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DEVELOPMENT OF A HIGH INTEGRITY CONTAINER FOR STORAGE, TRANSPORTATION, AND DISPOSAL OF RADIOACTIVE WASTES FROM THREE MILE ISLAND UNIT II

MASTER

R. E. Holzworth,
R. L. Chapman and H. M. Burton
EG&G Idaho, Inc.

Dr. W. W. Bixby
Department of Energy/TMI

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DISCLAIMER

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INTRODUCTION

In August of 1980, General Public Utilities Nuclear Corporation (GPUNC) completed the cleanup of contaminated water in the Auxiliary Building resulting from the March 28, 1979 accident at Three Mile Island. The EPICOR II ion exchange system used to decontaminate approximately 1900 m^3 of contaminated water in the Auxiliary and Fuel Handling Building (AFHB) generated 50 highly loaded and 22 lesser loaded organic resin liners. The 22 lesser loaded resins were shipped to a commercial disposal site, but the highly loaded liners have been stored on the island since their generation. One highly loaded liner, or prefilter, was shipped to Battelle Columbus Laboratories (BCL) in May, 1981 as part of the United States Department of Energy (DOE) Three Mile Island Information and Examination Program. The prefilter is being characterized to determine the behavior of the waste form with respect to time and the internal environment and to provide an information base for use in management and regulatory decisions relative to the storage, processing, and disposal of these wastes.

WASTE FORM CHARACTERIZATION

The first stage EPICOR II ion exchange prefilters were custom-designed to optimize cesium and strontium removal from individual batches of AFHB accident water and consist of layers of inorganic ion exchange media and/or anionic and cationic organic resins. Each vessel has an internal volume of 1.42 m^3 and contains 0.91 m^3 of ion exchange media with approximately 1300 Ci of gamma activity. These beds performed well relative to design predictions but produced a nonhomogeneous, fairly high specific activity waste form with an average bulk specific activity of about 1412 Ci/m^3. Organic resins routinely generated at other U. S. nuclear power plants do not normally exceed 350 Ci/m^3. At 1412 Ci/m^3, first stage EPICOR II organic resins would have a 300 year (10 halflives of ^{137}Cs) radiation exposure above 10^9 rads and may undergo significant degradation resulting in increased mobility of the collected radionuclides, agglomeration, gas evolution, and potential acid formation. Due to the unique characteristics of these wastes, the U.S. DOE is sponsoring programs, such as the BCL Sorbent Experiments Program, to evaluate their characteristics and to provide a High Integrity Container (HIC) Development Program which would improve waste suitability for disposal at a land burial facility. This paper addresses regulatory considerations, establishment of design criteria, proposed design concepts, system demonstration, and status of the HIC Development Program for storage, transportation, and disposal of high specific activity, low level radioactive wastes from Three Mile Island Unit II as typified by EPICOR II ion exchange media and liners.

REGULATORY CONSIDERATIONS

As noted above, these liners contain 4 to 400 times more long-lived radioactivity than routine power plant wastes, and no regulatory policy for such wastes is presently in place. Regulation and criteria governing disposal of radioactive waste are in a state of definition. The U.S. Nuclear Regulatory Commission (NRC) proposed regulations in 10 Code of Federal Regulations Part 60 for disposal of high level waste and more recently proposed regulations in 10 Code of Federal Regulations Part 61 for classification and disposal of low level waste. Lesser loaded resins from TMI-2 similar to normal reactor wastes are being disposed of at commercial disposal sites per established regulations, provided the risk to the public is similar to that presented by wastes routinely disposed of at these sites. However, due to the special nature and limited application of the highly loaded EPICOR II resins, adequate commercial capability is not available for handling and disposal. As a result of its efforts to develop suitable methods for immobilization and disposal of a wide variety of government and commercial radioactive wastes, the DOE has a combination of established personnel, technological capabilities, and facilities for handling such wastes. The DOE has agreed to accept the highly loaded EPICOR II prefilters and will administer a research and development program to provide a cost-effective disposal option for such wastes.

In January 1980 the low level waste disposal facility-license conditions were amended, defining solidification criteria as a free standing monolith void of free water, and set goals to enhance the stability of high concentration waste forms buried in shallow land burial. The U.S. NRC has determined that the highly loaded EPICOR II prefilter media are unsuitable for disposal in routine shallow land burial and must be solidified or immobilized and should be protected from intrusion.

CONCEPT BASIS

Direct solidification technology of high specific activity resins in concrete, bitumin, urea formaldahyde, epoxy, etc., consistent with U.S. regulatory requirements is under investigation. No successful commercial technique for EPICOR II resin solidification has been demonstrated. The HIC concept was selected as an alternative to solidification and other disposal options, such as incineration, vitrification, and elution with subsequent liquid processing, because of improved life cycle costs and manrem exposure considerations. Use of the HIC would lower personnel radiation exposure by eliminating resin handling, such as sluicing, and by eliminating concerns about leachability and chemical and structural integrity. The HIC concept is also much more economical than other immobilization options when considering life-cycle costs.

DESIGN CRITERIA

The HIC will be designed for burial of radioactive dewatered ion exchange media as characterized by the TMI-2 EPICOR II media. To function in this capacity, the containers must be capable of providing immobilization and isolation of the media for a minimum period of 300 years. This is a period of time sufficient to allow the radioactive contaminate to decay to acceptable levels. The HIC must maintain integrity during defined internal, external, natural, and induced environments as well as perform the functional operations during the lifetime of the HIC.

The design criteria shown in Table 1 were established by representatives of the DOE, national laboratories, the waste disposal facility, the Atomic Industrial Forum, utilities, Edison Electric Institute, and private industry.

