UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201

October 21, 2003

Dr. Margaret S. Y. Chu
Director
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Dr. Chu:

In its June 30, 2003, letter to you, the Nuclear Waste Technical Review Board promised a more detailed evaluation of data and analyses presented at the Board's May 2003 meeting. This letter briefly summarizes our concerns about waste-package corrosion during the thermal pulse — particularly localized corrosion but also general corrosion. In addition, we are nearing completion of a report on the technical bases for these and related concerns about various thermal pulse issues. We will provide the report to you soon.

1. *Localized Corrosion.* Localized corrosion processes are particularly insidious because initiation is difficult to predict and propagation rates can be very rapid. Information on localized corrosion (e.g., pitting, crevice corrosion, stress corrosion cracking) rates in representative repository environments is critical to predicting waste-package effectiveness. As illustrated by the attached overheads provided to the Board at recent meetings, data emerging both from the Yucca Mountain Project and from the Center for Nuclear Waste Regulatory Analyses (Center) suggest to the Board that crevice corrosion of Alloy 22 is likely to initiate during the thermal pulse (approximately the first thousand years after repository closure, when temperatures will exceed 95ºC for the current repository design). Project data show that initiation of crevice corrosion during the thermal pulse is likely in concentrated brines (with or without nitrates) at temperatures well below the peak waste-package surface temperatures expected in the Department's proposed repository design. Crevice corrosion initiated during the thermal pulse is likely to propagate during the remainder of the thermal pulse and also is likely to continue even after the thermal pulse, at temperatures below 95°C.

   Work at the Center and elsewhere indicates to the Board that welds and thermal treatment (aging) increase susceptibility to crevice corrosion. As currently designed, the waste package has both welded areas (i.e., closure welds) and many opportunities for crevice formation. Redesign studies for reducing or eliminating areas of increased susceptibility to localized corrosion may be a worthwhile option.

2. *General Corrosion.* In choosing candidate materials of construction, an important line of inquiry is the general (uniform) corrosion rate. If the general corrosion rate is known with confidence, then one can determine the mass of material (or thickness) required to perform for the life of the system. In the case of the Project, one needs corrosion-rate information in representative repository environments. Most corrosion data reported to date are for 95ºC (the approximate boiling point of pure water at the altitude of the repository site) or lower. These data may constitute an adequate technical basis if the surface temperatures of the waste packages in the repository never exceed 95ºC. Few data exist, however, at the higher temperatures of the thermal pulse. Moreover, the nature of the environments in contact with the waste packages (or drip shields) is not well known under such conditions. Concentration processes of various kinds may lead to aggressive chemistries.

The concern about localized corrosion during the thermal pulse is one of the data in hand showing that localized corrosion is likely. In contrast, the concern about general corrosion during the thermal pulse is one of corrosion-rate uncertainty due to the lack of corrosion data. That the aqueous environments necessary for corrosion exist during the thermal pulse is primarily due to deliquescence of salts. In the higher part of the thermal pulse range, deliquescence can be attributed mainly to chloride salts with divalent cations.

The Project data and the Center data are consistent in that both sets of data cast doubt on the extent to which the waste package will be an effective barrier under the repository conditions that have been presented to the Board. The waste package is both a key barrier and an extremely important element in providing defense-in-depth. Given the importance of the waste package to the repository, the Board requests that the Department address the Board's concerns about corrosion, particularly localized corrosion, during the thermal pulse.

The Board believes that total system performance assessment should not be used to dismiss these corrosion concerns.

As you are aware, the Board's responsibilities include evaluating the technical and scientific validity of the Department's activities related to the repository and reporting the Board's findings, conclusions, and recommendations. Our role is that of an independent technical advisor. We know that the Department's decision-making process must take into account not only technical and scientific factors but also many others. Nevertheless, because of the seriousness of these corrosion concerns, we strongly urge you to reexamine the current repository design and proposed operation. The Board believes that the high temperatures of the current design and operation will result in perforation of the waste packages, with possible release of radionuclides. The data currently available to the Board, provided by the Project and the Center, indicate that perforation is unlikely if waste-package surface temperatures are kept below 95ºC.

