UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 0 1 1983

Reference (410)

WMLL: 207.1

MEMORANDUM FOR: T. P. Speis, Director
Division of Safety Technology

FROM: Robert E. Browning, Acting Director
Division of Waste Management

SUBJECT: DRAFT REPORT ON THE PRIORITIZATION OF NON-NRR TMI ACTION PLAN ITEMS

Emmit
Include in 0933 only if it won't delay our schedule for submitting to EDO.
Will do!
RCE 4/12/83

In response to your memorandum dated March 4, 1983, we have reviewed the draft report entitled, "A Prioritization of Non-NRR TMI Action Plan Items."

In order to reflect completion of the Branch Technical Position (BTP) referenced in item IV.C.1, we suggest modifying the task description and reference section. We are enclosing a suggested mark-up for this section and a copy of the completed BTP.

If you have any questions, please contact Mr. Robert Browning at 427-4200 or Mr. Timothy C. Johnson at 427-4697.

Edward F. Hawkins
for Robert E. Browning, Acting Director
Division of Waste Management

Enclosure: As stated

NUREG

RES-2D-3

TASK IV.C: EXTEND LESSONS LEARNED TO LICENSED ACTIVITIES OTHER THAN POWER REACTORS

The objective of this task is to assure that the lessons learned from TMI are applied to other NRC programs.

ITEM IV.C.1: EXTEND LESSONS LEARNED FROM TMI TO OTHER NRC PROGRAMS

DESCRIPTION

This TMI Action Plan Item[48] required that lessons learned from TMI be extended to other key NRC programs where a potential exists for nuclear accidents including, but not restricted to, the transportation of nuclear materials, waste management, research reactors, fuel facilities, and Category I materials licensees. An NRC study was to be performed to identify the lessons learned from TMI and the resulting agency actions to determine if NRC policies and practices related to key programs, other than light-water power reactor safety, should be revised and upgraded.

A~~s a result of studies performed by NMSS~~, a ~~Draft~~ Branch Technical Position (BTP) on Waste Form[249] was COMPLETED IN FEBRUARY 1983 ~~prepared and issued for comments on October 30, 1981.~~ This BTP incorporates the resin degradation experience gained from the EPICOR-II system design used at TMI-2. ~~and is scheduled for completion in February 1983.~~[410]

CONCLUSION

The resolution of this item is available.

REFERENCES

48. NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident," U.S. Nuclear Regulatory Commission, May 1980.

249. ~~Draft~~ Branch Technical Position on Waste Form, Office of Nuclear Materials Safety and Safeguards, U.S. Nuclear Regulatory Commission, ~~October 30, 1981.~~ FEBRUARY 14, 1983.

410. Memorandum for H. Denton from J. Martin, "Prioritization of Non-NRR TMI Action Plan Items," December 30, 1982.

Branch Technical Position on Waste Form

A. Introduction

The regulation, "Licensing Requirements for Land Disposal of Radioactive Waste," 10 CFR Part 61, establishes a waste classification system based on the radionuclide concentrations in the wastes. Class B and C waste are required to be stabilized. Class A waste have lower concentrations, are segregated, and do not require stabilization. All Class A liquid wastes, however, require solidification or absorption to meet the free liquid requirements. Structural stability is intended to ensure that the waste does not degrade and promote slumping, collapse, or other failure of the cap or cover over the disposal trench and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder since it provides greater assurance that the waste form will be recognizable and nondispersable during its hazardous lifetime. Structural stability of a waste form can be provided by the waste form itself (as with large activated stainless steel components), by processing the waste to a stable form (e.g., solidification), or by emplacing the waste in a container or structure that provides stability (e.g., high integrity container).

This technical position on waste form has been developed to provide guidance to both fuel-cycle and non-fuel-cycle waste generators on test methods and criteria for waste forms acceptable to the NRC staff for implementing the 10 CFR Part 61 waste form requirements. It can be used as an acceptable approach for demonstrating compliance with the 10 CFR Part 61 waste stability criteria. This position includes guidance on the processing of wastes into an acceptable, stable waste form, the design of acceptable high integrity containers, the packaging of filter cartridges, and minimizing the radiation effects on organic ion-exchange resins.

