HANDLING, SHIPPING AND R&D DISPOSITION OF SPECIAL TMI-2 WASTES

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ABSTRACT

The March 1979 TMI-2 accident and cleanup activities to date have generated some radioactive wastes that are not typical of those wastes produced by normal light-water reactor operations. The U.S. Department of Energy, through its subcontractor, EG&G Idaho, is conducting research and development activities to effectively deal with the unique technical problems associated with safe handling, shipping, storage, and disposal of these special wastes. This paper includes an identification of the various types of special waste at TMI-2, a discussion of the associated technical problems, and a description of the research and development activities being performed.

BACKGROUND

In March 1982, the U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC) developed and signed a Memorandum of Understanding for dealing with Three Mile Island Unit 2 (TMI-2) accident-generated solid radioactive waste. The agreement allows the DOE to perform research and development activities associated with these special TMI-2 solid wastes. The information obtained from these activities will be of generic benefit to the light water reactor industry and will advance accident-radioactive waste management practices. Examples of these special TMI-2 wastes include:

- EPICOR II System wastes
- Submerged Demineralizer System (SDS) wastes
- Makeup and Purification System resins and filters
- Transuranic contaminated wastes.

The DOE research and development activities involving EPICOR II and SDS waste include TMI on-site preparations, packaging, and shipping to a DOE facility for characterization, waste immobilization studies, and disposal demonstrations. The Makeup and Purification System filters removed in 1982 are presently undergoing characterization. The purification demineralizer resins required research and development activities to conduct the in situ characterization necessary for planning the removal and shipment of these wastes to a DOE facility for studies and disposition. Present plans call for transuranic contaminated wastes to be characterized and stored at a DOE facility.

EPICOR II SYSTEM WASTES

Shortly after the March 1979 TMI-2 accident, more than 1900 m^3 of contaminated accident-generated water in the Auxiliary and Fuel Handling Buildings was decontaminated using a three-stage ion exchange system called EPICOR II. The first stage or prefilter removed the majority of the radioactivity, predominantly cesium and strontium, and resulted in a waste form more highly loaded with radioactivity than is normally encountered in the commercial nuclear power industry.

The major concerns associated with these highly loaded EPICOR II wastes include:

- Container or liner integrity
- Ion exchange media stability
- Generation of combustible gases
- Suitability for commercial land burial.

In order to address these concerns, DOE conducted characterization studies on two worst case liners. The first of these liners, prefilter number 16 (PF-16), was selected because its high curie loading of 2270 Ci and low residual water pH of 2.79 indicated that it would be the liner most susceptible to degradation. In May 1981, PF-16 was shipped to Battelle Columbus Laboratories (BCL) for characterization studies.

Prior to shipment, the PF-16 liner was vented for one hour by fully removing the liner vent plug. One of the preliminary characterization tasks involved obtaining a gas sample from the void space above the ion exchange media. Analysis of this sample indicated a concentration of 12.4% hydrogen in the liner. Other characterization tasks included liquid sampling, comprehensive visual examinations of the visible interior and exterior surfaces, and ion exchange media core sampling, examinations, and analysis. These examinations and analysis indicate no significant liner corrosion and no ion exchange media physical degradation.

The confirmed presence of hydrogen in PF-16 and the potential for combustible gases in other EPICOR II liners prompted the decision that all liners would require sampling, venting, and inerting with nitrogen gas prior to their shipment from TMI. To accomplish this shipment preparation task, a prototype gas sampler (PGS) was developed at the Idaho National Engineering Laboratory (INEL).

