THE AEROSPACE CORPORATION

Suite 4000, 955 L'Enfant Plaza, S.W., Washington, D.C. 20024, Telephone: (202) 488-6000

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Mr. Kien C. Chang
Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Chang:

MEETING AT BATTELLE COLUMBUS, MARCH 8, 9, 1984

Attached is a trip report for the meeting I attended in Columbus on March 8 and 9.

The meeting to discuss the Battelle Columbus work on corrosion and the new manufacturing-processes work by the Manufacturing Sciences Corporation was helpful to us in seeing how their outputs will feed into our work at Aerospace.

On March 9, I met separately with Dave Stahl and some of his people to discuss their modeling work, which has now been stopped. Although their "first cut" model is essentially deterministic, it may lend itself to incorporation into our analysis, especially for radionuclide releases. We are now reviewing the BCL work and will include the results in our methodology report, which will also discuss the waste package performance assessment techniques used by other organizations.

Very truly yours,

Kenneth W. Stephens

Kenneth W. Stephens
Manager, Technology Assessments
Eastern Technical Division

KWS/gbf
Attachment

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TRIP REPORT

MEETING ON BCL CORROSION WORK
AND
MSC MANUFACTURING PROCESSES PROJECT

Columbus, Ohio
8 March, 1984

K.W. STEPHENS
THE AEROSPACE CORPORATION
(FIN A-4165-4)

Summary

The meeting was held to review the Battelle Columbus Laboratories corrosion work and to coordinate the work with the manufacturing-processes project just getting underway at the Manufacturing Sciences Corporation in Boulder, Colorado. In addition to the BCL and MSC people, attendees included NRC (NMSS, RES, and the NRC representative at BWIP), an ONWI observer, consultants, and K.W. Stephens of The Aerospace Corporation. The format included six presentations by BCL and one by MSC, with time for discussion after each.

The meeting dealt with a number of topics of interest to the waste program in general and resulted in information which is of particular importance to the Aerospace waste package project. The individual presentations are discussed below.

General Observations

Long-Term Performance of Materials Used for High-Level Waste Packaging (Project Overview)

D. Stahl, the BCL Project Manager provided an overview of the objectives, strategy, and schedule. The intent is to develop an understanding of the processes that can lead to waste package failure and subsequent release of radionuclides.

The project originally was intended to perform experiments, develop separate-effects correlations, and develop a model to predict waste package performance and radionuclide releases. This was done, and a "first cut" model was developed.

Although the original plan was to develop subsequently an enhanced model, the project was redirected to concentrate on the understanding of the processes. The modeling work, as such, was for all practical purposes stopped. However, the ongoing correlations effort would lend itself to incorporation in future modeling work, by either BCL or other organizations.

Hydrogen Embrittlement of Cast Steel Canisters for High-Level Waste Containment

H. Cialone described how this part of the project is examining the effects of hydrogen on cast steel, investigating similarities and differences between degradation of cast steels and wrought steels, and estimating the hydrogen fugacities that may be expected in service. The project believes that centrifugally-chilled cast steel is the likely DOE candidate. Although little literature is available on hydrogen embrittlement in cast steels, there is information on wrought steels.

One of the slides showed the hydrogen content absorbed as a function of time during corrosion tests with basaltic groundwater at 250°C; there was a great deal of scatter in the data. After a suggestion from one of the participants that the presence of chloride ions might influence the results, Cialone said that experiments with ten-times-normal concentrations of basaltic groundwater indicated otherwise. M. McNeil views this as a significant finding.

Internal Corrosion

J. Beavers described the work to determine the long-term corrosive effects of the waste form on the canister. On the basis of the test results, the project has been asked to stop work on this issue. It has been judged to be less of a problem than other types of corrosion.

The experiments showed that the number of shallow pits increases rapidly with exposure time at all temperatures, but that the pit depth increases very slowly with time. At the real repository temperatures, the corrosion rate is slow, and the corrosion products appear to form a barrier to further attack.