Table 1

HIC REQUIREMENTS

Functional Requirements

Life Expectancy:	300 years at 15 to 30 meters with 20% safety margin allowance for corrosion rate
Containment Integrity:	Retain liquids and solids with controlled venting of gases
Lifting Provisions:	Recessed attachments allowing stacking and vertical lifting accelerations of 3g
Stacking:	Vertical array to a height of 6 containers
Weight:	Transportable by legal weight truck shipment (33,320 Kg GVW)
External Contour:	No entrapment or retained water and minimal void space formation due to backfilling
Bulk Density:	Specific gravity greater than 1.2

Internal Environment

Initial Heat Generation:	8 watts maximum
Atmosphere:	hydrogen, sulfer oxide, methane, nitrogen oxide, carbon monoxide, carbon dioxide, and tritium
Chlorice content:	2-200 ppm

Table 1 (Continued)

pH:	2 to 11 (free liquid)
Water:	less than 1% by volume occupied by resin of free standing liquid
Maximum Dose Rate:	1350 rad/hr on contact
Major Isotopic Contents:	192 Ci of ^{134}Cs 869 Ci of ^{137}Cs 15 Ci of ^{89}Sr 49 Ci of ^{90}Sr 0.27 Ci/ml of $^{3}H^{1}$ 50 Ci of ^{90}Y 820 Ci of ^{137}Ba
Total Integrated Dose:	10^9 rad Beta and 10^9 rad Gamma at the end of 300 years
Internal Pressure:	68.9 kPa

External Environment

Soil Temperature:	$20^{\circ} \pm 10^{\circ}C$
Soil Oxygen Content:	0 to 3 mg/liter
Soil Chloride Content:	0 to 300 ppm
Soil pH:	4.0 to 9.0
Water Content:	0 to saturated
Lithostatic Pressure:	662 kPa (15 to 30 meters burial depth)

Table 1 (Continued)

Stacking Pressure:	234 kPa (six containers)
Hydrostatic Pressure:	296 kPa
Combined Pressure:	1034 kPa uniform (include lithostatic, stacking, and hydrostatic pressures)

Storage & Transportation Environment

Temperature:	$-40^{o}C$ to $54^{o}C$
Solar Heat (top):	3.35×10^{7} Joule/m^2 per 12 hr day
Solar Heat (side):	1.68×10^{7} Joule/m^2 per 12 hr day
Freeze/Thaw Cycling	60 cycles over a 10 year period

General Requirements

- o Compatible with existing handling equipment at the reactor, storage and disposal sites, and transportation systems.
- o Capable of being loaded at the reactor site.
- o Identified with permanent markings, i.e., loading site, isotopic content, waste form, and source.

PROPOSED DESIGN APPRCACH

The EPICOR II liners will be installed in the HIC and transported in a licensed type B cask to the disposal site. Utilizing conventional burial site material handling and burial equipment, the overpack container is designed to be buried at intermediate depths from 15 to 30 meters.

The HIC is a 2.01 m x 1.56 m diameter right circular cylinder designed to retain liquids and solids for the 300 year lifetime of the container. Gas pressure buildup due to radiolytic decomposition and resin degradation is prevented by use of a vent system which is deactivated during shipping but functional during storage and burial. The vent system includes a porous metal filter and check valve to retain liquids.

Adequate allowance for corrosion compatibility with the specified internal and external environments is provided by the 15 cm reinforced concrete wall, the stainless steel primary liner, and the high density polyethylene secondary liner. The concrete outer surface is spray-coated with a 0.025 mm epoxy material to provide an additional protection barrier from the burial environment.

The removable composite concrete and polyethylene top permits installation of a liner without exceeding the allowed radiation exposure to operation personnel. Final closure is achieved using an epoxy grout, a seal capable of retaining all liquids and solids during the lifetime of the HIC. The seal is capable of holding 68.9 kPa gas pressure at 14 to 30°C over the 300 year lifetime and at 83°C for 60 days. The exterior surfaces are smooth, free of crevices, uninterrupted, and shaped to prevent retention of water. Lifting mechanisms are provided for handling the container and cover with or without the cover in place.

The HIC structural integrity provides for bearing the weight of six stacked and loaded containers including the specified combined hydrostatic, stacking, and lithostatic pressure of 1034 kPa. The body of the container is designed to withstand static loading while at rest, while being handled, or when it is buried.

A component acceptance and evaluating test program will be conducted to verify the following design parameters:

- o corrosion rate evaluation,
- o response to normal applied stress,
- o corrosion rate versus normal applied stress,
- o pressure and leak rate evaluation,
- o response to simulated accident conditions, and
- o vent system demonstration.

HIC SYSTEM DEMONSTRATION

On behalf of the DOE, EG&G Idaho, Inc. is preparing preliminary plans for demonstrating the qualification of the HIC system disposal concept. These plans propose to bury several loaded containers at intermediate depth and periodically monitor the containers for containment and immobilization characteristics. The burial site geological, hydrological, and meteorological conditions will be recorded for extended periods of time. The resulting information will provide data for acceptance of the HIC system concept for disposal of commercial reactor wastes. Resin wastes of the kind generated at TMI are generic to the commercial nuclear industry and the EPICOR-II liners provide an opportunity for accelerated testing of waste disposal concepts like the HIC.

PROGRAM STATUS

EG&G Idaho, Inc. has awarded a development contract to Nupac, Inc. of Tacoma, Washington. The preliminary designs have been completed and final production drawings and specifications are in preparation. A final design review is scheduled in November of this year with procurement and fabrication to immediately follow acceptance of the design.

The acceptance and evaluation test program will be performed during March and April 1982. An independent laboratory will conduct confirming verification tests. The HIC will be completed in May 1982 and will be available for production for commercial usage.