DEVELOPMENT OF TRANSPORT AND STORAGE CASKS FOR VITRIFIED HIGH LEVEL WASTES: CASTOR-GSF, ASSE TB 1 AND CASTOR HAW-21

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Abstract

DEVELOPMENT OF TRANSPORT AND STORAGE CASKS FOR VITRIFIED HIGH LEVEL WASTES: CASTOR-GSF, ASSE TB 1 AND CASTOR HAW-21.

The highly active liquid wastes (HAW) resulting from reprocessing are vitrified within steel canisters to allow safe handling, transport and final disposal. In order to demonstrate the safe disposal of such wastes in a representative geological formation, the Federal German Ministry of Research and Technology has initiated a programme, which is managed by the GSF. In this programme, vitrified HAW will be transported from Hanford, USA, in six Castor-GSF casks to the Asse salt mine. There the HAW canisters, 30 in total, are transferred into the Asse TB 1 cask, a GSF/GANUK design, which constitutes a special development to meet the very restrictive boundary conditions resulting from transportation and handling within the mine. The vitrified HAW which is returned to the Federal Republic of Germany after fuel reprocessing in France and the United Kingdom has to be stored above ground before final disposal. For this reason and due to the fact that final disposal facilities are not yet available, the Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen mbH and the Gesellschaft für Nuklear-Service mbH have developed the high capacity transport and storage cask Castor HAW 21, which will be licensed for transport and for interim storage. A prototype has been built and thermally tested at full scale.

1. TRANSPORT CASK CASTOR GSF

1.1. Introduction

On behalf of the Gesellschaft für Strahlenschutz und Tiefenforschung, GNS (Gesellschaft für Nuklear-Service mbH) has developed and produced a transport and storage cask for 5 test canisters, the Castor-GSF. The test canisters contain vitrified radioactive nuclides, which are produced in Hanford, Washington (USA) and used for a large scale trial in the Asse mine in the Federal Republic of Germany (FRG). These canisters are to be transported from the USA to the FRG in the Type B(U) casks Castor-GSF.

For this purpose, the Castor-GSF must meet the following requirements:

- Suitability for licensing as Type B(U) packaging
- Convertible to a storage cask for an FRG interim storage facility
- Total weight < 22.0 t
- Maximum heat generation of 11.5 kW
- Maximum glass temperature $< 450°$C
- Maximum surface dose rate < 0.1 mSv/h
- Leaktightness $< 10^{-4}$ mbar·L/s.

1.2. Description of design and function

The design of the cask is shown in Fig. 1. The cylindrical cask body is made of GGG 40 nodular cast iron with cast-on fins 140 mm long, whereby a wall thickness of 160 mm is realized. To meet the higher shielding requirements under storage conditions, the cask body has in addition a 85 mm thick lead lining. Because of the canister specification, the cask needs no neutron moderation.

The cask body is closed with a primary lid made of GGG 40 nodular cast iron. To accommodate the test canisters inside the cask, the fuel basket has 5 stations which are formed from a steel tube construction. For effective heat transfer, the empty space between stations and the wall of the cask cavity is filled with a heat conducting material.

The leaktight seal system, consisting of elastomer seals, guarantees that both during transport and IAEA accident conditions non-permitted radiation leaks cannot occur.

2. TRANSFER CASK ASSE TB 1

2.1. Introduction

The Gesellschaft für Strahlen- und Umweltforschung mbH, Munich (GSF) is carrying out a large scale trial for the emplacement and final storage of highly

