Recent Material Aging Degradation Related Issues

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BWR Pressure Boundary Integrity

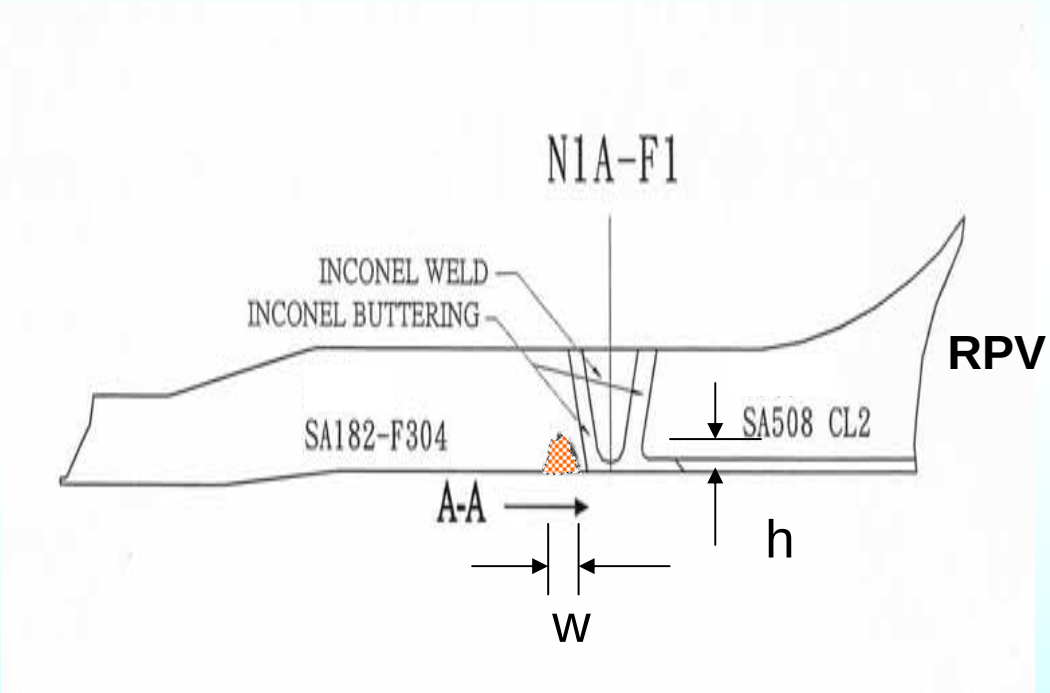
Background

- Cracks were found on recirculation piping from 1980s in Taiwan. Since 1995, TPC established augmented in-service inspection (ISI) plans according to GL 88-01 and NUREG 0313 Rev.2. All the relevant welds in the recirculation piping were fundamentally inspected every 2 refueling cycles.
- To mitigate IGSCC problems, the major betterment work includes：conducting IHSI for part of the welds, weld overlay for the cracked weld and replacements of risers for Chinshan and Kuosheng.
- For the last 2 years, TPC has revised ISI plans for both BWRs by following NUREG 0313 Rev.2 , citing EPRI BWRVIP-75 and considering the past inspection results.

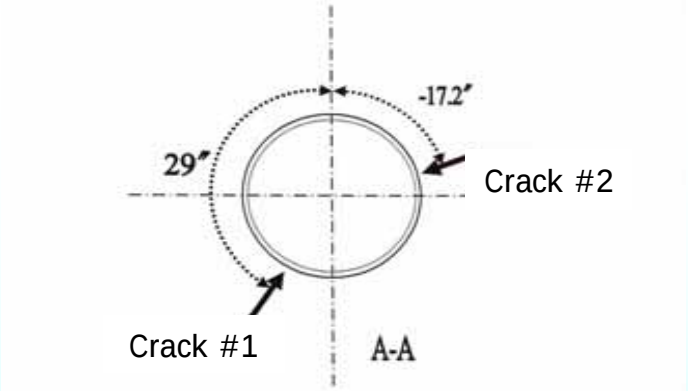
Background

- Besides, the personnel who perform ultrasonic testing must meet the requirements of Appendix VIII of Section XI of the ASME B&PV Code.
- During the recent scheduled refueling outages for both plants, crack indications were identified at the dissimilar metal welds connecting vessel nozzle to austenitic stainless steel piping of the reactor recirculation piping system of Chinshan Unit 1 (EOC-21, 2005) and Kuosheng Unit 2 (EOC-17, 2005) in addition to the cracks found at austenitic stainless steel piping welds.