Sincerely,

Michael L. Corradini, Chairman

Mark D. Abkowitz

Daniel B. Bullen

Thure E. Cerling

Norman L. Christensen, Jr.

Paul P. Craig

David J. Duquette

Ronald M. Latanision

Priscilla P. Nelson

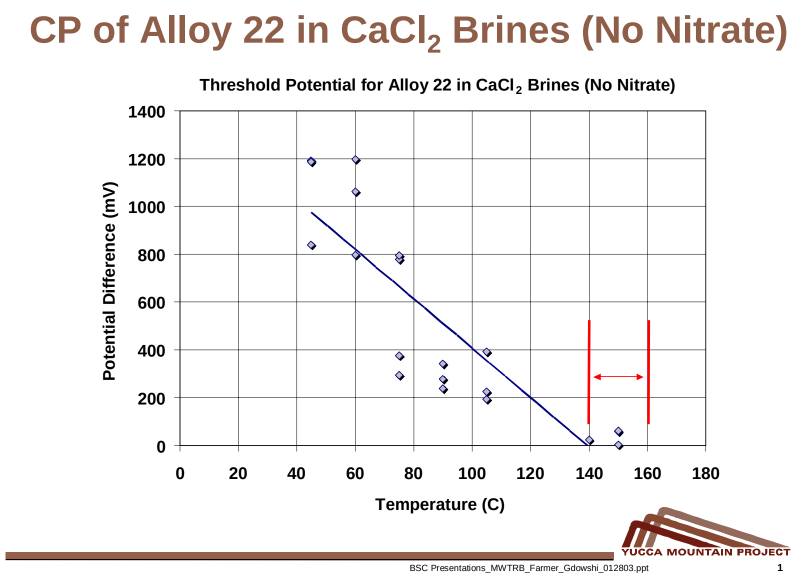
Richard R. Parizek

Attachment: Seven overheads presented at the Board's January and May 2003 meetings.

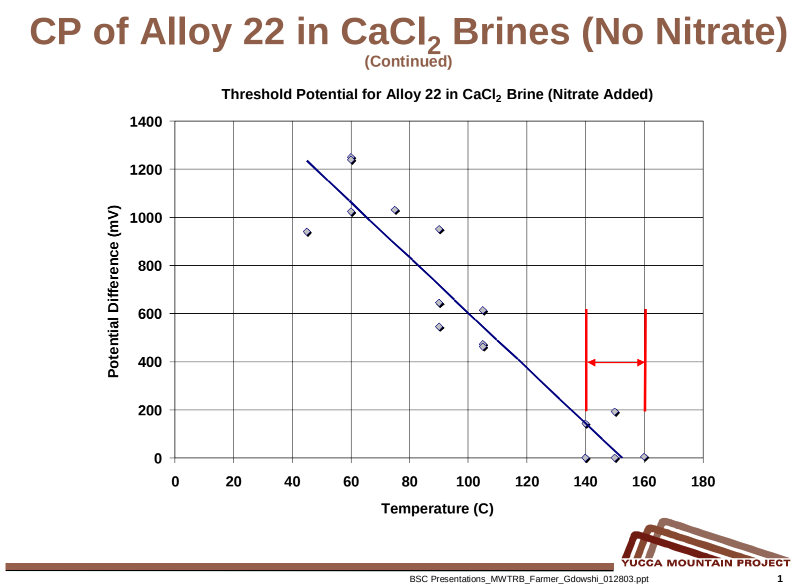
ATTACHMENT TO OCTOBER 21, 2003, LETTER FROM THE BOARD TO DR. CHU

This attachment contains seven overheads presented at the Board's January and May 2003 meetings. The first three overheads were part of presentations by Dr. Joseph C. Farmer of the Department of Energy's Lawrence Livermore National Laboratory. The next four overheads were part of a presentation by Dr. Gustavo A. Cragnolino of the Nuclear Regulatory Commission's Center for Nuclear Waste Regulatory Analyses.

