Pressurizer Heater Nozzle Replacement at San Onofre

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Discovery

- Planned to test two Alloy 600 heater sleeves
  - Both heater sleeves showed longitudinal indications above the J-weld
  - One heater sleeve showed a circumferential indication above the J-weld
  - No through wall indications and no leakage detected

Decision

- Replace all pressurizer heater sleeves during current U3 RFO
  - Conservative decision
  - Thirty heaters in pressurizer
  - Replace sleeves with Alloy 690
  - Complete replacement precludes a forced outage due to leakage prior to C14 RFO
  - See INPO OE 19405
- Project originally scheduled for C14 RFOs.

Some Alloy 600 Characteristics

- Subject to primary water stress corrosion cracking (PWSCC)
  - Typically a long incubation period (up to 27 years)
- PWSCC depends on:
  - Operating temperature
  - Heat treatment
  - Cold work
  - Chemical environment
- All Alloy 600 heats used in U.S. plants have been tested for PWSCC and failed (EPRI)

Locations Where Alloy 600 PWSCC Has Occurred

- Reactor head nozzles
- Reactor vessel safe ends
- Hot leg nozzles
- Steam generator drains
- Pressurizer heater sleeves
- Pressurizer water and vapor space instrument nozzles

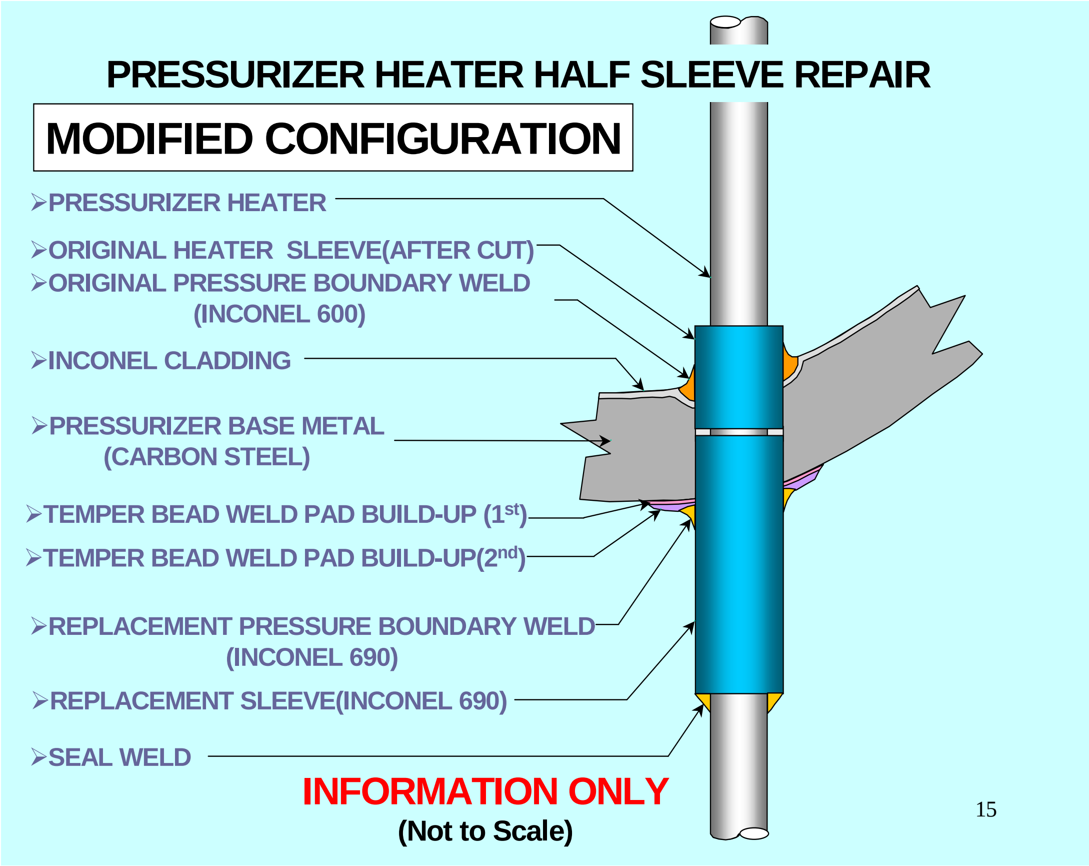
Major Project Evolutions

- Scaffold Erection (17’ to 40’)
- Determ/Reterm Heaters
- Remove/Replace Insulation
- Install Heater and Surge Line Shielding
- Cut Heater Seal Weld
- Remove Heaters
- Cut, Remove ½ of Sleeve