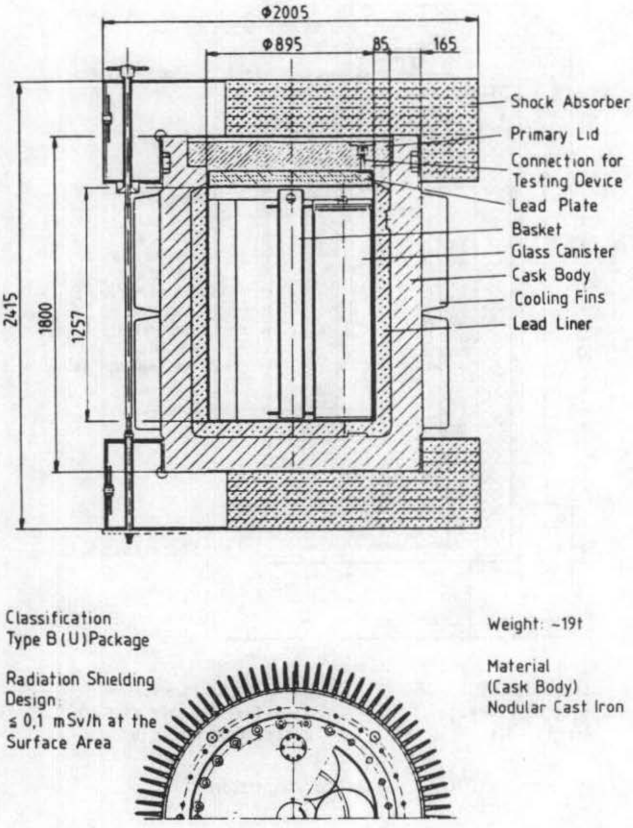

FIG. 1. Transport and storage cask for 5 test glass canisters.

active wastes (HAW) in the former saltmine Asse II in the northern part of the FRG. This trial is to involve amongst other things the testing of handling components for highly radioactive waste canisters with regard to possible use in the FRG repository planned in Gorleben.

The size, heat generation and radioactivity of the containers on the one hand, and the parameters specific to the Asse mine on the other hand, led to the development of a transfer cask to allow handling of the test sources both at the mine surface facilities and also underground. To meet the planned use at the Gorleben final repository it should also be possible to undertake handling of neutron emitting sources.

The trial as described above is planned with sources which contain only ^{137}Cs and ^{90}Sr.

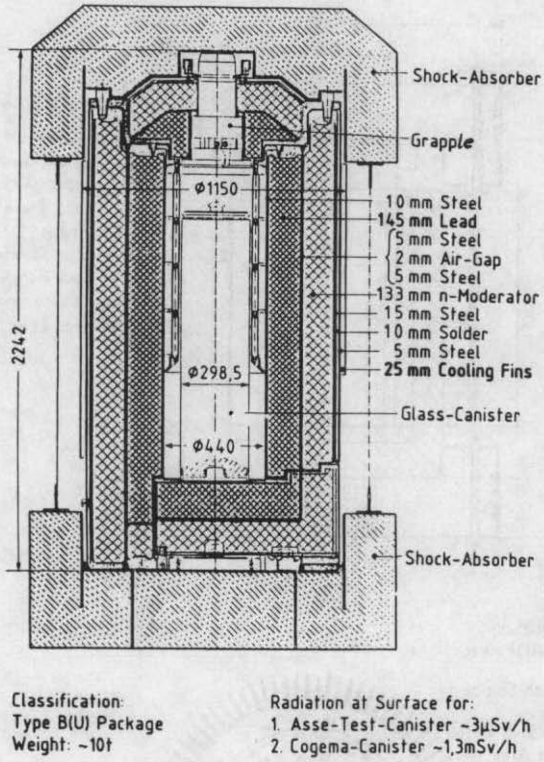

FIG. 2. Asse TB 1 canister.

