



Use of CASTOR[®] and CONSTOR[®] casks for RBMK and VVER fuel assemblies

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1. Introduction

The dry storage of spent nuclear fuel from Russian type reactors was successfully realised the first time worldwide in CASTOR[®] casks developed by the GNS/GNB company in the nineteen eighties and nineties. These casks made of Ductile Cast Iron are licensed for both transport and storage. They are in operation since 1983. Advanced CASTOR[®] cask design adaptations are able to accommodate VVER 440 fuel with higher enrichment and higher burn up.

The CONSTOR[®] design was developed as an alternative multipurpose cask concept for transport and dry storage, and in principle for final disposal of Russian spent nuclear fuel. This steel cask sandwich concept with heavy concrete as an additional shielding material fulfills the same safety criteria as the CASTOR[®] cask design. The maximum removable heat load is approx. 30 kW per cask. The main advantage of the CONSTOR[®] design is its cost-effective manufacturing by conventional engineering technologies and materials.

In the following, the different design versions of CASTOR[®] and CONSTOR[®] casks for Russian nuclear fuel will be presented. The status of its safety assessment and licensing is described and the operational experiences with CASTOR[®] and CONSTOR[®] casks are evaluated.

2. CASTOR[®] casks

2.1 Basic design

The cask body consists of a large cylindrical thick-walled casting incl. bottom made of ductile cast iron (DCI) with high ductility. On the outside wall, circumferential fins are machined in the body to improve the heat removal. For neutron moderation, axial bore holes are distributed uniformly in the cask wall. Two pairs of trunnions are attached onto the cylindrical part bottom side and lid side for handling and lifting.

Corrosion protection of the cask cavity and the sealing surfaces is made by nickel coating. The outside surface is protected by a decontaminable multilayer paint coating.

The lid system consists of two independent lids to realise the double barrier system which is required to fulfill the long-term storage criteria. The primary lid and the secondary lid are sealed by metal o-rings and fastened by socket head cap screws.

In order to accommodate the fuel assemblies (FA), a basket consisting of tubes for positioning of each FA is installed inside the cask cavity. The materials are steel for structural reasons and boronated materials for neutron absorption. The necessary heat removal is realised by aluminium plates arranged between the tubes for FA positioning.

For fulfilment of the IAEA-criteria for transport of type B-packagings, impact limiters are intended, which are screwed onto the lid side and the bottom side.

The safety analyses under normal operational and accidental conditions is performed by internationally accepted codes:

- Mechanical DYNA 3D; ANSYS
- Thermal ANSYS; COSMOS
- Shielding MCNP
- Criticality MCNP

They are verified by benchmark experiments.

2.2 CASTOR[®] RBMK 1500

The CASTOR[®] RBMK cask (see fig. 1) is designed for long-term storage of 102 RBMK half fuel assemblies which are positioned in the existing basket.



Fig. 1 Loaded CASTOR[®] RBMK casks in the Ignalina NPP Storage Site

The main technical data are:

- Overall length 4330 mm
- Outside diameter 2072 mm
- Cavity dimensions \varnothing 1483 x 3810 mm
- Total mass 85.2 t (Storage)

The fuel data are the following:

- U235-enrichment 2.0...2.4 wt-%
- Average burn up 20 GWd/MTU

The cask was licensed for long-term storage by the Lithuanian Competent Authority. Twenty casks have been delivered by GNB. They are loaded and in operation since 1997/1998.

2.3 CASTOR[®] 440/84

The CASTOR[®] 440/84 was developed for 84 FA's. Two design versions exist to accommodate FA's with different fuel specifications:

	CASTOR[®] 440/84	CASTOR[®] 440/84M
U235-Enrichment	3.6 wt-%	3.87 wt-%
Burn up	36 GWd/MTU	50 GWd/MTU
Decay heat	21 kW/cask	24.66 kW/cask

The CASTOR[®] 440/84 cask is licensed as a type B(U)F-package for transport in Germany and validated in the Czech Republic, Hungary and Slovakia. A license for interim dry storage on the site of Nuclear Power Plant Dukovany, Czech Republic is valid. More than 62 casks have been delivered, loaded and stored (s. Fig. 2) up to now, to fulfill the existing delivery contract. Within this contract, SKODA Plzen performs machinery, assembling and quality control under supervision of GNB.

