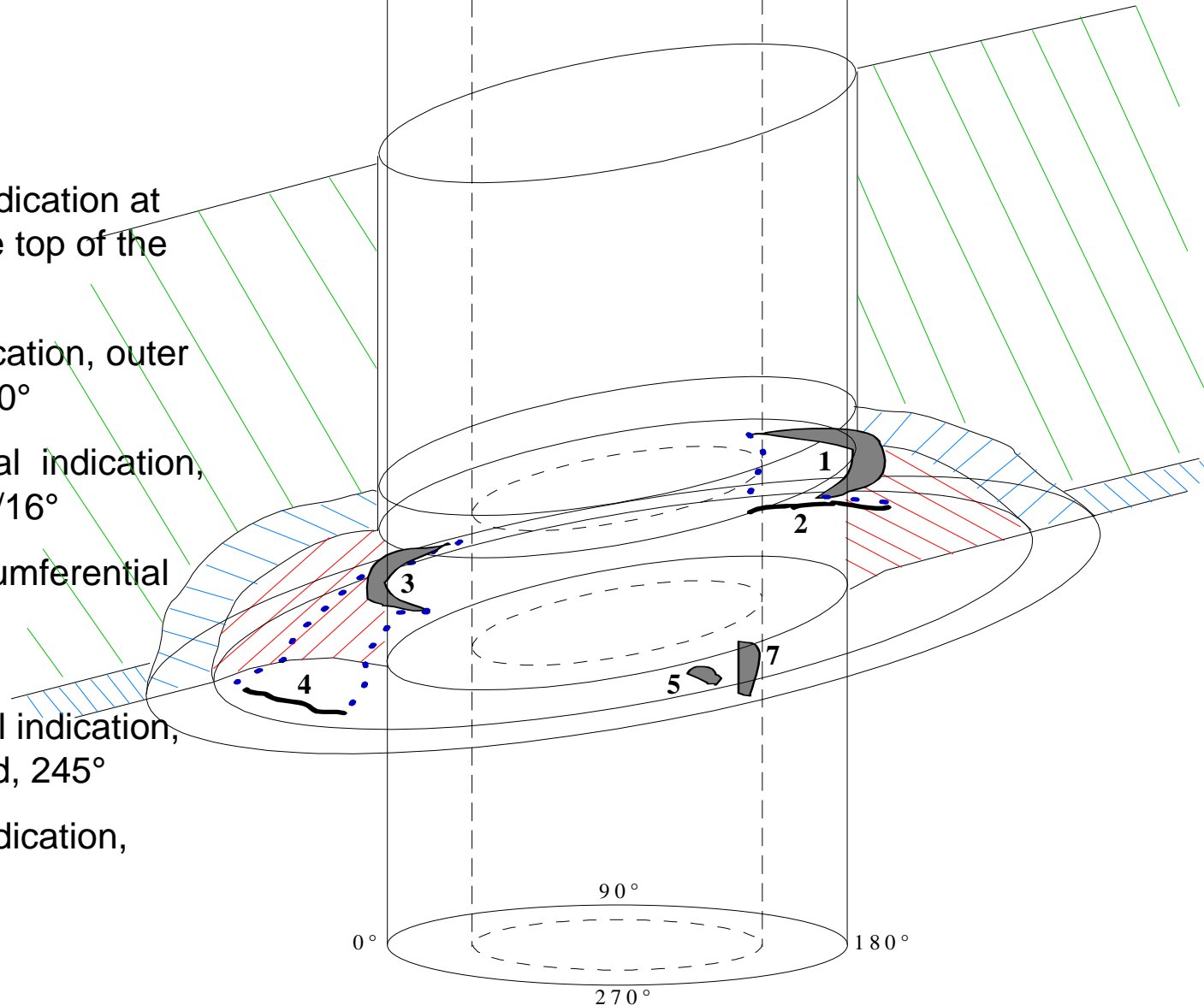
ET 2: weld surface indication, outer half of the weld, 115/140°

UT 3: OD circumferential indication, middle of the weld, 344/16°

ET 4: weld surface circumferential indication, outer portion of the weld, 333/353°

