**U.S. DEPARTMENT OF ENERGY**
**NUCLEAR ENERGY RESEARCH INITIATIVE**
**ABSTRACT**

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**Institution:** **SRI International**

**Title:** **Fundamental Understanding of Crack Growth in Structural Components of Generation IV Supercritical Light Water Reactors**

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Increasing the operating temperature of power plants above the critical point of water is being considered as a means of increasing the coefficient of efficiency. The higher temperature together with the relatively unknown corrosive properties of the supercritical water set higher requirements for the materials to be used in the in-vessel structural components. It would be attractive to use well-known structural materials, such as stainless steels and nickel base alloys. However, their material-environment interaction (including impurities) needs to be studied, taking into account new conditions, including $n+\gamma$ irradiation in conjunction with radiolysis and water chemistry at supercritical temperatures.

In the few experimental studies performed on different forms of corrosion under supercritical power plant conditions, corrosion has been shown to become potentially life limiting to the structural materials. Corrosion phenomena that are not yet understood have been found to occur.

The proposed work contributes to the design of safe and economical Generation-IV Super-Critical Light Water Reactors (SC LWR) by providing a basis for selecting structural materials to ensure functionality of in-vessel components during the entire service life and estimating life-time of structural components under a variety of normal and offset operating conditions.

The objectives of the proposed project are to

- Increase understanding of the fundamentals of crack growth in structural components of Generation-IV SC LWR made of stainless steels and nickel base alloys at supercritical temperatures.
- Provide tools for assessing the influence of the operating conditions in power plants with supercritical coolant temperatures on the electrochemistry of different types of corrosion processes taking place in the coolant circuits of supercritical power plants.
- Measure material-specific parameters describing the material's susceptibility to stress corrosion cracking and other forms of environmentally assisted degradation of structural materials at supercritical coolant conditions.
- Use these measurements to interpret the rate-limiting processes in the corrosion phenomena and as input data for lifetime analysis.

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- Use the SRI-developed FRASTA (Fracture surface topography analysis) technique to obtain information on crack nucleation times and crack growth rates via analysis of conjugate fracture surfaces. Identify candidate remedial actions by which the susceptibility to stress corrosion cracking can be decreased.

A unique combination of two advanced techniques for studying material reliability will be used. Controlled Distance Electrochemistry (CDE) will allow us to determine in relatively short experiments a measurable material parameter that describes the transport of ions or ionic defects in the oxide films and that will be correlated with the susceptibility to cracking, using fracture surface topography analysis (FRASTA) to reconstruct the evolution of crack initiation and growth.

In reference to the significant role of electrochemical phenomena within a crack in crack growth under subcritical conditions, a major task will be to apply the effective and economical CDE technique in supercritical water. We will then evaluate the role of electrochemical reactions and properties of oxide films in the crack growth mechanism under supercritical conditions. Successful identification of different anodic and cathodic reactions would also be very valuable from a fundamental and modeling viewpoint. The results of these studies will be combined and correlated with crack nucleation and growth data obtained from FRASTA examination of conjugate fracture surfaces of preloaded (constant stress intensity factor) compact specimens to estimate the residual life of in-vessel components under various operating scenarios.

The team assembled by SRI International is well suited to perform the proposed program successfully. SRI has expertise and equipment readily available for material testing at supercritical temperatures, advanced coating technologies, decades of expertise in material fracture, and a unique SRI-invented technology (FRASTA) for fracture surface analysis by laser topography. Participation of VTT Manufacturing Technology (Finland) will bring years of expertise on the role of oxide films and electrochemical reactions in material-environment interaction in light water reactors along with unique equipment provided via cost sharing.