Finding during CS1 EOC-21 outage



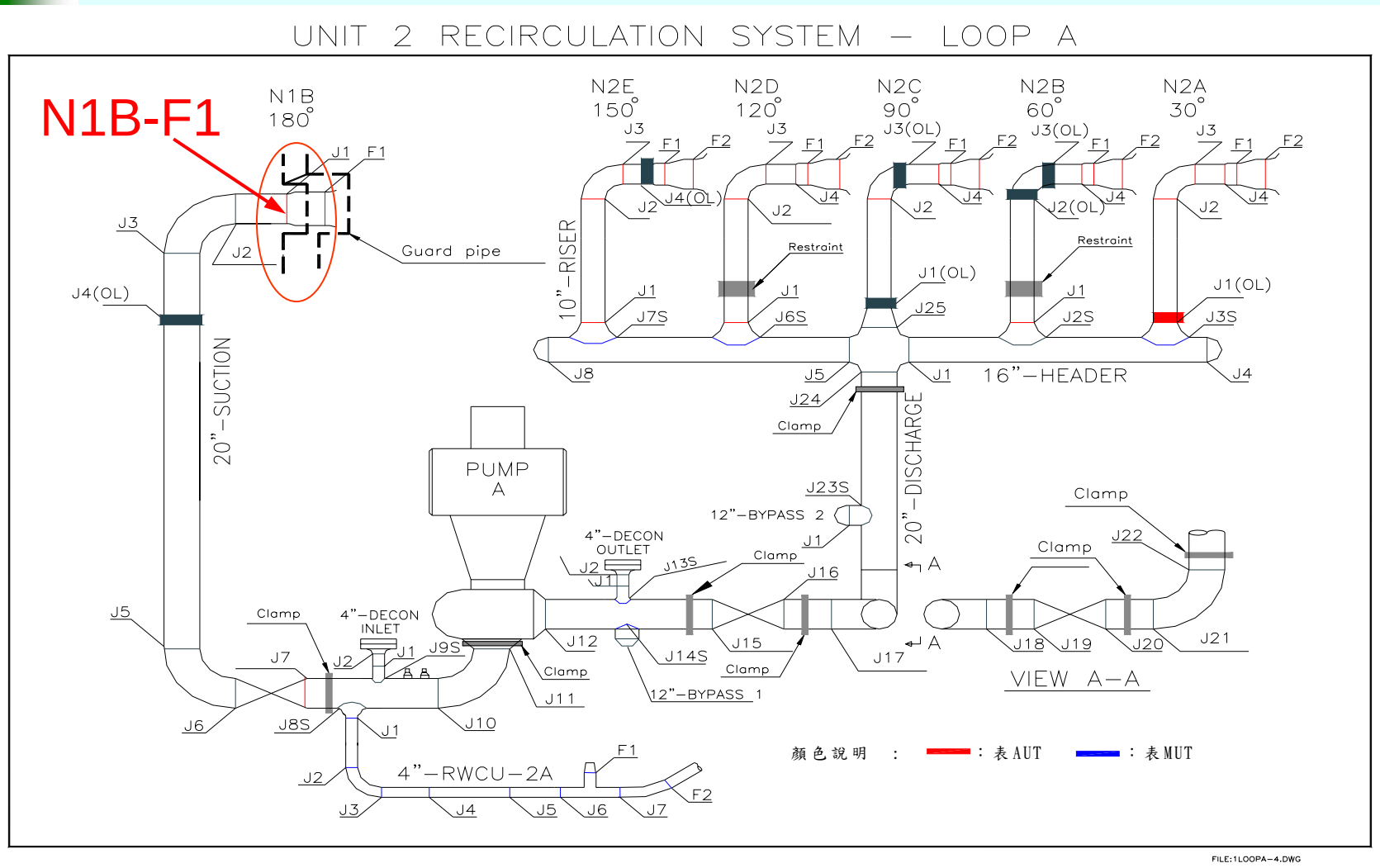
Flaw No	w	h
1	**0.82"**	**0.54"**
2	**0.4"**	**0.36"**



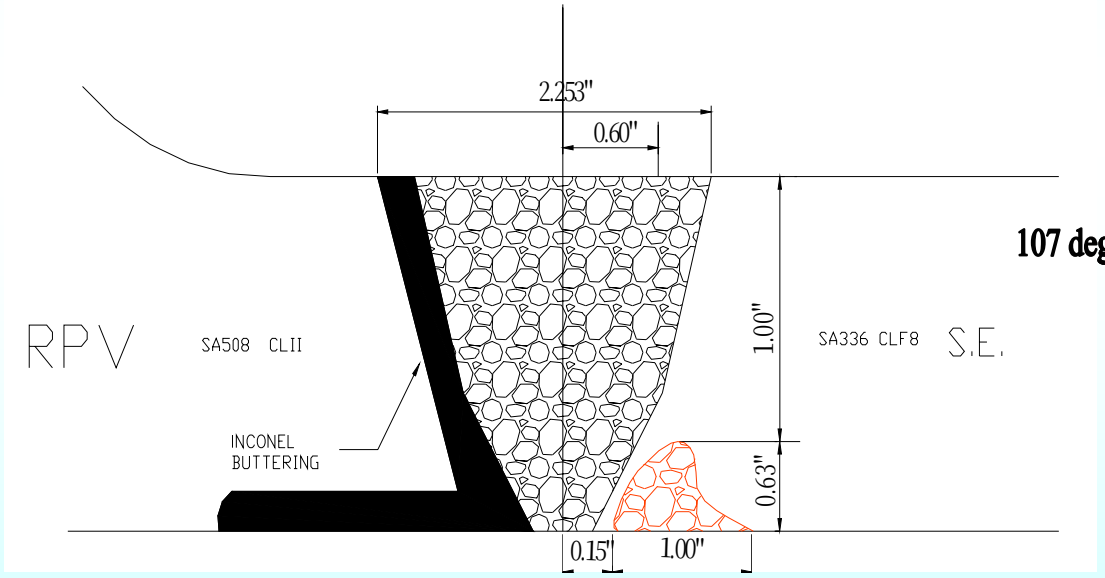
Two axial cracks at the N1A-F1 dissimilar metal weld

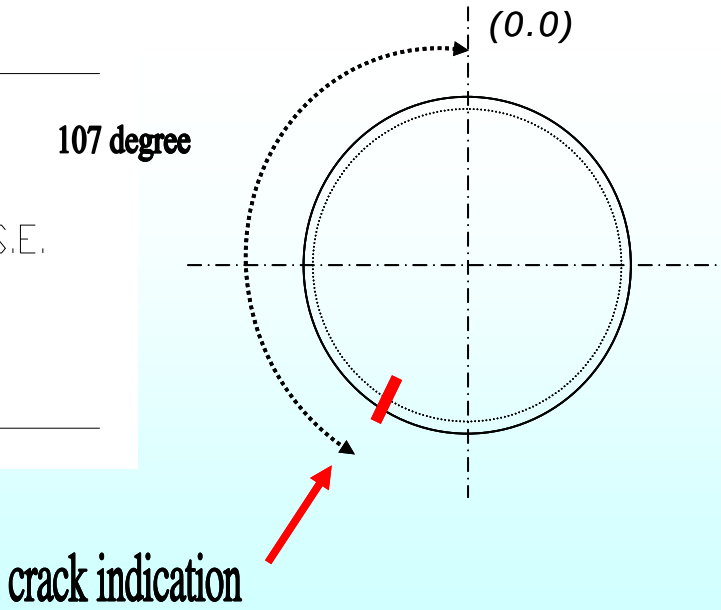
- TPC repaired it by weld overlay reinforcement

Finding during KS2 EOC-17 outage



- An 1”(l) × 0.63”(d) axial crack of KS2
- A similar crack identified at the same location found at CS1





- TPC repaired it by weld overlay reinforcement

Regulatory actions

- In view of crack indications, TPC usually uses weld overlay reinforcement method to repair the welds. Relevant regulatory activities were as follows:

1. If the crack was found, AEC generally requests TPC expanding the inspection scope to all the similar locations.
2. In view of cracks identified at the DM welds and the related foreign experience, TPC was requested to review the inspection frequency and technique.
3. After conducting weld overlay reinforcement, the primary shrinkage stress evaluation must be performed to ensure the structural integrity before the unit re-start.