The PGS was designed to remotely remove and reinstall the liner vent plug, sample the gas for analysis, and safely inert the liner with nitrogen gas to ensure safe shipments. A concrete shielding structure or blockhouse was built to support the PGS and to position the assembly over the liner stored in

a concrete module at the TMI solid waste staging facility. The PGS is lowered and roughly aligned over the liner vent plug using the liner lifting lugs as guides. Precise positioning of the tool tip over the vent plug is accomplished using remote TV cameras and air-driven motors with threaded adjustments. The blockhouse and module are then inerted with nitrogen gas. After the blockhouse and module have been inerted, the liner vent plug is removed and lifted clear of the port using an air-driven torque wrench. Plug removal is followed by gas sampling and inerting the liner with nitrogen until the hydrogen concentration has been reduced to less than 1%. The first liner prepared for shipment using the PGS was prefilter number 3 (PF-3), the second worst case liner used in the EPICOR II characterization studies. Gas analysis performed 16 days after PF-3 was inerted at TMI showed hydrogen concentration had not increased above 1%. This fact indicates that inerting EPICOR liners using the PGS will effectively minimize the hydrogen buildup hazard during shipping of these wastes.

PF-3 differs from PF-16 in that PF-16 contained both organic resin and inorganic zeolite, while PF-3 only contained organic resin and was in storage at TMI for a longer period. The characterization of PF-3 concluded that this all organic resin liner showed slightly more corrosion than PF-16; however, there was no evidence that the liner integrity was being compromised.

The remaining liners at TMI are being shipped to INEL, where they will be stored and used as part of a research and development program. This program will include studies of liner integrity by destructive examination, ion exchange media stability assessments, solidification tests, and lysimeter tests. It is expected that the majority of the liners can be disposed of as Class C low level waste in accordance with the proposed classification in 10 CFR 61.

A special High Integrity Container (HIC) is being developed by INEL for the disposition of the EPICOR liners by shallow land burial. The HIC is an internal-steel-jacketed reinforced-concrete overpack container approximately 2.1 m high and 1.6 m in diameter. The HIC is equipped with a special positive pressure hydrophobic gas ventiliation system installed in the lid. The development and use of a High-Integrity Container will provide an alternative to the immobilization of ion exchange resins such as EPICOR II and will permit disposal of these resins at a commercial disposal facility as Class C wastes. The overpack is an efficient barrier to intruders and will effectively provide for waste stability for 300 years--approximately 10 half-lives of the major isotopes, cesium and strontium.

SDS WASTES

Approximately 2450 m^3 of contaminated water in the TMI-2 reactor building basement was processed using the Submerged Demineralizer System (SDS). SDS vessels or liners contain a zeolite ion exchange material and have been loaded to as high as 60,000 Ci of cesium and strontium. After removal from service most SDS liners were found to generate hydrogen and oxygen by radiolytic disassociation of the residual water in the liner. This radiolytic process could produce unsafe gas concentrations in the liners during shipment. The gas generation rate was found to depend upon the curie loading and residual water content in the liner. Consequently, research and development activities were necessary to deal with this problem and to ensure safe shipment and disposal of these liners.

Several possible solutions were identified. These solutions included:

- In situ drying with dry air and pressurizing with dry nitrogen
- Self-drying by radiolysis, a process calculated to require 8 years
- Purging or elution drying, using carbon monoxide and carbon dioxide
- Suppression of radiolysis in a water-filled SDS liner by adjusting the water to an alkaline pH by adding ammonia or hydrogen
- Vacuum drying, assisted by self-heating from radioactive decay
- Catalytic recombination of the gas performed in conjunction with vacuum drying

Extensive analyses of these possible solutions by DOE technical experts concluded that the catalytic recombiner and vacuum drying approaches, used together, constituted the best alternative for maintaining the radiolytic gases at safe concentrations during shipment and burial.

The vacuum outgassing system for drying the SDS zeolites was designed and fabricated for DOE by Westinghouse Hanford Company (WHC). The platinum/palladium catalyst selected for testing and use is a commercially available compound supplied by Englehard Industries. The catalyst insertion tool used for adding the catalyst into the Johnson screen in the SDS liners was designed and fabricated by Rockwell Hanford Operations (RHO). Testing of the catalyst recombiner and vacuum outgassing approach included:

- Testing of the vacuum outgassing equipment
- Testing of the platinum/palladium coated alumina-oxide catalyst under expected operating conditions
- Testing of the catalyst at atmospheric pressure to simulate a failed liner and cas
- Testing of the catalyst in an accident scenerio upside-down test.

