REPORT PERIOD: March 1984

MONTHLY PROGRESS REPORT

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CONTRACTOR: The Aerospace Corporation, Washington, D.C.

SPONSOR: Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards

WORK PERFORMED/TECHNICAL PROGRESS

Work during March involved: continuing work on fault/event trees and other methods for waste package performance assessment, attendance at meetings with NRC contractors working on related projects, and review of documents as requested by NRC.

Schedued Work

The main effort during March was on the parallel tasks of fault/event tree work and review of methods used by DOE and others to assess waste package performance.

Comments on the fault/event trees delivered in December and January were received from NRC, and work is in process to revise the documents. In addition, considerable effort has been directed toward examination of the techniques for quantifying the trees. A reduced fault tree was developed for use in trial runs, and alternative probabilistic risk assessment (PRA) techniques were investigated.

Preliminary indications are that the Boolean techniques typically used in quantifying PRA's for nuclear power reactors are not adequate for quantifying the waste package fault trees. This is because of the interdependence of the barriers and the events affecting them, as well as the coupling between the time of failure of an individual barrier and the time of failure of the next barrier. Accordingly, work is continuing on the identification and development of other PRA techniques. Work is centering around the approaches mentioned in Appendix B of the event tree report delivered in January. The reasons for using alternate approaches will be discussed with NRC in a future briefing and will be included in the methodology report.

The performance assessment methodology review identified several techniques that merit further examination: WAPPA-based approaches used by DOE, Battelle Columbus models, Sandia models, the Brookhaven

approach outlined in the Draft Staff Technical Position on Waste Package Reliability, and the fault/event tree approach and other techniques developed at Aerospace. These methodologies are now being evaluated on a common basis, i.e., failure modes covered, characteristics of the models, assumptions and limitations, degree of maturity of the approach, etc.

Because the BWIP Waste Package Workshop was deferred and then cancelled, and because the BWIP Barrier Materials Test Plan will not include details on waste package performance assessment until the end of September, it has not yet been possible to characterize the BWIP approach definitively. For the purposes of the Aerospace methodology review, the presumption is that BWIP will use a WAPPA-based approach along with several other models, as described in the BWIP Performance Assessment Plan of early 1983. To the extent that additional information can be obtained, it will be used in the methodology review.

On 22 March, A.B. Crane and L.P. Boesch of Aerospace met in Albuquerque with personnel from Sandia National Laboratories and NRC to discuss areas of mutual interest. The meeting was productive in identifying how the Sandia and Aerospace projects relate to each other and in establishing the necessary interface. (For details, see the 6 April letter from K.W. Stephens of Aerospace to K.C. Chang of NRC.)

Special Support

K.W. Stephens attended the 8 March meeting at Battelle Columbus Laboratories (BCL), which dealt with the BCL corrosion project as well as the related manufacturing-processes work which has just started with the Manufacturing Sciences Corporation in Boulder, Colorado. The meeting covered a number of topics which have a direct bearing on the Aerospace project. One major result was that some of the earlier BCL modeling work was identified for incorporation in the Aerospace waste package methodology review. (For details see the 30 March letter from K.W. Stephens to K.C. Chang.)

Also during March, Aerospace reviewed NRC contractor documents, as requested. Included were two Sandia documents: "An Evaluation of Importance Measures for Probabilistic Resk Analysis Applications" and "Literature Review of Studies Related to the Safe and Permanent Disposal of Nuclear Wastes, Volumes I and II." The importance-measures document may be useful to the Aerospace project during the more advanced stages of the waste package assessment. Comments on the documents were transmitted to K.C. Chang on 14 March.

Aerospace also reviewed the February 1984 draft of BNL-NUREG-24297, "Determination of the Waste Package Environment for a Basalt Repository: Phase I-Gamma Irradiation Conditions in the Absence of Methane." Comments were transmitted with the 19 March letter from

K.W. Stephens to K.C. Chang. Aerospace concluded that the BNL experiment, coupled with other information from BWIP, casts doubt on the BWIP presumption that the repository will return to reducing conditions rapidly after closure. During the latter part of March, Aerospace continued to examine the issue and perform scoping calculations. The results are summarized in Attachment A to this report.

WORK PLANNED FOR NEXT MONTH

During April, the parallel PRA and methodology-review effort will continue. Because of the state-of-the-flux in both BWIP and the PRA quantification techniques, the scheduling for the methodology report has not been determined. An attempt will be made to obtain additional BWIP information when their people come to Silver Spring for the Barrier Materials Test Plan meeting the week of 7 May. In the meantime, as much BWIP information as possible will be collected by telephone. A revised work schedule will be discussed with NRC during April.

Aerospace will also review the Barrier Materials Test Plan in preparation for the meeting on 8 and 9 May and will provide support for the pre-meetings to be held late in April.

Attachment A

Basalt Repository Conditions After Closure

References

1. Letter from K.W. Stephens to K.C. Chang, "Review of Draft BNL-NUREG-24297," dated 19 March 1984.

2. BNL-NUREG-24297, "Determination of the Waste Package Environment for a Basalt Repository: Phase I-Gamma Irradiation Conditions in the Absence of Methane," February 1984.

3. PNL-SA-11456, "Behavior of Technetium-99 in Doped-Glass/Basalt Hydrothermal Interaction Tests," October 1983.

Reference 1 discussed a review of Reference 2 and dealt with the issue of the time required for a basalt repository to return to reducing conditions after closure. This attachment discusses follow-on work by Aerospace during March 1984.

Two significant studies have been carried out to assess the oxidation/reduction conditions that may occur in a basalt repository following closure. These studies, by BNL and PNL, References 2 and 3 respectively, make the assumption that the near field will be oxidizing at repository closure. There is near unanimous agreement on this point and on the point that basalt itself is fundamentally reducing.

The major question is when, or perhaps whether, the near field will revert to reducing conditions. In the BNL study, oxidizing conditions remained in effect after 60 days at 150°C. Their conditions tended to enhance the return to reducing conditions because of the presence of reducing hydrogen trapped at high pressure (35 psi) in the test cell. Radiolysis tended to maintain oxidizing conditions.

The PNL study did not include radiolysis and was carried out at 200°C. Reducing conditions were established after 700 hours. The lack of radiolysis and the use of such a high temperature greatly accelerates the return to reducing conditions.

In order to assess properly the question of time to re-establish reducing conditions, the following conditions should be imposed: (1) the lowest temperature to be expected in the near field at repository

closure; (2) the maximum radiation dose expected at repository closure (these first two are coupled and should be so treated); and (3) the assumption that hydrogen generated by radiolysis will escape.

Temperature estimates for the repository range to less than 100°C at the time of closure. If a constant temperature of 100°C is used for the PNL study, the minimum time to re-establish reducing conditions would be 79 years. The presence of radiolysis, the loss of hydrogen, and the certainty that the reaction rate dependence on temperature has been underestimated in this extrapolation to 100°C, could cause the time to extend to 1000 years or more. It should be noted also that the possibility exists (c.f., the BNL results) that radiolysis could establish oxidizing conditions to an extent that would effectively exhaust the surficial reducing capability of the basalt in the vicinity of the canister, thus producing what amounts to a permanent oxidizing environment.

At present, there is experimental evidence to suggest that reducing conditions will re-establish slowly, perhaps only in millenia. If there is evidence to support the idea of rapid re-establishment of reducing conditions, BWIP should present it. No convincing evidence has been found in the BWIP reports or elsewhere in the literature.