It is the intent of the NRC staff to add other guidance on waste form in additional technical positions as is necessary to address other pertinent waste form issues.

B. Background

Historically, waste form and container properties were considered of secondary importance to good site selection; the combination of a properly operated site having good geologic and hydrologic characteristics were considered the only barriers necessary to isolate low-level radioactive wastes from the environment. Experience in operating low-level waste disposal sites indicated that the waste form should play a major role in the overall plan for managing these wastes.

The regulation for near-surface disposal of radioactive wastes, 10 CFR Part 61, includes requirements which must be met by a waste form to be acceptable for near-surface disposal. The regulation includes a waste classification system which divides waste into three general classes: A, B, and C.

The classification system is based on the overall disposal hazards of the wastes. Certain minimum requirements must be met by all wastes. These minimum requirements are presented in Section 61.56(a) and involve basic packaging criteria, prohibitions against the disposal of pyrophoric, explosive, toxic and infectious materials, and requirements to solidify or adsorb liquids.

In addition to the minimum requirements, Class B and C wastes are required to have stability. As defined in Section 61.56(b) of the rule, stability requires that the waste form maintain its structural integrity under the expected disposal conditions. Structural stability is necessary to inhibit slumping, collapse, or other failure of the disposal trench resulting from degraded wastes which could lead to water infiltration, radionuclide migration, and costly remedial care programs. Stability is also considered in the intruder pathways where it is assumed that after the active control period wastes are recognizable and, therefore, continued inadvertent intrusion is unlikely. To the extent practical Class B and C waste forms should maintain gross physical properties and identity over a 300 year period.

In order to ensure that Class B and C waste or its container will maintain its stability, the following conditions need to be met:

a. The waste should be a solid form or in a container or structure that provides stability after disposal.

b. The waste should not contain free standing and corrosive liquids. That is, the wastes should contain only trace amounts of drainable liquid, and in no case may the volume of free liquid exceed one percent of the waste volume when wastes are disposed of in containers designed to provide stability, or 0.5 percent of the waste volume for solidified wastes.

c. The waste or container should be resistant to degradation caused by radiation effects.

d. The waste or container should be resistant to biodegradation.

e. The waste or container should remain stable under the compressive loads inherent in the disposal environment.

f. The waste or container should remain stable if exposed to moisture or water after disposal.

g. The as-generated waste should be compatible with the solidification media or container.

A large portion of the waste produced in the nuclear industry is in a form which is either liquid or in a wet solid form (e.g., resins, filter sludge, etc.) and requires processing to achieve an acceptable solid, monolithic form for burial. The liquid wastes, irregardless of its classification, are required to be either absorbed or solidified. In order to assure that the solidification process will consistently produce a product which is acceptable for disposal and will meet disposal site license conditions a process control program should be used. General requirements for process control programs are provided in the NRC Standard Review Plan 11.4, "Solid Waste Management Systems," (NUREG-0800[1]) and its accompanying Branch Technical Position ETSB 11-3, "Design Guidance for Solid Waste Management Systems Installed in Light-Water-Cooled Nuclear Power Reactor Plants," (revised in July 1981). These documents may also be used as the basis for individual solidification process control programs by other fuel-cycle and by non-fuel-cycle waste generators who would solidify wastes. The guidance in this technical position should be the basis for qualifying process control programs for Class B and C wastes. The use of applicable generic test data (e.g., topical reports) may be used for process control program qualification. Process control programs for solidified Class A waste products, which are segregated from Class B and C wastes, need only demonstrate that the product is a free standing monolith with no more than 0.5 percent of the waste volume as free liquid.

An alternative to processing some Class B and C waste streams, particularly ion exchange resins and filter sludges, is the use of a high integrity container. The high integrity container would be used to provide the long-term stability required to meet the stability requirements in 10 CFR Part 61. The design of the high integrity container should be based on its specific intended use in order to ensure that the waste contents, as well as interim storage and ultimate disposal environments, will not compromise its integrity over the long-term. As with waste solidification, a process control program for dewatering wet solids should be developed and utilized to ensure that the free liquid requirements in 10 CFR Part 61 are being met.

