

## EUROPEAN EXPERIENCE IN TRANSPORT / STORAGE CASK FOR VITRIFIED RESIDUES

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### ABSTRACT

Because of the evolution of the burn-up of used fuel to be reprocessed, the high activity vitrified residues would not be transported in the existing cask designs. Therefore, TN International has decided in the late nineties to develop a brand new design of casks with optimized capacity able to store and transport the most active and hottest canisters: the TN<sup>TM</sup>81 casks currently in use in Switzerland and the TN<sup>TM</sup>85 cask which shall permit in the near future in Germany the storage and the transport of the most active vitrified residues defining a thermal power of 56 kW (kiloWatts).

The challenges for the TN<sup>TM</sup>81 & TN<sup>TM</sup>85 cask designs were that the geometry entry data were very restrictive and were combined with a fairly wide range set by the AREVA NC Specification relative to vitrified residue canister.

The TN 81 & the TN 85 casks have been designed to fully anticipate shipment constraints of the present vitrified residue conditioning. It also used the feedback of current shipments and the operational constraints and experience of receiving and shipping facilities. The casks had to fit as much as possible in the existing procedures for the already existing flasks such as the TN 28 cask and TS 28 V cask, all along the logistics chain of loading, unloading, transport and maintenance.

In addition, years of feedback and experience in design and operations - together with ever improved materials - have allowed finding further optimization of this type of cask design. In order to increase the loading capacity in terms of radioactive source terms and heat load by 40%, the cask design relies on innovative solutions and benchmarks from the current shipping campaigns.

Currently, TN 81 and TN 85 are the only licensed casks that can transport and store 28 canisters with a total decay heat of 56 kW. It contributes to optimise the number of required transports to bring back high level waste residues to their producers. Three units have already been loaded and transported to ZWILAG (Zwischenlager Würenlingen AG) in Switzerland where they are stored for 40 years.

Based on the same design but integrating the German Authorities and German users specificities, the TN 85 cask is dedicated to the transport and storage of vitrified residues to Germany. It is presently at the final licensing stage. The transport cask approval expertise has now been granted, and the storage expertise is in the final steps. The first transport with TN 85 cask is scheduled up to now in 2008 and the commissioning operations are under preparation.

These two casks are key elements for the whole reprocessing system of AREVA as they enable the transportation and the storage of the vitrified residues.

## DESCRIPTION OF THE TN81 & TN85 CASK DESIGN

The TN81 & TN85 casks have a general cylindrical shape with about 7,215 mm length and 2,750 mm diameter. They can be provided with two transport configurations T1 and T2 as shown in figures 1 and 2 next pages.

The TN81 & TN85 casks are mainly composed of a thick steel forged cylindrical vessel, a welded bottom end made of forged vessel and two lids (primary and secondary) made of forged steel. All these elements are defining a cylindrical cavity with a 1,350 mm diameter and a minimal length of 5,120 mm. A quite innovative feature is that the external part of the cask is made of hollow aluminium profiles screwed on the vessel and filled with lead and neutron shielding. The primary lid is bolted on the body by a flange, and is equipped with two seals (one metallic for long term leak tightness and one elastomer).

In the T2 configuration, the secondary lid is installed over the primary lid. It is bolted on the cask forged body. As well as the primary lid, it is equipped with two seals (one metallic for long term leak tightness and one elastomer seal). The maximal mass of the cask in this configuration is:

- Cask empty (without canisters) : 102,000 kg (kilograms)
- Cask loaded : 116,000 kg

The secondary lid is not installed at the loading facility in AREVA NC La Hague plant, because it is only required for storage purpose and not for initial transport purpose. As a consequence, the casks have been designed to be transported in a T1 configuration (Fig. 1). In such configuration, an aluminium flange is installed in place of the secondary lid and acts as a spacer. This spacer is attached to the top shock absorbing cover.