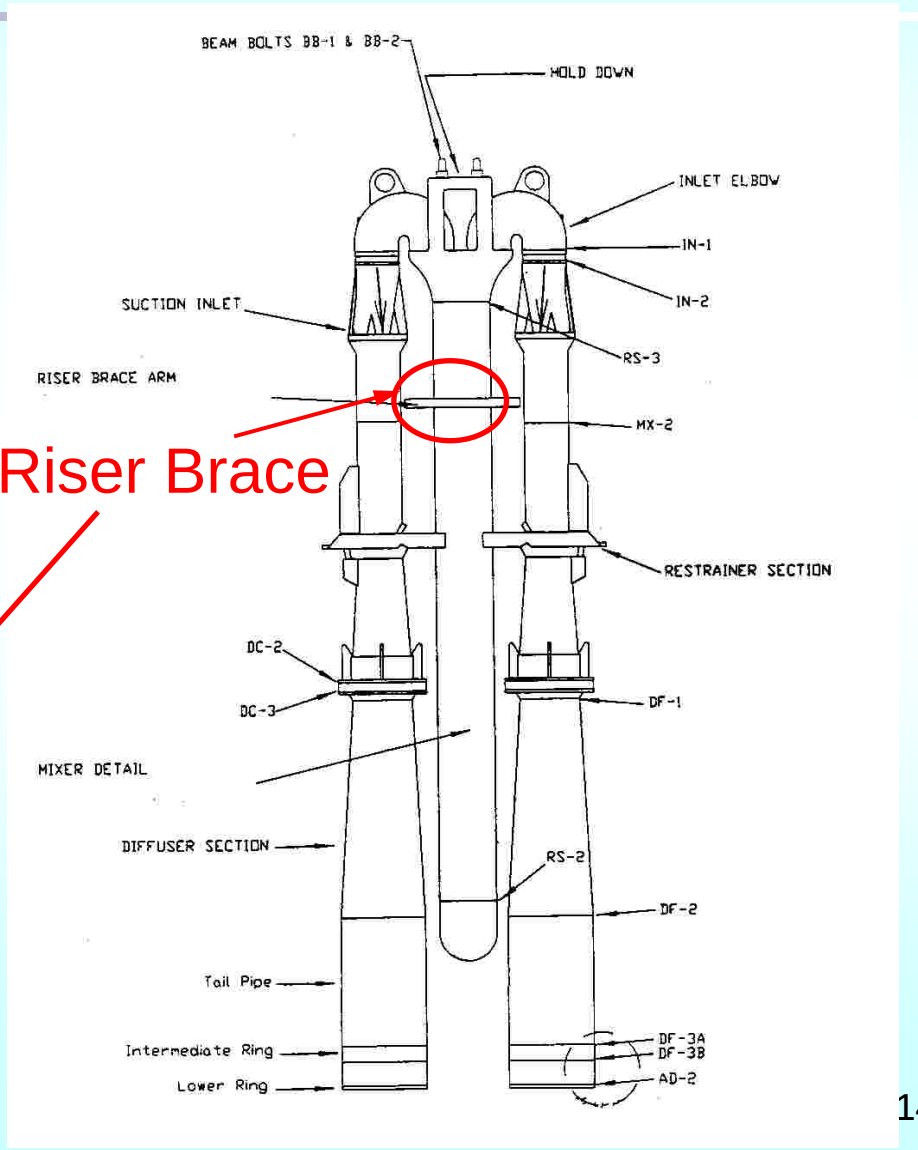
BWR Jet Pump Assembly Integrity

Background

- Jet Pump Assembly inspection is always performed through in-vessel visual inspection (IVVI) with remote VT-1, VT-3 and EVT-1 during refueling outages.
- TPC conducts the inspection program to jet pumps in accordance with Section XI of the ASME B&PV Code, BWRVIP-41, the manufacture's suggestion and the experience of other nuclear power plants.
- During the recent refueling outages at Kuosheng, crack indications were identified at the riser brace and the diffuser.

