Current Approval Procedures for Type-B Packages in Germany: Overview

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INTRODUCTION

This paper refers to papers presented at former PATRAM conferences (especially the paper of K. Wieser et al. 1989) and gives an overall view about Type B package-related activities of BAM, which is the responsible testing authority in Germany for shipping casks used for the transport of radioactive material. Some selected topics which were of special interest from the point of view of BAM are discussed in an additional paper presented at this conferece (Zeisler, P., et al. 1995).

The emphasis of the BAM Type B activities arose primarily from the necessity of the "Entsorgung" (disposal) of spent fuel elements from German nuclear power stations (NPS). This required new designs of CASTOR type casks for specified fuel elements. For the final disposal of spent fuel elements the POLLUX cask has been designed that will also be used for the transport and interim storage of fuel elements. The reprocessing of fuel elements of German NPS in foreign reprocessing plants requires shipping casks for the transport of vitrified high-active waste filled into small steel canisters to the German interim stores. The TS 28V and CASTOR 20/28 CG casks have been developed for such shipments. Both packages have been approved this year.

High-active radioactive waste concentrate (HAWC) produced by the German Test Reprocessing Plant WAK shall be either vitrified in Germany or (preferably) shipped to the reprocessing plant in Mol (Belgium) for vitrification. For these transports a specified CASTOR V/HAWC shipping cask shall be used. The part of certification in the responsibility of the BAM is nearly brought to a close.

The large amount of low-heat-generating waste produced in German nuclear plants required some modifications of the MOSAIK II-15 design in order to meet such requirements, which especially arose on special requests of clients and in consequence of different types of waste (i.e., different nuclide vectors, waste matrices, etc.). Meanwhile, the MOSAIK cask exists in nearly 10 modifications, partly to be approved separately.

The development of packages and from that resulting applications for approvals were accompanied by the BAM with performance tests of casks with three emphases: drop tests with the CASTOR VHLW cask including tests with artificial flaws beyond IAEA test conditions, drop tests with the POLLUX cask in a greater extent, simulating transport as well as storage conditions, and 9 m and 1 m IAEA drop tests with different MOSAIK casks which were necessary above all because of the increased weight of MOSAIK modifications.

Most of the large German Type B packages are manufactured from ductile cast iron (DCI). BAM as the responsible German testing authority for such packages did not recognize any problems in the past with that material: DCI is a qualified material for Type B packages if the necessary requirements (and restrictions) prescribed in Material Specifications (to be released by BAM) are considered. The last part of the paper shows the improvements of DCI properties illustrated by the ultimate elongation of that material.

APPLIED PACKAGE DESIGNS

Table 1 gives an overall view about the main characteristics of Type B packages appoved and certified since 1989 (i.e., the last overview in the paper of Wieser et al., 1989) and of packages presently being in the process of certification. Figure 1 illustrates the design concepts of these packages by schemes and Figure 2.1 and 2.2 show some more details of the POLLUX and CASTOR V/HAWC casks. Short descriptions of mechanical tests which have been performed with shipping casks in the last years are summarized in Table 2.

All packages are designed according to the requirements of the IAEA Regulations for the Safe Transport of Radioactive Material 1985 (As Amended 1990) which are fully included in the German national regulations (GGVS 1994). Type B packages which are also used for the interim storage of spent fuel or vitrified waste meet the requirements of the German Atomic Act and instructions based on it as well. Tests or test conditions to be taken into account are among others drops without shock absorbers with drop distances according to the real lifting heights of cranes, overturning of packages, air plane crashes onto packages, gas explosions, and a heating test of 1 hour duration at temperatures of 650 °C. Moreover, the POLLUX cask meets the specified requirements resulting from geologically induced deformations of the layers surrounding the storage location of the package (petrostatic pressure).

PERFORMANCE TESTS

Mechanical tests have been performed with the CASTOR VHLW shipping and storage cask, the POLLUX shipping and final storage cask, and with MOSAIK shipping casks in different design modifications. Short descriptions of tests which have been performed during the last 6 years are summarized in Table 2.

After completing the drop test program for the Type B qualification (Golliher, K.G.

et al. 1992), the CASTOR VHLW cask used for the transport and storage of vitrified radioactive waste has been dropped simulating beyond IAEA test conditions in order to demonstrate the safety margins of DCI casks. The tested cask with an artificial flaw of 120 mm depth (46.5 % of the wall thickness) in the region of maximum bending stresses has been dropped in a horizontal position without shock absorbers onto two steel bars positioned in a distance of 2.895 m (i.e., about 83 % of the cask length). The maximum drop height amounted to 14 m. A crack propagation did not occur even under these severe conditions (Droste, B. et al. 1995).