The maximal mass of the cask in T1 configuration is:

- empty (without canister) : 100,000 kg
- loaded : 114,000 kg

The main gamma shielding is provided by the forged vessel and lead installed in the aluminium profiles. The neutron shielding is ensured by a proprietary high density resin compound. At the bottom end of the cask, a steel casing is also filled with resin. The primary lid also carries a top steel casing filled by resin compound. The shock absorbing covers also provide additional neutron shielding thanks to the wood and resin they contain.

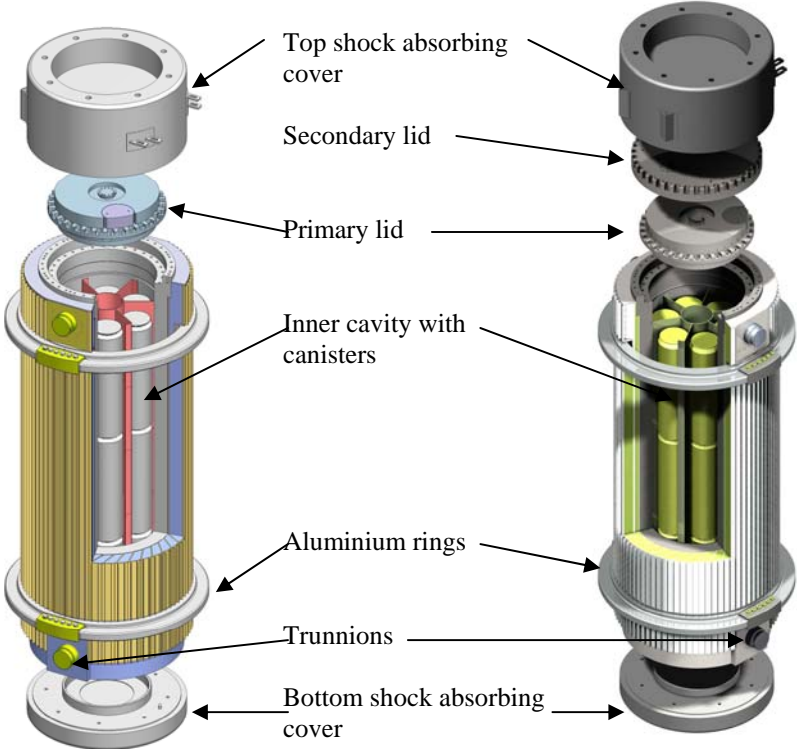
The aluminium profiles are produced directly with outer fins that enhance the heat dissipation of the vitrified residues heat power at the external surface to the ambient air. It is noticeable that the good thermal conductivity of the aluminium helps in keeping the gradient of temperature of the cask low enough.

Two pairs of trunnions on the forged vessel are used to handle, tilt and stow the cask during transport.

During transport, the shock absorbing function is performed by two lateral aluminium rings and by one lid and bottom shock absorbing covers. The lid and bottom shock absorbing covers are made of a stainless steel casing structure containing wood. The aluminium rings are made of two half rings screwed together with aluminium connecting plates.

An orifice, going through the primary lid, gives access to the internal cavity of the cask. Its function is to allow the vacuuming of the cavity, the backfilling with helium, the adjustment of the internal pressure or gas sampling. This orifice is closed by an orifice plug with an elastomer seal and by an orifice cover equipped with a double metallic seal.

The secondary lid (only installed in T2 configuration see Fig. 1) has orifices giving access to the inter-lid space



**Fig. 1 T1 and T2 configurations**

Depending on the transport configurations, several containment boundaries have been studied and analyzed in the safety report:

In T1 configuration, the containment boundary is made of the forged vessel with the bottom and its welding, the primary lid and its metallic seal, and the orifice cover with its metallic seal.

In T2 configuration, the containment boundary is made of the forged vessel, the bottom and its welding, the secondary lid and its metallic seal, and the transport orifice cover and its inner metallic seal, the coupling orifice cover and its metallic seal.