Major Project Evolutions Cont'd

- Install Sacrificial Plugs
- Temper Bead Pad Preparation
- Machine Pads, Remove Plugs
- Install New Inconel 690 ½ Sleeve
- New Pressure Boundary Weld
- Install New Heaters and Seal Weld
- Heater Cut Up and Disposal

Repair Process Diagram



Radiological Protection Challenges

- Any Prior Experience?
  - Palo Verde provided great assistance
- Workers in Close Proximity to Heater Sleeves and Surge Line
  - 100-300 mR/hr contact with sleeves
  - ~60 mR/hr general area
- 100s of mrad/hr smearable on heaters
- Potential for high airborne
- Inexperienced rad workers

Radiological Controls

- Tent the pressurizer skirt
- Maintain work platform at 10-50K dpm
  - Permitted single coveralls, reduced heat stress
- Extensive use of remote monitoring
  - Personnel (dose, voice, video)
  - AMS 4 air sampler
- Bubble hoods for heater removal, full face respirators for external sleeve cuts, face shield/dust mask for other work
- Two 1600 cfm HEPA and one HEPA vacuum for airborne control

Temporary Shielding

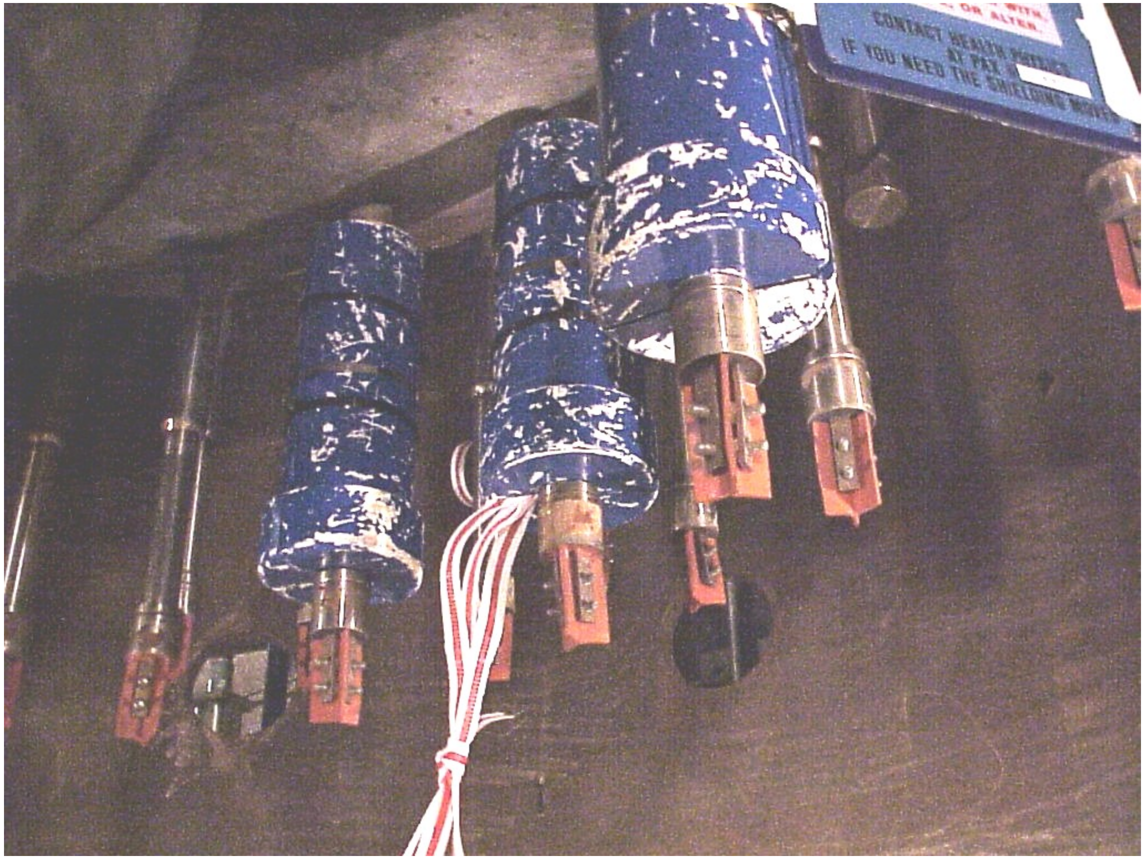
- Clam Shell Shield Over Heater Sleeves Until Heater Removed
- Lead Blankets Placed Around Surge Line
- Lead Blankets On Work Platform To Lower Exposure Rate In Area Used To Change PCs, and Control Work