The background, the test conditions, and the results of tests performed with the POLLUX cask are discussed in some papers of this conference, among others Gogolin, B., (1995), Quercetty, Th., (1995), and Zeisler, P., (1995).

The primary reason for 9 m and 1 m drop tests carried out with MOSAIK casks was the increased mass of some cask modifications caused by larger thicknesses of the inner lead shielding for specified contents (Originally: up to 80 mm, now: up to 140 mm). 1 m drop tests, i.e., horizontal drops onto a vertical bar with a diameter of 150 mm, have been performed in order to investigate the influence of the increased cask weight on the bending stresses in the neighbourhood of the non-protected central impact location of the cask. Though the stresses reached values in the order of the yield stress of the material, no crack initiation or propagation (of probably undetected cracks) was observed. However, in order to fulfill the BAM criterion with respect to the stress limitation ($\sigma < 0.5\ R_{p0.2}$ if fracture toughness is aditionally specified) the MOSAIK II-15 cask will be generally equipped with an additional middle shock absorber.

SUMMARY AND CONCLUSIONS

The paper gives an overall view about the certification activities in Germany during the last 6 years with respect to Type B shipping casks manufactured from DCI and the mechanical tests performed with those casks in that period. The mechanical tests covering beyond IAEA conditions demonstrated clearly the safety margins of ductile cast iron that is used in Germany as Type B cask material. Furthermore, the tests show that the BAM criterion with regard to the limitation of stresses in DCI components ($0.5\ R_{p0.2}$) includes a safety margin which is worthwhile to be investigated in more detail and and which can be extended by an explicit brittle fracture safety assessment.

ACKNOWLEDGEMENT

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REFERENCES

Droste, B., Gogolin, B., Völzke, H., Quercetti, Th., *Extended Drop Tests of DCI Casks with Artificial Flaws Demonstrating the Existing Safety Margins*, Second Technical Seminar on Brittle Fracture Safety Safety Assessment of Ductile Iron Containers for Shipping and Storage of Radioactive Material, Krefeld, Germany, 27-28 October 1994, RAMTRANS Vol. 6 (1995), Nos. 2/3, pp. 177-182

Gogolin,B., Droste, B., Quercetti, T., *Drop Test Program with the German POLLUX Cask for Final Disposal of Spent Fuel*, conference paper PATRAM '95, Las Vegas NV, USA (1995)

Golliher, K.G., Witt, C.R., Wieser, K.E., *Report on the Joint USA-Germany Drop Test Program for a Vitrified High Level Waste Cask*, proceedings of the 10th International Symposium on the Packaging and Transportation of Radioactive Materials, Yokohama City, Japan, vol. 3, p. 1123 (1992)

International Atomic Energy Agency, *Regulations for the Safe Transport of Radioactive Material, 1985 Edition (As Amended 1990)*, IAEA,Vienna, 1990

Quercetti, T., Droste, B., Gogolin, B., *Integrity of the German POLLUX Cask for Final Disposal: Experimantel Results of the Mechnical Tests*, conference paper PATRAM '95, Las Vegas NV, USA (1995)

Verordnung über die innerstaatliche und grenzüberschreitende Beförderung gefährlicher Güter auf Straßen (Gefahrgutverordnung Straße - GGVS) in der Fassung der Bekanntmachung vom 18.07. 1995, BGBL. I Nr. 42 S. 1025, Bonn, 10.08. 1995

Wieser, K.E., Aurich, D., Wüstenberg, H., *The Status of Ductile Cast Iron Shipping and Storage Containers in the Federal Republic of Germany*, proceedings of the 9th International Symposium on the Packaging and Transportation of Radioactive Materials, Washington DC, US, p. 701 (1989)

Zeisler, P., Droste, B., Rödel, R., *Rehmer, B., Current Approval Procedures for Type B Packages in Germany - Selected Topics*, conference paper PATRAM '95, Las Vegas NV, USA (1995)

Table 1: Large Type B Packages - Approved and Certified since May 1989 and Running Approval Procedures (Selection)