For this purpose the Asse TB 1 must meet the following requirements:

- Weight ⩽ 10 t
- Diameter ⩽ 1.15 m
- Permit as per Type B(U) cask, whereby the canister forms a 'tight envelope around the radioactive material'
- Compatibility with other components during emplacement and removal of the containers
- Specifications for canisters and test sources should be:

	WAW and Cogéma canister	Test source canister
diameter	430 mm	298.4 mm
height	1360 mm	1200 mm
weight	480 kg	250 kg
heat generation	2550 W	2065 W ± 10%
neutron activity	2.7.E+9 Bq	none
gamma activity	1.0.E+16 Bq	1.0.E+16 Bq ± 10%

2.2. Description of design and function

The Asse TB 1 cask is shown in Fig. 2. It is designed as a composite of steel, lead and neutron moderator material. The gamma shielding is an internal lead lining, the neutron moderator material (epoxy resin) is located on the outside. To improve heat conductivity, aluminium heat dispersing ribs are fitted inside the epoxy layer.

The cask is loaded from below and also unloaded via the base access. The base access is closed by a flat gate. This gate is fitted with mechanical locks to prevent unintentional opening during transportation. Inside the top end of the cask there is a grapple for handling the canister. To protect the neutron moderator material in the event of fire the Asse TB 1 cask has insulation of a special design. The outer, finned shell of the cask has a layer consisting of a low melting point solder. Under normal operating conditions this provides good heat conductance, but in the event of fire this layer will melt and run off, leaving behind an insulating air layer.

The actual thicknesses of the shielding, moderator and the structural materials are marked in Fig. 2.

The outer shell of the Asse TB 1 cask has been designed with a certain number of cooling fins. This additional surface area ensures that the fin temperature does not exceed 85°C.

The calculated shielding values with respect to the test source are:
at outer surface – 3 μSv/h (1.3 mSv/h for the Cogéma canister)
1 m from the surface – 0.8 μSv/h

2.3. Licensing procedure

The Asse TB 1 cask is to be used for internal operations transport. The Mining Office in Goslar as the competent permit office will issue the go-ahead.

The GSF as applicant foresees the following procedure:

- Asse TB 1 cask given permit for the planned canister types as a Type B(U) cask. The responsible licensing authority is the Physikalisch-Technische Bundesanstalt.
- The Mining Office requires additional consideration of the following scenario: Fire lasting one hour (calculated proof), bearing in mind that the neutron screening represents a neutral factor with respect to its behaviour in fire and the release of gases.

There are reasonable prospects of permission being granted for handling at least at the facilities of the mine. The use of transfer cask Asse TB 1 is planned for the end of 1987.

3. THE HIGH CAPACITY TRANSPORT AND STORAGE CASK CASTOR HAW-21

3.1. Introduction

The interim storage of vitrified highly active waste can be achieved in a block storage or an interim transport cask storage plant. The following description presents the design and experimental data of a transport and interim storage cask, which is under development by DWK (Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen mbH) and GNS.

The Castor HAW-21 cask must meet the following requirements:

- Guaranteed heat dissipation for all operational and incident scenarios
- Prevention of release of radioactive materials to the environment
- Shielding of environment and workforce against gamma and neutron radiation
- Ensuring recovery of encased glass container even after an EVA load scenario.

3.2. Cask concept and layout data

The cask concept is shown in the assembly drawing Fig. 3. This DWK/GNS development is designed to transport and store up to 21 HAW canisters of the Cogéma or WAW type with up to 2.5 kW each but still meeting the Type B(U) limitations. It consists of a massive GGG 40 nodular cast iron body weighing approximately 100 t.

This cask represents a further development of the current Castor type transport and storage casks for fuel elements. The walls are approximately 415 mm thick. Three concentric moderator rod layers are integrated within the wall, sufficient to produce a neutron radiation dose rate of less than 0.1 mSv/h. At the top, the vessel is sealed with a shielding cover. The cover seal must ensure a leakage of 10^{-7} mbar·L/s maximum. A protection plate protects the shielding cover against damage during transport and external effects.