C. Regulatory Position

1. Solidified Class A Waste Products

   a. Solidified Class A waste products which are segregated from Class B and C wastes should be free standing monoliths and have no more than 0.5 percent of the waste volume as free liquids as measured using the method described in ANS 55.1.[2]

   b. Solidified Class A waste products which are not segregated from Class B and C wastes should meet the stability guidance for Class B and C wastes provided below.

2. Stability Guidance for Processed (i.e., Solidified) Wastes

   a. The stability guidance in this technical position for processed wastes should be implemented through the qualification of the individual licensee's process control program. Through the use of a well designed and implemented process control program, frequent requalification to demonstrate stability is expected to be unnecessary. However, process control programs should include provisions to periodically demonstrate that the solidification system is functioning properly and waste products continue to meet the 10 CFR Part 61 stability requirements. Waste specimens should be prepared based on the proposed waste streams to be solidified and based on the range of waste stream chemistries expected. The tests identified may be performed on radioactive or non-radioactive samples.

   b. Solidified waste specimens should have compressive strengths of at least 50 psi when tested in accordance with ASTM C39[3]. Compressive strength tests for bituminous products should be performed in accordance with ASTM D1074[4].

Many solidification agents will be easily capable of meeting the 50 psi limit for properly solidified wastes. For these cases, process control parameters should be developed to achieve the maximum practical compressive strengths, not simply to achieve the minimum acceptable compressive strength.

c. The specimens for each proposed waste stream formulation should remain stable after being exposed in a radiation field equivalent to the maximum level of exposure expected from the proposed wastes to be solidified. Specimens for each proposed waste stream formulation should be exposed to a minimum of 10^8 Rads in a gamma irradiator or equivalent. If the maximum level of exposure is expected to exceed 10^8 Rads, testing should be performed at the expected maximum accumulated dose. The irradiated specimens should have a minimum compressive strength of 50 psi following irradiation as tested in accordance with ASTM C39 or ASTM D1074.

d. Specimens for each proposed waste stream formulation should be tested for resistance to biodegradation in accordance with both ASTM G21[5] and ASTM G22[6]. No indication of culture growth should be visible. Specimens should be suitable for compression testing in accordance with ASTM C39 or ASTM D1074. Following the biodegradation testing, specimens should have compressive strengths greater than 50 psi as tested using ASTM C39 or ASTM D1074.

For polymeric or bitumen products, some visible culture growth from contamination, additives or biodegradable components on the specimen surface which do not relate to overall substrate integrity may be present. For these cases, additional testing should be performed. If culture growth is observed upon completion of the biodegradation test for polymeric or bitumen products, remove the test specimens from the culture, wash them free of all culture and growth with water and only light scrubbing. An organic solvent compatible with the substitute may be used to extract surface contaminants. Air dry the specimen at room temperature and repeat the test. Specimens should have observed culture growths rated no greater than 1 in the repeated ASTM G21 test, and compressive strengths greater than 50 psi. The specimens should have no observed growth in the repeated ASTM G22 test, and a compressive strength greater than 50 psi. Compression testing should be performed in accordance with ASTM C39 or ASTM D1074

If growth is observed following the extraction procedure, longer term testing of at least six months should be performed to determine biodegradation rates. The Bartha-Pramer Method[7] is acceptable for this testing. Soils used should be representative of those at burial grounds. Biodegradation extrapolated for full-size waste forms to 300 years should produce less than a 10 percent loss of the total carbon in the waste form.

e. Leach testing should be performed for a minimum of 90 days in accordance with the procedure in ANS 16.1[8]. Specimen sizes should be consistent with the samples prepared for the ASTM C39 or ASTM D1074 compressive strength tests. In addition to the demineralized water test specified in ANS 16.1, additional testing using other leachants specified in ANS 16.1 should also be performed to confirm the solidification agents leach resistance in other leachant media. It is preferred that the synthesized sea water leachant also be tested. It is also preferable that radioactive tracers be utilized in performing leach tests. The leachability index, as calculated in accordance with ANS 16.1, should be greater than 6.

f. Waste specimens should maintain a minimum compressive strength of 50 psi as tested using ASTM C39 or ASTM D1074, following immersion for a minimum period of 90 days. Immersion testing may be performed in conjunction with the leach testing.