Name	Package mass [kg]	Contents	Remark
TN 900/1-21	88 000	max. 21 PWR (U/Mox) fuel elements	(test certificate)
CASTOR X/28F	134 000	max. 28 PWR (U/Mox) fuel elements	running
CASTOR 440/84	131 000	max. PWR (VVER 440) fuel elements	approved
CASTOR MTR 2	19 000	different research reactor fuel elements	approved
CASTOR V/19	140 000	max. 19 PWR (U/Mox) fuel elements	test certificate
CASTOR V/52	134 500	max. 52 BWR (U/Mox) fuel elements	running
CASTOR V/85	127 000	max. 84 FBR (SNR) fuel elements	running
CASTOR BARRE	101 500	absorber elements	approved
CASTOR THTR/AVR	27 600	THTR and AVR fuel elements (spherical)	approved
CASTOR MTR/F	13 240	MTR fuel elements, (Pu/U) contaminated wastes in drums (feed sludges, solid waste, etc.)	approved
MOSAIK 80T	89 000	structural components of fuel elements	approved
POLLUX	70 000	PWR or BWR fuel elements, complete or cut	running
CASTOR HAWC 20/28 CG	112 000	cans with vitrified waste from reprocessing	approved
TS 28 V	116 400	cans with vitrified waste from reprocessing	approved
CASTOR V/HAWC	89 600	high-active waste concentrate from reprocessed fuel	running
MOSAIK [1] II-15/15U(0-80)	7 750 - 10 100	dried and conditioned concentrates, dewatered ion exchanger resins, contaminated metals or solids (also Pu/U contaminated)	approved
MOSAIK II-15/15U(90140)	12 100 - 13 150	contaminated metals or solids, sources, Pu/U contaminated solidified or conditioned waste	approved
MOSAIK II-15 TR (0-80)	7 750 - 10 100	dried and conditioned concentrates, dewatered ion exchanger resins, contaminated metals	approved
MOSAIK II-15 DE (0-120)	8 950 - 12 340	dried and conditioned concentrates, dewatered ion exchanger resins, contaminated metals or solids (also Pu/U contaminated), Co60 sources	running
MOSAIK II-15 T/S, T/S4	about 8 800	complete activated ion exchangers	running
MOSAIK II-15 T ISAR,T/F ISAR		to be specified	running
MOSAIK II-15 B(U)F	7 750 - 10 100	same as MOSAIK II-15 (0-80) but larger Pu/U contents	running
Gußcontainer VII	about 22 000	dried precipitation sludges mixed with bitumen	running

[1] MOSAIK II-15 designs --->numbers in brackets: thickness of lead shielding (missing values in running procedures will be specified)

Table 2: Drop Tests performed since May 1989, with Type B(U) Packages in the Frame of Certification

Package Name	Test Conditions
CASTOR VHLW	3 performance tests with artificial defects at the location of maximum strains, horizontal onto cylindrical rails o geometry of package: dia.* wall thickness*length = 1156*260*3455 mm o mass of package: 21280 kg o flaw depth: 46.5 % of the wall thickness o test conditions (drop height/ distance of the rails) (1) 2.4 m/2595 mm (2) 3.5 m/3165 mm (3) 14.0 m/2895 mm
POLLUX[1]	(1) horizontal 9 m drop onto the shock absorbers/trunnions, unyielding target (2) 9 m drop flat onto the lid shock absorber, unyielding target (3) 9 m drop onto the edge of the lid shock absorber, unyielding target (4) 5 m drop onto the trunnions (without shock absorbers), real target (5) 5 m drop onto the bottom (without shock absorbers), real target Package mass: (1): 72870; (2),(3): 68070; (4),(5): 63270 kg
MOSAIK II-15 (90-140)[2] with lid and bottom shock absorber	(1) 9 m drop onto the edge of the lid shock absorber package mass: 11080 kg; unyielding target (2) 1 m IAEA drop test II onto a bar, horizontal, unyielding target package mass: 11932 kg impact location: unprotected middle part of the package (centre) (3) same as (2) but with a circumferential impact location of the package at the drilled hole for material samples (4) 1 m IAEA drop test II onto a bar, horizontal, unyielding target package mass: 10755 kg impact location: same as (2) (5) 2 m drop test II onto a bar, horizontal, unyielding target package mass: 5580 kg impact location: same as (2)
MOSAIK II-15 (90-140)[2] with lid, middle and bottom shock absorber	(6) 1 m IAEA drop test II, horizontal, unyielding target package mass: 12745 kg impact location: middle shock absorber (centre)
MOSAIK II-15 TR[2]	(1) 9 m drop flat onto the lid shock absorber, unyielding target package mass: 11745 kg (2) 1.2 m drop test II vertically with the lid side onto a bar, package equipped with shock absorber stiffened in the centre with a 400*40 mm circular plate, unyielding target package mass: 11080 kg (3) 1 m IAEA drop test II vertically with the lid side onto a bar, package without shock absorber, unyielding target package mass: 10420 kg

[1] Tests with the POLLUX cask:
Enlarged drop heights at the 9 m drop tests because of necessary compensation of the weight of one missing shock absorber (For further detailled information see Gogolin, B. et al. 1995 and Quercetty, T. et al. 1995)

