CASTOR V/HAWC Transport Cask for High Active Liquid Waste

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INTRODUCTION

In Germany it is intended to plan all needed equipment necessary for the removal of the high active liquid waste (HAWC) from the Karlsruhe Reprocessing Plant (WAK). It is planned to transport the HAWC waste solutions which are in the plant to the PAMELA vitrification facility in Dessel/Belgium, where they are to be conditioned to waste packages (glass canisters) suitable for final disposal. The corresponding licence request has been applied for from the authorities.

The transport from Karlsruhe to Dessel will be carried out with help of a cask developed under contract with KfK by GNB and WAK, the so-called CASTOR V/HAWC.

The cask is designed with the same technical features as are present in already approved shipping casks of the CASTOR family designed by GNB.

This transport cask fulfills all nuclear legislation as well as transport requirements.

CASK DESIGN

The design of the CASTOR V/HAWC type B(U) package is based on the design standards as are stipulated in the IAEA regulations and traffic regulations. In addition, the double wall inner cask (see Figure 1) is designed according to the established German AD regulations. The design of the trunnions is according to the German KTA regulation 3905.

DESCRIPTION OF THE CASK DESIGN

The CASTOR V/HAWC is a cylindrical shipping cask with a loading capacity of 3500 l liquid waste (HAWC) from the German reprocessing plant (see Figure 2). It consists of a cylindrical, inner cask of stainless steel welded to the primary lid of the CASTOR cask (see Figure 2). Together with the primary lid, the inner cask forms the leak-tight containment of the CASTOR V/HAWC. The inner cask is surrounded by a stainless steel liner, which is also welded to the primary lid. This liner forms together with the inner cask a closed space for monitoring of the leak tightness of the inner cask. The chosen material for the leak-tight containment and the liner is stainless steel 1.4306, the identical material used for HAWC-storage tanks at WAK with excellent experience regarding the HAWC-resistance for more than a decade. The sealing system (metallic and elastomeric seals) has been qualified to be an acceptable material choice for the transport of HAWC. Both shells are integrated in a monolithic cask body of nodular cast iron GGG 40 and closed by a secondary lid, which forms a further containment and guarantees the mechanical and radiological requirements of the type B(U) shipping cask.

For the operational handling of the cask, its appliances for filling, discharge, and testing are remotely handleable. The experience and findings from practical trials on a full scale functional model are heeded for this design.

In addition, particularly with respect to discharge, flushing, and sampling, attention is drawn to a multitude of cold tests in the framework of the qualification, of the filling apparatus, as are quoted specifically in the following sections of this report.

The cask is transported only in a horizontal position. Handling in the filling and discharge stations is intended at an inclination of 5°, with the cover side of the cask raised.

CONNECTIONS IN THE PRIMARY LID

The primary lid consists of stainless steel and has four connections with the following functions (Figure 3):

HAWC Connection for Filling

The primary lid has a bore hole for filling and discharge which is connected to a tube inside the cask which is conducted up to the suction point at the rounded bottom.

During transport, the bore hole is closed with a transport plug. The transport plug is attached to a leak-tight adapter ring which is bolted to the primary lid.

HAWC Auxiliary Discharge

The bore hole for the HAWC auxiliary discharge corresponds to the HAWC connection.

This serves for measuring the reference pressure in the transport cask, which is necessary for accurate level measurement according to the principle of the bubbling-through method. This adapter is also used for the cask ventilation.

A hose pipe can be inserted through this guide basket into the rounded bottom area (lowest point) and can be used as auxiliary discharge if the HAWC discharge connection fails.

Further, this guide basket is intended for the insertion of a high-pressure spray head on a flexible high- pressure line for decontamination of the cask. Through the circumferential guide basket, the entire cask can be freed of sediment, particularly in the bottom area.

Through the bore hole of the HAWC auxiliary discharge, the visual control of the interior of the cask is possible by an endoscope.

Triple Connection

Within this covering plate, corresponding bore holes connect the three primary lid bore holes for the level control, evacuation/exhaust of waste gas and a separate level measurement.