In Germany, 63 casks have been delivered and most of them loaded.



Fig. 2 CASTOR[®] 440/84 Casks loaded and stored at Dukovany NPP, Czech Republic

The advanced cask design and the respective dimensions of the CASTOR[®] 440/84M in the transport configuration are shown in Fig. 3 (longitudinal section)

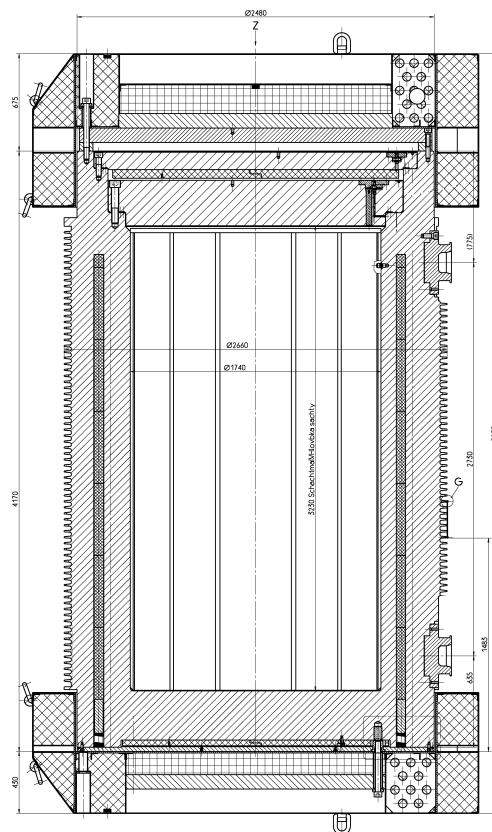


Fig. 3 CASTOR[®] 440/84M – Transport configuration

The cross section (s. Fig. 4) shows the two rows of neutron moderator holes in the wall and a top view onto the basket.

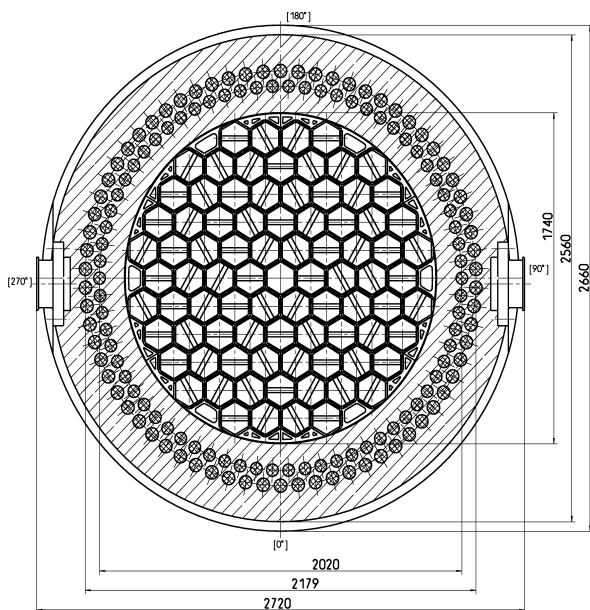


Fig. 4 CASTOR® 440/84M – Cross section and view onto the basket

The basket consists in principle of an arrangement of 84 hexagonal aluminium tubes for structural and heat removal functions. Between the tubes, boronated steel plates are arranged for neutron absorption. Currently, the licensing procedure for both transport and storage is running at the Czech Competent Authority. The licenses are expected early in 2005.

2.4 CASTOR® VVER 1000

This cask is designed for transport and long-term storage of 12 FA's with the following specification:

- U235 enrichment 4.4 wt-%
- Burn up 50 GWd/MTU

The main technical data are:

- Overall length 5505 mm
- Outside diameter 2253 mm
- Cavity dimensions Ø 1293 x 4730 mm
- Total mass 100 t (Storage)

The cask is in operation in the Russian NPP Novo Voronesh since 1984.