During testing, it was found that approximately 229 cm^3 of catalyst would effectively recombine the maximum anticipated gas generated in all SDS liners. To date the highest observed gas generation rate has been 1250 cc/hr; however, the catalyst recombiner was tested at simulated rates of 3000 cc/hr of hydrogen and oxygen.

Prior to shipment, the SDS zeolite is dried by vacuum outgassing at a water removal rates between 5 and 10 kilograms per day. This removal rate varies with the decay heat generated in a liner which is dependent on curie loading. When drying is complete, the liner is brought to atmospheric pressure, the catalyst is added and the vacuum outgassing is then repeated for a minimum of four hours to ensure that the catalyst is dry. The gas pressure in the first SDS liner prepared by vacuum-outgassing and catalyst

addition was monitored during a two week observation period to demonstrate the effectiveness of catalytic recombination in TMI SDS liners for a period twice the estimated shipment time. Subsequent SDS liners prepared in this manner will also be monitored prior to shipment.

A low curie liner, loaded with 13,000 curies, did not require use of a catalyst for combustible gas concentration control. It was prepared by inerting with nitrogen prior to shipment to Pacific Northwest Laboratory (PNL) for zeolite vitrification process demonstrations. The vitrification process effectively immobilizes the spent zeolites in a glass matrix. The first vitrification demonstration using SDS wastes was conducted in the summer of 1982. Samples from the resulting glass log were leach tested. The observed leach rates were comparable with Defense Department high level waste glass logs. Two additional liners, each with total curie loadings of approximately 112,000 Ci of Cs, Sr, and daughters will also be vitrified. The vitrified zeolite logs will be sampled, analyzed, and made available as test materials to the Test and Evaluation Geologic Facility.

The remaining SDS liners will be shipped to RHO and buried in a retrievable three foot thick steel reinforced concrete shielding container. This disposal technique will require the use of the catalyst recombiner to control liner pressure during burial. An additional long term safety precaution required the installation of a rupture disc filter assembly at the end of the vent hose attached to each liner. These SDS waste packages will be buried under approximately 3 m of soil at a DOE low level waste facility. Pressure and temperature in a representative buried liner will be monitored for several years.

MAKE-UP AND PURIFICATION SYSTEM WASTES

The TMI-2 reactor plant Makeup and Purification System was highly contaminated during the accident with both fuel particles and fission products. Research and development efforts to date have focused on characterization of the system's filters and demineralizer resin bed.

The makeup filters were removed from the plant and shipped to INEL for analysis. These analyses showed the paper media were degraded and had stripped away from the filter support structure. This degraded condition indicated that the filters were ineffectual in preventing fuel particles from reaching the demineralizer resins. Approximately 10,000 Ci of Cs and Sr are estimated to be contained in each demineralizer. The estimated amount of fuel contained in the demineralizers is 1.3 ± 0.6 kg in demineralizer A and 3.9 ± 1.5 kg in demineralizer B.

Other studies in which resins received an integrated dose of 1.7×10^9 rads while at various temperatures have determined the probable effect on the resins. The results of these studies indicate that the possibility for removing the resins by sluicing is favorable. Once removed, nondestructive analysis of the resins will determine the transuranic content and eventual disposition plans. Possible plans include vitrification in a planned PNL liquid-fed ceramic melter or solidification studies using cement or Dow polymer.

The ongoing research and development activities associated with handling, shipping and disposition of special TMI-2 wastes are providing information of generic benefit to the nuclear power industry. By identifying viable alternatives for handling these wastes, these activities have also made valuable contributions to the advancement of accident radioactive waste management practices.