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New Mechanical and Thermal Processes for Mitigating Stress–Corrosion and Corrosion-Accelerated Fatigue

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ABSTRACT

This paper describes new mechanical and thermal processes which have been developed and verified to mitigate stress–corrosion cracking and corrosion-assisted fatigue in operating plants. These processes inhibit the initiation of cracks in as-fabricated components and piping systems. They can also prevent the further growth of cracks initiated before application of the process provided that the stresses can be kept below the threshold values for crack propagation. The processes introduce high residual compression, thus reducing the effective operating stresses which propagate existing defects or cracks.

Both the mechanical and thermal processes described herein were conceived from basic theoretical considerations regarding the elastic–plastic behavior of pressure vessels, piping and structural materials. Due to small magnitudes of applied plastic strains, the metallurgical properties of the materials are not essentially altered by either process. Residual tensile stresses, which enhance crack initiation and propagation, are replaced by residual compressive stresses, which inhibit crack initiation and propagation.

The Mechanical Stress Improvement Process (MSIP) has been used extensively to treat weldments in nuclear power plants. The process introduces a slight permanent contraction of the pipe nozzle, elbow or other component next to the circumferential weldments. The resulting plastic flow redistributes the residual as-welded stresses and generates beneficial compressive stresses at the inner pipe surface in the region of the weldment. The area of residual compression includes the weld metal and heat-affected zones, thus encompassing material which may be sensitized to stress–corrosion attack or metallurgical notch effects.