T1 configuration will mainly be used to transport the casks after the loading from AREVA NC La Hague plant to the storage sites. The T2 configuration will be used to transport the cask after its storage period at the ZWILAG or Gorleben interim storage facility. The secondary lid shall be installed during storage the storage period and need not be removed before transport.

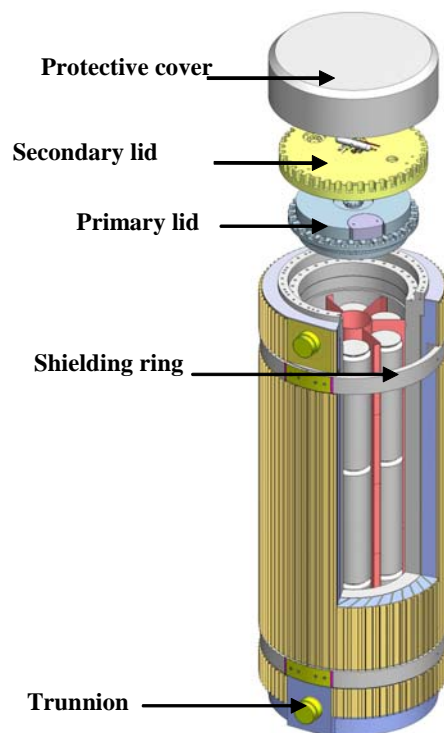
The main elements of the casks in the main storage configuration S1 (Fig. 2) are as follows:

- A forged vessel with a welded bottom.
- Shielding steel casing at the bottom filled with neutron shielding compound.
- External part of the cask covered with aluminium profiles screwed to the body and filled with gamma and neutron shielding.
- Four trunnions.
- 2 shielding rings

A closure system defining with the forged vessel two independent leak tight boundaries:

- One primary lid (with a metallic seal in its internal groove) equipped with an orifice with a plug and a cover (with a double metallic seal).
- A secondary lid (with a metallic seal in its internal groove) equipped with two orifices closed respectively by a pressure sensor and an orifice cover (with a metallic seal).
- A protective cover.

The length of the cask is about 6,200 mm, the diameter is 2,480 mm and the Weight is 110,000 kg.



**Fig. 2 : S1 storage configuration**

For the TN<sup>TM</sup>85 cask, in the very unlikely case of a leak on the primary lid during the storage period, the repair concept consists in the installation and tight welding of a service lid on top of the secondary lid. The cask is then equipped three lids: the primary, secondary and service lids. A specific protection plate is used for this configuration, making the storage configuration S2. The secondary and the service lids are defining two independent leak tight boundaries. The primary lid is no longer considered as a leak tight boundaries.

In such storage configuration, the length of the cask is 6,292 mm, the diameter 2,480 mm and the maximal mass 112,000 kg.

Figures 4 and 5 show the radioactive content of the casks, which consists in 28 universal canister-vitrified with the following characteristics:

- external diameter : 430 mm
- total height : 1,338 mm
- container glass volume : 150 liters
- maximal mass : 550 kg (for 1 canister)
- maximal thermal power at transportation time : 2 kW

The total maximal mass of the content is limited to 14,000 kg and the total thermal power 56 kW.

The definition of the radioactive content is made in accordance with the AREVA NC Specification 300AQ016 for the vitrified residue canister. For instance, the U (Uranium) and Pu (Plutonium) contents are respectively lower than 4500 and 110 g per container.

The maximal content of fissile isotopes (U233, U235, Pu239, Pu241) per is lower than 400 g of Pu239 equivalent. The following relations are used: 1 g of Pu241 is equal to 2 g of Pu239, 1g of U235 is equal to 0.65 g of Pu239 and 1g of U233 is equal to 1g of Pu239.

The canisters are positioned in a copper basket with seven cells each accepting 4 stacked canisters.

The cavity is back filled with helium.

