The TN 24 Dual-Purpose Cask Program for Doel, Belgium

O. Konirsch
Transnucléaire

J.L. Catoire
Belgatom

J. Danguy
Synatom

INTRODUCTION

At the present time, the Belgian utility ELECTRABEL operates 7 PWR nuclear units located on two sites (Tihange and Doel). Part of the spent fuel has been or will be reprocessed at the COGEMA facility at La Hague and the other are currently stored in the spent fuel pools of the units.

Synatom, the Belgian nuclear fuel management organization, has asked the engineering and consulting company Belgatom to perform a technical and economic study in order to define the most appropriate solutions for interim storage facilities in order to keep available the capacity of the existing pools.

Finally, the conclusion of the study led, for the Doel site, to a dry storage in metallic dual purpose casks in a non-bunkered concrete building. The main advantages of this solution are its flexibility and its reversibility: the casks are ordered according to the need and can be used to transport the spent fuel either to a reprocessing facility or to a conditioning facility according to future decisions.

According to that choice, Transnucléaire proposed two different dual-purpose package designs issued from the TN 24 family casks: the TN 24 D for Doel 3 and the TN 24 XL for Doel 4.

Since 1992, Synatom has ordered for Transnucléaire 14 casks (8 TN 24 D and 6 TN 24 XL). The first cask was loaded in November 1995.

DESIGN CRITERIA

The two packagings TN 24 D and TN 24 XL meet all the requirements issued from the needs of the nuclear plants and from the local and international regulation. The main characteristics of the spent fuels to be loaded in the first series of dual-purpose casks are:

Site	Fuel type	Active length	Enrichment	Average Burn-up	Maximum Burn-up	Cooling time
DOEL 3	17 x 17 PWR	3 658 mm (12')	3.4 %	36.000 MW.d/tU	40.000 MW.d/tU	8 years
DOEL 4	17 x 17 PWR	4 267 mm (14')	3.4 %	40.000 MW.d/tU	45.000 MW.d/tU	8 years

The packagings are compatible with the requirements of the Doel 3 and Doel 4 nuclear power plants (mainly handling equipments), with the standard rail transport regulation in Europe, and with the requirements of reprocessing facilities like La Hague.

For transport, both packages must meet the Type B(U) F requirements of IAEA regulation and a quality factor of 20 for the neutron shielding has been taken into account in accordance with the ICRP 60.

As Belgium is a country with a high population density and with a rather high air traffic, the risk of aircraft crash cannot be disregarded, and the Belgian Safety Authorities required that the storage facilities must be resistant to this accidental event. For economical reasons, casks no the building have been designed to be resistant to aircraft crash.

The reference of the aircraft crash was as follows:

Aircraft type	:	Military fighter (F16)
Weight	:	14.600 kg
Impact speed	:	150 m/s

After such an accident, the allowed gas and aerosol release should not lead to a dose higher than 0,02 Sv within one week at the site boundary.

Complementary resistance to accident conditions were required such as a fire at 600°C during one hour and a free drop from 2.5 meters on to concrete in storage configuration (no shock absorber).

CASK DESCRIPTION

In order to optimize the quantity of spent fuels loaded in each cask, Transnucléaire has proposed to develop two different designs (one for each type of spent fuel) based on the TN 24 cask family from which some packagings have been already designed and licensed for several years.

The TN 24 D can contain 28 spent fuels 17 x 17 and the TN 24 XL, 24 long spent fuels 17 x 17. The main characteristics of the two packagings are:

	TN 24 D	**TN 24 XL**
CONTENTS	**28** spent fuels 17 x 17 PWR 900 MW	**24** spent fuels 17 x 17 PWR 1300 MW
STORAGE		
Overall height	5,000 mm	5,735 mm
Overall diameter (without trunnions)	2,480 mm	2,325 mm
Weight	112 tons	112 tons
TRANSPORT		
Overall length	5,710 mm	6,400 mm
Overall height	2,677 mm	2,650 mm
Overall width (trunnions)	2,500 mm	2,500 mm
Weight	112 tons	112 tons

During the storage phase, the main components of each type of packaging are:

- The body is made of a thick forged steel welded to a forged steel bottom. Outside the shell, longitudinal heat conductors made of copper allow the thermal transfer to the external shell. Between the heat conductors, boronated resin provides a neutron shielding. There is no complementary orifice. Six trunnions are bolted on the body and are used for the handling, tilting and transport operations. During accidental drop tests from 9 meters, they participate to the absorption of the shock energy.

- The basket is essentially composed of assembled extruded profiles of boronated aluminium which provides a sufficient mechanical resistance and a good uncriticality effect during the accidental conditions, and a very good thermal conductivity during normal conditions. The basket is removable.

- The primary lid is made of forged steel and boronated resin is bolted on the top of the body. The lid is equipped with an orifice essentially used during the loading operation for draining and drying the cavity. The leaktightness is obtained with two metallic gaskets on each orifice.

