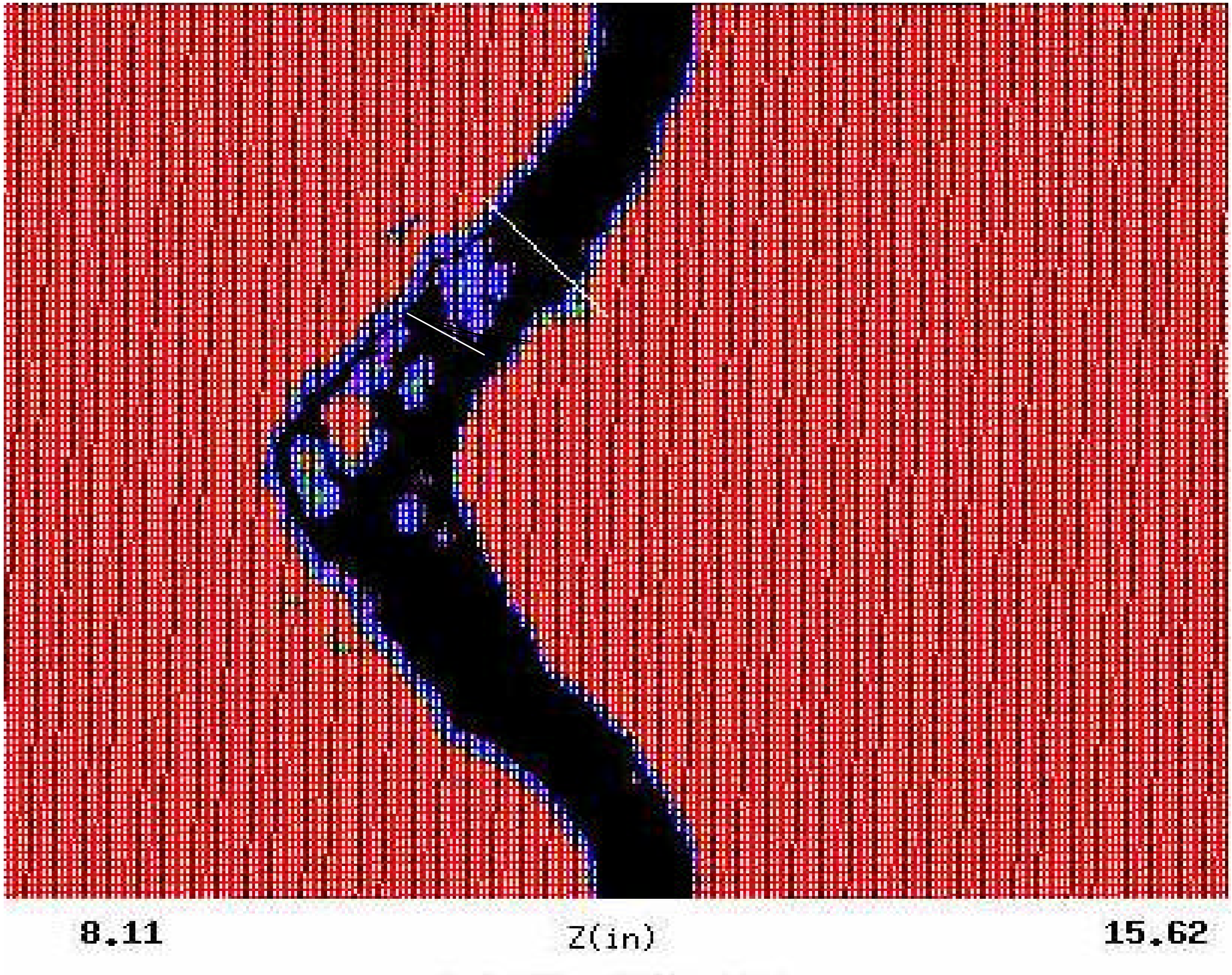
Conclusion

Coldworking is not a significant contributing factor

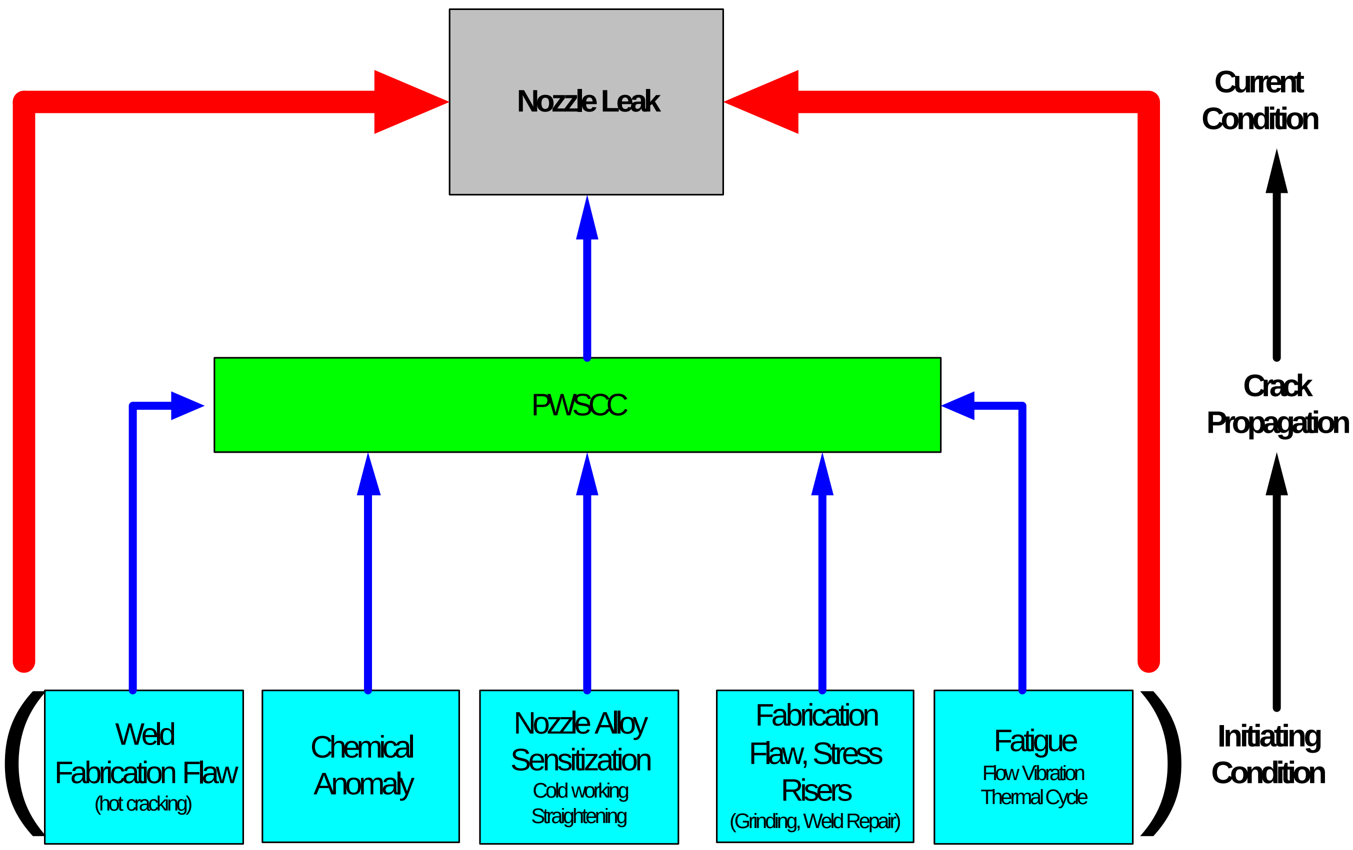
Axial Scan of Penetration 46 with Flaws Overlayed



Most Likely Causes

- Residual fabrication stresses
  - J-groove weld grinding, welding, welding rework
- Lack of J-groove weld fusion to nozzle OD
- Weld cracking; fabrication defects / contaminants
- Combination of one or more with PWSCC

Root Cause Focus



Planned Additional Testing

- Volumetric UT of vessel around #1 and #46
- Helium test for #1 and #46 annulus
- Visually examine inside bore #1 and #46
  - Perform after nozzle capped and separated
  - Possibly detect irregularities
  - Look for known through-wall flaw in #1

Planned Additional Testing (cont'd)

- Eddy current profilometry of #1 and #46
  - Performed from the bottom after nozzle is capped and separated from guide tube
  - Captures data on ID characteristics like ovalization at J-groove weld zone
- Visual exam of vessel at #1 and #46 after portion of old nozzle removed

Planned Additional Testing (cont'd)

- Metallurgical analyses of removed nozzle ends

- Boat samples from #1 and #46 flaw zones

Repair and Startup Are Safe

- Inspections limit repair scope to the two leaking nozzles
  - Extensive NDE reveals no flaws in other nozzles

Repair and Startup Are Safe (cont'd)

