Demonstration Test for Transporting Vitrified High-Level Radioactive Wastes

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INTRODUCTION

Japanese utilities have contracts with COGEMA and BNFL for reprocessing spent fuels discharged from their commercial nuclear power reactors. These contracts include an option for the return of residues arising from reprocessing operation, and it is anticipated that the vitrified high active wastes will be returned back to the Japanese storage facilities from both companies.

To ensure safe transport of these vitrified wastes from COGEMA reprocessing plants at La Hague and BNFL reprocessing plants at Sellafield, a demonstration test program on a full-scale model of a transport cask is now in progress. In this program transport casks for vitrified wastes are being designed and fabricated, and subjected to drop tests and thermal tests, etc., to assure that the requirements are satisfied in accordance with the performance and acceptance standards prescribed in the domestic transport regulations for radioactive material.
This paper gives a description of the design concepts and configuration of the demonstration test cask, as well as the test plan for normal and accident conditions.

This demonstration program is being carried out by the Central Research Institute of Electric Power Industry (CRIEPI) from FY1986 to FY1994, under the sponsorship of the Science and Technology Agency.

METHODOLOGY

The purpose of this program is to evaluate the integrity of two types of transport casks for vitrified wastes being developed by COGEMA and BNFL. However, because it costs a great deal to fabricate and test both types of casks, and the experiments are not necessary for conventional structures used for existing spent fuel casks, the demonstration test cask designed combines the COGEMA and BNFL cask with specific structural features of both types. This cask, called the HYBRID-type cask, will be subjected to a series of normal and accident test conditions as prescribed in the transport regulations. Analysis of the behavior of each structural feature established by the results of this demonstration test for the HYBRID-cask will be used to evaluate both COGEMA and BNFL casks for actual transport. Figure 1 shows the entire schedule of the demonstration test program.

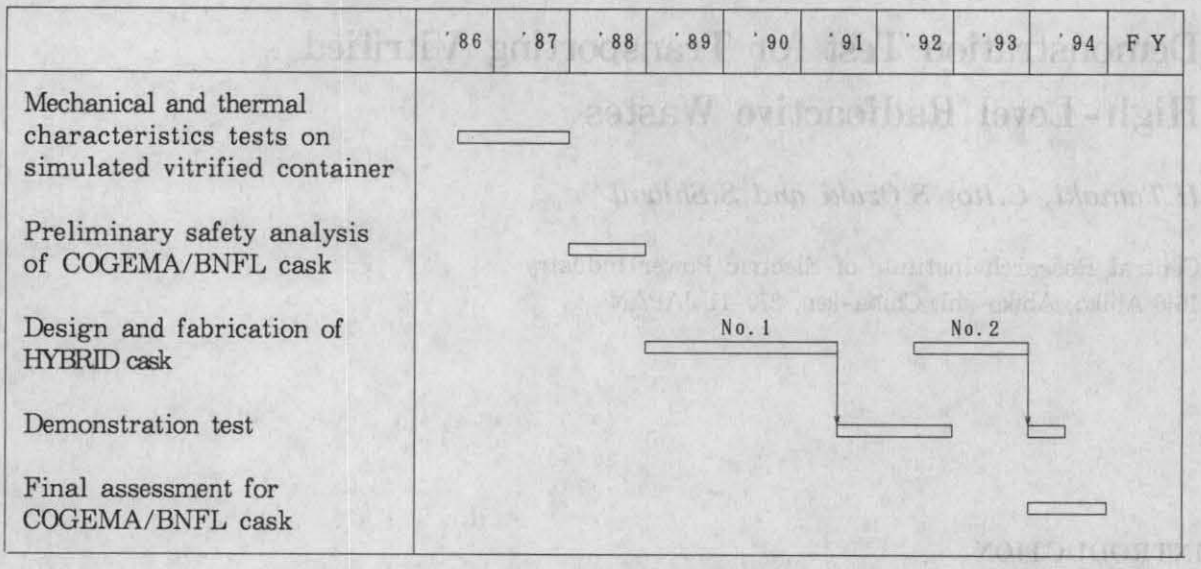

Figure 1. Schedule of demonstration test program

SPECIFIC FEATURES OF THE COGEMA/BNFL CASK

The licensing procedure for the COGEMA cask has been completed in France and is currently under way in Japan, and it is under way for the BNFL cask in the U.K. Main specific features of both casks are described hereafter.

COGEMA type cask (Kirchner):

— The containment vessel of the cask consists of a cylindrical forged steel shell approximately 250mm thick with the base welded to the body shell, providing the major part of the gamma shielding. A layer of resin acting as a neutron shield is enclosed between the body and an outer steel shell.

— Forty longitudinal cooling fins made of copper welded to the body and the outer shell convey the decay heat power of the vitrified waste containers through the resin. Heat transfer within the cavity is effected by conduction and radiation.

— The removable monolithic basket is made of aluminium with seven cylindrical compartments and provides accommodation for 28 vitrified waste containers, with a total decay heat output of 41kW, in seven stacks of four.