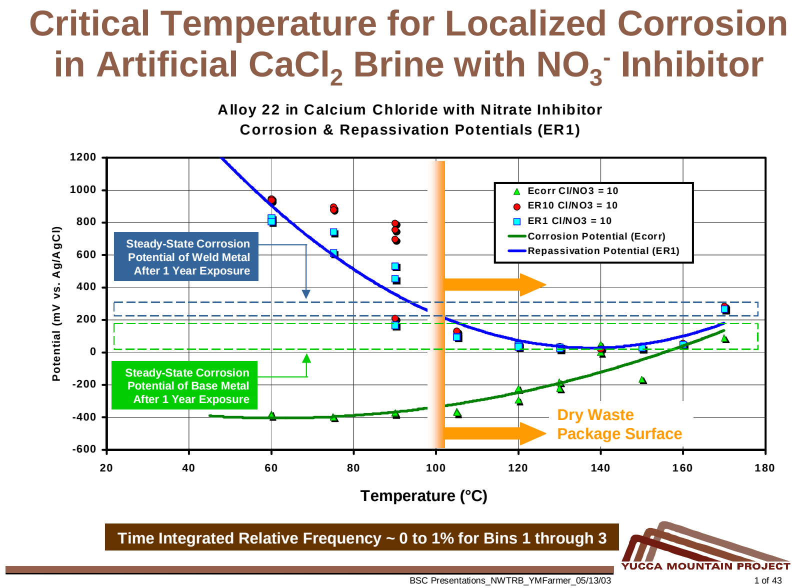
This figure is an overhead from Dr. Farmer's presentation at the January 28, 2003, Board meeting in Las Vegas. Localized corrosion is virtually certain to initiate when the Potential Difference falls below 0. For Alloy 22 in a concentrated solution of calcium chloride with no nitrate added, the overhead indicates that the Potential Difference is below 0 for temperatures of approximately 140ºC and higher. (Peak waste package surface temperatures in the current design are approximately 180ºC.)



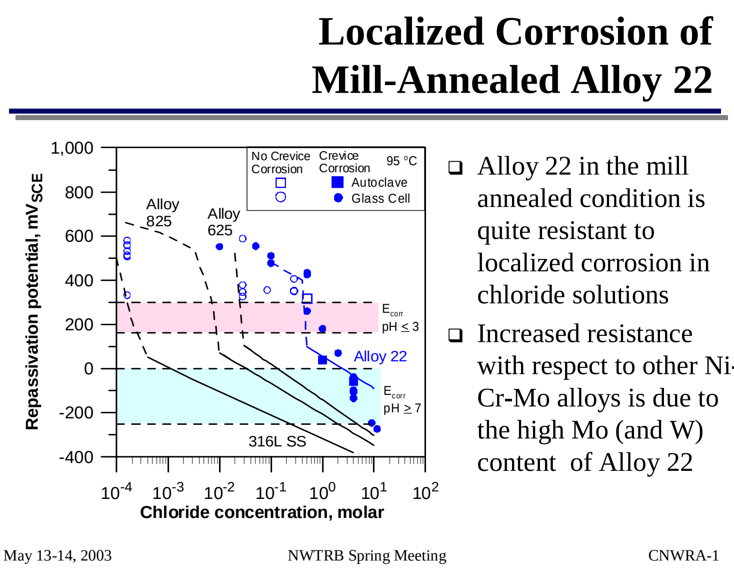
This figure is another overhead from Dr. Farmer's presentation at the January 28, 2003, Board meeting. (There is an error in the title. Instead of "No Nitrate," it should read "Nitrate Added.") Again, localized corrosion is virtually certain to initiate when the Potential Difference falls below 0. For Alloy 22 in a concentrated solution of calcium chloride with nitrate added, the overhead indicates that the Potential Difference is below 0 for temperatures of approximately 150ºC and higher.



This figure is an overhead from Dr. Farmer's presentation at the May 13, 2003, Board meeting in Washington, D.C. Note the dashed boxes. They indicate that base-metal steady-state corrosion potential moves in a noble (positive) direction with time and that welded-metal corrosion potential moves even farther in that direction with time, indicating increasing susceptibility to crevice corrosion with aging time and in welded structures. Although the overhead appears to state that waste package surfaces are dry above approximately 120ºC, deliquescence of salts in the dust on waste package surfaces can cause brines to form at temperatures up to approximately 150º-160ºC.