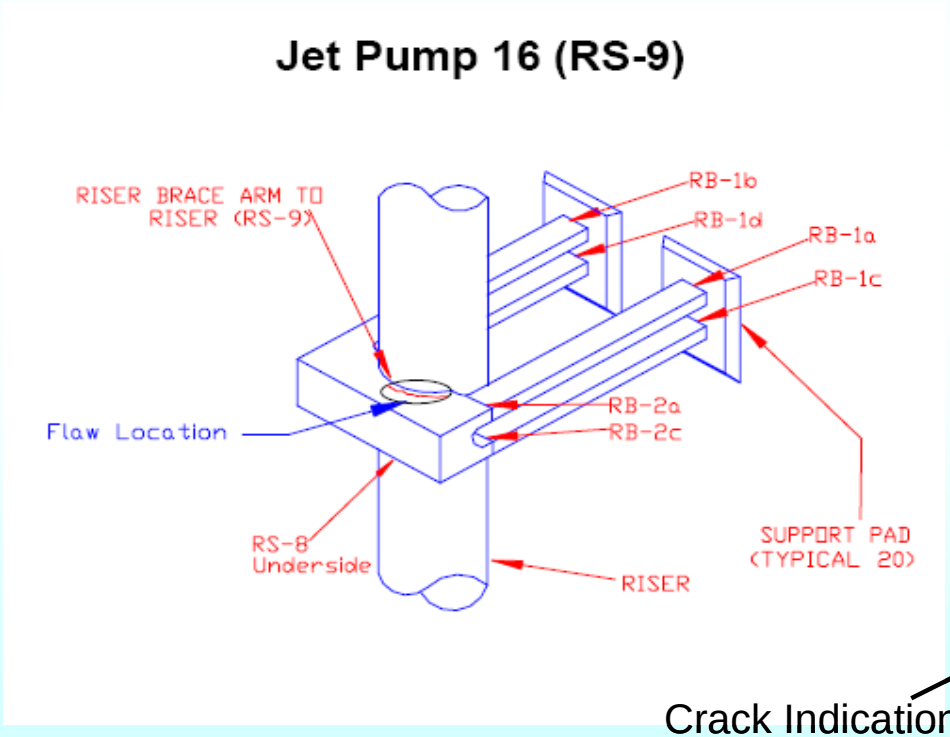
Finding during KS1 EOC-16 outage

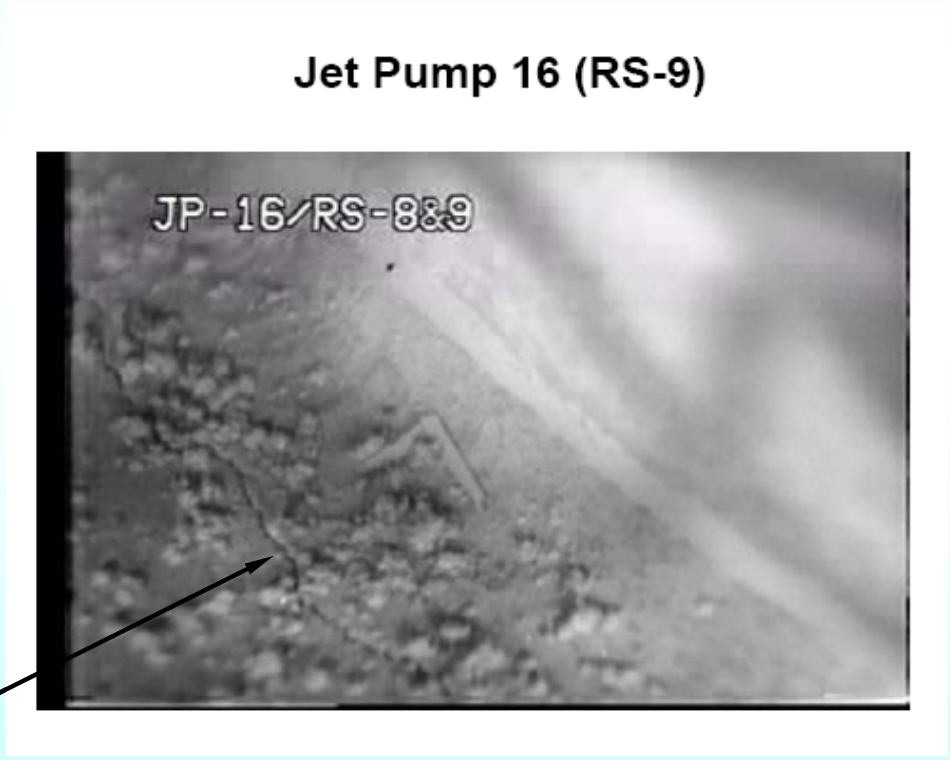
- The RS-9 weld on the riser brace of jet pumps No.15/16 contained a 6.6 inches crack indication (21% around the circumference of this riser pipe)



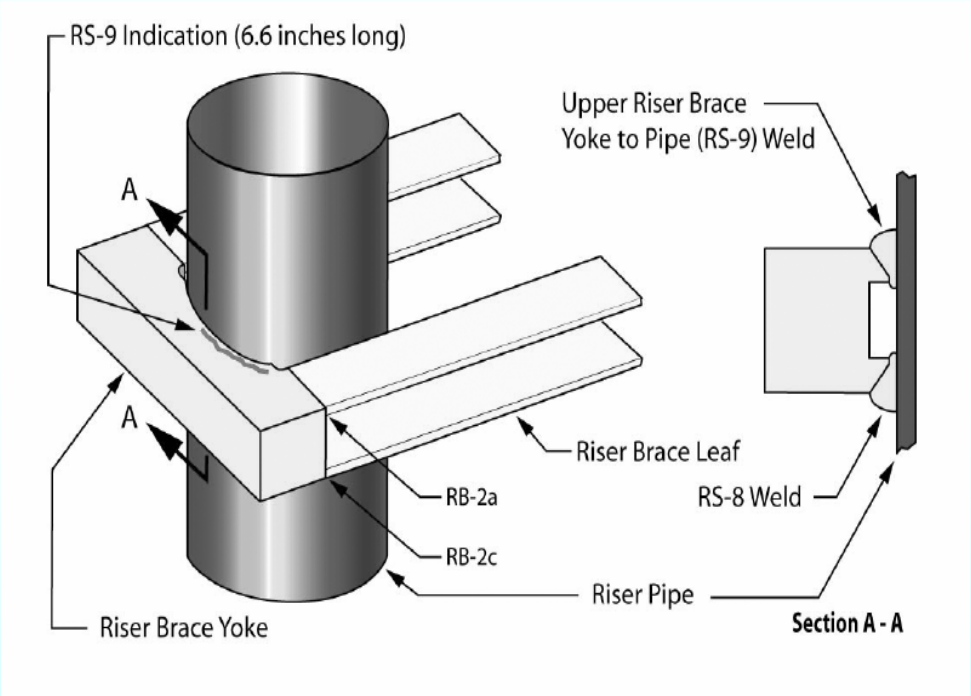
Finding during KS1 EOC-16 outage (cont.)

