U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: ALTERNATE WASTE PACKAGE MATERIALS CONCEPTS

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JANUARY 18-19, 1990

Reasons for an Alternate Materials Program

- Meets a regulatory requirement [10 CFR 60.21 (c)(1)(ii)(D)].
- Protects against a different set of environmental circumstances
  - More water
  - More aggressive water chemistry.
  - Higher loads.
- Performance assurance
  - Containment and release requirements may not be met by metal barrier.
- Provides licensing conservatism
  - Redundant design.

Alternate Container Material Selection

- Screening of concepts.
- Criteria development.
- Degradation mode surveys.
- Parametric testing.
- Selection.
- Performance testing and development of models for performance assessment.

Accomplishments

- SIP written and approved.
- SIP revised to 1988-89, Rev. 2 QA plan.
- Activity plan written.
  - QALA's assigned and graded.
- Ceramic studies initiated
  - Workshop conducted.
  - Trip to Sweden to review their container progress.
  - Candidate manufacturer survey completed.
  - Closure study started
    - Closure model report written.
- Graphite workshop conducted.
- Prepared to reassign task to M&O
  - Prepared turn over package.

Alternate Container Material Concepts Considered

- Ceramics.
- Graphites.
- Bimetals.
- Single metals.
- Coatings.
- Fillers.
- Thicker wall metals. – e.g. canada 4" thick copper compare 3 cm

Ceramic

- Primary candidates include alumina and titania.

- Both alumina and titania have superior corrosion resistance than metals.

  - Swedish immersion tests
    - <1 mm per 10,000 years for alumina.
    - $<10^{-12}$ mm per 10,000 years for titania.

- Delayed failure due to defects can be eliminated by minimization of resudual stress during fabrication and closure.

- Fabrication technology and mass production of high quality alumina is well understood.

- Closure is major concern, but fabrication of containers from either alumina or titania appears feasible.

Ceramic Study

- Workshop at LLNL - November 2, 1988.
- Alumina and Titania.
- RFP issued
  - Fabricate half-scale demonstration containers.
  - Specifications and drawings prepared.
- LLNL closure studies initiated.
  - Requisitions placed for parts and supplies.
- Preliminary NDE study initiated.
  - Concerns:
    - Residual stress.
    - Voids.
    - Defects.
- Preliminary HIP study for closure initiated.
  - Localized heating.
  - Non-uniform thermal stress.
  - Compressive pressures.
    - Up to 30 KSI available for closure.

Candidate Ceramic Manufacturer Survey

- Six U.S. alumina fabricators contacted
  - GTE Wesgo.
  - McDaniel Refractory Company.
  - Industrial Materials Technology.
  - International Pressure Services.
  - Coors Ceramics.
  - ABB Autoclave Systems.
- Favorable response for the feasibility of fabricating half-size alumina or graphite containers.
- Received commitments from these fabricators for long-term participation.

LLNL Ceramic Closure Study

- High quality closure at temperatures <650°C are feasible.
  - Lower temperatures are necessary to protect spent fuel package.
- 30 KSI pressure using HIP is a key factor in closure consideration.
- For metal to ceramic closure single phase bonding is important.
- Matching of thermal expansion is necessary.
- Developed two closure techniques.

Graphite Workshop

- LLNL - November 17, 1988.
  - 25 Participants.
  - 16 From outside LLNL.
- Issues considered:
  - Aqueous corrosion and oxidation resistance.
  - Mechanical strength and fracture toughness.
  - Remote handling and closure.
  - Permeability to gasses and liquid water.
  - Fabrication, cost, and availability.
  - Annual allowable container failure rates.
  - Fire safety resistance.
  - Irradiation effects.
- Graphite should be considered.
  - Studies should be initiated.

Bimetals

- Double-walled container fabricated separately (or by diffusion bonding) using standard techniques.

- Outer (anodic) liner provides containment at high temperatures and gamma dose rates. Inner (cathodic) liner provides long-term stability at low temperatures and gamma dose rates.

- Possible candidates include nickel and iron-base alloys versus copper alloys, and mild or low alloy steel versus a nickel-base alloy.

- Must predictably resist galvanic attack and localized corrosion.

- Considered a promising alternative concept.

Single Metals

- Single-wall container of similar configuration to present container candidate materials.
  - Interpretation of containment requirements may change.
  - More in-depth knowledge of degradation mode scenarios
    - e.g. MIC.
  - Closure process may indicate some problems with some materials.
  - Technological advancements.
- Possible candidates include Monel, Titanium Alloys, and Hastelloys (e.g. C-22).

Coatings

- Protective corrosion-resistant layers applied or deposited directly onto the inside or outside wall of the container.
- Possible candidates include ceramics (oxides or nitrides) and metallics (aluminum or Ni-Cr-Al).
- Must demonstrate closed porosity and substrate adherance and possess crack and corrosion resistance.

Fillers

- Continuous or discontinuous solids that fill the void spaces within a container to provide mechanical support and load damping.
- Also provides long-term protection against corrosion and radionuclide release in the continuous form.
- Possible candidates include magnetite, glass, aluminum, copper, lead, and zinc.
- Must demonstrate compatibility, wetability, and void detectability.

Summary

- A container materials alternate concepts program was established.
- A turn over package was prepared for reassignment of the program to an M&O.
- Planning documents are in place to conduct the program under 1988-89, Rev. 2 QA Plan.