3. CONSTOR® casks

3.1 Basic Design

The cask consists of a thick-walled cylindrical “sandwich” cask body, including an inner and an outer liner fabricated from fine-grained steel. The liners are welded to the massive fine-grained steel head ring to form a double barrier containment. For additional shielding, the cavity between the liners is filled with CONSTORIT. Inside the CONSTORIT layer, heat conducting elements are arranged, and on the outer surface, there are fins serving for dissipation of decay heat.

The lid system consists of three lids:

- a bolted primary lid
- a welded sealing plate and
- a welded secondary lid

For fulfilment of the transport requirements, an overpack over the cylindrical part and impact limiters at the ends is attached.

The design features are described in detail in [1], which is presented on the PATRAM 2004, too.

For assessment of the CONSTOR[®] basic design, several thermal and structural test programs were performed since 1997, using half scale models. A full scale drop test program is starting during the PATRAM 2004. The respective test programs are described in [2], which is presented during the PATRAM 2004.

3.2 CONSTOR[®] RBMK 1500

The CONSTOR[®] design was adapted in the nineties in order to accommodate half fuel bundles of RBMK 1500 reactors. The existing fuel basket is used. This cask type is licensed for storage in Lithuania. The type B(U)F transport license was issued in the Czech Republic. Sixty casks were delivered and are successfully in operation in the Ignalina NPP storage site.

The advanced CONSTOR[®] RBMK 1500 M2 design (see Fig. 5) is developed to accommodate FA's with the following specification:

- | | |
|-------------------|------------------|
| - U235 enrichment | 2.85 wt-% |
| - Burn up | 26 GWd/MTU |
| - Cooling time | 5 years |
| - Heat load | ≤ 12.5 kW / cask |

The cask can be loaded alternatively with:

- up to 51 RBMK-1500 intact or gas-leaking SFAs in the 32M-basket and 40 intact or gas-leaking SFAs in the ring basket, or
- up to 51 intact or gas-leaking SFAs in the 32M-basket and about 20 mechanically damaged SFAs in a special ring basket

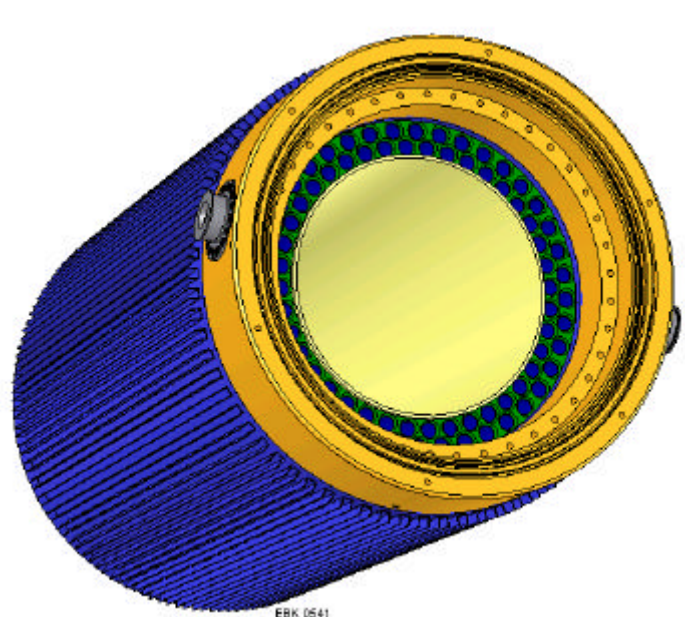


Fig. 5 CONSTOR RBMK 1500 M2 storage cask

The main technical data are:

- Overall length 4511 mm
- Outside diameter 2610 mm
- Cavity diameter \varnothing 1930 x 3800 mm
- Total mass 104 t

The cask design fulfils all safety criteria under both normal operational and hypothetical accident conditions. The CONSTOR[®] 1500 M2 is intended for use in the Ignalina storage site.

3.3 CONSTOR[®] 440/84

The CONSTOR[®] adaptation for VVER 440 fuel is shown in Fig. 6.

