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TMI-2 REACTOR FUEL REMOVAL, LOADING, TRANSPORT, AND STORAGE[a]

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ABSTRACT

Preparations and operations are highlighted for loading and transporting TMI-2 reactor core debris and receiving and storing that material at the Idaho National Engineering Laboratory (INEL). The phases of getting canisters from TMI to INEL are discussed. Lessons learned are indicated and benefits derived are noted.

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INTRODUCTION

The accident at Unit 2 of the Three Mile Island Nuclear Power Station (TMI-2) resulted in a severely damaged and highly radioactive reactor core. That presented the engineering and scientific communities with many challenges. Some have been resolved, others are being resolved, and still others have yet to be resolved. Some challenges that have been resolved include storage and disposal of highly contaminated liquids,[1,2] disposal of dewatered but heavily loaded filter systems,[3,4] development of equipment for accessing the damaged core,[5] and remote examination and sampling

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of that core.[6] Challenges now being resolved include removing and packaging the core debris,[7] transporting the debris from TMI to INEL,[9] and receipt and storage of that material at Idaho National Engineering Laboratory (INEL).[10] Challenges yet to be resolved include cleanup of primary cooling system and peripheral in-containment areas, storage and ultimate disposition of abnormal wastes, and repackaging or processing of stored core debris for eventual disposal at a federal repository.

This paper highlights preparations for transporting the TMI-2 core debris from TMI to INEL, and receiving and storing that material at INEL. Challenges discussed include interfacing equipment and facilities at TMI, loading canisters into the cask, developing and testing the cask, and receiving and storage operations at INEL.

PROJECT PHASES

The operational sequence of getting core debris canisters from TMI into safe storage at INEL can be divided into three phases: loading at TMI, transporting between TMI and INEL, and receiving and storing at INEL. Each phase necessitated resolving technical constraints before initiation of operations. The constraints were resolved in straightforward ways, resulting directly in development of hardware, and technology, or and indirectly in regulatory guidelines that will benefit industry and government. Cost benefits were realized through hybridization of programs at INEL, sharing of hardware common to those programs, and use of surplus hardware from previous programs at INEL.

LOADING AT THREE MILE ISLAND

When a decision was made to develop the NuPac 125-B Rail cask, the last technical challenge at TMI was to interface the cask with facilities. Two stipulations included in the restart license for Unit 1 issued by the U.S. Nuclear Regulatory Commission (NRC) limited activities and use of space in the Truck Bay for operations related to Unit 2. Specifically, cask and loading operations in the Truck Bay related to Unit 2 are not to infringe on space dedicated to operation of Unit 1, and operations and equipment must not damage underlying support structures and electrical cabling for Unit 1. In accordance with those stipulations, weight, space, and seismic constraints within the Truck Bay necessitated designing/constructing several pieces of equipment that simultaneously permit passage of the rail cask and railcar, are removable in part, facilitate lifting the rail cask/transport skid assembly from the railcar, and satisfy safe-shutdown earthquake criteria.

At TMI, several activities related to defueling Unit 2, storing canisters, and readying the rail cask for loading occur simultaneously through out the Unit 2 facility, and in and outside the Truck Bay. After a canister is loaded with core debris (a schematic of which is shown in Fig. 1), it is sealed closed, withdrawn from the reactor vessel, and raised into the shielded transfer device. That device conveys the canister to the refueling canal, where it is transferred to the upender and shuttled through the fuel transfer tube from the Reactor Building to the "A" Pool of the Fuel Handling Building. There, the canister is placed in the storage rack. At the appropriate time, it is ~~retrieved,~~ dewatered using forced argon gas, leak-tested and monitored for a perscribed period, and readied for retrieval by the fuel transfer cask.

