Background
Stress corrosion cracking (SCC) in reactor internals poses a significant problem for the nuclear industry. SCC occurs when the following three factors combine:

- Susceptible material
- Corrosive environment
- Tensile stress

Eliminating any one of these factors mitigates SCC. Laser peening eliminates the tensile stress component and thus eliminates the potential for SCC. Laser peening is a carefully controlled process that mechanically deforms the surface of the SCC-susceptible material and eliminates the tensile stress.

Description
- A focused, short-pulse (10-nanosecond) laser irradiates the metal surface in water.
- A high-pressure (5-gigapascal) plasma forms on the metal surface.
- The high-pressure plasma impinges the metal surface and its pressure exceeds the yield strength of surface material. As a result, tensile stresses in the surface layer are converted to compressive stresses.
- The compressive stresses go approximately 1 millimeter into the surface of the material.
- The compressive stresses are permanent and require no additional future efforts.
- To achieve SCC mitigation, laser peening is applied to the heat-affected zone (HAZ) at each toe of the weld.

Benefits
The laser-peening process is a permanent solution that mitigates SCC for the life of the plant. It can be used to protect and preserve reactor internals in both pressurized water reactors and boiling water reactors. Internals degradation occurs through two mechanisms:

- Growth of existing cracks, which is predictable
- Initiation of new cracks, which is unpredictable

Eliminating the risk of new cracks allows reliance on standard crack growth rates in order to predict future degradation accurately, and it eliminates the costs and risks associated with emergency repairs due to new cracking.

- No surface preparation is required.
- Laser peening is a fully automated process and has excellent reactor accessibility.
• Unlike other processes, there is no tool-reaction force, making the tooling lightweight and unobtrusive to refueling work.

• Successful laser peening can be easily confirmed by a visual exam.

• Effects have been verified for the following materials:
  - Base metal: Type 304/304L/316/316L, alloy 600/690
  - Weld metal: Stainless steel, alloy 182(132)/82/52

**Experience**

• Laser peening has been used for SCC mitigation in boiling water reactors (BWRs) since 1999. Eight BWRs have had core shrouds, control rod drive stub tubes and in-core monitor housings peened successfully using lasers.

• Laser peening has been used for SCC mitigation in pressurized water reactors (PWRs) since 2004. Two PWRs have had bottom mounted nozzles, reactor vessel nozzles and safety injection nozzles successfully peened using fiber lasers.