ET 5: weld surface axial indication, outer portion of the weld, 245°

ET 7: axial nozzle ID indication, below the weld, 200°



North Anna 2 RPV Head Vendor NDE Examinations

- NDE Vendors
 - PG&E
 - Framatome
 - Wesdyne
 - Brooks
- Vendors performed inspections at own expense
- Nondisclosure agreements in place
- One week allowed for each vendor
- Inspections performed between December 15, 2003 and March 12, 2004
- Preliminary inspection data under review by EPRI



Vendor NDE Examinations

- Guided Wave EMATS
- Blade Probe Ultrasonics (TOFD)
- Open tube Ultrasonics (TOFD, Shear Wave and Straight Beam)
- Tube Inside Diameter Eddy Current (Surface, sub-surface and deep penetrations)
- J-Groove Weld Wet Surface Eddy Current

Technology evaluation; not vendor comparison
Data to be used for benchmarking NDE techniques
with DE results



North Anna 2 RPV Head Silastic Molding of Penetrations

Performed molding of inner volume for four nozzles:

- Provides information on inside features such as:
 - Deformation and ovality that could be used for residual stress calculations from assembly and welding operations
 - Surface defects such as machine marks (possibly even surface cracks)
- Allows correlation of penetration geometry with spatial position
- Highly accurate molds (micron level)



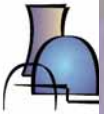
Silastic Molding of CRDM Penetrations Cap Attachment



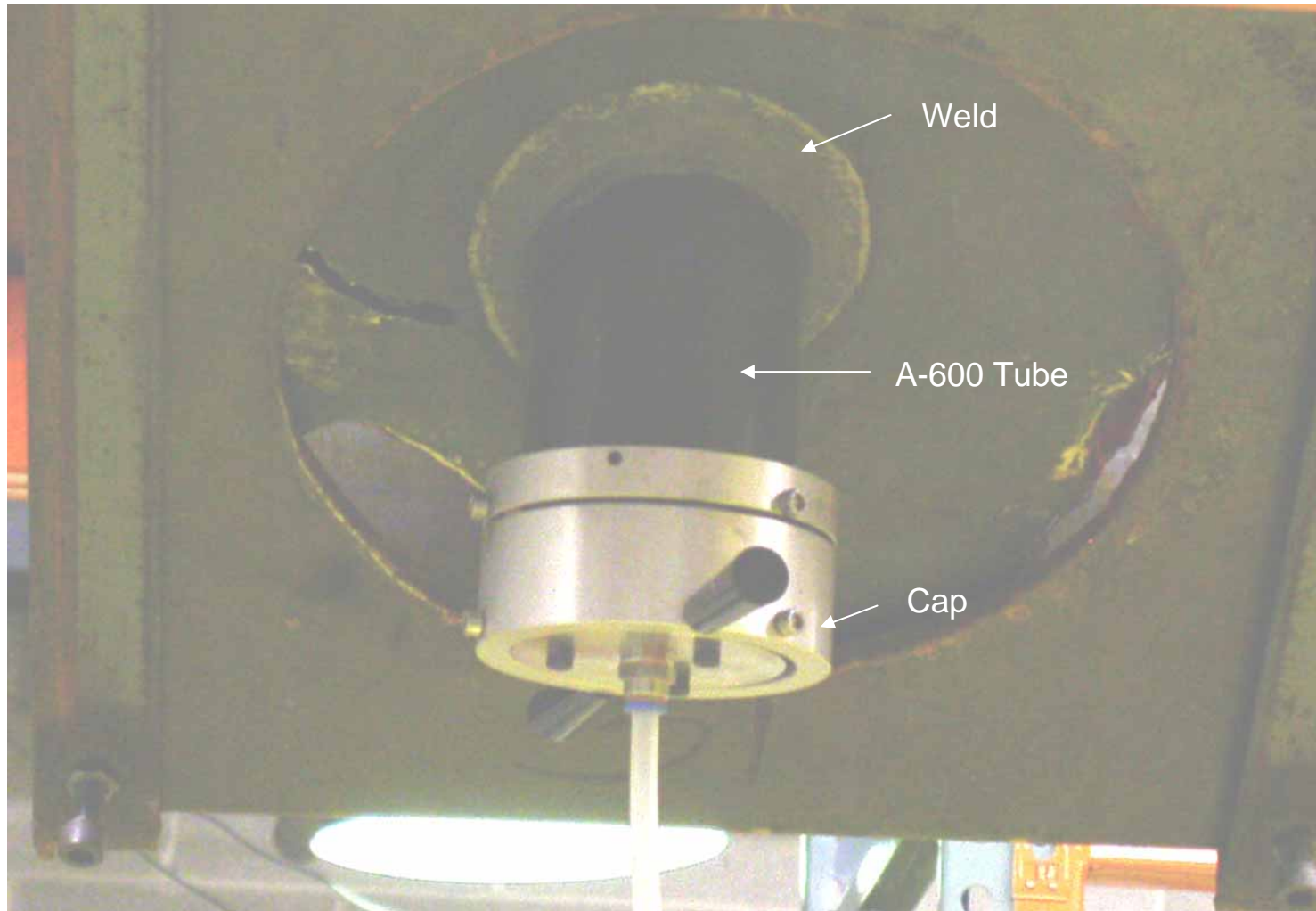
Nozzle In Place for Bottom Up Examination



