June 8, 2007

MEMORANDUM TO: Andrea D. Valentin, Chief
Corrosion and Metallurgy Branch
Division of Fuel, Engineering, and Radiological Research
Office of Nuclear Regulatory Research

FROM: Samantha Crane, Materials Engineer ***/RA/***
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SUBJECT: SUMMARY OF MEETING BETWEEN THE NUCLEAR REGULATORY COMMISSION (NRC) STAFF, INDUSTRY REPRESENTATIVES, AND ELECTRIC POWER RESEARCH INSTITUTE/MATERIALS RELIABILITY PROJECT REPRESENTATIVES ON MITIGATION OF PRIMARY WATER STRESS CORROSION CRACKING

On May 30, 2007, Nuclear Regulatory Commission (NRC) staff met with representatives of the Electric Power Research Institute (EPRI) Materials Reliability Program (MRP), General Electric (GE) Company, the Nuclear Energy Institute, the Pressurized Water Reactor Owners Group (PWROG), and Westinghouse Electric Company in a public meeting at NRC headquarters in Rockville, Maryland. A list of meeting attendees is provided as an enclosure to this memorandum.

Summary:

The purpose of this meeting was to discuss the status of research addressing the possibilities of reducing the susceptibility of primary water stress corrosion cracking (PWSCC) nucleation or growth by mitigation of stress, by materials modification, or by control of, or chemical addition to the reactor coolant. This meeting was held so the NRC technical staff and the public could gain knowledge on the progress of industry programs related to PWSCC mitigation as well as plans for future tests, experiments, and examinations in this area.

John Wilson, representing the PWROG, gave an overview of industry activities on mitigation of PWSCC in nickel-based reactor coolant system (RCS) components. The industry approach to mitigation includes the following: (a) chemical methods to alter the chemical environment in the reactor coolant system, (b) mechanical methods to alter the stress state or rejuvenate the damaged surface layer of base or weld metals, and (c) replacement or isolation of susceptible materials.

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(a) Chemical Methods:

Peter Andresen of GE Global Research discussed the optimization of dissolved hydrogen in primary water to mitigate PWSCC in nickel-based RCS components. The addition of dissolved hydrogen to the RCS is one chemical method being explored for PWSCC mitigation. The extra dosing of PWR coolant with dissolved hydrogen lowers the electrochemical potential at the exposed nickel-base alloy surfaces, which has been shown to reduce the crack growth rate. Dr. Andresen presented the technical basis for increasing the hydrogen fugacity, or concentration, in the RCS to reduce the PWSCC crack growth rate. Currently, the Japan Atomic Power Company is developing a multi-year plan to investigate reactor operation with reduced hydrogen fugacity. Dr. Andresen discussed the issues and difficulties associated with trying to reduce the hydrogen fugacity to obtain the same type of PWSCC crack growth rate decrease.

Peter Andresen also presented the effect of primary water zinc injection in nickel-based RCS components. The addition of soluble zinc compounds (usually zinc acetate) alters the constitution of the tightly adherent spinel films; however, the benefit of zinc in the nickel oxide (NiO) structure that is present at the crack tip is uncertain. While zinc addition has been shown to be beneficial in the thin walled steam generator tubes, this does not necessarily transfer to thick walled RCS components and Alloy 82/182 welds. Preliminary research indicates that zinc can reduce the growth rate in shallow cracks with low stress intensity in thick Alloy 600 components; however, testing to date has not shown a reduction in crack growth rate in high stress areas since the zinc can not diffuse into the crack tip as quickly as the crack is growing. The PWROG is in the process of conducting further testing in this area. They will also be conducting testing on Alloy 182, as well as exploring the synergistic effects of zinc additions and elevated hydrogen fugacity.

Richard Jacko of Westinghouse gave an update on the PWROG Farley zinc program. The PWROG, supported by Westinghouse engineers, is conducting experiments to assess whether additions of zinc to the primary coolant at the Farley Unit 2 system successfully suppressed nucleation of PWSCC in their vessel head penetrations, most of which have been fabricated from a heat of Alloy 600 that has cracked in four other domestic plants. Laboratory and test reactor experiments have shown reduced general corrosion and PWSCC mitigation benefits from the addition of zinc, which has incorporated deep into the oxide films and deposits. The PWROG is conducting a five year program with five distinct phases. Dr. Jacko outlined each task and the major deliverables.

