"QUICK-LOOK" REPORT ON FOREIGN TRAVEL TO U. K. AND JAPAN BY
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From June 25 to July 4, 2003, I visited Professor R. Newman of the University of Manchester Institute of Science and Technology (UMIST), Manchester, U.K., Dr. T. Shinohara of National Institute for Materials Science (NIMS), Tsukuba City, Japan, and Professor S. Fujimoto of Osaka University (U.), Osaka, Japan. I consulted with them on the alternative corrosion models to assess the waste package (WP) container lifetime in the disposal of high-level waste (HLW) and subsequently to develop the alternative models with the NRC Total-system Performance Assessment (TPA) Code. During the visit, I presented a summary of work done at the NRC related to modeling of uniform corrosion, localized corrosion, and stress corrosion cracking (SCC).

We focused our discussion on (1) the critical potential for localized corrosion and (2) issues involved in uniform corrosion and SCC. For Alloy 22 WP material in the proposed Yucca Mountain (YM) repository, the localized corrosion is considered more risk significant compared with uniform corrosion and SCC. Data on uniform corrosion from various tests, models and analogs suggest a WP lifetime exceeding 10,000 years. It appears unlikely that SCC would occur. Furthermore, SCC can be also mitigated by applying compressive stress. However, currently both DOE and NRC have concerns that localized corrosion could occur above approximately 90° C depending on the various deliquescence salts deposited on the WP surface. The DOE and NRC's current assessment of the localized corrosion is based on generally accepted conservative critical potentials for localized corrosion. Unlike SCC, localized corrosion may not be mitigated by design, and WP perforations from the localized corrosion may grow continuously.

(1) the critical potential for localized corrosion:

Because the currently adopted repassivation potential as the critical potential is considered too conservative by DOE and the corrosion community, it is important to evaluate alternative models. The group formerly led by T. Shinohara originally proposed the use of the repassivation potential for industrial applications. R. Newman and S. Fujimoto group further established theoretical bases. DOE and NRC have developed rationales for its use in the long-term repository. During this trip, we examined various interpretations of the critical potentials including the repassivation potential in more popular systems such as stainless steels for industrial applications. Many uncertainties in the theoretical model for localized corrosion were identified and discussed. Examples include (a) relationships among critical potentials, depassivation pH and critical chemistry, (b) shift in potential for crevice corrosion either in anodic direction or in transpassive direction, and (c) relationship between initiation potential and repassivation potential. Based on this discussion, these three groups (UMIST, NIMS and Osaka U.) commented on the current DOE and NRC's efforts to achieve more realistic and less conservative criteria that take into consideration the effects of alloying elements such as molybdenum and of inhibitors such as nitrates. These groups also questioned applicability of critical potential models to predict long-term behavior. The current laboratory electrochemical measurements may not be stable in the repository time scale. Accumulated corrosion products may alter the aqueous chemistry adjacent to bare metal by the selective aqueous species transport through the corrosion products. The corrosion products can also act as some large surface cathodes to accelerate uniform corrosion.

(2) issues involved in uniform corrosion and SCC:

- Stress redistribution after SCC propagation may not be significant in arresting continuous crack growth, according to the UMIST research.
- Anodic sulphur segregation in Alloy 22 potentially leads to accelerated uniform corrosion. This may be interpreted similarly to tungsten or other metal segregation in aluminum alloys. UMIST has extensive research experience in aluminum alloys.
- Density and size of pits may remain constant for a long period of time with the separation of

cathodes or pit penetration through the wall. However, this needs confirmation.

- Although a lead-induced SCC is unlikely, R. Newman cautioned that at grain boundaries of oxides, lead may be accumulated and could be mobile to expose bare metal to accelerated corrosion.
- Ni-Cr alloys in sulphate containing high-temperature high-pressure water solutions (Osaka U.) and Ti-based alloys in chloride solutions (NIMS) showed that the repassivation potentials increase above around 100° to 150° C.
- Ti alloys may have an optimum cathodic condition under which Ti^{2+} is stable and hydrogen absorption is maximized (Osaka U.).
- There were different views on the effects of sulphate ions as an inhibitor. Whereas UMIST and NIMS agree with the inhibiting roles to localized corrosion, Osaka U. observed that sulphate ions promoted the passivity breakdown of Ni-Cr alloys in high-temperature high-pressure water.
- Osaka U. does not believe that DOE's seemingly anodic peak of Alloy 22 in simulated dilute and simulated concentrated YM groundwaters would disappear in long-term period. They often observed these peaks in Ni-Cr alloys in high-temperature high-pressure water.
- The groups discussed other topics relevant to repository corrosion issues. These include thin film aqueous corrosion (NIMS), photochemical study of passive film (Osaka U.), surface modifications for corrosion protection by laser (UMIST) and by the coating semiconducting titanium dioxide (NIMS), extreme pit size analysis (UMIST), and hydrogen embrittlement of Ni-based alloys (Osaka U.).

No sensitive information was discussed during these meetings and no policy decisions affecting NRC were made. A recommendation will be made to the NMSS management (1) to incorporate the present information in the future NRC and the Center OPS Plan for FY04 and (2) to inform the DOE of the present information during the upcoming NRC/DOE technical exchanges and Appendix 7 meetings. This type of interaction offered an excellent short-term rotational experience by working intimately with world renowned experts. The interaction was very intensive and the desired information exchange was fully achieved. I highly recommend that staff seek similar opportunities to participate in this type of interaction with various experts. A more detailed trip report will be submitted by August 7, 2003. In the mean time, please contact me at 415-5812 or at <tma@nrc.gov>, if you have any questions.