CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: 11th International Conference on Environmental Degradation of Materials in Nuclear Power Systems—Nuclear Reactors
Project Number 20.06002.01.081; AI 06002.01.081.316

DATE/PLACE: August 10–14, 2003, Stevenson, Washington

AUTHOR: Gustavo A. Cragnolino

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PERSONS PRESENT: The conference was attended by approximately 200 people. Joseph Muscara, William Cullen, Charles Green and Louise Lund [Nuclear Regulatory Commission (NRC)] were also present.

BACKGROUND AND PURPOSE OF TRIP:

The author was invited by the Organizing Committee of the Conference to co-chair the session on Nuclear Waste Materials. The opportunity to attend the conference was used to become more acquainted with new research and technical developments in the field of degradation of reactor materials related to environmental effects including the interaction of corrosion, mechanical, thermal, and radiation processes.

SUMMARY OF PERTINENT POINTS:

The conference was well attended during all the sessions the author participated. Unfortunately, due to a shoulder injury, the author returned to San Antonio earlier and only attended the sessions held on August 11 and 12, 2003. An additional motivation to attend the conference was the inclusion in the preliminary program of several papers dealing with the degradation of the reactor pressure vessel head at Davis-Besse. However, all these papers were withdrawn prior ro the conference and will not be included in the Proceedings to be published as a CD

The session on Nuclear Waste Materials was relatively well attended. Unfortunately, from the 7 papers included in the preliminary program, three papers were withdrawn, including two on the Yucca Mountain project. These papers were withdrawn because Professor Denny Jones (University of Nevada at Reno), who was one of the authors, passed away and his coauthors decided to cancel their presentation just before the Conference. Nevertheless, these two papers will be included in the Proceedings because the peer-review process was completed.

The session on Nuclear Waste Materials was initiated with a paper by R. Jones [Pacific Northwest National Laboratory (PNNL)], who was one of the members of the DOE Waste Package Peer Review Panel. Jones presented an overview of the corrosion related issues for the proposed high-level waste container, summarizing many of the analyses and observations contained in the Panel report. One of the main points emphasized in his presentation was related to the issue of heat treatment for the mitigation of residual stresses. A careful evaluation of quenching or cooling rates following post weld treatments was recommended. Another subject of importance was the need to evaluate in more detail the possible depletion of

chromium and molybdenum as a result of thermal operations accompanied by microchemical changes indicating that such changes may lead to the initiation of intergranular corrosion or intergranular stress corrosion cracking. Significant emphasis was placed on several fabrication issues and also on the influence on performance of compositional variations. More detailed information will be found in the proceedings, but the panel report is already the best source of information. No new information was discussed by Jones beyond that presented by Lawrence Livermore National Laboratory investigators at the 2003 NACE Conference.

B. Rosborg (Rosborg Consulting, Sweden) discussed the influence of surface defects introduced by drilling on the pitting resistance of copper containers on the basis of the electrochemical noise measurements. The laboratory experiments were conducted in a synthetic bentonite equilibrated groundwater with the purpose of comparing results with those obtained in Aspo Hard Rock Laboratory. However, the validity of the electrochemical noise measurements was questioned and in particular the definition of a localization factor. The localization factor was defined as the quotient between the electrochemical noise current and the product of the surface area of the specimen multiplied by the average corrosion current, estimated through electrochemical impedance methods.

G. Gordon (Framatone ANP) presented a paper on constant load testing of waste package materials for the proposed Yucca Mountain repository. The tests were conducted using an apparatus which allows the simultaneous testing of up to 150 smooth, round tensile specimens in a single environment consisting of a hot, mixed salt solution containing the anionic species present in groundwaters in the vicinity of Yucca Mountain. The paper was essentially an extension of a previous one presented at the 2003 NACE conference. Although the testing time was extended from 9,000 to 14,000 hours, no failure of Alloy 22 specimens was reported, even though the specimens were stressed to very high levels, heat treated in the range of topologically close-packed phases precipitation, or cold worked. It is not clear if stainless steels parts in contact with the specimens may act to protect the Alloy 22 specimens a result of galvanic coupling when the stainless steel parts were corroded. The tests also confirmed the higher susceptibility to stress corrosion cracking of Ti grade 7.