- The monitoring device allows to control permanently the pressure of 6 bars between the two metallic gaskets. In case of a leak, this overpressure will avoid any leak from inside to outside. The monitoring device is connected to the control room of the storage facility.

- The anti-aircraft crash cover is simply put on the top of the package.

For the transport configuration, the TN 24 packaging is composed of:

- The body, the basket, and the primary lid identical to those described for the storage configuration;

- The secondary lid, made of a forged steel plate bolted on the top of the body over the primary lid. It is equipped with an orifice. The leaktightness is obtained with two elastomer gaskets on each orifice;

- The top and bottom shock absorbers, which are bolted to the secondary lid and to the bottom of the body. They are mainly made of wood protected by stainless steel casings.

Only one set of secondary lid and shock absorbers is necessary for each type of packaging.

TRANSPORT AND STORAGE LICENSE

In order to prove the compliance of the TN 24 packages with the IAEA. Transport Regulation and especially for accidental conditions, six drop tests were performed with a 1/3-scale model of the TN 24 D. Those tests were carried out in April 1993 at the Moronvilliers test facility (France), operated by Transnucleaire. The test program was:

- 9-meter drop test on the corner of the top shock absorber
- 1-meter puncture drop test in vertical position
- 9-meter drop test on horizontal position on shock absorbers
- 9-meter drop test on vertical position on the top
- 9-meter drop test on the corner of the bottom shock absorber
- 9-meter drop test on horizontal position on trunnions

After all these tests, the transport requirement (maximum A2 per week) was met.

The other requirements on criticality, shielding, thermal, and mechanical behavior in normal and accident conditions were demonstrated by calculation.

The Safety Analysis Report for the TN 24 D package was applied for by Transnucléaire and the French license for transport was obtained in February 1994.

For the TN 24 XL design, no test was performed and all the requirements were justified on calculation and on the results of the TN 24 D tests. The transport license is expected to be obtained in the beginning of 1996.

For storage, two 2.5-meter drop tests on concrete and without shock absorbers were carried out just after the transport tests of the TN 24 D model.

In June 1993, an impact test was performed at the CEA facility. From a numeric model, a tube, with different thicknesses in order to represent the crash of an F16 aircraft, was projected at a speed of 150 m/s on the 1/3 scale model. Although it was not a requirement, the same scale model was used for the transport and storage tests without any modification between tests. After all the tests, no leak was detected.

Based on these tests and on complementary calculation, Transnucléaire had established for the TN 24 D a Topical Safety Analysis Report which Belgatom incorporated to the general report of the Doel Storage facility. The belgian transport and storage licenses were obtained in the beginning of 1995.

For the TN 24 XL, no complementary test was performed and an extension of the storage license was applied by Belgatom, on behalf of Synatom, in order to obtain the storage license in 1996.

MANUFACTURE

The choice of a forged steel body gives the advantage that a large variety of manufacturers can fabricate casks of the TN 24 family.

With components purchased in several European countries and the United States, the basket is assembled in France, and the final cask assembly takes place in Belgium.

All the manufacturers are qualified by Transnucléaire and the fabrication is carried out under Quality Assurance in order to guarantee the conformity of the manufactured casks with the transport and storage licenses.

The manufacturing time of a cask is approximately 18 months. Four units have already been manufactured and four more will be delivered beginning of 1996.

CASK OPERATION AND MONITORING

The TN 24 casks are loaded under water in the storage pool. Then, the primary lid is placed on the cask which is raised towards the preparation area where it is drained and dried through the orifice.

The tightness between the two metallic gaskets of the primary lid is controled and the cavity is filled with helium. The tightness of the orifice plug is then controled.

The cask is ready to be transferred to the storage pad. There, the cask is equipped with the monitoring device which is connected to the control room of the storage facility. Finally, the anti-aircraft crash cover is simply placed on the cask.

The cask is on storage configuration. At any time, the cask can be easily transformed in transport configuration by removing the anti-aircraft crash cover and the monitoring device, by placing the secondary lid and controling the tightness, by tilting the cask on a transport frame and placing the two shock absorbers.

It also can be easily transferred to a pool where the spent fuels can be unloaded.

CONCLUSION

Upon the conclusion of the Belgatom study for metallic dual purpose casks at the Doel site, Synatom ordered from Transnucléaire in June 1992, eight TN 24 D casks. In accordance with the contract, the first cask was delivered 19 months later with the storage and transport license based on experimental tests.

The second contract for six TN 24 XL specifies the delivery of the first cask within 22 months, in February 1996.

The optimization of the capacity of each package, the extremely high level of quality of the tests results, the respect of the delivery time for licenses and manufacturing were possible due to the choice of developing a TN 24 packages family which benefits from the long experience of Transnucléaire in transportation of spent fuels in dry forged steel casks and which can be easily adapted to many different spent fuels (PWR, BWR, VVER, MTR).

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FIGURE 1: TN 24 D TRANSPORT/STORAGE CASK