Test Connections for Leak Testing

To control the leak-tightness of the common closure plate of the three connections, a test connection in the primary lid is designed.

The space between the inner and outer O-ring seal of the closing plate can be connected to a helium leak test device to measure the helium leak rate of the seal.

CONNECTIONS IN THE SECONDARY LID

The secondary lid consists of stainless steel and has connections for tightness testing of the secondary lid seal and for testing contamination in the space between primary and secondary lid.

CONNECTIONS ON THE CASK BODY

In the cask bottom there are three axially arranged bore holes with graded diameters. They receive the control devices for monitoring pressure and temperature as well as a coupling for making accessible the space between liner and inner cask (see Figure 4).

This space is filled with an inert gas under elevated pressure. The inert gas pressure is monitored with a pressure switch. The coupling to the inert gas filling and the pressure switch are sealed in such a way that in the event of leakage at the inner cask no liquid escapes to the environment.

A thermoelement serves for temperature monitoring (contact measurement at the liner). The connections are closed by closure lids.

SHOCK ABSORBERS

During transport with the wagon and during handling by crane, shock absorbers are fitted to the CASTOR V/HAWC shipping cask at both ends. They cover the shipping cask at a length of approximately 1 m on each side. Their attachment to the cask is effected with clamping devices between the shock absorbers.

CASK INVENTORY

GENERAL POINTS

To cover the range of analysis of the real HAWC to be transported from the WAK storage tanks, the description of the content of the shipping unit is based on a data record which is enveloping for all design computations. The process engineering of the filling apparatus guarantees that the admissible content of the shipping unit is limited to 500 Ci/l or 4200 W/container.

SPECIFICATION OF THE HAWC

The description of the content is shown in the following table:

HAWC-volume	max. 3500 dm^3/cask
density	max. 1,39 Kg/dm^3 (1,25 Kg/dm^3 for shielding calculations)
° molarity (HNO_3)	3,5-6,5 mol/dm^3
° content of solids	max. 33 g/dm^3
° chemical form of fissile materials	U, Pu in nitriate in solid oxide
° heat inventory	1,2 W/dm^3
° specific heat	3.300 J/(kg · K)
° heat conductivity	0,62 W/(m · K)
° filling temperature	50°C
° neutron source	3,45E + 16 γ/s
° gamma source	2,79E + 9 n/s

° specific activity

	- operation	1,85 E13 Bq/dm³ (500 Ci/dm³)

° content of total activity — $5{,}93$ E06 A_2 for release calculations

° content of fissile materials

	- uranium	max. 10,0 g/dm³ with max. 1,0 % U-235
	- plutonium	max. 0,3 g/dm³ with max. 80,0 % Pu-fiss

Approximately one-third of the plutonium and 1 % of the uranium are in the solid phase; rest is nitrate in solution.

MECHANICAL CASK DESIGN

The mechanical layout of the safety-relevant components of the package is designed under the aspects of the IAEA regulations and the transport regulations.
The calculations have shown that the CASTOR V/HAWC is safeley designed for the loads under normal transport conditions as well as under type B testing conditions.

An analytical demonstration was made for the following IAEA-testing conditions.

9-m-drop on the side wall	(with shock absorbers)
9-m-drop on the top of the cask	(with shock absorbers)
9-m-drop on the bottom	(with shock absorbers)
1-m-drop onto the pin	(lid region with shock absorber and cask side wall)

THERMAL LAYOUT

With the aid of thermal calculations, the component temperatures of the CASTOR V/HAWC shipping cask are determined with hood during transport and without hood during filling and discharge.
The highest decay thermal power of the inventory of 4200 W is taken into account for the calculations.

The results show that transport regulations for a type B(U) shipping cask as well as the plant requirements made of the HAWC temperature are safely observed.
For the given boundary conditions, the surface and inventory temperatures are calculated for the transport and for filling or discharge:

	transport conditions	handling conditions
surface of transport hood	54°C	--
cask surface	71°C	36°C
inventory	78°C	42°C

SHIELDING CALCULATIONS

The design of the shielding of the CASTOR V/HAWC meets the requirements made of a B(U) type shipping cask.