[2] Tests with MOSAIK II-15 casks:
Different masses in consquence of different thickness of the lead shielding;
Enlarged drop heights at drop test II because of the necessary compensation of missing shock absorber(s) and/or lead shielding and contents

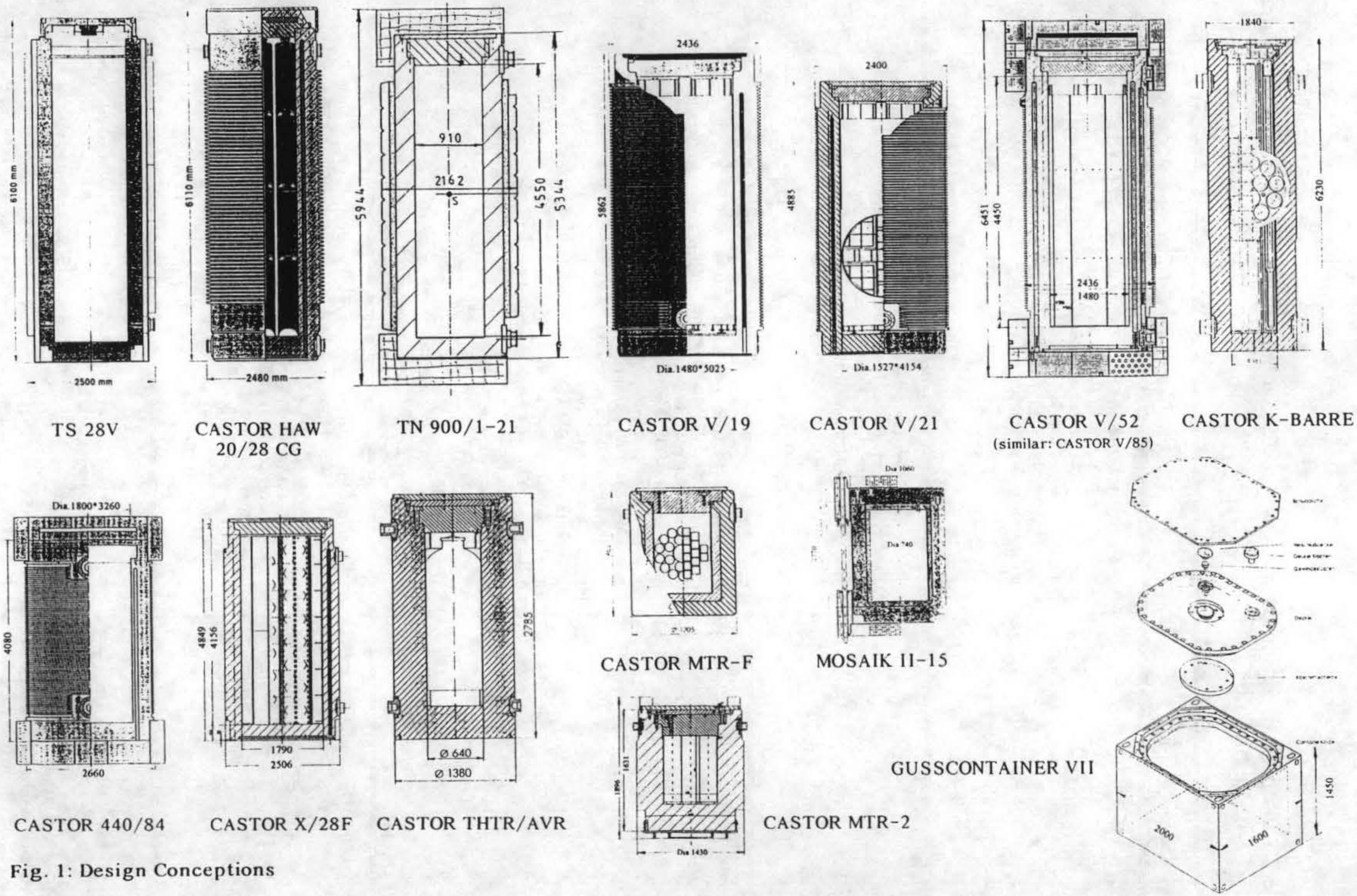