- Regardless of final root cause, half-nozzle repair is the appropriate corrective action
  - Bounds potential causes
  - Establishes new ASME Code pressure boundary
  - Utilizes proven industry process
  - Upgrades material to Alloy 690

Repair and Startup Are Safe (cont’d)

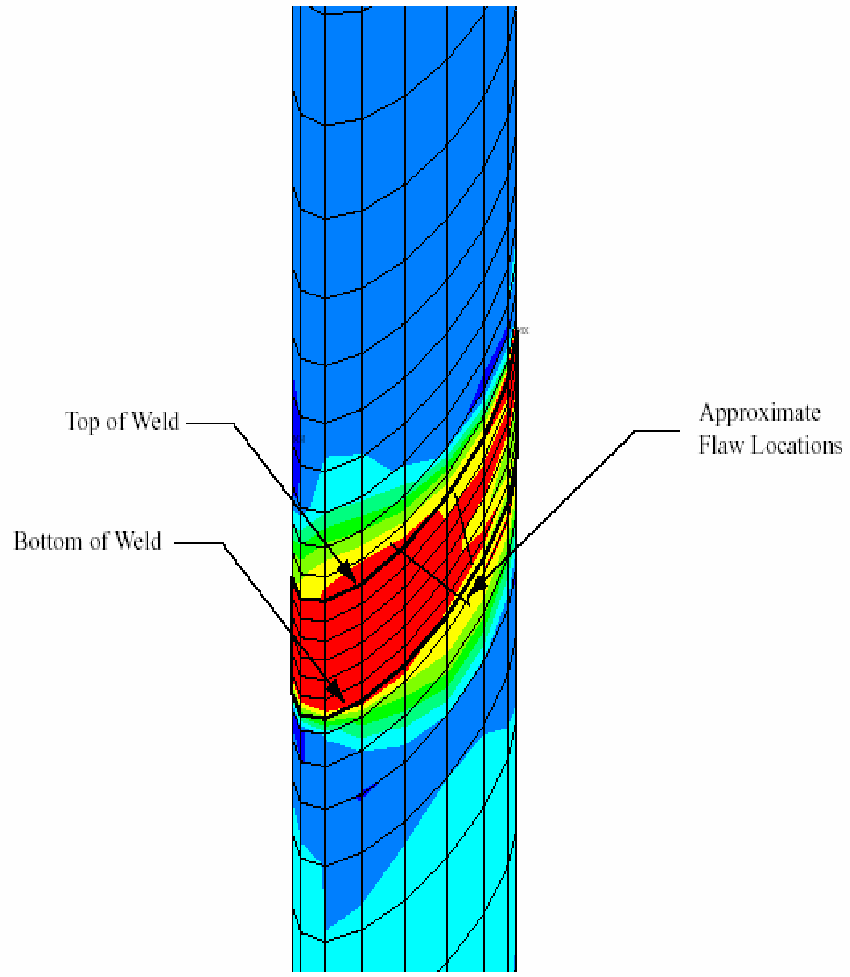
- Evaluation of evidence indicates minor nozzle leakage is worst potential consequence

Severe Consequences Not Likely

Small Break Loss of Coolant Accident (SBLOCA)

- Residual stresses favor axial crack orientation
- No circumferential cracks

Flaw Locations and Stresses



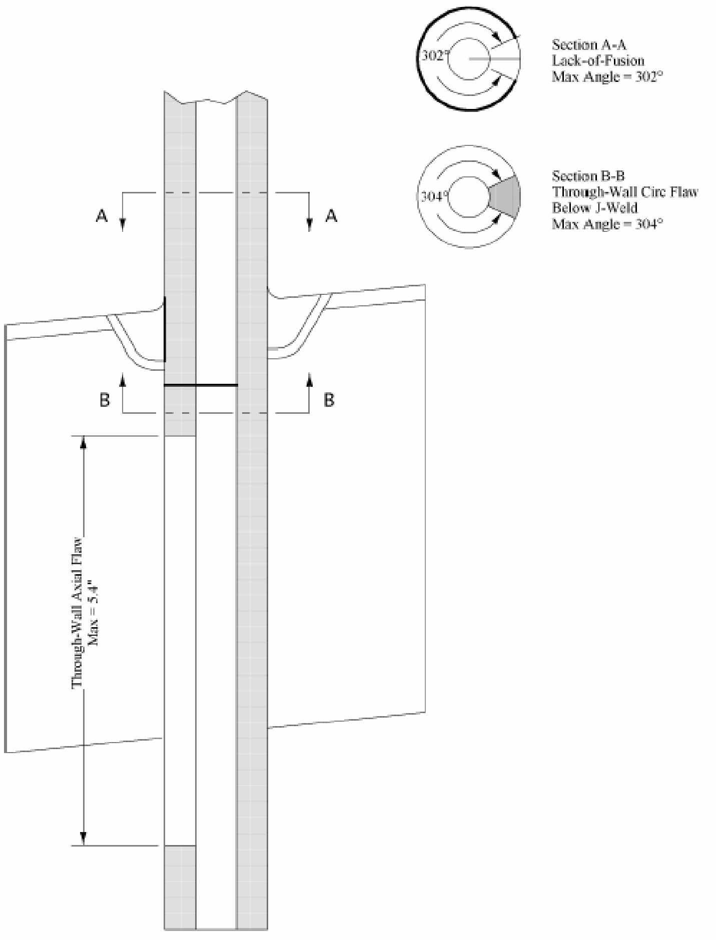
Nozzle Alone, Showing Approximate Flaw Locations and
Stresses In the Direction Parallel to the Plane of the Weld