It is shown that the admissible limits according to the transport regulations for B(U) type shipping units, 2000 μSv/h at the surface and 100 μSv/h at 2 m distance, are reached.

The results of the detailed shielding calculations are shown in the following table:

area	distance [m]	γ-dose [μSv/h]	n-dose [μSv/h]	total dose [μSv/h]
side	0	51	82	133
	1	25	37	62
	2	16	26	42
bottom	0	188	120	308
	1	117	75	192
	2	57	37	94
above	0	31	134	165
secondary lid	1	20	86	106
	2	10	43	53
with bottom	0	24	<1	24
shock-	1	13	<1	13
absorber	2	7	<1	7
with lid	0	1	1	2
shock-	1	<1	<1	<1
absorber	2	<1	<1	<1
transport hood	0	2	35	37
(shelter)	1	1	19	20
	2	1	14	15

QUALITY ASSURANCE DURING MANUFACTURE

The quality assurance concept for the CASTOR V/HAWC shipping cask has the objective of establishing and documenting the quality of the cask from planning to handling.

The administrative and organizational measures required for this purpose are summarized by the manufacturer in a quality assurance manual. In this manual it is made the duty also of subcontractors and producers of component parts to use a quality assurance program, and the inspection measures and the inspection directives are defined.

TESTS BEFORE COMMISSIONING

After final inspection and testing of the cask components and after the defined characteristics have been ascertained, the cask is assembled according to the assembly regulation, and a subsequent assembly test is conducted.

The assembly of the sealing system to generate the leak-tight containment is conducted according to the handling and test instructions for the loading of the cask.

PERIODIC INSPECTIONS

The periodic inspections (WKP) for the components of the shipping cask have the objective of guaranteeing the operativeness in handling and transport over the service time of the cask.

The inspections and inspection intervals take the following factors into account:

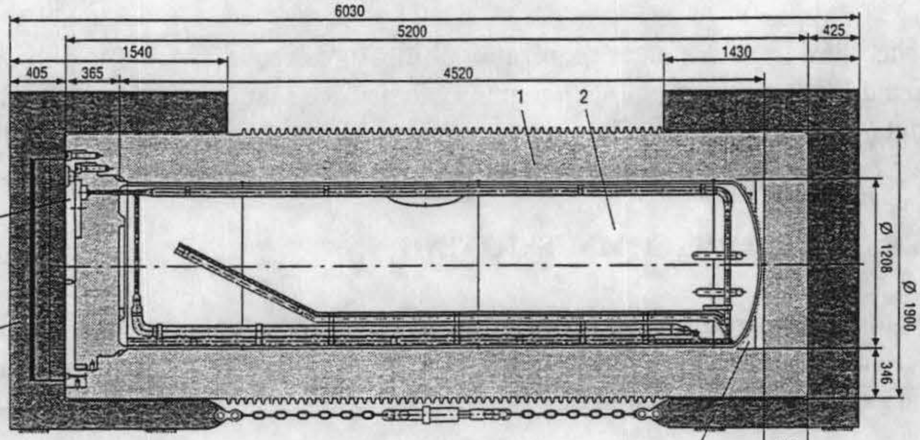
- number of transports
- loading of the components
- attack by corrosive media

The periodic inspections are laid down in a special test program.