Meanwhile, in preparation for loading, the overpacks are removed from the rail cask and the railcar with cask is pushed into the Truck Bay under both the tower and cask unloading station. The cask and transport skid are lifted from the railcar, the railcar is withdrawn from the Truck Bay, and the rail cask/transport skid assembly is lowered onto the floor. Next, the cask is rotated to vertical, a platform is bolted to the tower, the cask is opened, and the shielded loading collar is installed (Fig. 2). Then, the mini-hot cell withdraws a shield plug from a predetermined tube in the cask (Fig. 3). The fuel transfer cask retrieves a dewatered and weighed canister from the "A" Pool, transfers it into the cask (Fig. 4), and the shield plug is replaced. The transfer/loading process is repeated six more times until the cask containes seven canisters. After loading is complete, each lid of the rail cask is replaced and leak-tested (leak-tight defined as 10^{-7} atm·cc/s), ensuring that the cask is assembled correctly. The cask is returned to horizontal and lifted, using the cask unloading station. The railcar is retrieved from outside and the cask reattached thereto. The overpacks are placed on the rail cask, and the package is surveyed and certified for release to EG&G Idaho at the front gate of TMI.

Transportation

Transportation aspects of the project involved two separate but interrelated components. The first was evaluating transportation strategies and optimizing numbers of casks and cyclic transcontinental trips needed to move all core debris from TMI to INEL. The second was designing and building a new cask--one that provided double containment of plutonium. The task of licensing that cask by NRC was shortened by building and testing models and full-sized components of the transportation package.

During the planning stages, EG&G Idaho, Inc. (prime contractor of INEL) investigated transporting canisters via truck or rail, using existing casks and/or fabricating and licensing new ones. Whereas available truck-mounted casks could transport one to three canisters each, the cost effectiveness of increased payload capacity of a rail cask resulted in the selection of a rail cask rather than a truck cask. The decision was made to transport canisters in a new design rail cask. Thus, the Nuclear Packaging Inc. (NuPac) 125-B Rail Cask was designed, tested, fabricated, and licensed specifically for tranporting the TMI core debris to INEL (Figures 1 and 2).

Heretofore, licensing a new design cask generally took several years after preliminary design, as well as additional time for fabrication after licensing. However, the NuPac 125-B Rail Cask (Fig. 5) was designed, built, and licensed in less than 24 months (Certificate of Compliance issued by NRC on 11 April 1986). Such an accomplishment was made possible by (a) the combined efforts and professional dedication of several commercial entities, a government contractor, several national laboratories, and two federal agencies; (b) completion of drop tests of the cask and canisters (described in References 11 and 12) in a minimum time period; and (c) the willingness of the contractor (Nuclear Packaging, Inc.) to dedicate its resources to designing, testing, and building the rail cask within the limits of an abbreviated schedule.

Drop testing involved building 1/4-scale models of the rail cask and canisters and subjecting them to a series of five tests at the Transportation Technology Center of Sandia National Laboratories (Fig. 6); then subjecting a full-scale core debris canister to a series of four tests by the Chemical Technology Division of Oak Ridge National Laboratory (Fig. 7). All tests satisfied concerns voiced by NRC regarding structural behavior of the cask and canisters during postulated accident scenarios.

After the decision was made to build the NuPac 125-B Rail Cask, the next activity was to evaluate different transportation strategies; that is, evaluate regular train service or exclusive-use trains and numbers of casks. Into that evaluation was factored the number of casks per shipment, dynamics of canister inventory at TMI, safety considerations, duraction of the transport campaign, and costs and schedules at TMI and INEL. The strategy selected involved using two casks, a combination of exclusive train service by Conrail and regular train service by Union Pacific, one cask per train, and approximately 20 round trips between TMI and INEL per cask.

RECEIPT AND STORAGE

After the rail cask is received at Central Facilities Area (CFA) of INEL, the overpacks are removed and stored. The Gantry crane transfers the cask from the railcar to the truck transporter (Fig. 8). After transfer, the cask is hauled slowly to the Hot Shop of TAN-607 at INEL.

In the Hot Shop, after the cask has been rotated to vertical, tested for internal airborne contamination, and opened, all operations involving manipulation of canisters are conducted remotely. Each canister is withdrawn from the cask, conveyed to the Vestibule of the Water Pit, and lowered into a storage module situated atop an underwater pool cart. Each module holds a maximum of six canisters. When a module is full, each canister is vented and filled with demineralized water. Then, the module is conveyed to the Water Pit, where modules simply are placed together in rows, forming a storage rack. Computer analysis of a module has shown it to be seismically stable and criticality safe in all accident orientations. Once each module is in place, a vent line is connected to each canister.

Storage of TMI core debris at INEL is planned for as long as 30 years. That means all storage equipment, including the canisters, must endure the environment of the Water Pit for 30 years minimum, and stored canisters must be criticality safe under routine situations during that period. About the only maintenance anticipated on hardware will be replacement of seals in the connectors and fittings in the heads of canisters.

