July 21, 2010

MEMORANDUM TO: Mirela Gavrilas, Chief
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FROM: Darrell S. Dunn, Materials Engineer ***/RA/***
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SUBJECT: SUMMARY OF PUBLIC MEETING BETWEEN THE NUCLEAR REGULATORY COMMISSION STAFF AND REPRESENTATIVES OF THE NUCLEAR POWER INDUSTRY REGARDING INDUSTRY SPONSORED PRIMARY WATER STRESS CORROSION CRACKING MITIGATION AND ALLOY 690 RESEARCH ACTIVITIES

On July 13-15, 2010, Nuclear Regulatory Commission (NRC) staff met with representatives of the Electric Power Research Institute (EPRI), General Electric (GE) Company, Westinghouse Electric Company, AREVA, Dominion Engineering Inc. (DEI), Structural Integrity Associates (SIA), GE-Hitachi, Thyssen Krupp VDM, Bechtel Marine Power Corporation-Knolls Atomic Power Laboratory (BMPC-KAPL), Consejo de Seguridad Nuclear (CSN) and other industry and utility representatives in a public meeting in Rockville, Maryland. The purpose of this meeting between the staff and industry representatives was to present and discuss the technical bases for various proposed primary water stress corrosion cracking (PWSCC) mitigation and Alloy 690 research activities.

PWSCC Mitigation Summary

NRC held a public meeting inviting industry representatives to present information on current and future PWSCC mitigation techniques for Alloy 600/182/82 materials exposed to primary coolant. Furthermore, staff from the Office of Nuclear Regulatory Research (RES) presented an overview of their overarching confirmatory research program. In addition, an overview of the Welding Residual Stress Validation and an update on the Extremely Low Probability of Rupture Program and computer code were discussed. Staff from the Office of Nuclear Reactor Regulation (NRR) also presented perspectives on PWSCC mitigation.

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During the meeting, the industry provided an update on both the current and proposed mitigation techniques with key points summarized below:

- Industry representatives presented an update to the ongoing MRP-169 (optimized weld overlay) effort. Currently, the staff is finalizing the SER for this document. In addition, industry representative presented the details of the application of the first optimized weld overlays at the Davis Besse plant. The application of this overlay occurred as planned with few problems.

- Industry representatives presented a new PWSCC mitigation technique called Excavation and Weld Repair (EWR). This process is planned to be used in locations where other techniques cannot be used due to interference or lack of allowable surface area. This process is still in the design stage and is considered a work in progress.

- Industry representatives discussed the abrasive water jet procedure and how it used in the repair process of upper head penetration repairs. It was presented that this technique imparts a compressive residual stress on the surface, and could also be used to remove small surface breaking defects.

- Industry representatives presented ongoing research and development activities for several surface modification mitigation techniques. Currently, the processes being considered are fiber laser peening and water jet peening. An MRP document has been generated (MRP-267) that discusses the technical basis for these processes.

- Industry representatives presented information on the weldability issues with Alloy 52. Discussions on hot cracking and ductility dip cracking were conducted focusing on the chemical composition of these welds that may make them susceptible to cracking. In addition, a series of experiments and results were discussed that illustrated that higher concentrations of sulfur and silicon in the weld due to dilution can cause cracking. Weld controlled weld procedures and weld design are needed to ensure that the probability of weld cracking is limited.

- Industry representatives described their ongoing activities to develop an overall chemical mitigation plan through environmental modification of PWR primary coolant water. This program currently promotes a change in the primary coolant hydrogen concentration levels along with zinc additions. The industry has written a report that discusses the technical basis (MRP-263) for the effects of these additions. In short, the addition of higher levels of hydrogen decreases the PWSCC growth rate while elevated zinc levels decrease the PWSCC initiation susceptibility. Results from ongoing laboratory testing of zinc may help refine the improvement factors on PWSCC initiation.

The NRC staff presented an update and initial results from the pilot study using the Extremely Low Probability of Rupture (xLPR) computer code. This presentation focused on the initial test version of the code and presented the plan to finalize Version 1.0 of the code. The discussion focused on how the results can be used and touched on how mitigations, such as the ones presented in this meeting, would be incorporated.

Alloy 690 Research Summary

RES staff provided an overview of the NRC confirmatory research program. The regulatory prospective was presented by NRR staff. Several outstanding issues for Alloys 690/152/52 were identified such as factors that influence crack growth rates, welding defects, dilution effects, and PWSCC mitigation using the high chromium filler metals.

