A4171
~~426.1/CHP/8/27/86~~

SEP 2 1986

Dr. Charles G. Interrante
Program Manager
Corrosion Section - Metallurgy Division
U.S. Department of Commerce
National Bureau of Standards
Gaithersburg, MD 20899

Dear Dr. Interrante:

This is to request short-term technical assistance under Task 4 of FIN A-4171-6, "Evaluation and Compilation of DOE Waste Package Test Data," as detailed in Attachment 1. We request that you complete this work and submit a letter report to us by October 10, 1986.

If you wish to discuss this or have any questions, please call either me (427-4111) or Chuck Peterson (427-4546).

Actions resulting from this letter are considered to be within the scope of FIN A-4171-6. 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,

/s/

Everett A. Wick
Engineering Branch
Division of Waste Management, NMSS

Enclosure:
Attachment 1

cc: Dr. Neville Pugh, Director
Metallurgy Division

Dr. Ugo Bertocci, Acting Section Leader
Corrosion Section - Metallurgy Division

WM-RES
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ATTACHMENT 1

Statistical Approach to Prediction of Waste Package Life

Background

The current DOE conceptual design of a geologic repository for high-level radioactive waste is described in the final Environmental Assessment reports. The repository in salt proposes emplacement of 55,642 packages of spent fuel, CHLW, DHLW and remote handled TRU (Reference 1, Volume I, page 5-27). This includes 7899 spent fuel packages.

These packages will be assembled offsite, shipped to the repository, possibly repackaged, transported to the underground facility and emplaced. The borehole will then be backfilled with crushed salt. Within 100 years after emplacement, the entire underground facility will be permanently closed. The DOE design is to provide "essentially complete containment" for at least 300 years and not more than 1000 years after permanent closure. Thereafter a gradual release rate will be permitted (Reference 2, Section 60.113).

Implementation of these requirements means the DOE must provide the NRC with "reasonable assurance" as to the performance of the repository. While each package will undoubtedly receive extensive individual inspections during manufacture and assembly, it is clear that some surrogate evidence will be needed as to waste package life till failure. One approach is to perform the following experiment.

1. Select a representative number, n, of waste package overpacks.

2. Expose these to repository conditions for a time t and observe the number of failures. "Failures" needs to be defined, but it could be (a) loss of corrosion allowance, (b) penetration of the overpack wall by a single pit, (c) exposure of sufficient portion of the surface of the waste to permit an unacceptably high release of radionuclides from the waste package, or (d) some other criterion.

3. Make an inference from these failure data as to the cumulative number of failures expected within the containment period.

4. Estimate the release rate and compare with the regulatory requirement.

In a recent report, Dr. Ralph E. Thomas of Battelle Columbus explored this experimental plan by a statistical approach based on the Weibull Distribution (Reference 3). He concluded that if 1171 containers were tested for one year at conditions ten times as severe as repository conditions with zero failures, then one could state that there will be a 95% chance that the package life will be at least 300 years. An independent check by NRC staff by industrial quality control statistical methods yielded a comparable result: if a sample consisting of 389 packages were tested and not more than one failure was found, the entire lot of containers from which the sample was taken would be accepted 94% of the time in the expectation that 99.9% of all package lives would be at least the desired length. Package life does not enter explicitly in this calculation but must be related to the 300 year minimum desired life by the severity factor and possibly some extrapolation from the test time actually used. In this example, there would also be a 10% chance that only 99.0% of the packages would have the desired life.

The finding that a large number of packages would have to be tested appears likely to have an important influence on the direction to be taken by experimental work on waste package life. NRC desires to explore this finding more thoroughly. On the one hand, the Thomas analysis appears to use an unconventional approach to hypothesis testing. Further, the use of the Weibull Distribution is questionable. For shape factor b = 1, the Weibull becomes the exponential distribution, which is characterized by a constant failure rate. For other shape factors, the number of packages to be tested is very sensitive to the particular value of this parameter.

Statement of Work

1. Objective

   Assess the feasibility of using failure rate statistics in experimental determinations of waste package life under repository conditions.

2. Tasks

   2.1 Review the Thomas report (Reference 3) and determine whether the argument presented is statistically sound.

   2.2 Determine whether the number of specimens (packages) to be tested could be reduced by using other values for the Weibull parameters in the following ranges:

Desired life, y	L	300-1000
Test duration, y	D	1-10
Overstress factor	f	1-10
Shape factor	b	1-3
Type I error	α	0.05
Type II error	β	Open

2.3 Determine whether the number of specimens (packages) to be tested could be reduced by use of lot acceptance sampling plans as per Reference 4.

2.4 Assess the theoretical applicability of particular distributions to waste package failures. Include at least the Weibull and its special cases. For example, should the exponential distribution be considered as inapplicable because it requires that the failure rate be constant and it implies failed specimens are replaced?

3. Report and Schedule

Work performed and results obtained shall be documented in a letter report by October 10, 1986 and should ultimately appear in the semi-annual report that will be due in May 1987.

4. Resources

It is anticipated that the work outlined in Section 2 will require one man-month of professional time plus secretarial support.

REFERENCES

1. Environmental Assessment, Deaf Smith County Site, Texas, May 1986. U.S. Department of Energy, Office of Civilian Radiactive Waste Management, Washington, DC.

2. Title 10, Code of Federal Regulations, January 1, 1986. Office of the Federal Register, National Archives and Records Administration, Washington, DC.

3. Thomas, R.E., A Feasibility Study Using Hypothesis Testing to Demonstrate Containment of Radionuclides Within Waste Packages, BMI/ONWI-599, April 1986. Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

4. Duncan, A.J., Quality Control and Industrial Statistics. Part II. Lot Acceptance Sampling Plans. Revised 1959. Richard D. Irwin, Inc., Homewood, IL.

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