TYPE B(U) CONCRETE STORAGE/TRANSPORT CASK FOR SPENT PEBBLE BED REACTOR FUEL

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Abstract

TYPE B(U) CONCRETE STORAGE/TRANSPORT CASK FOR SPENT PEBBLE BED REACTOR FUEL.

A cask has been developed and licensed for the transport and storage of spent pebble bed reactor fuel that combines both safety and economy. This cask is made of heavy concrete and is enclosed by an inner and outer steel casing. It has the potential to be used for final storage underground.

INTRODUCTION

There has arisen a need for the intermediate storage of spent fuel from the AVR, a prototype pebble bed reactor located at the Nuclear Research Center, Jülich. The fuel for this high temperature gas cooled reactor consists of small coated particles of uranium dioxide or mixed thorium-uranium dioxide embedded in spherical fuel elements made from graphite. The fuel particles used are characterized by a four-layer coating. A relatively porous inner buffer layer of carbon is coated with a chemically very resistant silicon carbide (SiC) layer, followed by a dense double coating of pyrolytic carbon. The hard, non-porous SiC layer, together with the dense and pressure-stable, double-pyrocarbon coating, enhances fission product retention and thus forms a very effective containment barrier for the radioactive material.

For the purposes of transport and intermediate storage, a cask design based on concrete shielding has been developed and the Type B(U) licensing procedure has been initiated. The cask design also has the potential to act later on as an underground final storage cask.

DESIGN FEATURES OF THE CASK

The fuel discharged from the reactor is transferred to hot cells, where it is loaded into stainless steel canisters, each with a capacity of about 950 elements. The canisters are subsequently closed by an automatic arc-welding device in order to obtain a high degree of leaktightness (of 10^{-9} mbar·L/s). In this form the containment of the package is in accordance with transport regulations (see Fig. 1).

A drop test from a height of 7 m using the aforementioned fuel canister filled with 950 graphite elements, and applying IAEA test requirements, has been performed. The fuel can showed only minor deformation on the bottom edge. The leak-rate measurement after the drop test revealed no loss of gas tightness and the required value of 1×10^{-4} mbar·L/s was confirmed. All fuel elements retained their physical integrity. Reference data for an AVR fuel element and the storage canister are given in Table I.

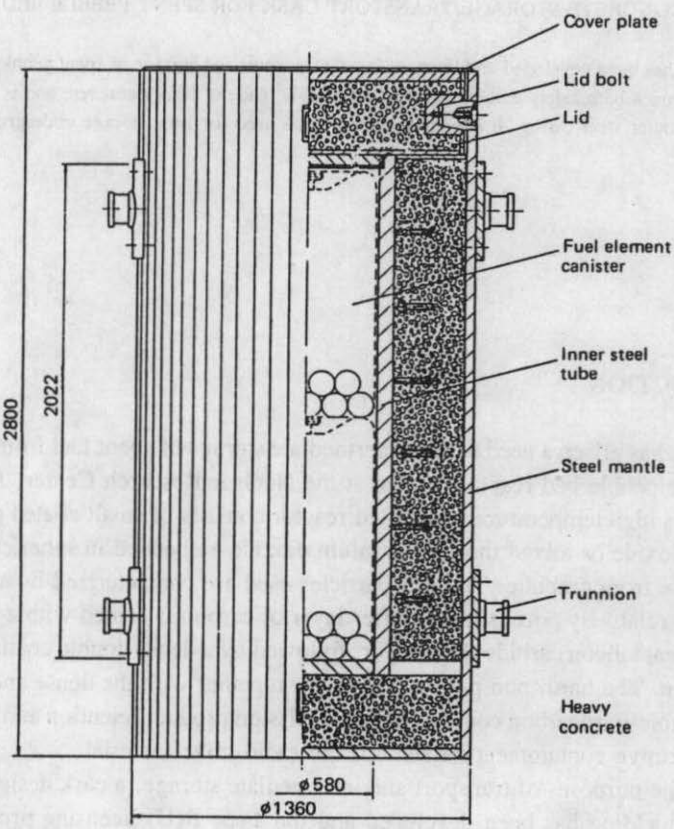

FIG. 1. Transport and storage cask designed for spent AVR fuel elements using a steel–concrete combination structure.

TABLE I. REFERENCE DATA FOR AN AVR FUEL ELEMENT AND INTERIM STORAGE CANISTER

Mass of fresh spherical fuel element		200 g
U-235		1.0 g
U (total)		1.08 g
Th (natural)		5.0
Diameter of fuel sphere		60 mm
Mass of spent fuel element:		
U-235		0.65 g
Other fissile isotopes: (U-233, Pu-239/241)		0.10 g
Number of fuel elements per canister		≤ 960
Total radioactivity per canister		$< 10^{-14}$ Bq ($\sim 10^{4}$ Ci)
Dose rate at the surface of canister		< 10 Sv/h ($< 10^{-3}$ rem/h)
Decay heat output		< 57 W
Surface temperature		$< 30^{\circ}$C
Cooling time of fuel elements		> 4 years
Specified leak test rate	with elastomer gasket	1×10^{-4} mbar·L/s
Measured He leak test rate	with elastomer gasket	1×10^{-6} mbar·L/s
Measured He leak test rate (arc-welded)		2×10^{-9} mbar·L/s

A shielding overpack is formed with concrete, which is encased in steel on the inner and outer surfaces. The outer container body consists of a 40 mm rolled steel-plate cylinder tube. The inner tube has a wall thickness of 60 mm. The space between them is filled with high-density concrete (ϕ = 3.5 g/cm^3). Reinforcement of the concrete is achieved by steel bolts attached to both steel cylinders. The shielding lid is fixed in position by means of three pins oriented laterally. Each overpack contains two canisters. The net weight of the container amounts to 16 750 kg and 17 450 kg loaded with fuel, assuming 1900 fuel elements. The package is made complete by two removable shock absorbers situated at the lid and the bottom side of the cask. The shock absorbers are only used during transport, not for storage.

As the cooling time before storage is four years, the decay load of a package is only about 120 W. No special means for heat transfer are necessary and there are no temperature problems with the concrete shielding.

TESTING OF THE CASK

Drop tests in various orientations were performed with a one-third scale model of the package at the Bundesanstalt für Materialprüfung, in Berlin (West). This test demonstrated that the shielding was retained after the accident. Only very minor deformation occurred; the shielding efficiency of the package was completely maintained.

STORAGE

It is envisaged that the casks will be stored in a vertical position, with two casks on top of each other. Storage will be in an extension of an existing building for the storage of radioactive wastes at the reactor site. Start of operation is scheduled for the end of 1986.

ECONOMIC COMPARISON

Transnuklear has made an economic comparison of the casks made of concrete and nodular cast iron. The result of this comparison shows an advantage of about 40% in favour of the concrete cask in this specific case.

CONCLUSION

It has been demonstrated that concrete is an adequate material for a Type B cask in the case where the decay heat load is low. The concept meets both safety and economic requirements.