g. Waste specimens should be resistant to thermal degradation. The heating and cooling chambers used for the thermal degradation testing should conform to the description given in ASTM B553, Section 3. Samples suitable for performing compressive strength tests in accordance with ASTM C39 or ASTM D1074 should be used. Samples should be placed in the test chamber and a series of 30 thermal cycles carried out in accordance with Section 5.4.1 through 5.4.4 of ASTM B553. The high temperature limit should be 60C and the low temperature limit -40C. Following testing the waste specimens should have compressive strengths greater than 50 psi as tested using ASTM C39 or ASTM D1074.

h. Waste specimens should have less than 0.5 percent by volume of the waste specimen as free liquids as measured using the method described in ANS 55.1. Free liquids should have a pH between 4 and 11.

i. If small, simulated laboratory size specimens are used for the above testing, test data from sections or cores of the anticipated full-scale products should be obtained to correlate the characteristics of actual size products with those of simulated laboratory size specimens. This testing may be performed on non-radioactive specimens. The full-scale specimens should be fabricated using actual solidification equipment.

j. Waste samples from full-scale specimens should be destructively analyzed to ensure that the product produced is homogeneous to the extent that all regions in the product can expect to have compressive strengths of at least 50 psi. Full-scale specimens may be fabricated using simulated non-radioactive products, but should be fabricated using actual solidification equipment.

3. Radiation Stability of Organic Ion-Exchange Resins

In order to ensure that organic ion exchange resins will not produce adverse radiation degradation effects, resins should not be generated that have loadings which will produce greater than 10^8 Rads total accumulated dose. For Cs-137 and Sr-90 a total accumulated dose of 10^8 Rads is approximately equivalent to an 10 Ci/ft^3 concentration. This position is applicable to resins in the unsolidified, as-generated form. In the event that the waste generator considers it necessary to load resins higher than 10^8 Rads, it should be demonstrated that the specific resin will not undergo radiation degradation at the proposed higher loading. The test method should adequately simulate the chemical and radiologic conditions expected. A gamma irradiator or equivalent should be utilized for these tests. There should be no adverse swelling, acid formation or gas generation which will be detrimental to the proposed final waste product.

4. High Integrity Containers

a. The maximum allowable free liquid in a high integrity container should be less than one percent of the waste volume as measured using the method described in ANS 55.1. A process control program should be developed and qualified to ensure that the free liquid requirements in 10 CFR Part 61 will be met upon delivery of the wet solid material to the disposal facility. This process control program qualification should consider the effects of transportation on the amount of drainable liquid which might be present.

b. High integrity containers should have as a design goal a minimum lifetime of 300 years. The high integrity container should be designed to maintain its structural integrity over this period.

c. The high integrity container design should consider the corrosive and chemical effects of both the waste contents and the disposal trench environment. Corrosion and chemical tests should be performed to confirm the suitability of the proposed container materials to meet the design lifetime goal.

d. The high integrity container should be designed to have sufficient mechanical strength to withstand horizontal and vertical loads on the container equivalent to the depth of proposed burial assuming a cover material density of 120 lbs/ft^3. The high integrity container should also be designed to withstand the routine loads and effects from the waste contents, waste preparation, transportation, handling and disposal site operations, such as trench compaction procedures. This mechanical design strength should be justified by conservative design analyses.

e. For polymeric material, design mechanical strengths should be conservatively extrapolated from creep test data.

f. The design should consider the thermal loads from processing, storage, transportation and burial. Proposed container materials should be tested in accordance with ASTM B553 in the manner described in Section C2(g) of this technical position. No significant changes in material design properties should result from this thermal cycling.

g. The high integrity container design should consider the radiation stability of the proposed container materials as well as the radiation degradation effects of the wastes.

Radiation degradation testing should be performed on proposed container materials using a gamma irradiator or equivalent. No significant changes in material design properties should result following exposure to a total accumulated dose of 10^8 Rads. If it is proposed to design the high integrity container to greater accumulated doses, testing should be performed to confirm the adequacy of the proposed materials. Test specimens should be prepared using the proposed fabrication techniques.