Severe Consequences Not Likely (cont'd)

Small Break Loss of Coolant Accident (SBLOCA)

- Residual stresses favor axial crack orientation
- No circumferential cracks
- Robust design
- Limiting flaw size

Limiting Flaw Size



Locations of Analyzed Axial and Circumferential Flaws

Figure 5-1

Severe Consequences Not Likely (cont'd)

Small Break Loss of Coolant Accident (SBLOCA)

- Residual stresses favor axial crack orientation
- No circumferential cracks
- Robust design
- Limiting flaw size
- Very large safety factor
- Bare metal inspection
- Leak before break

Severe Consequences Not Likely (cont'd)

No evidence of vessel wastage

- No significant iron in residue
- No wastage residue
- No visual indication
- Confirmed by UT

Severe Consequences Not Likely (cont'd)

Loose Parts

- No flaws above weld
- No circumferential flaw
- Residual stresses favor axial crack orientation

Conclusions

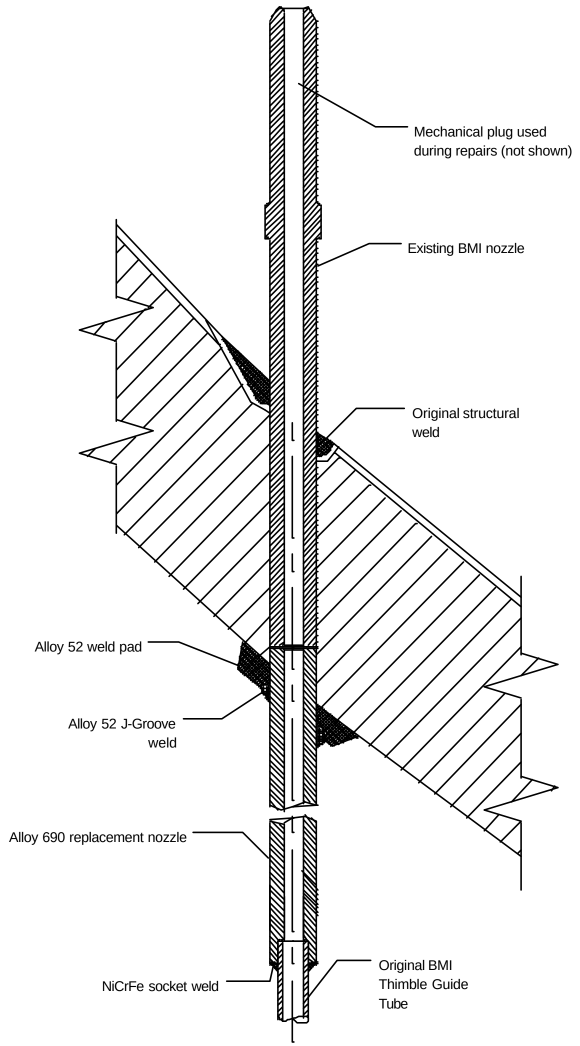
- We have good data
- Repair scope limited to #1 and #46
- Repair bounds likely causes
- Root cause will determine monitoring plan