EPRI and industry staff reviewed the history and motivation for conducting PWSCC research, objectives of the NRC and industry efforts, organization and focus of working groups, and expectations of the meeting. Both EPRI and NRC RES staff provided an update to the current status of efforts to address the previously identified knowledge gaps for the high chromium nickel alloys. High priority items included the PWSCC crack growth rates in weld heat affected zones (HAZ), the influence of weld defects on PWSCC initiation and growth, the effects of weld metal composition and weld procedures, and the effects of welding and fabrication repairs. The medium-high priority items included the effects of thermo-mechanical processing on Alloy 690, resolution of the large differences in reported crack growth rates for the weld metals, and the relevance of thermal processing mode. Medium priority items included low temperature crack propagation, and the development of crack growth rate curves for Alloys 690/152/52. Low to medium priority items included acquiring detailed information on PWR replacement components and crack initiation data on heterogeneously deformed Alloy 690.

EPRI staff provided an update to the industry materials degradation and issue management initiatives. The materials degradation matrix prioritizes materials issues, identifies potential degradation mechanisms, and documents information obtained from experts, research and operating experience. The issues management tables address the significance of material degradation, defines where materials are used, and identifies programs for assessment, inspection, mitigation and repair and/or replacement. EPRI staff also provided an update to the PWSCC initiation testing that is scheduled to start in 2010 and is scheduled to be completed in 2014. Initiation testing will be conducted in supercritical water using interrupted constant extension rate tests and wedge loaded ring samples. Alloy 600, 690, 52 and 152 to be tested were discussed and will include materials with well characterized crack growth rates.

The recommended testing matrix for Alloy 690 was presented and the progress towards conducting the testing was discussed. EPRI staff presented an update to the acquisition and characterization of recommended test materials. Following these presentations, additional coordination between testing laboratories was discussed to maintain focus and provide timely updates on test results.

Representatives from EPRI, Tyssen Krupp VDM, and BMPC-KAPL each provided updates to weld metal development and assessing the effects of weld metal chemistry on the type and magnitude of weld defects. Calculated solidification temperature ranges, differential thermal analysis, microstructural analysis and multiple tests to determine weldability including cast pin tear tests, and varistraint tests were used to assess the effects of alloy composition on the susceptibility to welding defects were discussed. Results for two newly developed weld metal compositions, Alloys 52MSS and 52i, indicate that these alloys have improved weldability with compositions that should be resistant to PWSCC; however, the new filler metals are still susceptible to either hot cracking or ductility dip cracking.

Results from EPRI sponsored research included crack growth rate data cold rolled and forged Alloy 690 base metals, HAZ material, and weld metals. Crack growth rates below 1 x 10^{-8} mm/s were considered to be of low significance for thick section pressure boundary components; however, faster crack growth rates were obtained for some cold rolled plate and billet materials. Forged materials tested had lower crack growth rates but additional tests are necessary to compare the same heats in the cold rolled and forged conditions. Results of tests with HAZ material indicates lower PWSCC susceptibility compared to cold rolled Alloy 690. Measured crack growth rates below 1 x 10^{-8} mm/s were obtained in tests with weld metals.

NRC sponsored research conducted at Pacific Northwest National Laboratory (PNNL) shows that cold rolling increases crack growth rates in Alloy 690 heats that are resistant to PWSCC in the as-received condition. Thermal treatment that removes carbides from grain boundaries decreases crack growth rates in cold rolled Alloy 690. Crack growth rates for weld metals were generally in the range of 3 x 10^{-9} mm/s. Recent test results from Argonne National Laboratory (ANL) show that previously reported constant load crack growth rates greater than 1 x 10^{-8} mm/s obtained with an Alloy 152 weld metal heat are repeatable. Tests with Alloy 52M overlay on an Alloy 182 weld showed decreasing crack growth rates as the crack advanced toward the Alloy 182/52M interface. Measurements will be conducted to determine if changes in the residual stress profile alter the crack growth rates. A new weld using the Alloy 152 heat that was shown to be susceptible to PWSCC was also recently completed.

Staff from INL provided information on the testing and sample handling capabilities including the Advanced Test Reactor (ATR) and the Center for Advanced energy Studies (CAES). INL currently has SCC testing capabilities for PWR and boiling water reactor (BWR) environments. Additional facilities are planned for testing of irradiated materials.

Staff from AREVA provided an update to the data application working group activities. This included a listing of the likely used of Alloys 690/152/52 in new reactors and specimen configurations to represent component designs and materials. Staff from EPRI provided an update to the baseline characterization of materials acquired for testing. A database that includes descriptions and microstructural characterization will be supplied to all testing participants.

There were 5 action items recorded:

1. EPRI, NRC and testing laboratories will provide input on a standard simplified format of test parameters and results to document and monitor progress on test matrix for Alloy 690, HAZ, and welds.

2. EPRI staff will complete and distribute a spreadsheet and characterization data on materials available for testing.

3. Results of testing with Alloy 690 plates in the 20% cold rolled and 20% forged condition will be used to determine need for additional processing and subsequent tests.

4. Materials for PWSCC initiation tests will be reviewed and the final test matrix will include alloy heats with previously measured crack growth rates.

5. NRC and ANL staff will provide an update on availability of the recently completed Alloy 152 weld.

Enclosures:
List of Attendees
Presentations (34)

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