Overpack Corrosion

John Beavers described the objective as development of an understanding of the corrosion processes which can lead to overpack failure. The approach is to combine electrochemistry work with selective exposure experiments (mostly autoclave) and accelerated stress corrosion testing (slow-strain-rate testing). The conclusions from the literature survey disclosed that a number of potential cracking agents are present at low concentrations in repository environments and that the most serious threat to integrity of the overpack with respect to stress corrosion cracking is through concentration of these species. Their identification and effects characterization are included in next year's work.

The electrochemistry work is important because the radiolysis products may affect electrochemical conditions and thereby affect corrosion. The potentiodynamic polarization experiments are conducted

between 90°C and 250°C using normal, concentrated, and basaltic groundwater doped with radionuclides. During the discussion, F.R. Cook suggested that a packing-material/groundwater mixture might be more appropriate. The BCL work does not include plans for such experiments, but they were not ruled out as possible future work.

In summary, the findings for carbon steel in a basaltic environment show that stress corrosion cracking may occur as a result of concentration of cracking agents, that rates of general corrosion are low under deaerated conditions, and that pitting initiation is likely. Vapor phase corrosion is seen as a potential problem area and is being studied further.

Separate-Effects Analysis

Alan Markworth described the objective of the separate-effects analysis as development of a quantitative understanding of individual waste package degradation processes using physically based models, along with physically based interpretation of experimental results.

The current activities include water chemistry, waste form dissolution, and corrosion (general and pitting). The water-chemistry work will characterize the real repository environment, including non-steady-state conditions. The general-corrosion analysis considers mass-transport kinetics, radiolysis, and chemical reactions. Because a rigorous solution of the resulting partial differential equations would be difficult, the essential task is to determine how best to simplify. The general and pitting-corrosion work is currently limited to examination of single species at a time. Other simplifications have been applied, such as the assumptions of no fluid flow and no chemical reactions within solutions.

The near-term objectives of the general corrosion work are: to obtain numerical descriptions of corrosion kinetics for special cases, to include repository-specific items (e.g., heat flow, radiolysis), and to include water chemistry analysis. The pitting-corrosion work will continue the analysis of pit initiation and growth and will also incorporate repository-specific contributions.

High-Level Waste Package Performance Experiments

S. Nicolosi discussed the efforts to tie all the pieces together. Originally, the intent was to have an overall waste package system code, but the work was redirected after the "first cut" model was developed. The early modeling work identified the potential combined effects, revealed the limitations of current understanding of the processes, and demonstrated the need for experimental research.

The research approach now is to perform experiments to address the individual combined effects and to perform integral experiments. The integral experiments include a gamma radiation field, basaltic

groundwater/packing mix, 90°C and 200°C tests, flowing conditions (at 90°C only), and various package conditions and materials. The experimental design includes provisions for examining the performance of degraded package materials, i.e., steel plates with holes in them.

The output of the experiments will include: release of radionuclides and silica (total release and release normalized to exposed surface area), data on the mobility of radionuclides and silica as a function of position and chemical state, analysis of surface and interface effects, and data on chemical speciation and colloids.

Effects of Manufacturing Processes on Failure of High-Level Waste Containers

Early in calendar 1984, the Manufacturing Sciences Corporation started a project for NRC on the effects of manufacturing processes on waste-container performance. D. Floyd and A. Liby of MSC discussed the status and plans for the project.

The project will examine use of low-carbon steel and austenitic stainless steel for casting, wrought processing, and welding. The work will include process and material definition, literature and analytical research, and experimental research.

The process and material definition phase will consider basalt, salt, and tuff (above and below the water table). The analytical research will determine desirable process limits for casting and welding, examine metallurgical characteristics, formulate a model for characterizing the finished product, and assess methods for quality control and non-destructive examination. The experiments will be used to determine limiting microstructures, verify process limits (e.g., welding parameters), and demonstrate the changes that may occur due to repository storage (i.e., look for synergistic effects).

The overall intent of the project is to identify how manufacturing processes influence package performance, and to provide that information in a form that will be helpful to both the package designer and the performance analyst.