CHP/A4171 T1 INTPAP

JAN 27 1989

Dr. Charles G. Interrante, Program Manager
Metallurgy Division - Corrosion Section
National Institute of Standards and Technology
U. S. Department of Commerce
Gaithersburg, Maryland 20899

Dear Dr. Interrante:

The pro-active work under Task 1 of the Statement of Work for FY89 includes preparation of summary papers on specific degradation phenomena of materials. In accord with our discussions, this letter requests initiation of such work and provides guidance on the direction and scope of these papers.

Background

One of the principal technical tasks the DOE faces is that of showing compliance with the requirement of 10 CFR Part 60 that containment of radionuclides within waste packages emplaced in a geologic repository shall be substantially complete for 300 to 1,000 years after permanent closure of the repository. The NRC, however, reserves the authority to approve some other containment period. It is expected that at least one sealed container will be included in the waste package design that will be fabricated from a metal or metal alloy. The DOE has disclosed their intention of testing three alloys in the stainless steel family and three in the copper family. The CNWRA has recommended testing Hastelloy C also.

Containment can be breached by mechanical stresses or chemical attack. Cases in which purely mechanical stresses are present will be examined separately. Chemical attack can proceed via general corrosion or local corrosion. It is our current judgement that the latter is likely to result in an earlier breach of the container than general corrosion and should therefore be investigated first. Three modes are of interest:

1. Stress corrosion cracking (SCC)

    a. Intergranular
    b. Transgranular

2. Pitting corrosion

3. Hydrogen effects

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A large body of technical literature exists on all of these modes, to which the DOE is adding the results of further studies for the Yucca Mountain repository environment. However, it is not clear how completely the operative mechanisms in these corrosion modes have been demonstrated. Knowledge of mechanisms is of considerable importance in reducing the uncertainties in predictions of long-term behavior of materials. The DOE programs are expected to provide information on mechanisms, but at some future time. Rather than reacting to these results at that time, the NRC elects to undertake an independent review of the available information on mechanisms now. This effort will achieve two other objectives:

1. It will enable us to provide early guidance to the DOE with respect to the direction and adequacy of their technical program.

2. It will provide us with an information base from which to assess DOE conclusions.

Task Request

We therefore request that the NIST, under Task 1 of the Statement of Work for FY89, prepare three interpretive papers as follows:

1. Mechanisms of Stress Corrosion Cracking in Stainless Steels
2. Mechanisms of Pitting Corrosion in Zircaloys
3. Mechanisms of Corrosion of Copper and Copper Alloys

Since resources permit work on only three papers, hydrogen effects are designated as deferrable. The schedule objective is to complete an initial draft based on the readily available information by March 31, 1989. Each author should submit a proposed outline of his/her paper within three weeks of the receipt of this letter. Attachment 1 contains guidance as to the content of these papers.

Actions resulting from this letter are considered to be within the scope of FIN A-4171. No changes in costs or delivery of contracted products are authorized. Please notify me immediately if you feel this letter will result in additional costs or delay in delivery of contracted products.

Sincerely,

C. H. Peterson

Charles H. Peterson
Engineering Branch
Division of High-Level Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: Att. 1

cc: w/Att. 1:

Dr. Neville Pugh, Director
Metallurgy Division, NIST

Dr. David Anderson, Group Leader
Metallurgy Division, NIST

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ATTACHMENT 1

GUIDANCE ON THE CONTENT OF INTERPRETIVE PAPERS

General Guidance

1. The objective of each paper is to identify existing specific mathematical models of the corrosion mechanisms described and to perform in-depth critiques of the validity of these models and mechanisms.

2. The papers shall identify completely the sources and authors of the information used.

3. The search for information should begin with U. S. DOE documents but should then be extended to other documents as necessary to establish the origin and basis of the mechanisms and models.

4. Primary attention should be given to corrosion under environmental conditions corresponding to a geologic repository at the Yucca Mountain site. Similarly, the metals considered initially should be those in the current DOE test plans as disclosed by the Nevada SCP.

5. The papers are not to serve as vehicles for transmitting data from other sources. Data may be cited, summarized, and abstracted to illustrate or support particular conclusions.

6. The papers should address the questions listed under "Specific Guidance". However, each author may propose other questions that appear to be of equal or greater importance to understanding of mechanisms.

Specific Guidance

A. Mechanisms of Stress Corrosion Cracking in Stainless Steels

1. It is hypothesized that SCC occurs because carbon migrates to grain boundaries, reacts with chromium to form $Cr_{23}C_6$, thereby weakening the alloy along those boundaries.

   a. Why and how fast does the carbon migrate?

   b. What are the steps leading to the formation of the final carbide? Is there any significance to the fact that the formula is almost (Cr_4C_6)?

   c. What is known about the thermodynamics of this reaction?

2. It is hypothesized that subjecting stainless steels to elevated temperatures for several hours may be sufficient to sensitize them to SCC, i.e., favor carbon migration.

   a. Is there any evidence of a threshold temperature below which carbon migration cannot occur?

   b. What is the role of the mechanical forces applied during fabrication in sensitization of steels?

   c. From what location and along what paths do the carbon atoms migrate?

3. It is hypothesized that certain anions (chloride, bicarbonate and perhaps sulfate) have a role in SCC.

   a. What are these roles?

   b. How is the SCC affected by the concentration of dissolved oxygen?

   c. What is the effect of a radiation field of the type and strength expected for waste packages?

B. Mechanism of Pitting Corrosion in Zircaloys

1. It is hypothesized that pitting initiates at heterogeneities on the surface of the metals.

   a. What is the evidence supporting this hypothesis?

   b. Is there any pattern in the spatial distribution of pits?

c. Are different mechanisms operating to cause differences in the pit geometries?

2. What is the rate of corrosion under "passive" conditions?

3. What is the distribution of thicknesses of the passive film?

4. If the passive film is ruptured, would the metal surface be repassivated under repository conditions?

C. Mechanisms of Corrosion of Copper and Copper Alloys.

1. It is hypothesized that copper alloys are subject to stress corrosion cracking (SCC).

   a. What is the role of oxidation in SCC?

2. It is known that copper alloys are subject to pitting.

   a. What factors affect the pit aspect ratio?

3. It is likely that crevices may be present in the waste package assembly.

   a. How do the mechanisms of crevice corrosion differ from other forms of corrosion?