January Weather in Richland, WA



Silastic Molding of CRDM Penetrations Resin Injection



Silastic Molding of CRDM Penetrations

Mold Removal



Silastic Molding of CRDM Penetrations

Finished Mold



North Anna 2 RPV Head Destructive Examination Objectives

- Establish correlation of NDE indications to actual crack characteristics
- Provide technical insight in crack morphology for the observed weld and base metal cracking
- Characterize any pressure vessel steel boric acid corrosion that may have occurred around the leaking nozzles



North Anna 2 Destructive Examination Benefits

- Reduce conservatism in upper head safety assessment and inspection plan and extend findings to BMI penetrations
- Obtain initiation and crack tip data on complete field-recovered flaws, including interaction of hot cracking with PWSCC that is of great value for 690 replacement as well
- Identify conditions that lead to LAS corrosion and predict rate and extent of LAS degradation at other RCS locations
- Calibrate current NDE methods, helping interrogation of other RCS locations and Alloy 690/52/152 materials
- Develop an improved management strategy for Alloy 600/82/182 and 690/52/152



North Anna 2 RPVH Penetrations DE Vendor Selection

- Received competitive bids from seven vendors in 2003
- Selected two laboratories (Westinghouse and AECL) for destructive examinations
- Re-evaluated DE objectives and obtained revised proposals from Westinghouse for Nozzle 54 and AECL for Nozzle 31
- Because of MRP funding profile, DE of Nozzle 54 is planned in 2004; DE of Nozzle 31 is deferred
- Currently negotiating work scope with Westinghouse; expect work to begin in April 2004



North Anna 2 RPVH Penetrations DE Nozzle 54 DE Preliminary Work Scope

- Receipt, inspection and photography
- Sectioning plan
- Sectioning and surface examinations
- Metallographic and fractographic examinations
- Chemistry evaluations
- Mechanical properties
- Root cause assessment
- Micro-chemical characterization of fracture surfaces
- Annulus deposit analysis (Optional)
- Technical report



North Anna 2 RPVH Penetrations DE DE and NDE/DE Reporting

- EPRI currently performing review and analysis of vendors' NDE data for the four nozzles
- Will compare flaw data from DE of the nozzle(s) with the NDE techniques used at PNNL
- Will prepare an MRP report documenting results, without identifying vendors with NDE data
- Expect the comparison for Nozzle 54 will be done in late 2004
- NRC RES will be provided a summary report documenting Nozzle 54 DE and NDE/DE comparison
- Investigating ways to fund DE of Nozzle 31 (MRP, NRC RES)



North Anna 2 RPV Head

Joint Program Between NRC RES & MRP

- Joint effort with NRC RES where RES will review Nozzles 54/31 work scope and participate in review meetings
- MRP will provide to NRC RES:
 - Summary of NDE results for the four nozzles
 - Summary of DE results for Nozzles 54 and 31
 - Comparison of NDE/DE results for Nozzles 54 and 31
- Currently discussing NRC RES interest in NDE/DE of remaining nozzles (#10 and 59) and possibly joining MRP on DE of Nozzle 31