## **TN85 TRANSPORT AND STORAGE LICENSING PROCESS**

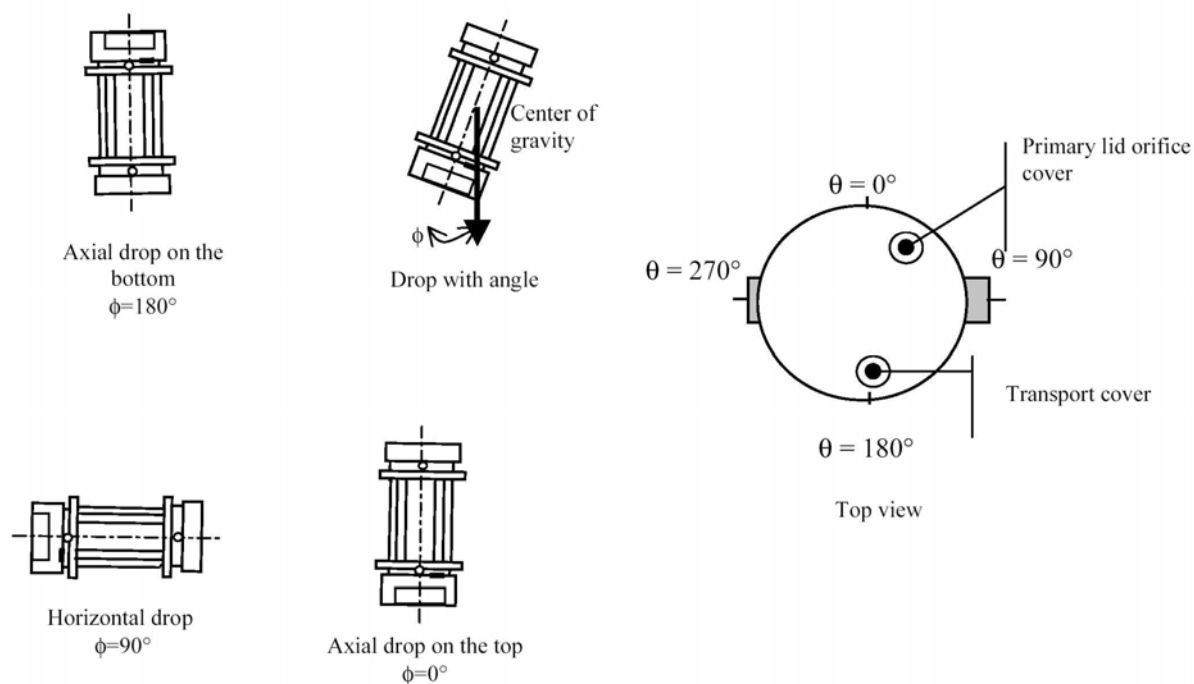
In 1998, the application for the cask transport license according to the 1996 IAEA (International Atomic Energy Agency) regulations was made simultaneously in France and Germany.

In order to demonstrate that the cask fulfil the IAEA requirement concerning accidental conditions of transport a 1/3 scale model has been manufactured for drop test purpose. The manufacturing of the scale model has been followed by TÜV (Technische Überwachungs-Verein) Berlin and the drop tests have been performed by BAM (Federal Institute for Materials Research and Testing).

A total amount of eight drops (Fig. 3) has been performed distributed in four sequences with most of the time an association of a 1 meter drop on a punch and a 9 meter drop on an unyielding target. The cask has drop in a horizontal and a vertical way in order to obtain the most damaging results. The main parts of the closure system such as the primary lid orifice cover have been used as target for the drop.

The value of leak tightness obtained for the primary barrier defined by the primary lid gasket and the orifice cover gasket after the drop has never been higher than  $5,8.10^{-8} \text{ Pa.m}^3.\text{s}^{-1}$  (Pascal. Cubic meter/second), which is sufficient to ensure a value of dose rate after accident less than the value defined in IAEA.

The value of leak tightness obtained for the secondary barrier defined by the secondary lid gasket, the transport and coupling orifice gasket after the drop has never been less than  $3.10^{-6} \text{ Pa.m}^3.\text{s}^{-1}$ , which is sufficient to ensure a value of dose rate after accident less than the value defined in IAEA.