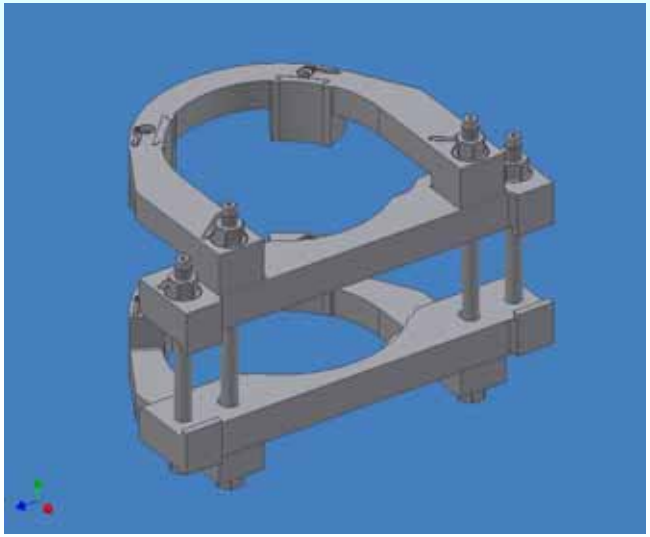
- The crack indication appeared to be caused by IGSCC.

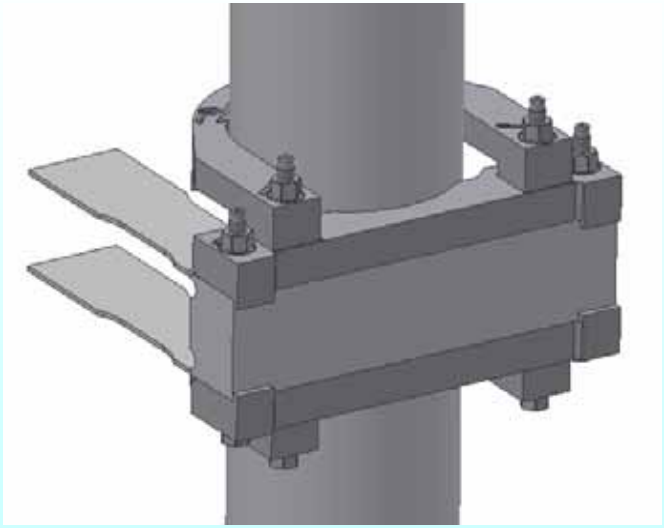




Repair during KS1 EOC-17 outage



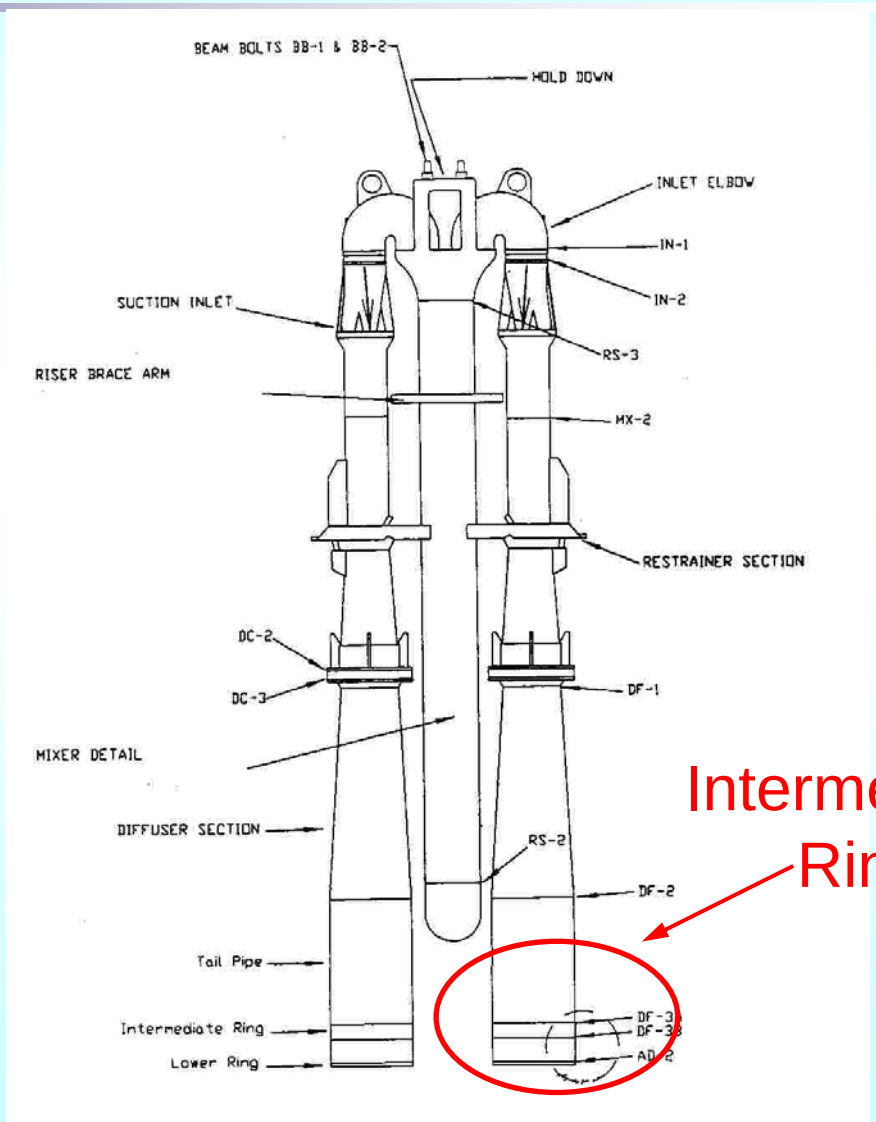




Repair during KS1 EOC-17 outage (cont.)