LESSONS LEARNED

Important lessons were learned while resolving challenges at TMI and INEL; moreover, others are being learned daily as defueling of the TMI-2 reactor progresses. Some lessons have widespread value and utility for the industry at large and for the regulatory agencies. For example, early in the TMI-2 program it was realized that interfacing equipment with facilities at TMI would be complicated; therefore, intensive and continuous planning, combined with close cooperation between competing organizations at TMI, eventually produced hardware, software, and facility modifications which meshed smoothly. Technical accomplishments at TMI demonstrate that early recognition of complexities followed by detailed planning can resolve perplexing questions. Moreover, resolving complexities like those at TMI is dependent in large on establishing and maintaining close interfaces with federal and state agencies (particularly regulatory organizations), the utility and its many contractors, and outside interests.

In dealing with the regulator, it was prudent to respond in ways which did not challenge regulations. Wherever possible, the TMI-2 Program involved the regulator in interpretation of guidelines and demonstrated how conservative assumptions met regulatory requirements. And when it was realized that a testing program for certain hardware would shorten review processes, developing such a program and quickly seeing it through to completion in support of the license application was effective management. The TMI-2 Program, following advice of the regulator, made only one application in licensing the NuPac 125-B Rail Cask. That single submittal avoided the pitfall of altering courses of action which sometimes accompanies multiple submittals.

Other lessons learned included (a) whenever possible, assumptions were validated [time and dollars spent examining the core of Unit 2, for example, paid off many times, not only in determining how best to remove the damaged fuel, but how to handle, transport, and store it]; (b) technical assessment and evaluations by independent groups proved useful, both in reviewing and gaining consensus and support from participants, technical and political communities, and review/regulatory organizations; (c) most issues related to TMI-2 were more institutionally complex than technically complex [for example, transporting the rail cask from TMI to East St. Louis (Ill) by the quickest and most direct route necessitated negotiating exclusive use train service with Conrail. That increased costs but reduced the transportation time by Conrail from 13 days to

3 days maximum.] and (d) comment and advice was received from elected officials from all levels of government [each comment and piece of advice was responded to promptly and responsibly by appropriate members of the Program].

BENEFITS

Many benefits have been and are being derived from TMI. Feasibility and economic evaluations will have been made of dry loading of nuclear fuel in the transport cycle from reactor to storage facility and/or terminal repository. New types of hardware (canisters, fuel transfer cask, and related equipment) are available for manipulating containers filled with damaged fuel. The nuclear industry and government now have a rail cask which provides double containment of damaged fuel; and acquisition of the NuPac 125-B Rail Cask shows that cask procurement and licensing periods can be shortened. Incidentally, acquisition of that cask is the road map through the maze of institutional issues--not technical ones. The significance is not in designing/building a new cask, but in addressing institutional issues, ~~such as management of radioactive wastes, legal and regulatory~~ systems, acceptance by the public, ~~and dry~~ loading of nuclear fuel, to name a few. ~~And final~~ly, the scientific community will have a resource (core debris, samples, core bores) available at INEL for future examination and research. Because of those benefits, TMI can be recognized as an experiment whose usefulness lies in benchmarking safety codes predicting reactor behavior during transients, and which indirectly will reduce the risks of a reoccurrence. in the Western World.

CONCLUSIONS

In conclusion, technical challenges discussed in this paper were met within the present regulatory framework and guidelines because the federal entities, government contractors, and many private industries involved had the resolve to openly discuss issues confronting all participants. Open dialogue was initiated early in the project, when it was realized that interfacing equipment with facilities at TMI would be complicated. Dialogue has continued throughout the project and will continue until all core debris is loaded safely into canister, transported to Idaho, and stored at INEL.

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EG&G TIO FORM 004

TMI DATABASE INDEX FORM

007027025

1	SEQNO	
2	PROG	1
3	WKPKG	101
4	RTYPE	13
5	TITLE	Joint TMI 2 Information and Examination Program: EPRI Participation and Support
6	DATE1	85 01 00
7	DATE2	
8	DATE3	
9	ORIG1	EPRI NP 3810 SR
10	ORIG2	EPRI
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