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Field Demonstration Assesses Early Hydrogen Water Chemistry for Crack Mitigation in Boiling Water Reactors

The demonstration at Exelon's Peach Bottom Station in late 2011 confirmed laboratory results with respect to controlling the electrochemical corrosion potential in the reactor coolant system of boiling water reactors.

An industry-first demonstration of early hydrogen water chemistry in October 2011 accomplished a key milestone in EPRI's research efforts to control electrochemical corrosion potential (ECP) and mitigate stress corrosion cracking. Early hydrogen water chemistry involves hydrogen gas injection into the reactor coolant during startup to lower the ECP to a level where intergranular stress corrosion cracking is mitigated.

Although normal hydrogen water chemistry has proven successful in mitigating cracking of reactor piping and internals, hydrogen injection can't begin until the power is high enough to place the offgas/recombiner system in service. During heatup and low power, however, stress corrosion cracking rates can be more than 10 times higher than during normal operation, and can account for 6% or more of the crack extension for an operating cycle. Therefore, additional crack mitigation would be particularly beneficial during startup.


EHWC Hydrogen Injection Equipment

Building on ECP testing in pressurized water reactors, EPRI performed a number of laboratory tests using hydrazine, carbohydrazide, methanol and hydrogen gas. While all except methanol were successful in the laboratory, hydrogen was the preferred option for boiling water reactors (BWR) based on its effectiveness and industry experience handling hydrogen. During a BWR startup at temperatures between 200ºF and 400ºF, EPRI determined that only a small amount of hydrogen would be required to lower ECP to a point where intergranular stress corrosion cracking is mitigated at wetted surfaces treated with noble metal. Feasibility studies also showed that stress corrosion cracking mitigation could be achieved at startup without exceeding the 4% explosive hydrogen concentration limit set for the mechanical vacuum pump in BWRs.

The demonstration project team installed temporary equipment at Peach Bottom Unit 3 to inject hydrogen gas into the reactor recirculation system through an existing sample line and into the feedwater system through a pressure sensing line during startup. Hydrogen was supplied from compressed gas cylinders in the reactor building and the existing hydrogen water chemistry supply station in the turbine building. The project team also installed temporary equipment to admit air into the mechanical vacuum pump suction stream to dilute injected hydrogen gas and equipment to monitor

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the hydrogen concentration in the pump discharge stream. Electrodes in the mitigation monitoring system provided data on electrochemical corrosion potential.

The project team completed the Peach Bottom Unit 3 demonstration over a few days in October 2011 safely and without impacting plant startup. Acceptance criteria – keeping the reactor water hydrogen-to-oxidant molar ratio greater than 2 and the hydrogen concentration in the vacuum pump less than 4% – were met at low hydrogen injection rates. An average hydrogen injection rate of 1.1 standard cubic feet per minute during steaming with the mechanical vacuum pump in service reduced reactor water sample oxygen from greater than 100 ppb to less than 2 ppb, resulting in ECP levels indicative of corrosion cracking mitigation.

A report documenting the results of the demonstration (EPRI product 1025137) will be published later in 2012. This report will support nuclear plants in evaluating the implementation of early hydrogen addition to enhance corrosion cracking mitigation.

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