**Fig. 3 : Orientation of drops**

All the tests have been completed in 2001 and have demonstrated excellent leak tightness compatible with transport requirements.

The subsequent expertise of the cask transport safety analysis report by the French authorities has led to the granting of the French B(U) certificate of approval of the TN85 cask design according to IAEA 96 regulations in March 2005.

The expertise of the cask transport safety analysis report by the German authorities has been completed in January 2006. The granting of the German B(U) certificate of approval of the TN85 cask design according to IAEA 96 regulations has been made in March 2006.

The granting of the German Certificate of Approval is mandatory for the storage of the TN85 at Gorleben. The additional requirements to store the cask at Gorleben are also defined by the storage site license and mainly include:

- analysis of an accidental drop during handling
- analysis of the consequences of a fire
- thermal requirements
- dose rate requirements :  $100 \mu \text{ Sv/h}$  (micro Sievert /hour) for the gamma (average maximal value at the external surface of the cask) and  $250 \mu \text{ Sv/h}$  for the neutron (average maximal value at the external surface of the cask)

The expertise of the topical safety analysis report for the cask storage at Gorleben ended in July 2006 and Certificate for storage has been obtained in May 2007.

## **TN85 MANUFACTURING, PROCUREMENT AND PROSPECTS**

The manufacturing of the cask is made in two main steps:

- the forgings and the machining of the forgings
- final assembly of the elements fixed on the forging vessel

The TN81 is the original version of the TN85 cask, licensed in France and delivered up to now in Switzerland. Three TN81 casks have already been manufactured for KernKraftwerk Gösgen (KKG, Switzerland). Less than 24 months were necessary to manufacture the first unit from the forging procurement to the final tests of the cask.

The three TN81 units of KKG have already been loaded at AREVA NC La Hague plant and stored in ZWILAG site (Fig. 4).

In Germany, already twelve TN85 casks have been ordered by GNS on behalf of the German utilities. The manufacturing of these casks has been started in November 2004 in parallel of the completion of the licensing process. The German Transport Certificate of Approval has been obtained in March 2006. The first unit has been delivered in January 2007 and the delivery of the subsequent ones shall occur on a monthly basis. They will be used for the return transport of vitrified residues from AREVA NC La Hague plant to Gorleben. Further units are expected to be used for the transports that will take place until 2011.



**Fig. 4 TN 81 stored in Zwilag**



## **TN85 CASK COMMISSIONING**

The TN 85 cask commissioning has already started with the participation of the German Authorities to the loading of the third TN 81 cask at AREVA NC La Hague plant. Considering the strong similarities between the two casks designs, this participation has allowed the demonstration of the AREVA NC La Hague plant capability to load and shipped the TN 85 casks.

The next commissioning operations shall be performed on the first TN 85 cask available during the first half of 2007. They will consist mainly in the performance of cold handling operations at Gorleben. In addition, the verification of the possibility to implement some procedures specific to the TN 85 cask during loading at AREVA NC La Hague plant shall be verified upon arrival of the first cask there. The first loading of a TN 85 in AREVA La Hague plant is to take place in October 2007.

## **CONCLUSION**

The TN81 & TN85 casks have been designed to fully anticipate shipment constraints of the present vitrified residue conditioning. They also used the feedback of previous shipments and the operational constraints and experience of receiving and shipping facilities. They are also designed in order to comply with the applicable regulations of France and Germany.

In order to increase the loading capacity in terms of radioactive source terms and heat load by 40%, the cask design relies on innovative solutions and benchmarks from the current shipping campaigns.

Currently, the TN81 and TN85 are the only licensed casks, able to transport and store 28 canisters with source terms up to the maximum of the AREVA NC and its customers Specification relative to vitrified residue canisters and a total decay heat of 56 kW. According to their specific design, the TN81 and TN85 shall contribute to reduce the high level waste number of transport between reprocessing facility and their customers. These two casks are thus a key element of the vitrified waste management in Europe.