Finding during KS2 EOC-16 outage

- The diffuser weld DF-3B on jet pump No.12 had a 12.06” crack indication. (26% around the circumference of this diffuser, not a through- wall crack)

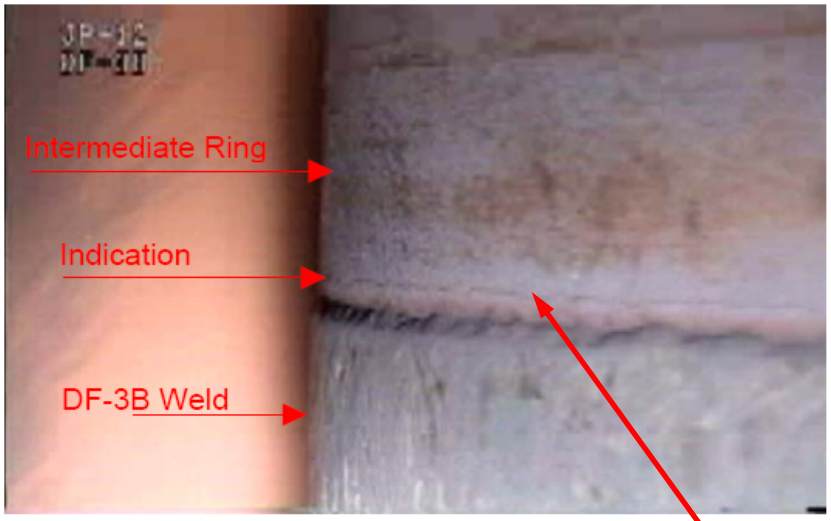


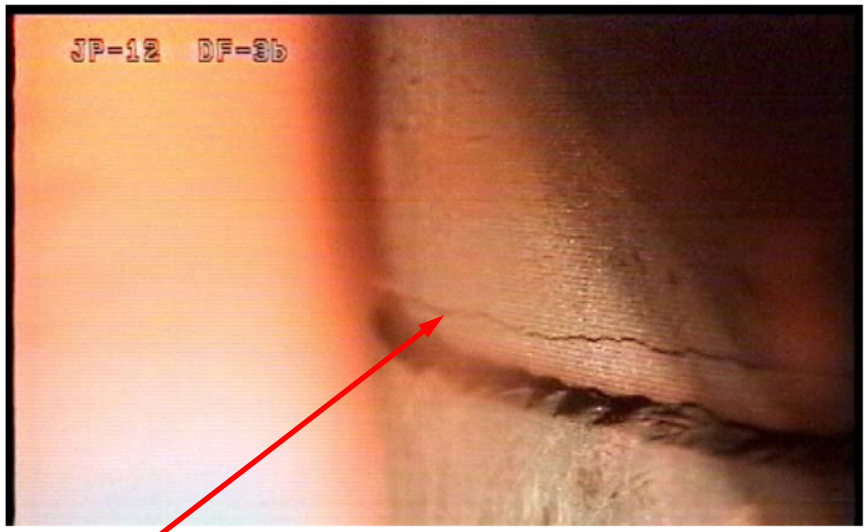
Finding during KS2 EOC-16 outage (cont.)

- The crack indication appeared to be caused by IGSCC.

INR KS2-01-004 Rev 1 (INR-04 Rev 1)

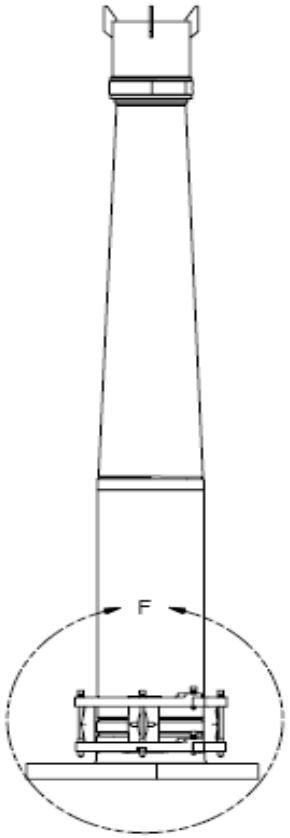
DF-3B

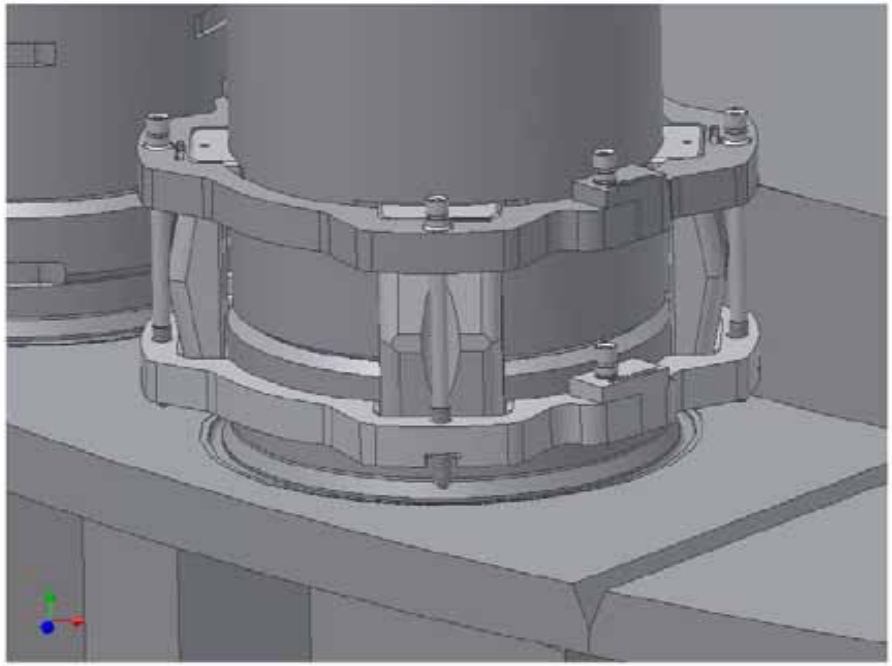


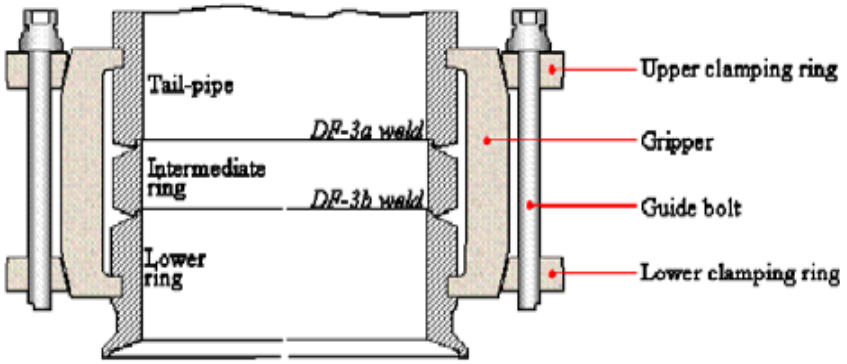


DF-3B Crack

Repair during KS2 EOC-17 outage







Repair during KS2 EOC-17 outage (cont.)