— Each end of the cask is equipped with shock absorbers to provide impact protection for the ends of the cask. The top side shock absorber is removable, while the bottom side one forms an integral part of the cask body. The envelope dimensions are about 2.4m in diameter by 6.6m in length, with a gross weight of about 112t.

BNFL type cask (Coulthart, Emmison, et al., 1991):

— The containment vessel of the cask consists of a cylindrical carbon steel forging approximately 300mm thick with the base welded to the body shell, providing the major part of the gamma shielding. Circumferential cooling fins are welded to the cask surface on a 40mm pitch. A layer of neutron shielding material is contained in sealed compartments at the fin roots and at the ends of the cask.

— The waste containers are carried in an internal support structure which is built up from 30 individual aluminium segments to form seven longitudinal circular compartments. Each segment is rigidly clamped to the cask wall to ensure close contact and good conduction. The internal structure provides accommodation for 21 containers, with a total decay heat output of 42kW, in seven stacks of three.

— Each end of the cask is equipped with removable shock absorbers to provide impact protection for the ends of the cask. The envelope dimensions are about 2.5m in diameter by 5.8m in length, with a gross weight of about 110t.

CONSIDERATION FOR HYBRID CASK

Specific design features of the COGEMA and BNFL casks should be taken into account when the HYBRID cask used for the demonstration test program is designed. Behavior which cannot be predicted from experience with existing spent fuel transport casks should also be considered. The followings are specific structures of the COGEMA and the BNFL-type casks that need to be evaluated on this demonstration test program.

Impact performance design — In the case of the COGEMA cask, a layer of neutron shielding material covered with an external shell provides the major part of the impact protection for side drop. The BNFL cask has a number of circumferential cooling fins on the surface of the cask body which provide impact protection for side drop. Thus, the external structure of the COGEMA-type is used in the HYBRID cask since our experience on the results of the demonstration test on spent fuel cask (Nagakura et al., 1986) is available for analysis of side drop behavior of the BNFL-type.

Thermal design — In case of the BNFL cask, aluminium segments are firmly clamped to the cavity wall to keep good conduction during a normal operation. However, since it is anticipated that the clamping system would break off in the event of a 9m drop accident, radiation will contribute as an important means of heat transfer performance between the segments and the cavity wall. The COGEMA cask has a monolithic type basket which CRIEPI also has some experience with conventional spent fuel casks. Thus the specific internal structure of the BNFL type is introduced to the HYBRID cask.

HYBRID CASK DESCRIPTION

Specifications of the HYBRID cask were defined as follows, based on the above considerations.

— The HYBRID cask is designed to satisfy the requirements for type B(M) package. The envelope dinensions are about 2.4m in diameter by 6.8m in length fitted with shock absorbers. The gross weight is about 115t with 28 vitrified waste containers and a total heat power of 41kW.

— The body is manufactured from a forged carbon steel sheel approximately 250mm thick with the base welded to the body, providing the major part of the gamma shielding. The lid is manufactured from a stainless steel forging and incorporates a double elastomer O-ring sealing system with leak testing facilities. It is bolted to the cask body.

— A layer of silicon rubber acting as a neutron shield is enclosed between the body and an outer shell of 20mm thick carbon steel. 48 longitudinal cooling fins made of copper welded to the body and the outer shell convey the decay heat power of the waste containers through the neutron absorber.

This structure will provide the mechanical behavior of absorbing impact energy by inelastic deformation of the COGEMA cask in the case of the cask being subjected to a side drop accident.

— An internal support structure consists of 42 individual aluminium segments similar to the BNFL cask. Each segment is rigidly fixed to the cask wall by a clamping system to form seven logitudinal circular compartments that receive 28 waste canisters in stacks of four. This structure will provide mechanical and thermal behavior of the internal cask under normal operation and accident conditions such as side impact, fire, etc.

— The cask has a pair of trunnions bolted to each end of the body for handling and tie down.

— Each end of the cask is equipped with a steel clad, wood filled removable shock absorber in order to limit the impact forces from vertical or corner drop accidents. A layer of silicon rubber filled in each clad provides axial neutron shielding.

— 10 out of 28 dummy waste containers accommodated in the cask are filled with glass with similar compositions of COGEMA's, and the rest are filled with cement with the same weight and heat characteristics as the glass. All of the containers have electric heaters within the glass or cement to simulate a total decay heat output of 41kW of the actual highly active wastes.

Figure 2 illustrates an outline of the HYBRID cask.