The final paper in the session was presented by P. Andresen (GE Global Research). This paper was essentially the same paper that was presented at the 2003 NACE Conference. It should be noted that in test conducted with the addition of lead to the environment no effect was observed on crack growth rate. Following this final paper of the session, a discussion took place covering several aspects of engineering design and testing.

In the session on primary side of pressurized water reactor steam generator, P. Scott (Framatone ANP) presented a paper on mechanisms of stress corrosion cracking of Alloy 600. After discussing several mechanisms postulated by various authors, Scott noted that in studies using extremely sensitive transmission electron microscopy conducted at PNNL by Bruemmer and Thomas on steam generator tubing exposed to primary water for many years intergranular cracks exhibited a porous oxide filling the cracks. The oxide was predominantly a Cr (III)-rich oxide at the tip of the crack and the interesting observation was the occurrence of small voids in the metal ahead of the crack tip. These voids may have been formed by coalescence of vacancies which cannot diffuse away at the operating temperature of 320 °C [608 °F]. The observation of voids close to the metal/oxide interface could be relevant to the modeling of long-term passivity based in the point defect model.

J.H. Kim (Seoul National University, Korea) presented a paper on the use of *in-situ* Raman spectroscopy to study the oxide film formed on Alloy 600 exposed to high temperature simulated primary water (boric acid plus lithium hydroxide with an overpressure of hydrogen). Both Ni-Cr spinels and Cr(III) oxi-hydroxide were detected on the metal surface..

In the sessions on secondary side pressurized water reactors, after a review paper presented by J. Gorman (Dominion Engineering) on corrosion and stress corrosion cracking of Alloys 600 and 690, R. Staehle (University of Minnesota) reviewed the occurrence and mechanism of lead-assisted stress corrosion cracking in which he questioned the commonly accepted view that the crack morphology is predominantly transgranular. Staehle also holds the view that lead-stress corrosion cracking is not so extended despite the relative abundance of lead in secondary water because many species either complex or precipitate lead ions. Among the species that can precipitate lead ions, Staehle mentioned phosphates, sulfates, aluminates, silicates, etc, and cautioned that improved water treatment that remove these anionic species may increase the risk of stress corrosion cracking as a result of lead ions becoming available at higher concentrations.

Y.C. Lu (AECL, Canada) presented a paper on the relative corrosion susceptibility of Alloys 600 and 690 to localized corrosion under simulated steam generator conditions in the presence of lead. Lu presented plots of potentiodynamic polarization curves in which anodic peaks were attributed to enhanced current density, and hence corrosion, due to the effect of lead in solution. Following questions, he insisted that anodic peaks observed on platinum electrodes can be clearly distinguished from those observed on the nickel base alloys .

IMPRESSION/CONCLUSIONS:

Overall, attendance at this meeting was beneficial because the conference provided an opportunity to interact with researchers from all over the world working on corrosion problems prevailing in reactor power systems. These corrosion problems in certain respects resemble potential corrosion problems envisioned in the disposal of high level radioactive waste. The information on waste package and containers materials was limited, but in part it can be attributed to the absence of two speakers.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

Future attendance to these type of conferences that takes place every other year could be useful to keep track of the current developments in an industry characterized by high technology

and sophisticated techniques as compared with other industries requiring corrosion services. It appears that the session on waste materials will be maintained in future conferences.

REFERENCES

Proceedings of the conference which contains peer reviewed papers will be available as a CD-ROM.

A volume of brief abstracts and the final program are available from the author of this report, as well as preprints of some papers of direct interest to our program.

SIGNATURES:

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Staff Scientist

9/17/03
Date

CONCURRENCE:

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