Regulatory Actions

- The cracks at the jet pumps had been repaired by using mechanical clamping systems to replace the cracked welds. AEC has paid great attention on the jet pump assembly inspection at Kuosheng units through on-site inspection. Relevant regulatory activities includes:

1. When the crack indication was reported, TPC was requested to expand the inspection scope to include the similar location of all jet pumps and take the same actions to the other unit during the next refueling outage.
2. In addition to conducting safety analysis, a structural integrity inspection was required after repair and needed to be conducted again in the next refueling outage.

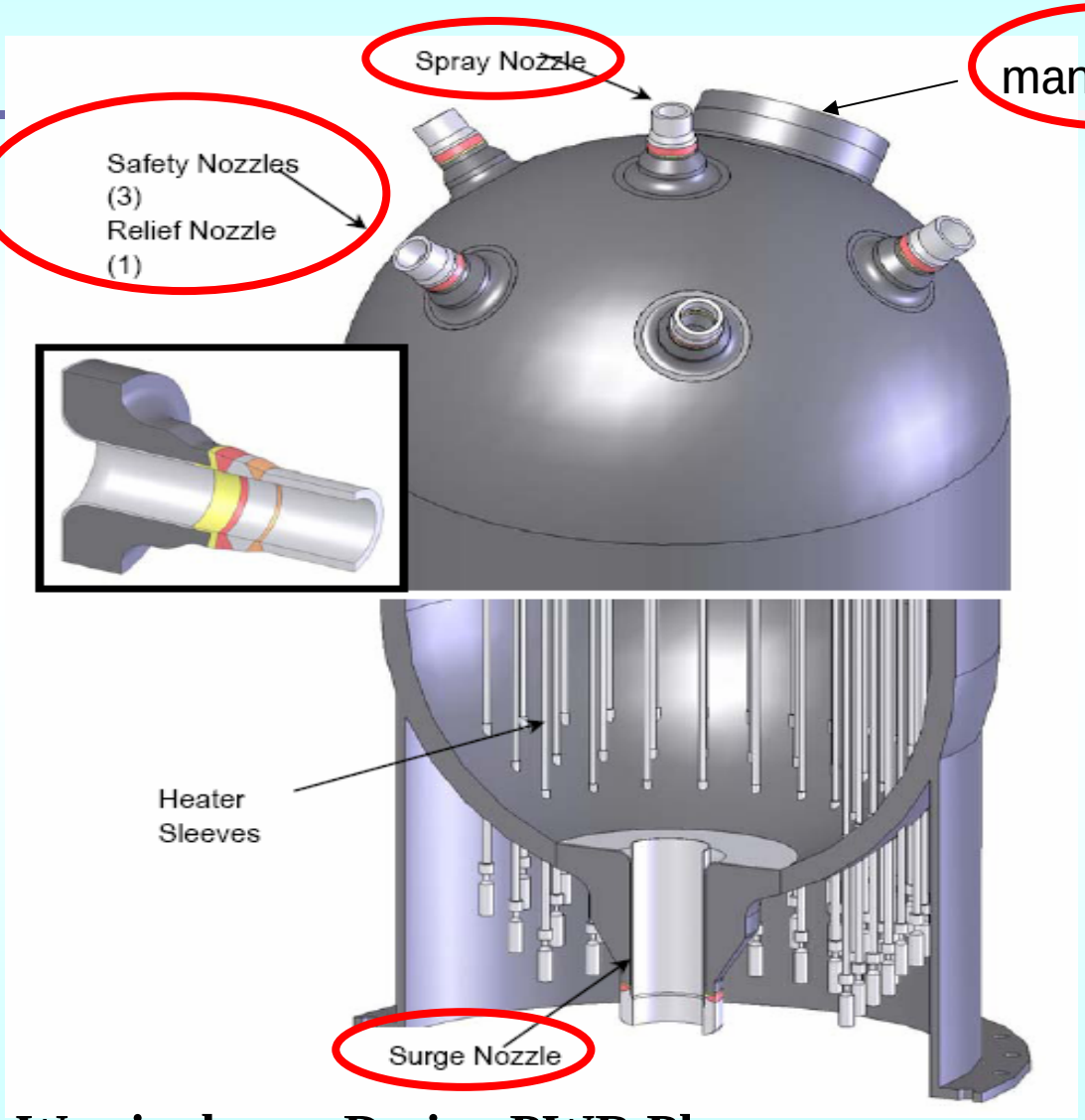
PWR Pressure Boundary Integrity

PWR Pressure Boundary Integrity

- Several instances of PWSCC of Nickel Based Metal degradation have prompted intense inspections of the Reactor Coolant System Pressure Boundaries at Maanshan. Items include:
  - Reactor Vessel Head CRDM Penetration Nozzles
  - Reactor Vessel Bottom Mounted Instrumentation Penetrations
  - Steam Generator Tubes
  - Pressurizer Penetrations and Steam Space Piping Connections
  - Reactor Vessel Nozzle Hot & Cold Leg Welds
  - Steam Generator Nozzle Welds

PWR Pressure Boundary Integrity Overall Inspection Results

- Vessel Head Penetrations /ECT, UT, VT/ - No Flaws
- Vessel BMI Penetrations /VT/ - No Leakage
- Steam Generator Tubes /ECT,UT/ - Plugging Rate <1.8%
- **PZR Penetrations Weld /UT,PT,RT/ - One Acceptable Flaw at unit 2 Spray Nozzle DM Weld**
- Reactor Vessel Hot & Cold Leg Nozzle Welds /UT,PT/ - No Flaws
- Steam Generator Nozzle Welds /UT,PT,VT/ - No Flaws, No Leakage