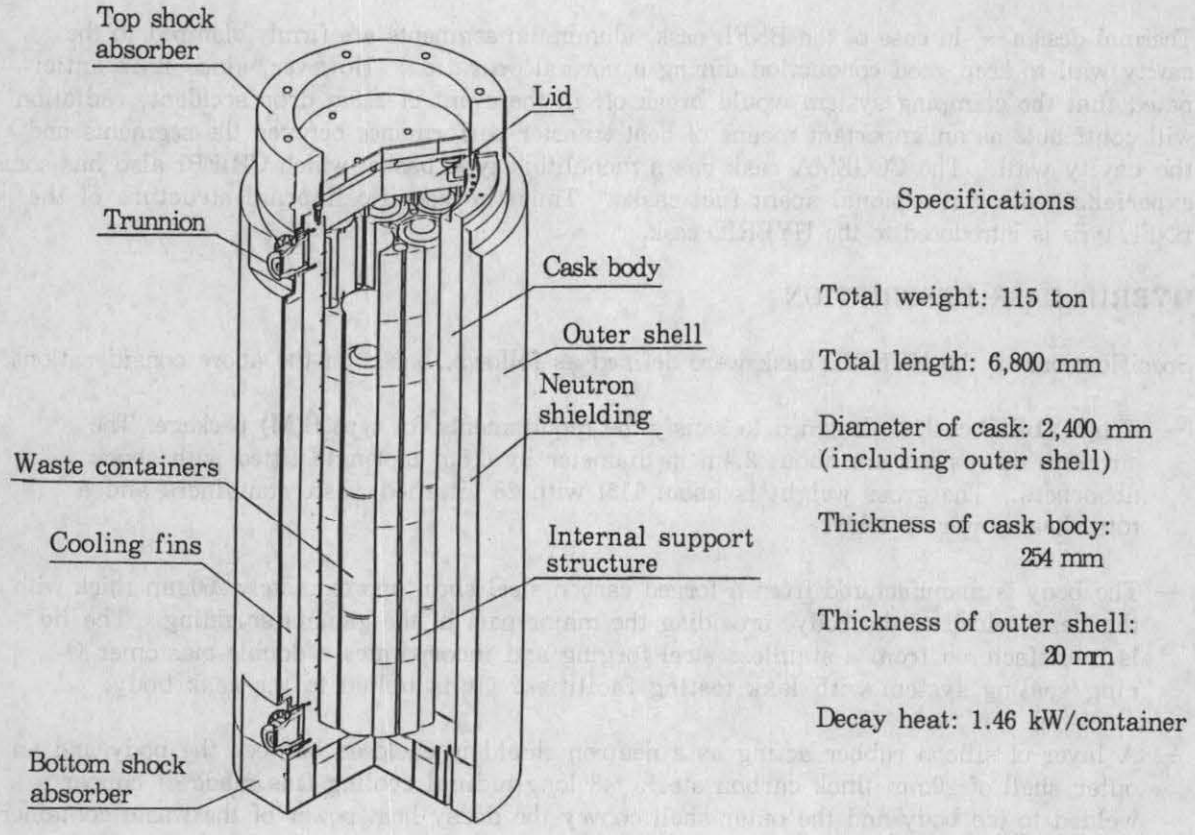

Figure 2 HYBRID-type demonstration test cask

TEST PLAN

The evaluation and certification of the HYBRID cask is performed by subjecting them to normal and accident test conditions stipulated in the transport regulations.

The test procedure for the HYBRID cask is given in Figure 3. The Shielding test for gamma and neutron source, the heat transfer test in an 38 ℃ environment, the 0.3m free drop test in a horizontal attitude and leak tests were performed as normal operation in FY1991 at test facilities of CRIEPI Yokosuka Research Laboratory. Tests for hypothetical accident conditions will be compieted by the end of FY1992. It was judged that other test requirements which are not included in Figure 3 could be evaluated on the basis of analytical methods established in experimental studies for the spent fuel casks.

CONCLUSION

The HYBRID-type demonstration test cask for transporting vitrified waste containers was designed and fabricated on the basis of specific structural features of transport casks designed by COGEMA and BNFL. The test cask was subjected to normal test conditions prescribed in the transport regulations, which had no effect on the integrity of the cask. Details of the test results are reported in other papers in PATRAM'92.

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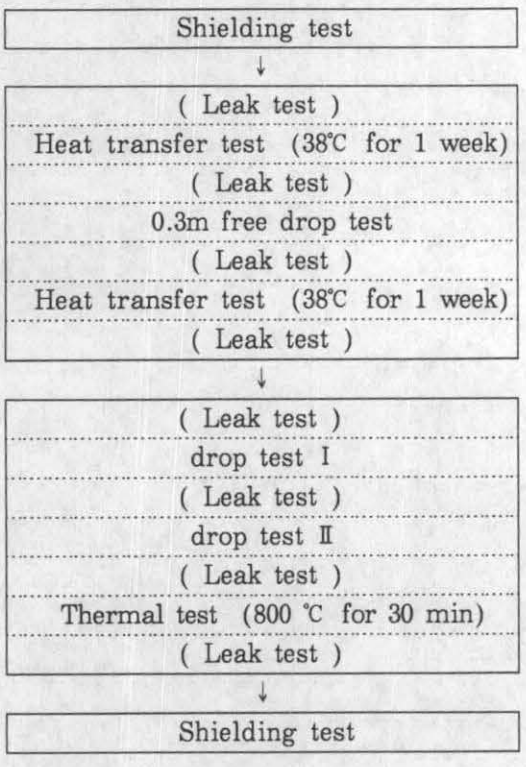

Figure 3 Demonstration test procedure on HYBRID cask

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