Fig. 1: Design Conceptions

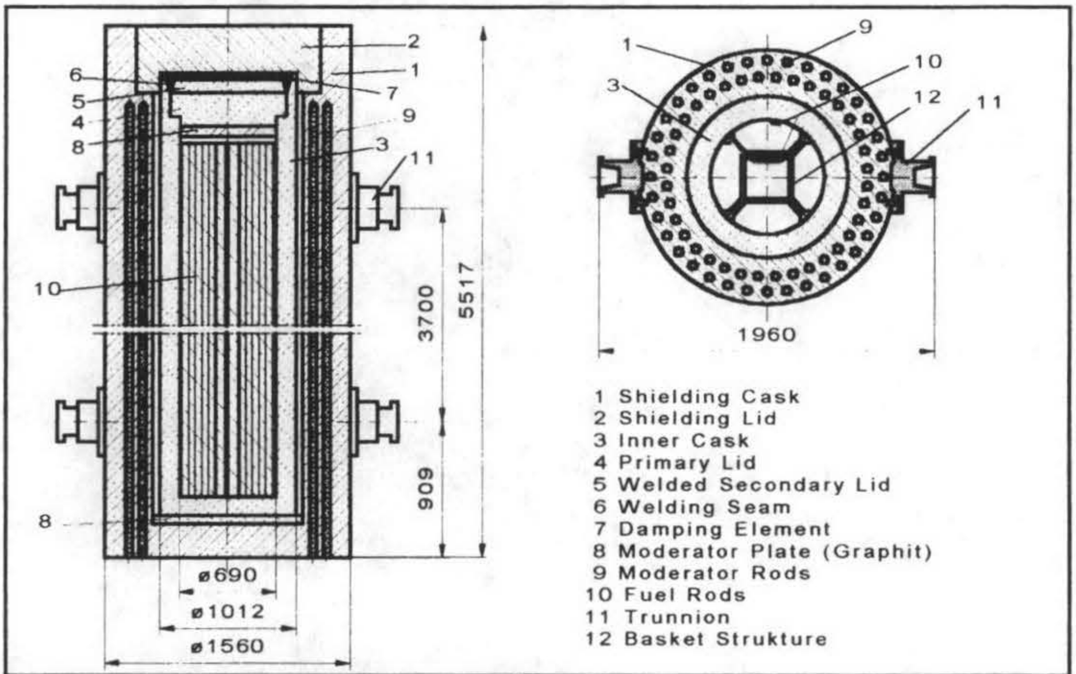

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Fig. 2.1: POLLUX Final Disposal Cask

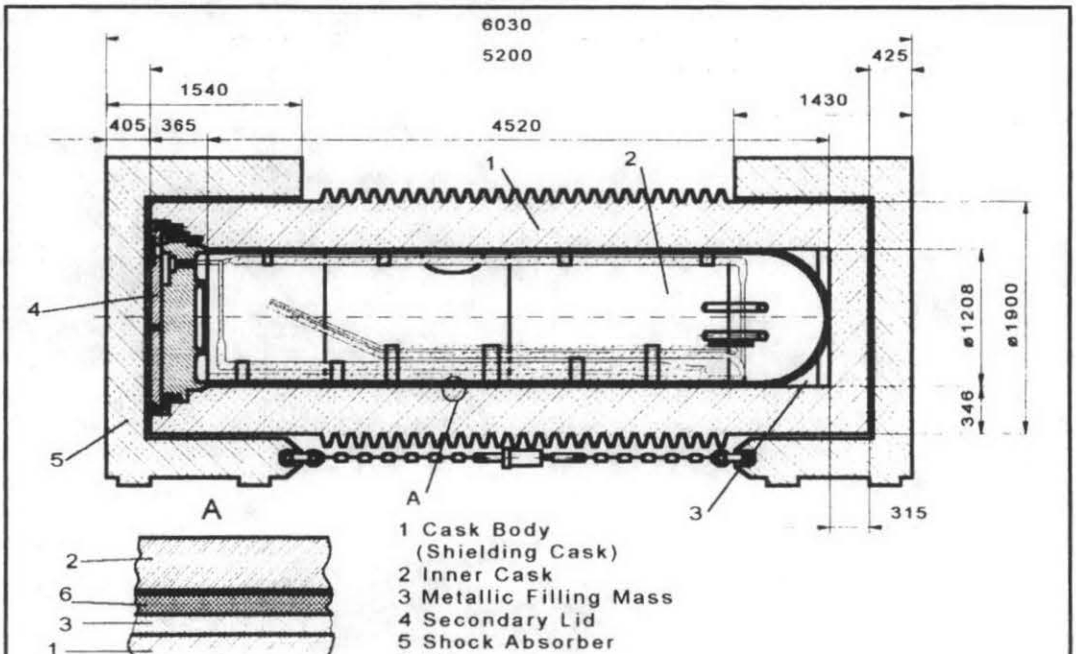

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Fig. 2.2: Transport Cask CASTOR V/HAWC Longitudinal Cut