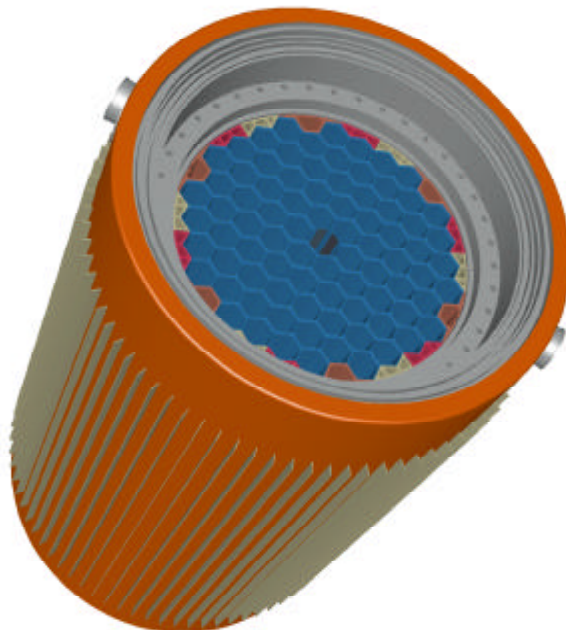


Fig. 6 CONSTOR[®] 440/84 - general view

The main technical data are:

- Overall length 4100 mm
- Outer diameter 2700 mm
- Cavity height 3242 mm
- Cavity diameter (incl. fins) 1740 mm
- Cask weight loaded ~110 tons

The fuel specification and the basket design are identical with the CASTOR[®] 440/84M. This cask will be used first in the Interim Storage Site of Kozloduy NPP. The storage licensing procedure will start at the end of 2004.

3.4 CONSTOR[®] 1000/19

This cask was designed for 19 FA's from VVER 1000 reactors with the following specification:

- U235 enrichment 4.4 wt-%
- Burn up < 55 GWd/MTU

A new basket made of aluminium disks and boronated hexagonal steel tubes was developed (s. Fig. 7).

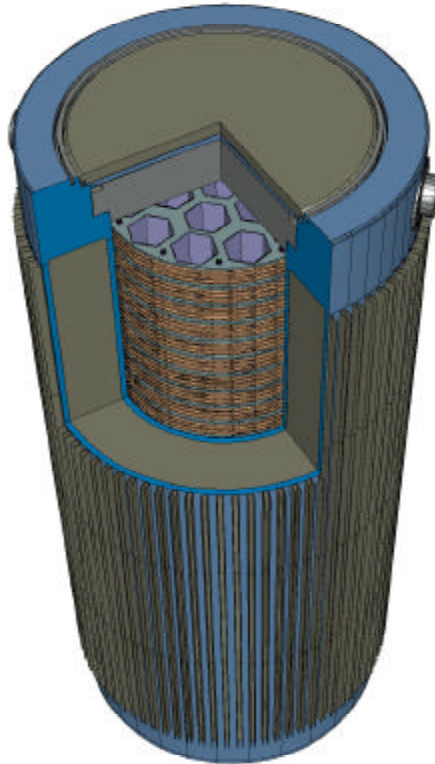


Fig. 7 CONSTOR[®] 1000/19 transport and storage cask

The main technical data are:

- Overall length 5530 mm
- Outer diameter 2570 mm
- Cavity height 4620 mm
- Cavity diameter (incl. fins) 1510 mm
- Cask weight loaded ~ 133 tons

4. Summary and Conclusion

CASTOR[®] casks for Russian type reactor fuel made of ductile cast iron are well established and successfully in operation in Germany, Lithuania and the Czech Republic. They are licensed for both storage and transport conditions.

The CONSTOR[®] steel sandwich cask for Russian type reactor fuel is an economic alternative to the CASTOR[®] casks. Thermal and mechanical test programs have confirmed that all safety criteria for storage and transport are met.

Literature

- [1] Thomas Funke/Rudolf Diersch
"The use of the CONSTOR[®] cask concept for light water reactor fuel"
PATRAM 2004
- [2] Sabine König/Rudolf Diersch
"Half and full scale drop tests for qualification of CONSTOR[®] casks as type B(U)F packages"
PATRAM 2004