Pre & Post-Shielding Dose Rates

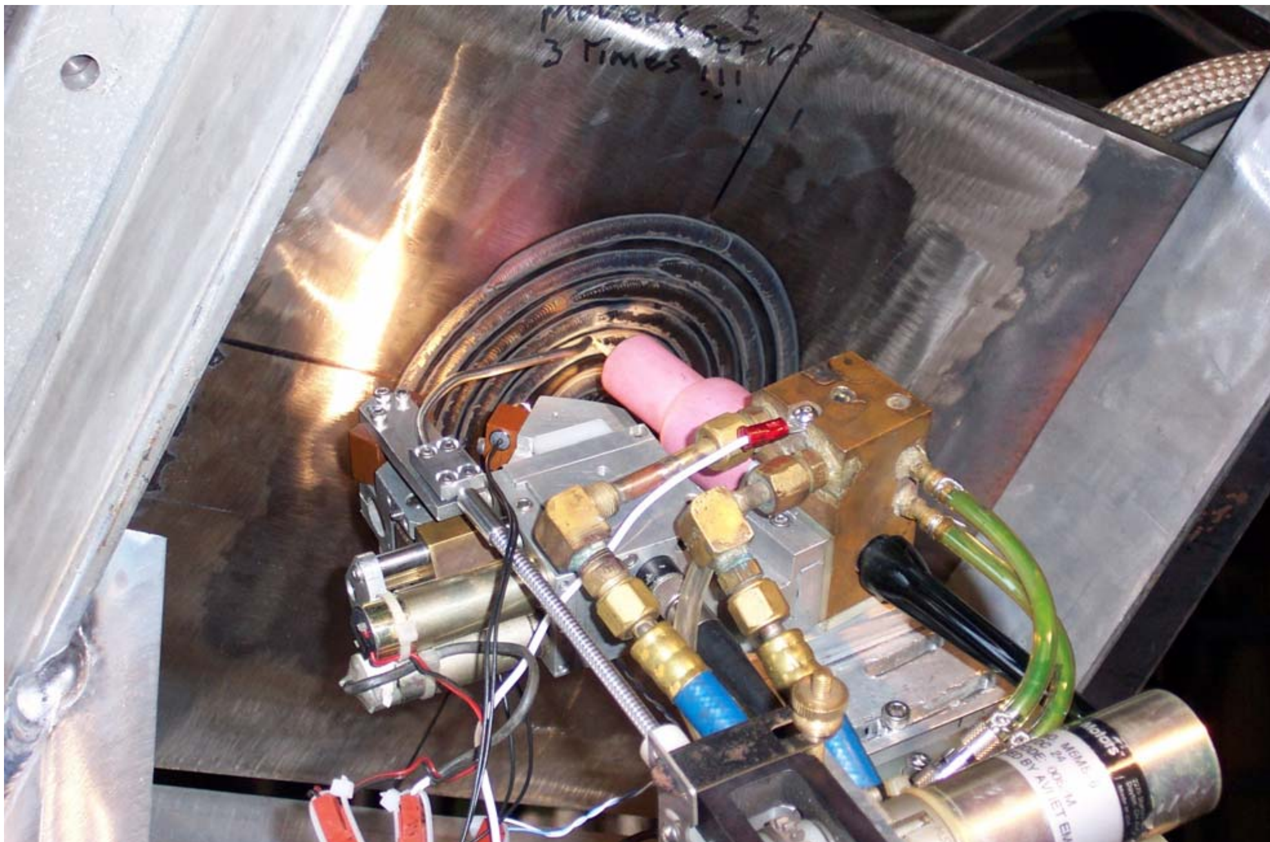
- Sleeve Shields
  - ~300 mR/hr contact, 180 mR/hr at 30 cm to
  - ~120 mR/hr contact, 80 mR/hr at 30 cm
- Surge Line Shielding
  - ~140 mR/hr contact, 60 mR/hr at 30 cm to
  - ~50 mR/hr contact, 50 mR/hr at 30 cm
- Platform Shielding
  - 20-60 mR/hr (knees to head) under pressurizer
  - 5-12 mR/hr inside platform work/change area

Bottom of Pressurizer, Heaters Still Installed

Heater Shielding



Weld Pad Preparation



Radiation Exposure

- Initial Estimate = 81.5 p-rem
- Actual Dose = 64.9
- 47 Dose Extensions > 1 rem
- Highest Individual Dose = 1685 mrem
  - Dosimeter located on head for most work due to overhead radiation source
- RWP hours = 18,700
- Job duration = 53 days

Personnel Contaminations and Intakes

- Contaminations
  - 40 for workers
    - 16 were “planned”
  - 9 for HP coverage
  - 4 for scaffolding work
- Intakes
  - 2 for workers
  - 1 for HP coverage

Lessons Learned

- Poor scaffold platform
- Inexperienced workers yielded poor rad worker practices
- Poorly secured heater dropped after cut
- Vendor weld equipment problems
- Unsuccessful effort to weld pads with pressurizer filled.