

December 6, 2000

The Honorable Richard A. Meserve  
Chairman  
U. S. Nuclear Regulatory Commission  
Washington, D.C. 20555-0001

Dear Chairman Meserve:

SUBJECT: ALLOY C-22 CORROSION STUDIES

During its 122<sup>nd</sup> meeting on October 18, 2000, the Advisory Committee on Nuclear Waste (ACNW) heard presentations on the corrosion resistance of the nickel-based alloy C-22 from consultants to Nevada.<sup>1</sup> The Committee also heard presentations from the Center for Nuclear Waste Regulatory Analyses (CNWRA) and from the Department of Energy (DOE) on their C-22 studies during the 123<sup>rd</sup> ACNW meeting on November 28, 2000, in San Antonio, Texas. The ACNW has previously reviewed and discussed NRC/CNWRA and DOE studies of the corrosion of C-22 in a June 10–11, 1998, working group meeting on the Near-Field Environment and the Performance of Engineered Barriers at Yucca Mountain.

The longevity of waste packages is a key attribute of DOE's repository safety strategy. According to DOE's current calculations, the putative resistance of C-22 to corrosion will prevent any significant releases of radioisotopes from the waste package to the repository for more than 10,000 years. Thorough study of the alloy's potential degradation modes and corrosion resistance in the Yucca Mountain environment is obviously important to NRC's analyses of a license application for the site.

#### Conclusions and Recommendations

1. Preliminary experiments conducted by the State of Nevada consultants demonstrated that C-22 corrodes rapidly under extreme conditions. These conditions are not representative of those expected at Yucca Mountain.
2. Neither DOE nor NRC has yet thoroughly investigated the role of trace elements, such as mercury and lead, in the corrosion of C-22.
3. NRC and CNWRA staffs are identifying conditions in which the presence of trace elements could promote corrosion. They should verify that the absence of trace elements in previous work did not bias the conclusions about the susceptibility of C-22 to corrosion.

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<sup>1</sup> This project is part of Nevada's Oversight Assessment Program of the Engineered Barrier System for the proposed Yucca Mountain high-level waste repository.

4. NRC and CNWRA staffs should proceed with plans to evaluate the performance of C-22 under the full range of conditions that occur or may occur at Yucca Mountain. The ACNW believes that it is essential to understand the mechanisms of corrosion to allow extrapolation of performance over 10,000 years.

### Background

A key concern of the Committee, expressed in a 1998 letter, is the need to bound the extreme environments that C-22 may encounter in Yucca Mountain over the long term [Reference 1]. More recently the Committee commented on corrosion issues in a letter report on the Importance of Chemistry in the Near Field [Reference 2]. The ACNW noted that pit, crevice, and stress corrosion are still concerns. NRC needs to understand the mechanisms of these corrosion processes better before credit can be taken for the very long-term protection that DOE may postulate in its License Application (LA). The Committee recommended in the letter that the NRC staff continue collecting as much confirmatory data as possible on the corrosion rates and mechanisms over the range of expected conditions. The NRC staff agreed with these recommendations.

### Issues from Nevada-Sponsored Research

The State's consultants presented research results of accelerated testing of C-22 corrosion in the presence of minor contaminants (e.g., lead and mercury) known or suspected to cause local corrosion, such as pitting and stress corrosion cracking (SCC). The research, which is being done by chemists and materials scientists from The Catholic University of America and Dominion Engineering, shows that C-22 experiences pitting corrosion and SCC under extreme conditions. One fundamental issue is whether these conditions can be extrapolated to conditions more representative of the waste packages in the repository environment.

Presentations by Geosciences Management Institute addressed the presence of mercury and lead in the geologic strata surrounding the proposed Yucca Mountain high-level waste (HLW) repository site. From the presentations it appears likely that both mercury and lead are present in low concentrations in the rock above the proposed repository. Both of these elements may also be found in the pore water and perched water of the unsaturated zone and in other ground water at the site. It is unknown whether these or other potentially harmful elements exist in either sufficient concentrations or appropriate chemical forms to be detrimental to long-term performance of the waste packages and other engineered barriers in the near-field environment at Yucca Mountain.

Another consultant to Nevada reviewed SCC failures of nickel-based alloys in nuclear power plant steam generators. These failures were caused by small concentrations of lead (a few ppm) in cooling water. He also discussed scenarios that could lead to enhanced corrosion of C-22 and titanium alloys inside the disposal drifts of a Yucca Mountain repository. A key issue is the relevance of the lead-induced corrosion in steam generators to waste package corrosion in the HLW repository. On the basis of these experimental results, the State of Nevada's consultants concluded that the presence of mercury and lead in the Yucca Mountain environment could significantly shorten the period DOE could expect protection from C-22.

It is the opinion of the Committee that the experiments described by the consultants to Nevada were not representative of the conditions likely to occur at Yucca Mountain. Furthermore, the work did not include sufficient control experiments. The experiments showed C-22 corrodes rapidly under extreme conditions and at least suggest that under some conditions mercury, lead, and possibly other minor or trace chemicals can affect corrosion. The Committee concludes that the nature and extent of this effect need to be elucidated under realistic conditions.

The role of stress in the corrosion of C-22 also needs to be studied further. NRC particularly needs to understand the residual stresses on the C-22 waste package and how DOE will ensure that significant tensile stresses are not left on the surface of the finished waste package.

#### Planned NRC and DOE Activities

On November 28, 2000, the Committee heard from NRC/CNWRA and DOE about planned confirmatory studies to address a number of significant corrosion issues, including those discussed above. The DOE has agreed, as part of the issue resolution process, to do tests to establish the window of susceptibility of C-22 to SCC and to understand the role of trace metals in the corrosion of C-22. The NRC staff has also planned studies to illuminate mechanisms of corrosion of C-22. The Committee strongly supports tests and studies planned by both NRC and DOE.

Sincerely,

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B. John Garrick  
Chairman

#### References:

1. ACNW letter dated September 9, 1998, to Shirley Ann Jackson, Chairman, U.S. Nuclear Regulatory Commission, from B. John Garrick Chairman, ACNW, Subject: Issues and Recommendations Concerning the Near-field Environment and the Performance of Engineered Barriers at Yucca Mountain
2. ACNW letter dated January 11, 2000, to Richard A. Meserve, Chairman, U.S. Nuclear Regulatory Commission, from B. John Garrick Chairman, ACNW, Subject: Comments on the Importance of Chemistry in the Near-Field to DOE's Yucca Mountain Repository License Application