The external jacket is designed with machined radial fins as indicated in Fig. 3. To increase the heat dissipation surface area, the radial finning is supplemented by longitudinal slots. The heat producing highly active glass containers are supported within the cask by a special cast iron basket. To improve the heat conduction inside the cask, it is filled with helium, and the tolerance gap between basket and cask is reduced to zero, under operating conditions, and the gap between encased glass and basket is reduced to a minimum of 5 mm.

The design layout data for the cask can be summarized as follows:

- Shielding gamma and neutron radiation to ensure external surface dose rate of 0.20 mSv/h maximum
- Heat dissipation such that the internal container temperature does not exceed 450°C and the external contact surface temperature does not exceed 85°C

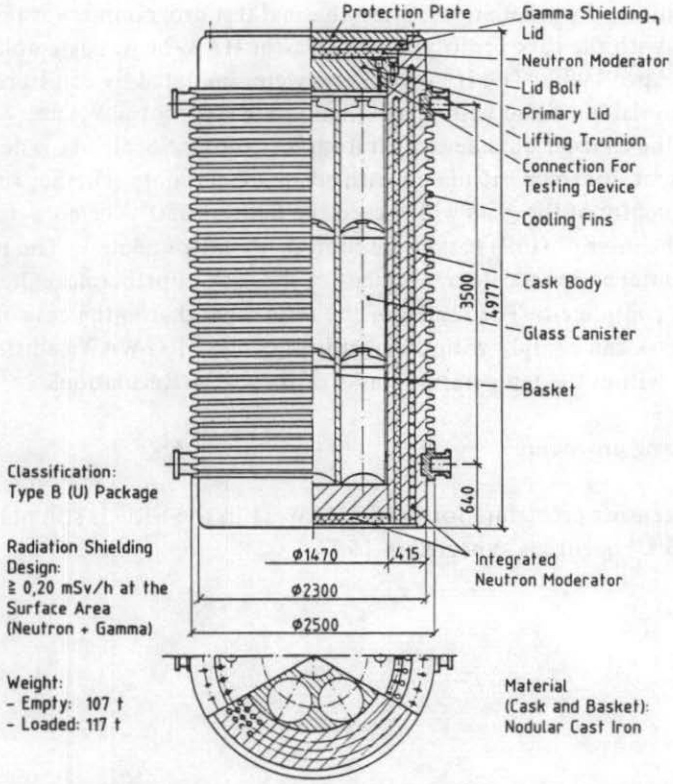

FIG. 3. Castor HAW-21: transport and storage cask for 21 HAW glass canisters.

- Highly effective cover seal system, with a leakage rate of 10^{-7} mbar·L/s maximum
- Optimal storage volume to ensure an economic transport and storage concept
- Fulfilment of all other statutory transport and nuclear licensing requirements.

3.3. Cask heat dissipation

The finned surface of the cask must dissipate a thermal output of approximately 52 kW. Since this thermal output represents a limiting criterion for the cask, three dimensional temperature field calculations were performed in the framework of the concept design work with the US–NASA code NASTRAN for a 30° segment section. The results show that the temperatures at the core of the central encased glass container do not exceed 450°C and that the temperature of 85°C at the external surface (fin tips) is not exceeded.

To confirm the calculations, a 1:1 thermal test programme was performed in 1985/86 with the cask prototype. The Castor HAW-21 was assembled for this purpose in April 1985. The HAW canisters were simulated by canisters of the original material but filled with magnesium oxide and central heaters.

Once the canister outside temperature for constant heat flux is determined by experiment, it can be calculated with adequate certainty whether the temperature of the centre of the glass will exceed the limit of 450°C or not. The cask body and the interior (full) basket are thoroughly instrumented. The tests consider both horizontal and vertical arrangement of the cask. Furthermore, helium and air filling were considered. The results of the tests show that in the case of helium filling the cask can comply with the heat load of the FRG WAW canisters and still remain within the temperature limits of the IAEA Regulations.

3.4. Licensing procedure

The licensing procedure for Castor HAW-21 in the FRG is still under way. The Type B(U) licence is expected in 1987.