CONCLUSION

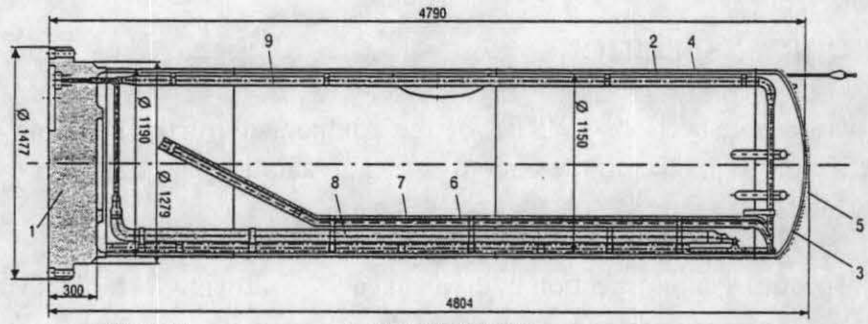
The explanations have shown that a modification of the CASTOR cask concept for irradiated fuel elements is able to give the solution for the transport cask for liquid high-level waste. The layout and the calculations summarized in the safety analysis report have shown that the manufacturing, quality, and safety demands can be fulfilled according to the national and international regulations.

The safety analysis report for type B(U) licensing has been submitted to the competent authorities and has led to a positive preliminary report regarding the B(U) capability. Type B(U) license is expected at the end of 1995.



1 Cask Body (Shielding Cask)
2 Inner Cask
3 Metallic Filling Mass
4 Secondary Lid
5 Shock Absorber

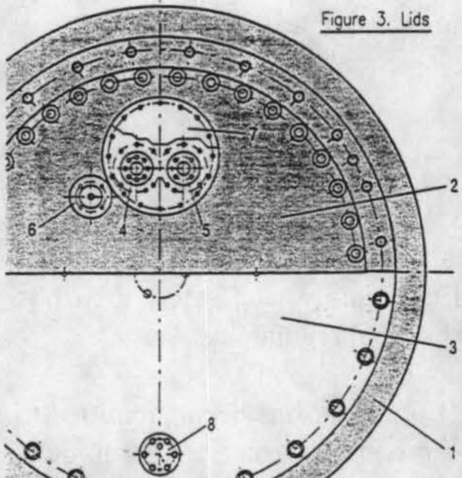
Figure 1. CASTOR V/HAWC package



1 Primary Lid
2 Inner Cask
3 Inner Cask-Rounded Bottom
4 Liner-Inner Cask
5 Liner-Rounded Bottom
6 Filling and Emptying Tube
7 Sampling Tube
8 Puls Tube
9 Bubble Tube

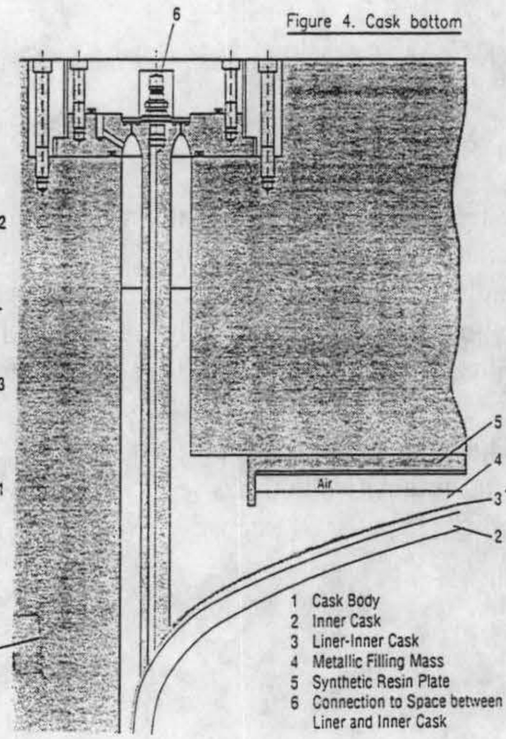
Figure 2. Inner Cask

Figure 3. Lids



1 Cask Body
2 Primary Lid (Inner Cask)
3 Secondary Lid
4 HAWC Filling and Discharge Connection
5 HAWC Auxiliary Discharge
6 Test Connection
7 Closure Plate
8 Connection for Contamination Test

Figure 4. Cask bottom



1 Cask Body
2 Inner Cask
3 Liner-Inner Cask
4 Metallic Filling Mass
5 Synthetic Resin Plate
6 Connection to Space between Liner and Inner Cask