EXPERIENCES IN DEVELOPMENT, QUALIFICATION, AND USE OF CONCRETE HIGH-INTEGRITY CONTAINERS IN COMMERCIAL DISPOSAL OF RADIOACTIVE WASTES

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ABSTRACT

Disposal of EPICOR prefilters as commercial radioactive wastes is being accomplished by using a first-of-a-kind, reinforced concrete, high-integrity container in lieu of prior in situ solidification of resins before disposal of prefilters. Experiences in developing, testing, certifying, and using high-integrity containers are an untold story worthy of review for the benefit of the nuclear industry at large. The lessons learned in gaining regulatory acceptance of the concrete HIC are discussed in this paper.

INTRODUCTION

In the past four years, much has been written about the EPICOR-II Program at the Idaho National Engineering Laboratory (INEL).[1,2] Disposal of EPICOR-II prefilters from Unit-2 of the Three Mile Island Nuclear Power Station (TMI-2) as commercial radioactive wastes is being accomplished by using a first-of-a-kind, reinforced concrete, high-integrity container in lieu of prior in situ solidification of resins before disposal. Now that the commercial disposal campaign funded jointly by the U.S. Department of Energy (DOE) and General Public Utilities Nuclear is nearing completion, the experience gained in developing, testing, certifying, and using high-integrity containers (HICs) is worth reviewing for the benefit of the nuclear industry at large. The lessons learned from that experience are the thrust of this paper.

Perspective

In 1983, the Nuclear Regulatory Commission (NRC) prepared a technical position paper on implementing waste-form requirements of 10 CFR Part 61.[3] As part of that paper, NRC discussed the structural stability of the waste forms (particularly Class B and C wastes) and advised that waste forms should not either degrade or promote slumping, collapsing, or other failures to caps over disposal pits or trenches. Also, stability of waste forms was discussed in relation to (a) exposure of an inadvertent intruder, and (b) nondispersibility of contaminants during their hazardous lifetimes. NRC noted that structural stability of a waste form either can be provided by the waste form itself (as with large activated stainless steel components or solidification), or ensured by placing the waste in a stable container or structure (e.g., high-integrity container). In the latter case, NRC indicated that the high-integrity container (HIC) should contain less than one percent free liquid by volume of waste, endure a minimum lifetime of 300 years, resist corrosive and chemical effects of both the waste contents and disposal environment, possess sufficient mechanical strength to withstand horizontal and vertical loads on the container equivalent to the depth of disposal, resist biodegradation, consider thermal loads, use construction materials that provide radiation stability, meet requirements for a Type A package, avoid collection or retention of water on its top surfaces, and provide a positive seal for the design lifetime of the container (see Ref. 3 for details).

Although there has been considerable interest in the use of HICs as an alternative to solidifying of ion exchange resins and filter media, HICs have not been used widely in packaging wastes for disposal. At the present time, polyethylene HICs are accepted at the Barnwell disposal facility by the State of South Carolina[4] and the concrete HIC discussed herein is accepted at the commercial disposal facility in Benton County by the State of Washington. The State of Washington also has granted provisional approval for use of a specified number of ferrallium HICs by Nuclear Packaging, Inc. (NuPac) for disposal of specific types of wastes at the commercial disposal facility (personal communication between Harley W. Reno and Mrs. Nancy Kirner, Supervisor, Department of Social and Health Services, 7 February 1985).

Development of Concrete HIC

As part of DOE's involvement in the cleanup of TMI-2, EG&G Idaho, Inc. contracted with Sandia National Laboratories (SNL) in 1981 to develop design requirements for an HIC to be used at a commercial disposal facility for disposing the higher specific activity EPICOR-II prefilters. The resulting requirements were similar to, but more comprehensive than, those adopted by the State of South Carolina[4] and formulated before issuance of the NRC position paper. However, the requirements were developed with cognizance NRC and subjected to extensive peer review.

After a Memorandum of Understanding between DOE and NRC was signed in which DOE agreed to accept 50 EPICOR-II prefilters for research, interim storage, and disposal, a contractor NuPac was selected to render those requirements to design and fabricate therefrom two prototypes for testing. In 1982, NuPac completed construction of both prototypes and initiated testing on the first. It also prepared the second for transport to EG&G Idaho for additional testing. The design requirements, fabrication of prototypes, and initial testing with results are included in Ref. 5.

Meanwhile, Chem Nuclear Systems, Inc. and U.S. Ecology, Inc. (both operators of commercial, low-level radioactive waste disposal facilities) were contacted by EG&G Idaho in early 1982 concerning interest in developing Use Agreements with regulatory agencies of the States of South Carolina and Washington for using concrete HICs. U.S. Ecology was selected to develop and submit an application for a Use Agreement to the Department of Social and Health Services of the State of Washington. The submitted application included a draft of the design analysis report for the concrete HIC, and procedures for disposing HICs at the commercial disposal facility in the State of Washington. The application officially was filed with the Department of Social Health Services in early 1983 and amended in mid-1983.

Discussions were held between DOE and NRC on the design and testing of the HIC from its inception. Comments by NRC on the preliminary design analysis of the concrete HIC were transmitted to DOE in 1982; responses thereto by EG&G Idaho for DOE were returned to NRC later that same year. Discussions held with NRC in 1981 and 1982 apparently contributed to the formulation of design guidelines included in the position paper issued by NRC in 1983, because those adopted by the State of South Carolina, formulated by SNL, and published by NRC are remarkably similar (see Table I).