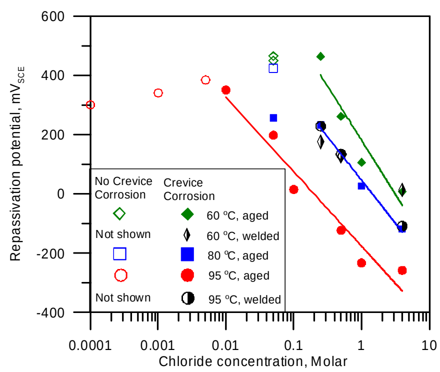


This figure to the right is an overhead from Dr. Cragnolino's presentation at the May 14, 2003, Board meeting in Washington, D.C. Note that Alloy 22 is more resistant to localized corrosion than other nickel-chromium-molybdenum alloys (alloys 625 and 825) and than a nickel-chromium alloy (316 stainless steel).



This figure is an overhead from Dr. Cragnolino's presentation at the May 14, 2003, Board meeting. It illustrates the increased susceptibility of welded and thermally aged Alloy 22 in comparison to mill-annealed material.

Effect of Fabrication Processes on Localized Corrosion

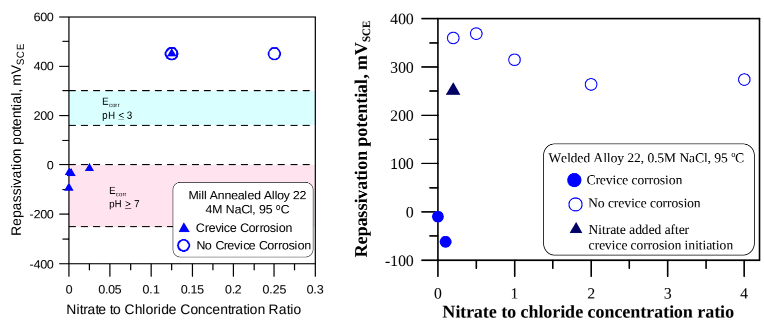


- Welding and short-term thermal aging increase localized corrosion susceptibility
- Localized corrosion observed at lower [Cl$^-$] and lower temperatures compared to the mill annealed condition

May 13-14, 2003 NWTRB Spring Meeting CNWRA-1

This figure is an overhead from Dr. Cragnolino's presentation at the May 14, 2003, Board meeting. It illustrates the beneficial effect of nitrate on localized corrosion susceptibility of Alloy 22 at 95ºC. There is an error in the next-to-last line. Rather than "1.2 for mill-annealed material," it should read "0.12 for mill-annealed material."

Effect of Nitrate on Localized Corrosion of Alloy 22



- Nitrate is an efficient inhibitor of localized corrosion induced by chloride
- Critical nitrate to chloride molar concentration ratio is 1.2 for mill-annealed material and 0.2 for welded material

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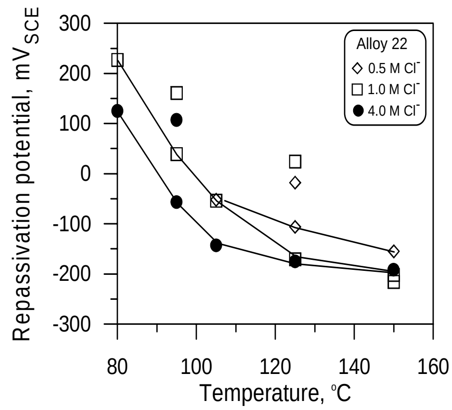
This figure is an overhead from Dr. Cragnolino's presentation at the May 14, 2003, Board meeting. It illustrates how repassivation potential decreases with temperature.

Effect of Temperature on Localized Corrosion



- E_{rcrev} measured using creviced specimens in autoclave systems
- Significant decrease of E_{rcrev} with increasing temperature from 80 to 105 °C
- At higher temperatures E_{rcrev} values tend to level off

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