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TRANSPORTING FUEL DEBRIS FROM TMI-2 TO INEL*

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Abstract

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Transportation of the damaged fuel from Unit 2 of Three Mile Island (TMI-2) presented noteworthy technical challenges involving complex institutional issues. The transportation programme resulted from both a need to package and remove the accident debris and also the opportunity to receive and study damaged core components. These combined to establish the safe transport of the TMI-2 fuel debris as a high priority for many diverse organizations. The capability of the sending and receiving facilities to handle spent fuel transport casks in the most cost-effective manner was assessed and resulted in the development by Nuclear Packaging, Inc. (NuPac) of the NuPac 125-B cask. The paper reviews the technical challenges in the preparation of the TMI-2 core debris for transport from TMI-2 to the Idaho National Engineering Laboratory (INEL) and receipt and storage of that material at INEL. Challenges discussed include design and testing of fuel debris canisters; design, fabrication and licensing of a new rail cask for transport of spent fuel; cask-loading operations, equipment and facilities at TMI-2; transportation logistics; and receipt, storage and core-examination operations at INEL.

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1. INTRODUCTION

Transportation of damaged fuel from Unit 2 of Three Mile Island (TMI-2) has progressed from an understanding that TMI-2 would not be a long-term storage site for damaged fuel to an integrated program for packaging of accident debris, safety checks before transport, safe transport in a new design rail cask, receipt operations for long-term storage and retrieval and examination of debris samples [1, 2].

This paper reviews the technical challenges in preparation of the TMI-2 core debris for transport from TMI-2 to the Idaho National Engineering Laboratory (INEL) and receipt and storage of that material at INEL. Challenges discussed include design and testing of fuel debris canisters; design, fabrication and licensing of a new rail cask for spent fuel transport; cask-loading operations, equipment and facilities at TMI-2; transporation logistics; and receipt, storage and core examination operations at INEL.

1.1 Background

Public involvenment in cleanup activities at TMI-2 has been active since the accident in March 1979. The Nuclear Regulatory Commission of the United States (NRC) developed for public consideration a programmatic environmental impact statement on the decontamination and disposal of radioactive wastes resulting from the TMI-2 accident [1]. Subsequently a Memorandum of Understanding was signed by NRC and the U.S. Department of Energy (DOE) which provided for transportation of the damaged core to a DOE facility for interim storage [3]. More recently, DOE and GPU Nuclear Corp. (GPU Nuclear) signed a contract under which DOE agreed to accept the core debris in canisters for transport and storage, as well as examination and preparation for final disposal [4]. EG&G Idaho, Inc. (EG&G Idaho) was selected by DOE to manage the TMI-2 program.

After investigation of alternatives, a comprehensive plan was developed by EG&G Idaho for preparation and transportation of core debris from TMI to INEL [5]. GPU Nuclear packaged the core debris in ways that met applicable federal and state regulations and complied with receiving and storage requirements at INEL [6]. EG&G Idaho managed development and procurement of two rail casks and contracted for their transport. Coordination of diverse activities of EG&G Idaho and GPU Nuclear was accomplished by regular meetings of a Core Shipping Technical Working Team, which effected timely, efficient and accurate exchange of information between program participants.

Procurement of rail casks was preceded by evaluations of the capabilities of facilities to handle casks during loading/unloading operations and support personnel needed. Results showed that rail casks would have lower costs and that the rail cask would have to be loaded dry in the truck bay at TMI. The competitive procurement of transport casks followed development of core defueling equipment and canisters to contain the core debris. As a result, cask-to-canister interfaces, for the most part, were set before selection of the cask supplier.

2. CORE DEBRIS CANISTERS

The defueling equipment and tools developed by GPU Nuclear to disassemble the damaged reactor of TMI-2 included a contract to the Babcock and Wilcox Co. for design of three types of canisters for containing the core debris; descriptions of canisters are given in [7]. The first--called a fuel canister--has a removable lid for remote loading of partial length fuel assemblies. The second canister--called a knockout canister--collects pieces of debris that settle in it during a hydraulic vacuuming operation. The last canister--called a filter canister--removes fine particulates from the water of the reactor vessel. After fuel is loaded during defueling operations, each canister is prepared for transport by dewatering using argon gas to force water out of a drain line in the canister and establish an inert atmosphere in each canister. Gas controls before transport ensure that overpressurization by radiolytic gases (H_2 and O_2) does not occur. Internal catalyst beds are included in ends of each canister. The catalysts control the buildup of combustible gases (H_2 and O_2) by recombining them into water.

The catalyst beds were designed by Rockwell Hanford Operations (Hanford, WA), after a comprehensive development program to test performance of catalytic recombiner in environments which simulate the inside of a canister during transport. Sizes and shapes of beds, as well as combinations of catalytic recombiners, were studied. Also, dissolved and suspended chemicals in water were investigated to assess their effects on the performance of catalytic recombiners wetted during defueling operations. Development and testing of catalyst beds provided the conclusive evidence that radioactively produced hydrogen and oxygen will be controlled safely during transport of TMI-2 fuel debris [8].