Polymeric high integrity container designs should also consider the effects of ultra-violet radiation. Testing should be performed on proposed materials to show that no significant changes in material design properties occur following expected ultra-violet radiation exposure.

h. The high integrity container design should consider the biodegradation properties of the proposed materials and any biodegradation of wastes and disposal media. Biodegradation testing should be performed on proposed container materials in accordance with ASTM G21 and ASTM G22. No indication of culture growth should be visible. The extraction procedure described in Section C2(d) of this technical position may be performed where indications of visible culture growth can be attributable to contamination, additives, or biodegradable components on the specimen surface that do not affect the overall integrity of the substrate. It is also acceptable to determine biodegradation rates using the Bathta-Pramer Method described in Section C2 (d). The rate of biodegradation should produce less than a 10 percent loss of the total carbon in the container material after 300 years. Test specimens should be prepared using the proposed material fabrication techniques.

i. The high integrity container should be capable of meeting the requirements for a Type A package as specified in 49 CFR 173.398(b). The free drop test may performed in accordance with 10 CFR 71, Appendix A, Section 6.

j. The high integrity container and the associated lifting devices should be designed to withstand the forces applied during lifting operations. As a minimum the container should be designed to withstand a 3g vertical lifting load.

k. The high integrity container should be designed to avoid the collection or retention of water on its top surfaces in order to minimize accumulation of trench liquids which could result in corrosive or degrading chemical effects.

l. High integrity container closures should be designed to provide a positive seal for the design lifetime of the container. The closure should also be designed to allow inspections of the contents to be conducted without damaging the integrity of the container. Passive vent designs may be utilized if needed to relieve internal pressure. Passive vent systems should be designed to minimize the entry of moisture and the passage of waste materials from the container.

m. Prototype testing should be performed on high integrity container designs to demonstrate the container's ability to withstand the proposed conditions of waste preparation, handling, transportation and disposal.

n. High integrity containers should be fabricated, tested, inspected, prepared for use, filled, stored, handled, transported and disposed of in accordance with a quality assurance program. The quality assurance program should also address how wastes which are detrimental to high integrity container materials will be precluded from being placed into the container. Special emphasis should be placed on fabrication process control for those high integrity containers which utilize fabrication techniques such as polymer molding processes.

5. Filter Cartridge Wastes

For Class B and C wastes in the form of filter cartridges, the waste generator should demonstrate that the selected approach for providing stability will meet the requirements in 10 CFR Part 61. Encapsulation of the filter cartridge in a solidification binder or the use of a high integrity container are acceptable options for providing stability. When high integrity containers are used, waste generators should demonstrate that protective means are provided to preclude container damage during packaging handling and transportation.

D. Implementation

This technical position reflects the current NRC staff position on acceptable means for meeting the 10 CFR Part 61 waste stability requirements. Therefore, except in those cases in which the waste generator proposes an acceptable alternative method for complying with the stability requirements of 10 CFR Part 61, the guidance described herein will be used in the evaluation of the acceptability of waste forms for disposal at near-surface disposal facilities.

References:

1. NUREG-0800, Standard Review Plan

2. ANS 55.1, "American National Standard for Solid Radioactive Waste Processing System for Light Water Cooled Reactor Plants," American Nuclear Society, 1979

3. ASTM C39, "Compressive Strength of Cylindrical Concrete Specimens," American Society for Testing and Materials, 1979

4. ASTM D1074, "Compression Strength of Bituminous Mixtures," American Society for Testing and Materials, 1980

5. ASTM G21, "Determining Resistance of Synthetic Polymeric Materials to Fungi," American Society for Testing and Materials, 1970

6. ASTM G22, "Determining Resistance of Plastics to Bacteria," American Society for Testing and Materials, 1976

7. R. Bartha, D. Pramer, "Features of a Flask and Method for Measuring the Persistance and Biological Effects of Pesticides in Soils," Soil Science 100 (1), pp-68-70, 1965

8. ANS 16.1, "Measurement of the Leachability of Solidified Low-Level Radioactive Wastes," American Nuclear Society Draft Standard, April 1981

9. ASTM B553, "Thermal Cycling of Electroplated Plastics," American Society for Testing and Materials, 1979