REPAIR PLAN

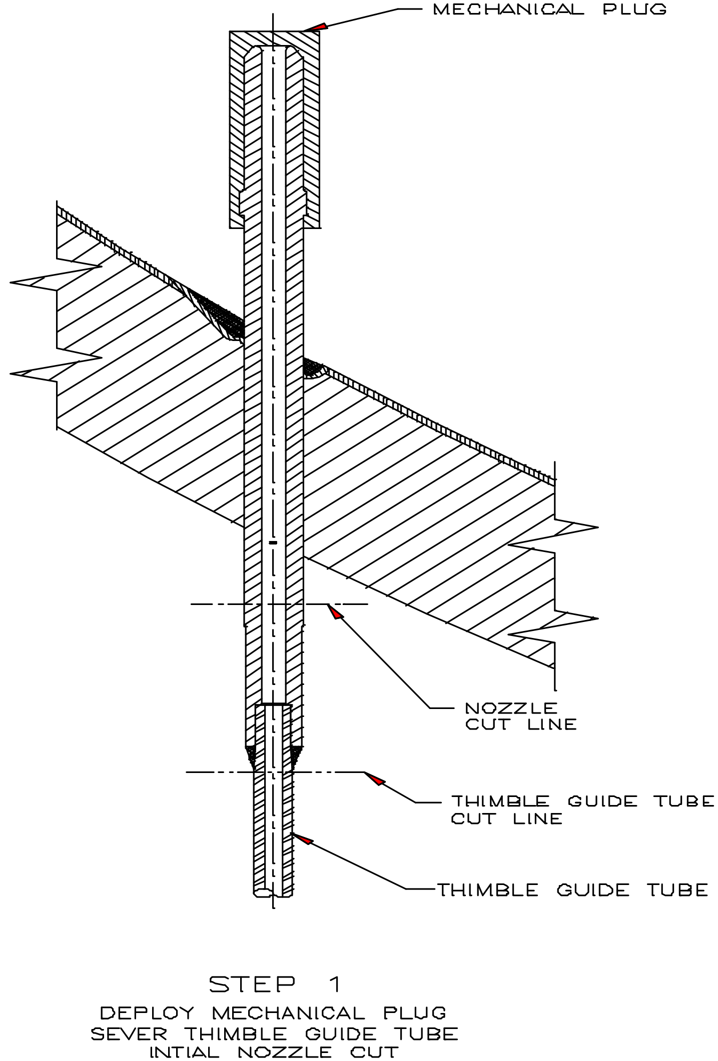
Steve Thomas

Manager, Plant Design

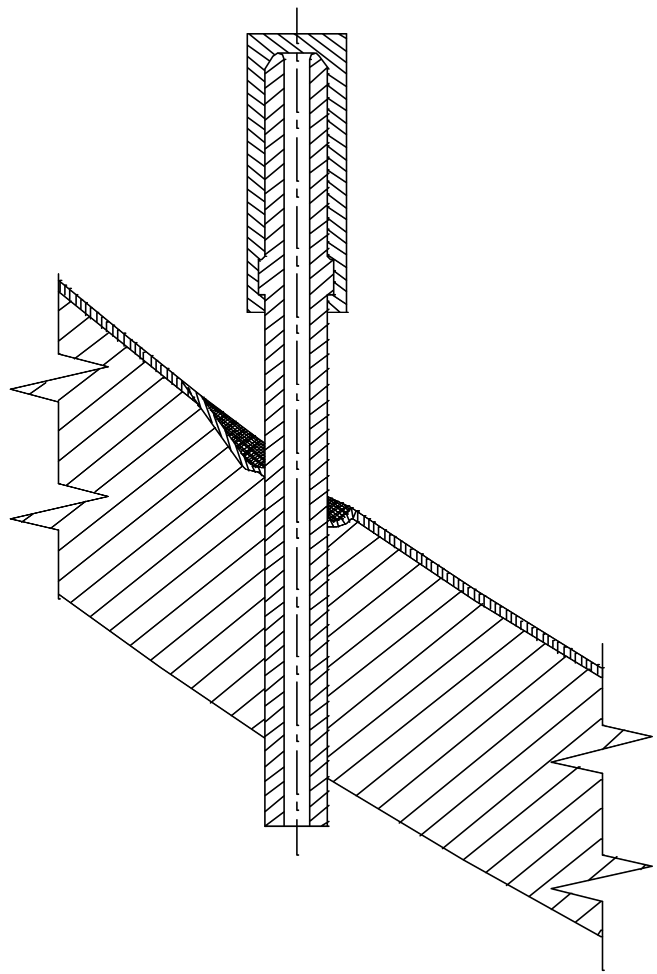
Half-Nozzle Repair



Deploy Plug; Cut Guide Tube / Nozzle

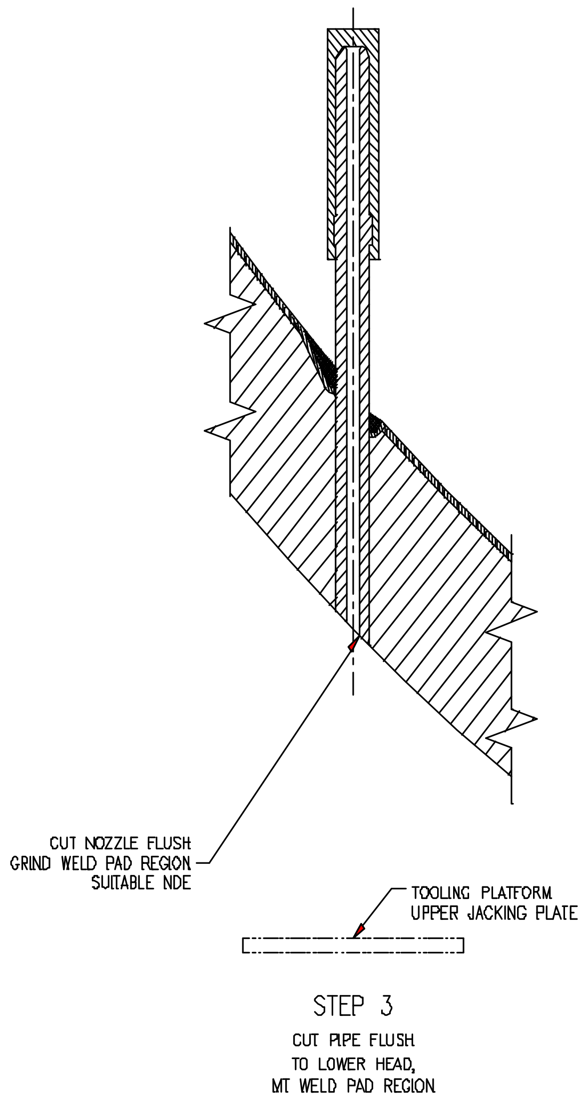


Inspect for Leaks

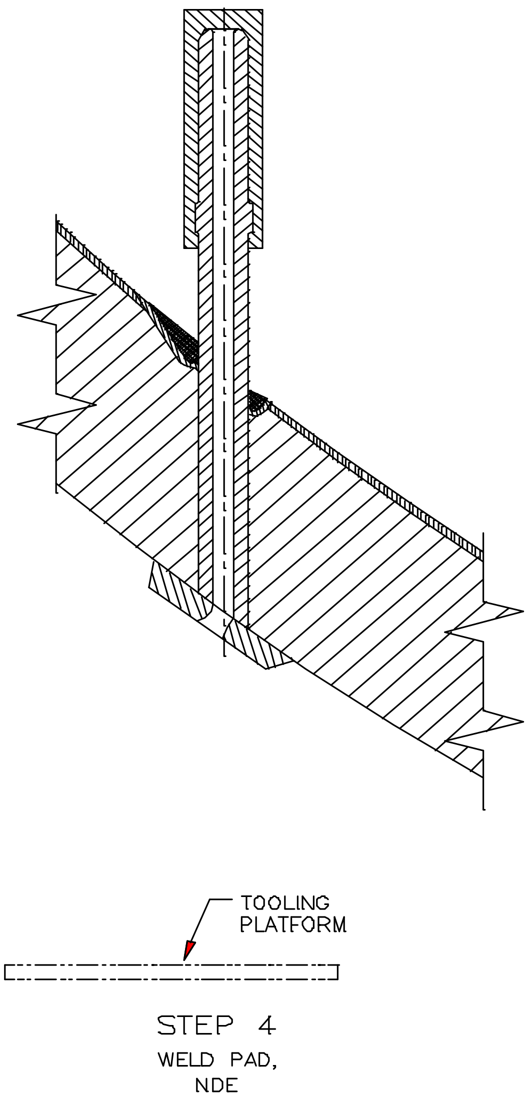


STEP 2
INSPECT FOR LEAKS

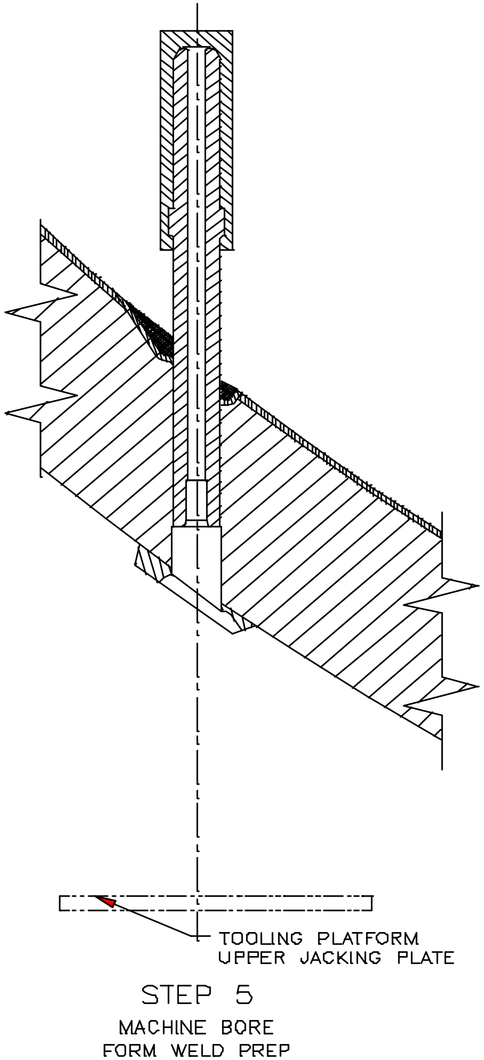
Cut Nozzle Flush with Head



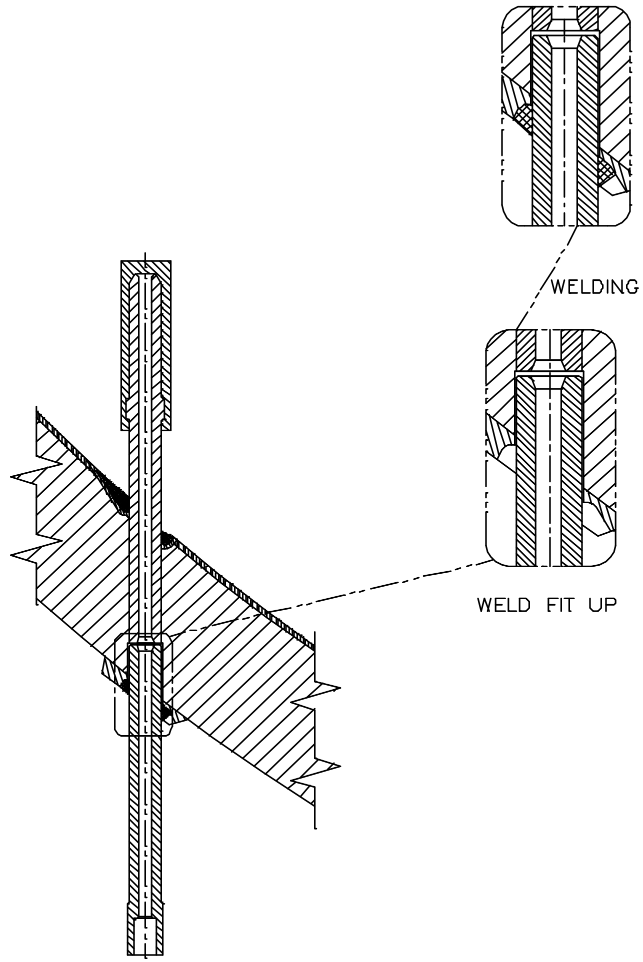
Form Weld Pad and NDE



Machine Bore and Form Weld Prep

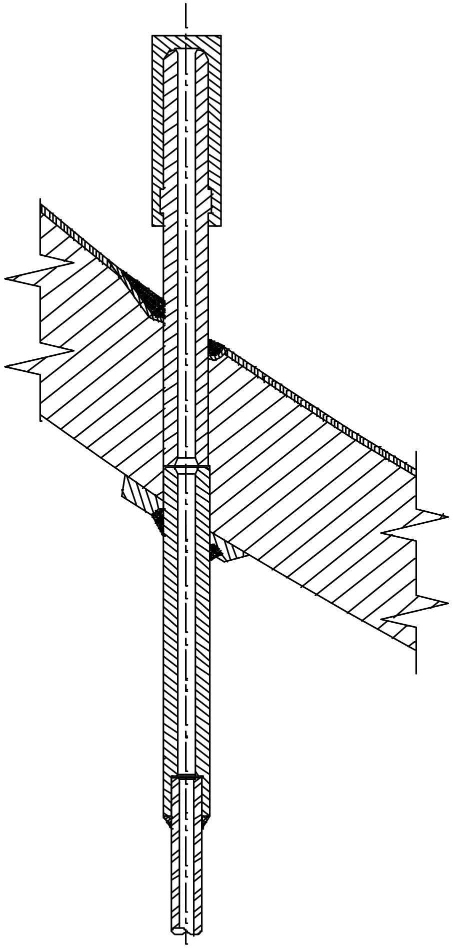


Install Nozzle; Weld; NDE



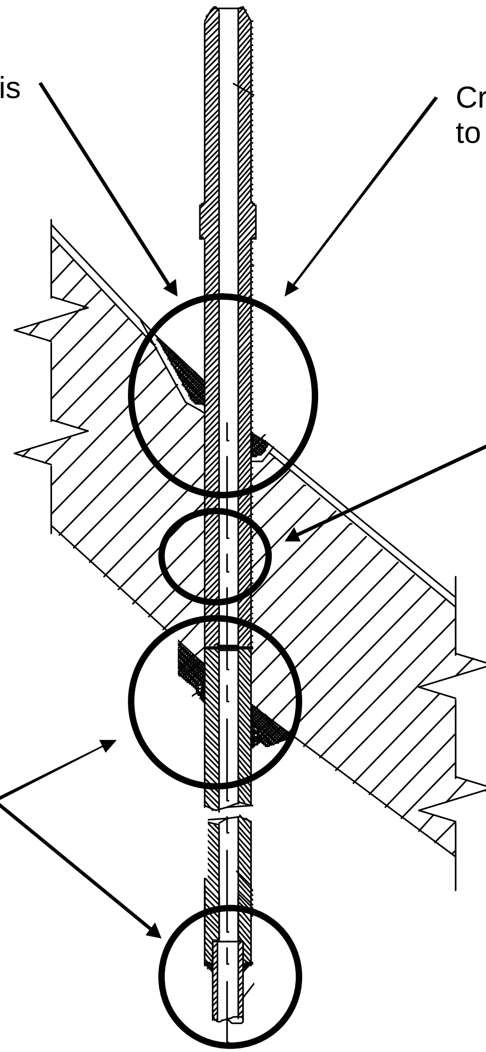
STEP 6
INSTALL REPLACEMENT NOZZLE, WELD, NDE