In April 1983, EG&G Idaho instituted an independent evaluation of the concrete HIC using the second prototype received from NuPac. The evaluation effort by EG&G Idaho involved leak testing of seals, corrosion testing of rebar, and vibration testing of assembled components (viz., filter assembly) fabricated in the lid. Results of that evaluation are included in Refer. 5 and 6. In response to a request from the State of Washington related to use of the container in disposal operations, the second prototype HIC was loaded with 1542 kg of damp sand (simulating the weight of an EPICOR-II liner). The HIC was lifted with a crane and dropped from 7.6 m onto INEL soil (a yielding surface similar to soils found at the commercial disposal facility in the State of Washington). The test sequence is shown in Reference 1. The HIC survived the test while retaining the contents and exhibiting almost no detectable damage; only a small chip of coating and concrete was knocked loose when the rigging cable struck the bottom edge of the container.

Also early in 1983, EG&G Idaho contracted with Bingham Mechanical and Metal Products, Inc. for fabricating two concrete HICs based upon the tested design developed by NuPac. One HIC was selected for use in the disposal demonstration of the first EPICOR-II prefilter (specifically PF-18) planned in 1983 at the commercial facility in the State of Washington. However, that disposal demonstration

TABLE I.

COMPARISON OF DESIGN REQUIREMENTS FOR HICs AMONG SOUTH CAROLINA (SC), SANDIA NATIONAL LABORATORIES (SNL), AND NUCLEAR REGULATORY COMMISSION (NRC)

Requirements	SC	SNL	NRC
Maximum allowable free liquid <1% of waste volume	-	X	X
Minimum design lifetime of 300 years	X	X	X
Resist corrosive and chemical effects of contained waste form and disposal environment	X	X	X
Sufficient mechanical strength to withstand horizontal and vertical loads equivalent to depth of proposed burial	X	X	X
Design mechanical strengths for polymeric material conservatively extrapolated from creep test data	-	-	X
Consider thermal loads from processing, storage, transportation, and burial with container materials tested in accordance with ASTM B553	X	X	X
Consider radiation stability of container materials and radiation degradational effects of wastes ($>10^8$ rads)	-	X	X
Resist biodegradation of container materials	X	-	X
Container and lifting fixtures to withstand forces applied during lifter operations	X	X	X
Avoid collection and retention of water on top surfaces	-	X	X
Provide positive seal for design lifetime of container (passive vents acceptable)	X	X	X
Test prototype to demonstrate ability of container to withstand conditions of waste preparation, handling, transportation, and disposal	-	X	X
Fabricated in accordance with acceptable quality assurance program	-	X	X

was delayed until 1984, because the review and approval process was not complete. The State of Washington, as an NRC Agreement State, solicited technical assistance from NRC in reviewing the concrete HIC and its intended use. That solicitation spawned a critical review of all documentation on the HIC by NRC, and resulted in extensive communications among NRC, State of Washington, U.S. Ecology, NuPac, EG&G Idaho, and DOE. Additional details about that exchange of information is found in Ref. 2.

On 1 February 1984, NRC wrote the State of Washington and recommended approval of using concrete HICs as overpacks in the disposal of EPICOR-II prefilters being stored at INEL. Shortly thereafter, the State of Washington issued to U.S. Ecology, Inc. a Certification of Compliance (in lieu of a Use Agreement) for HICs used in disposal of 50 EPICOR-II prefilters at the commercial facility. That issuance opened the way for conducting the disposal demonstration and started the campaign for disposing the remaining EPICOR-II prefilters during 1984 and 1985.

Lessons Learned

Results of review procedures developed for this container by the State of Washington and NRC established a precedent for evaluating other types of HICs. For example, the 25-ft drop test onto a yielding surface requested by the State of Washington is being required of other HICs. Also regulatory guidelines and requirements found inappropriate (e.g., potential biodegradation) for this container are being reevaluated by the regulatory authority.

Completion of the HIC disposal demonstration did six things: first, it symbolized the end of a complex process which integrated actions of conceptualizing, testing, and using a first-of-a-kind, low-level radioactive waste disposal system at a time when regulatory positions on HICs were not well established, criteria for HICs were still being developed, and concepts of HICs relatively untested. Second, it demonstrated that the HIC is a safe and adequate alternative to solidification of resin waste for disposal and that the remaining EPICOR-II prefilters can be disposed in a similar manner. Third, it ended a process which took four years. [That was made possible through cooperative efforts between federal and state governments, government contractors, a public utility, and several private industries working together for a common goal. The process was a pathfinder which will shorten regulatory deliberation for similar actions in the future.] Fourth, it, along with the disposal campaign, illustrates DOE's effectiveness in assisting in the clean-up of TMI-2, and in obtaining a maximum amount of usable information from an unusual type of nuclear waste. Fifth, it represents fulfillment of an agreement between DOE and the State of Idaho to temporarily store unusual TMI-2 wastes at INEL. And sixth, it exemplifies DOE's effectiveness in helping develop an article of generic benefit to the nuclear industry.

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