(b) Mechanical Methods:

Al Ahluwalia of EPRI discussed surface remediation for mitigation of PWSCC in nickel-based materials. He focused on the four main remediation technologies under review by EPRI/MRP: the supersonically induced mechanical alloying technology (SIMAT) process by Westinghouse, the ReNew™ process from GE, surface treatment from AREVA, and the stabilized chromium process (SCrP) developed by EPRI.

The SIMAT process uses a supersonic flow of metal powder, which kinetically welds to the surface upon high velocity impact. This process creates a coating over pre-existing cracks and has been shown to mitigate cracking when applied manually. SIMAT is in the process of being converted from a manual to an automated process.

The ReNew™ process uses highly flexible, abrasive filled, motorized bristle brushes similar to those used for cleaning and deburring metals. The method is tailored for application underwater. The process changes surface tension to high compression (cracks do not grow into regions of compressive stress), removes existing environmentally degraded layers and small defects, and reduces surface strain-intensity by creating a smooth surface finish. Laboratory testing showed a significant factor of improvement for this process.

AREVA is currently performing research on surface oxidation for its surface treatment process. The objective of the research is to understand which in-field parameters lead to long incubation times for crack initiation, and to investigate the possibility of mitigating PWSCC through the removal of a thin surface layer of aged material prior to crack initiation. AREVA found that PWSCC initiation times in Alloy 182 are linked to surface residual stresses induced by surface grinding and plastic straining, and that the critical surface parameter is cold work. AREVA has also found that electro-polishing prior to PWSCC testing of previously exposed Alloy 600 delayed initiation times.

EPRI's SCrP involves the following process: surface cleaning and electropolishing, deposition of a thin layer of chromium by electroplating, and subsequent pre-oxidation in steam. The chromium layer is added due to the key role that chromium content plays in PWSCC. EPRI found that treatment with SCrP delayed crack initiation.

Peter Ricardella of Structural Integrity Associates summarized the pre-emptive weld overlay project, MRP-169. He discussed the differences between full structural and optimized weld overlays, both of which improve the residual stress condition, and the design considerations and inspectability concerns of each type of overlay. The main issues that they are exploring are inconsistencies in post overlay in-service inspection (ISI) schedules, the use of optimized overlays for repair and mitigation, additional qualification for exams of inner diameter surfaces, leak before break re-analysis requirements, and the fatigue crack growth evaluation period.

Jack Spanner of EPRI continued the discussion of preemptive weld overlays by giving a status report on non-destructive evaluation (NDE) considerations. The project aims to close inspection gaps through the use of additional mock-ups that include unique configurations such as tapers and thickness and diameter changes, cast components, and overlays. In addition it will address the need for data to support both full structural overlays and optimized overlays of thick components.

(c) Replacement or Isolation of Susceptible Materials:

Ron Payne of AREVA discussed the weld inlay program. He discussed the history of reactor vessel primary nozzle inlays, gave an overview of the process, the change in inspection implementation schedule (based on MRP-139) by removing/isolating susceptible material, inspection and design considerations, and the qualification of the inlay program.

Dana Couch of the Tennessee Valley Authority discussed the qualification of surface stress improvement technologies. He discussed both cavitation peening and fiber laser peening, and the factors that led the MRP to focus on fiber laser peening.

The NRC staff asked detailed questions during the presentations. Generally, the staff questions were intended to elicit more technical details, the mechanistic bases for the chemical mitigation methods, or information about project completion dates. The staff encouraged the industry participants to continue their efforts, and to keep the NRC staff informed of progress, observations and conclusions. The public was provided several opportunities to ask questions.

The meeting was adjourned at 4:30 pm.

Enclosures:
1. List of Attendees
2. Agenda

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DATE	06/08/07		06/08/07	

PWSCC Mitigation Meeting
May 30, 2007
8:30am - 4:30pm

Name	Affiliation
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I Anchondo	NRC
G Cheruvenki	NRC
Y Chung	NRC
J Collins	NRC
S Crane	NRC
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F Gonzalez	NRC
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A Valentin	NRC
R Payne	AREVA
D Waskey	AREVA
J Poehler	Constellation
M Arey	Duke Energy
A Ahluwalia	EPRI
P Crooker	EPRI
J Spanner	EPRI
J Wilson	Exelon
P Andresen	General Electric
M Melton	NEI
D Johnson	NEI
D Horner	Platts
M Dove	Southern Nuclear Company
B Auvil	Structural Integrity Associates
P Riccardella	Structural Integrity Associates
D Couch	TVA
R Jacko	Westinghouse
A Vaia	Westinghouse