Install Tube; Weld; NDE; Remove Plug



STEP 7
INSTALL THIMBLE GUIDE TUBE,
WELD, NDE REMOVE MECHNICAL
PLUG

Analyses Supporting Repair



ASME Design and Analysis is consistent with the original reactor vessel requirements

CORROSION ASSESSMENT

Rick Gangluff
Manager, Chemistry

Half-Nozzle Replacement Corrosion Assessment

- Small gap between Alloy 600 remnant and new Alloy 690 nozzle
- Carbon steel (SA 533B) in annulus region exposed to primary coolant
- No mechanism to concentrate boric acid
- Corrosion rates are very low (~1.5 mil/yr)

Corrosion Rates Addressed by CEOG for Nozzle Replacement

- SER issued for Rev. 0 of CEOG Report
- NRC found CEOG report methods and analyses to be acceptable
- STP plant-specific analyses in accordance with SER nearing completion

BMI General Corrosion Acceptable

- Corrosion rate identified in report acceptable for STP based on projected capacity factors
- Lifetime increase in diameter
  - 24 years 0.073”
  - 44 years 0.135”
  - Less than most limiting nozzle

CONCLUDING REMARKS

Mark McBurnett

Manager, Quality & Licensing

Deliverables

Nozzle finite element stress analysis	Avail.
Flaw size limits to prevent net section collapse	Avail.
NRC site review visit	TBD
Submit LER	**6-12**
NDE inspection report	6-14
Design change (Section III, Section XI, corrosion)	6-14
Annulus dilation analysis	6-15
Submit temper bead relief request	**6-17**
Nozzle inservice acceptability analysis	6-30

Deliverables (cont'd)

Preliminary cause report (FMEA summary, bounding cause, safety significance, corrective action, monitoring plan)	**7-12**
Rockville meeting (cause report)	-
Public meeting at STP	-
Relief request approval	-
Half-nozzle lab analysis report	9-21
Boat sample analysis report	9-21
Submit LER supplement (final cause report summary)	**10-12**

Conclusions

- NDE campaign successful
- Condition/repair scope known
- Repairs enable safe return to operation
- Continued close cooperation with industry and NRC on cause analysis