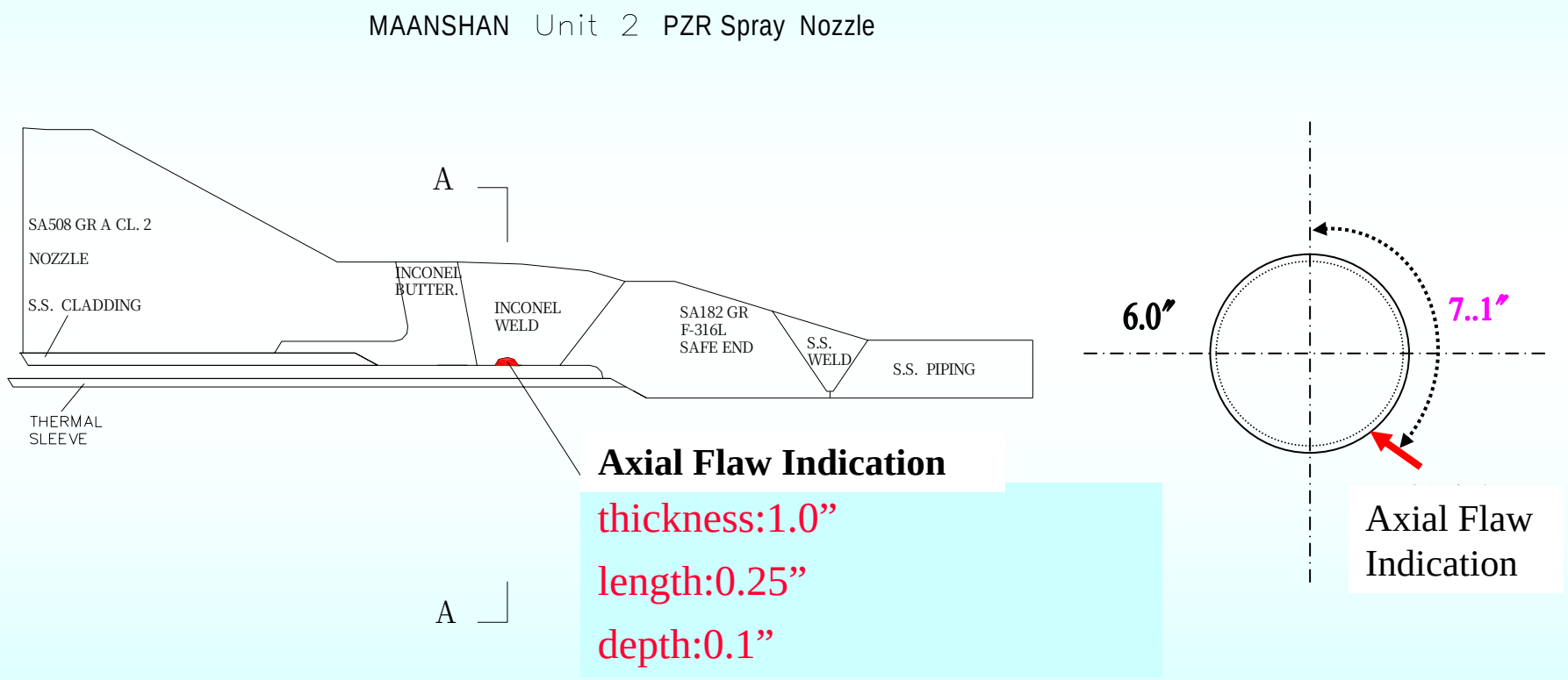


Westinghouse Design PWR Plants

Pressurizer Alloy 82/182 DM Weldment Locations

3/21/2007 after RCS cooldown and PZR solid, water leakage from man-hole is clear.

Pressurizer Spray Nozzle to Safe End Weld



Meet ASME CODE SEC.XI TableIWB-3514-2 “ALLOWABLE PLANAR FLAWS”Criteria

Maanshan Action Plan

- Recent instances (both foreign and domestic) of PWSCC of Nickel Based Metal degradation have forced Maanshan to take the following action plan.
  1. Enhanced RCS leakage monitoring until nozzles inspected or mitigated
  2. Complete Maanshan-1 pressurizer nozzle welds baseline UT inspection during next refueling outage (October 2007) and perform UT inspection at Maanshan-2 Pressurizer Spray Nozzle every refueling outage until mitigated

Maanshan Action Plan (Cont.)

3. After finishing the baseline inspection, pressurizer nozzle welds will be reinspected through UT at least once every 4 years until mitigated.
4. Taipower will be required to perform VT and PT examinations every refueling outage on all of the DM welds until mitigated.
5. Organize a plan to complete baseline UT inspection of RCS hotleg & coldleg DM welds before 2010.
6. Taipower will plan to conduct weld overlay for all of pressurizer DM welds. It could be started from April 2009.

Regulatory Actions

- A regulatory conference was held at AEC headquarters after the PZR manhole leakage and a axial flaw identified at safe end.
- AEC has reviewed the action plan proposed by Maanshan plant.
- AEC will send inspector for on-site review of PZR related inspection results when Maanshan conducts refueling-outage inspections.

Conclusion

- A complete procedures including the inspection program, flaw evaluation, repair and quality control for the recirculation piping have been established in Taiwan.
- If any crack indications reported, structural evaluations should be conducted to justify the safety margin for continued operation or if repair/replacement is needed to maintain the structural integrity.
- Enhanced regulatory activities and requirements on safety review, parallel extension of inspection, on-site inspection, reinforced continue operation requirement, etc. have been taken during the relevant refueling outages and/or the operation period.

Conclusion (cont'd)

- Through the recent experience, Taipower is requested to put in more effort in the following areas:
  - establishing short term and long term aging management
  - reinforcing recirculation piping axial and circumferential crack inspection technique
  - in addition to the current similar metal weld overlay technique, building up self-owned dissimilar metal weld overlay technique.
  - The pressurizer nozzle DM weld overlay at Maanshan will be closely monitored and assessed.
  - tracing the effectiveness of HWC at Chinshan and Kuosheng.

Thank You
for
Your Attention.