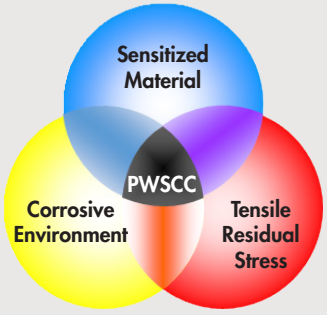
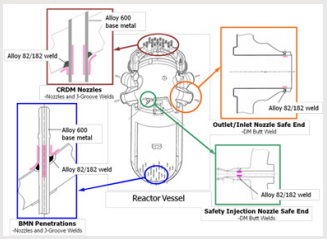
EPRI ELECTRIC POWER RESEARCH INSTITUTE

2016 EPRI TECHNOLOGY TRANSFER AWARD

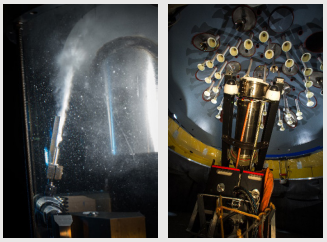
First-of-a-Kind Application of Peening for Primary Water Stress Corrosion Cracking Mitigation



Conditions for PWSCC



Alloy 600/182 PWR components



Ultra-high pressure water jet peening (left), Reactor pressure vessel head (right)

Peened surface

Corrosion by primary water stress corrosion cracking (PWSCC) has been observed in Alloy 600 base and 82/182 weld materials that are used in control rod drive mechanisms, and bottom-mounted instrumentation nozzles and J-welds, and in dissimilar metal butt-welds in the primary coolant loop pressure boundary components of pressurized water reactor (PWR) nuclear power plants. PWSCC is enabled by material susceptibility, environment, and tensile stresses. PWSCC cracking and leakage concerns have necessitated costly inspections, repairs, replacements, and lost power production. Ultra-high pressure water jet peening mitigates PWSCC by forming a compressive residual stress at the wetted surface which prevents future initiation of PWSCC and arrests growth of any existing cracks located in the compressive stress zone. In 2016, in the first application of peening for PWSCC mitigation in the United States and the first for an Alloy 600 head in the global PWR fleet, Exelon applied ultra-high pressure water jet peening at their Byron Unit #2 station.

Benefits

- Safety
  - Proactively reduces the potential for future PWSCC-induced cracks and associated leakage paths.
  - More effectively protects the health and safety of the public by making components safer.
  - Minimizes cumulative dose and exposure by not performing reactive repairs.
- Strategic
  - Extends life and improves reliability of plant components.
  - Reduces need for reactive repairs or replacement, providing significant cost savings.
  - Eliminates outage extensions for reactive repairs.
  - Improves potential for inspection relief.
  - Provides potential for additional dose and outage savings related to reduced future periodic inspections.
  - Delivers additional schedule and cost savings when in-service inspection and surface mitigation scopes are combined.
- Technical
  - Exceeds Materials Reliability Program requirements for compressive stress depths.
  - Tolerates a wide array of surface conditions and geometries
    - Rough vs. smooth surfaces
    - Cold vs. non-cold worked surfaces
    - High vs. low initial residual stresses
    - Rough vs. smooth surfaces
  - Leaves no abrupt edges between peened and non-peened regions.
  - Allows for performance of nondestructive evaluation (NDE) post-mitigation.
  - Mitigates all wetted nozzle surfaces.
  - Avoids damage to component surfaces.
  - Minimizes foreign material exclusion concerns as process only uses water.

Application

- Developed first-of-a-kind application in the world of peening for Alloy 600 reactor closure head penetration PWSCC mitigation.
- 10 CFR 50.59 screening/evaluation for peening to be completed, reviewed, and approved by the U.S. Nuclear Regulatory Commission (NRC).
- Implemented peening as special process in United States per 10 CFR 50 Appendix B Criterion IX.
- Demonstrated NDE technique used at Bryon #2 is still valid after peening.
- Encouraged The American Society of Mechanical Engineers (ASME) Code Case N-729-5 to incorporate peening into ASME Code (now approved).
- Encouraged technical and implementation acceptance by NRC
- Encouraged NRC to complete safety evaluation for peening to reduce/eliminate regulatory uncertainty in future decisions on peening.
- Encouraged U.S. PWR utility acceptance of peening for mitigating PWSCC—three additional plants have peened Alloy 600/182 components including bottom-mounted nozzles and reactor coolant inlet and outlet nozzles.