3. CASK DESIGN AND LICENSING

The special design features and licensing approach for the NuPac 125-B Cask are described more fully in a companion paper in this symposium [9]. Briefly, the cask provides double containment of TMI-2 core debris included in canisters. The cask is comprised of two separate and strong vessels (one inside the other) individually closed with a thick lid. Each lid has two O-rings forming bore seals which have a 'leaktight' leakrate of less than 10^{-8} Pa-m^3/s (10^{-7} atm-cm^3/s). The outer vessel has a composite wall made of lead sandwiched between two shells of stainless steel. The inner vessel has seven tubes, each of which accommodates a canister. The spaces between the tubes and structural components of the inner vessel are filled with neutron-absorbing materials for maintaining subcriticality. There are impact limiters (energy absorbers) at the ends of each tube to protect canisters axially in case of sudden decelerations. Large energy-absorbing overpacks cover the ends of the cask, protecting the cask and contents in case of a transportation accident. The cask, including overpacks, is 7.1 m long by 3.0 m in diameter. The total weight of the loaded cask (with overpacks, seven canisters, and transport skid) is about 93 300 kg.

Certification of the NuPac 125-B Cask is based on compliance with requirements in 10CFR71 as documented in a Safety Analysis Report (SAR) reviewed and approved by the Transportation Certification Branch of NRC [7]. The SAR contains results of computer analyses and data from drop tests performed to demonstrate the structural adequacy of the cask and canisters. A quarter-scale model of the cask was tested in a series of five drop tests [9]. In addition, a full-scale knockout canister was subjected to four 9.3 meter drop tests at Oak Ridge National Laboratory. Two tests were with the canister vertical and two with the canister horizontal. The tests showed that internal structures of the canister could safely withstand the force of the core debris impacting the tubes containing the neutron absorber materials. Compression, tension, bending and twisting forces in the tests did not result in structural deformations beyond that calculated by computer analysis. Additional information on drop testing the canister is described in a companion paper in this symposium [10].

4. CASK LOADING

GPU Nuclear evaluated the TMI-2 facility to determine the most cost-effective approach to cask handling. Underwater loading of a cask was impractical due to addition of equipment to the TMI-2 spent fuel pool for accident recovery operations. That led to a decision to load the cask dry in the Truck Bay of TMI-2 by bringing the canisters to the cask.

The cask-loading procedure begins after the overpacks are removed from the cask. The railcar and cask are positioned under a cask-unloading station in the Truck Bay of the Fuel Handling Building. Screw jacks on the cask-unloading station are used to lift the cask and transport skid from the railcar. The railcar is moved out of the Truck Bay, the cask and skid lowered to the floor, and door of the Truck Bay closed. The cask-unloading station is moved and stored out of the way. Two hydraulic cylinders are attached to right the cask from a horizontal to a vertical position and the unit is locked in place by attachment to a support tower. A work platform is bolted around the cask to the tower. The cask is opened by removing the lids of the outer and inner vessels and a shielded loading collar installed. A mini hot cell is moved over the cask and collar to remove and hold a shield plug from one of seven tubes in the cask. A canister is transferred from the spent fuel storage pool by the fuel transfer cask. The fuel transfer cask with canister is placed on the cask. The canister is lowered into the cask and the loading process repeated six more times, using the shielded equipment to reduce radiation exposure to personnel.

After loading is finished, lids of the inner and outer vessels are replaced and individually leak-tested to ensure that the rail cask is assembled correctly. The cask is rotated to the horizontal, placed on the railcar, reassembled with overpacks, inspected, and surveyed for radiation levels before being moved to the North Gate of TMI for delivery to the railroad.

5. TRANSPORTATION

Both GPU Nuclear and EG&G Idaho evaluated the expected time for cask loading and unloading operations. Based on their estimates and estimates of transit times by the railroads, EG&G Idaho ordered two rail casks, each of which accommodates seven canisters. Two casks will provide sufficient capability to transport canisters shortly after being filled during defueling operations. Defueling of the TMI-2 core may generate enough debris to fill 250 or more canisters. That many canisters will require two or more years to transport, beginning mid-1986. That schedule is possible, provided each cask is transported by regular train service with one cask per train and one cask is being loaded while the other is in transit or being unloaded. The casks are transported on new eight-axle railcars with a load capacity that comfortably exceeds the loaded weight of the cask.

6. UNLOADING

At INEL, the cask is removed from the railcar by a gantry crane and transferred to a truck transporter for a trip to a research and storage facility (called the Hot Shop) at Test Area North. In the Hot Shop, after the cask has been rotated to vertical, moved to a cask storage stand, 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 an underwater module situated atop the 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 are placed together (but not interconnected) to form the 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-2 core debris at INEL is planned for a maximum of 30 years. During that period, the scientific community will have core debris material available for examination and research. Samples of material will be collected after removing a canister from the water pit, transferring it to a hot cell in the Hot Shop and opening it remotely.

7. CONCLUSIONS AND BENEFITS

The technical challenges discussed in this paper were overcome by dedicated efforts on the part of many individuals and organizations. Open dialogue enabled complex interfaces to be integrated in an efficient manner on an abbreviated schedule. The benefits of cleaning up the TMI-2 accident and providing a valuable resource for scientific investigation of degraded core conditions are a result of the program established to safely transport the TMI-2 debris.

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