EUROPEAN OPERATING EXPERIENCE OF TN 24 DUAL PURPOSE SPENT FUEL STORAGE CASKS

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Abstract

TN 24 dual purpose spent fuel storage casks offer utilities a modular solution for the interim storage of spent fuel in robust metal casks which are fully suitable for off site transports. This flexible product can be readily adapted to suit individual user needs. This paper recalls the typical design features of a TN 24 dual purpose cask and presents the operational experience to date in Belgium and Switzerland.

TN 24 dual purpose spent fuel storage cask design

Figure 1 shows the typical design features of a TN 24 dual purpose cask which is constructed as follows:

- The basic structure is a thick steel cylindrical forging with a welded on forged bottom and two forged steel lids. Containment and gamma shielding features of the cask are mainly provided by this basic structure.
- 4 or 6 trunnions are attached to this structure for handling, tilting and tie down.
- Inside the cylindrical cavity, a Boron aluminium basket is fitted and provides a structural support for the fuel assemblies and criticality control.
- Surrounding the cylindrical cavity, a resin layer is encased in an outer shell and provides the neutron shielding features of the cask. Heat conductors ensure the thermal evacuation of the heat from the main shell to the outer shell of the cask.
- A leak tightness monitoring system and an anti-aircraft crash cover (when needed) are installed during the storage period of the cask.
- A set of shock absorbing covers is fitted to the flask for transport operation, as well as lateral impact limiters for some TN24 cask design.

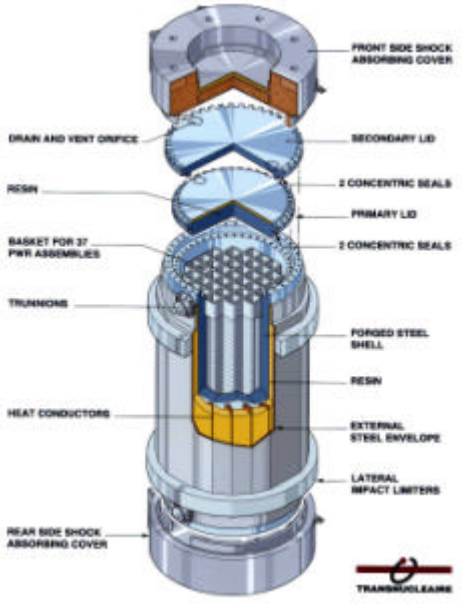


Figure 1

Today, more than fifteen versions of the TN24 have been developed by TN engineers based on the same basic features.

TN 24 operational experience in Belgium

Following an international tender, Transnucléaire were contracted by SYNATOM to provide dual purpose casks for spent fuel from the DOEL Nuclear power station in Belgium. The first TN 24 cask was the TN 24 D for DOEL 3 and was loaded in 1995. A total of 10 TN 24 D casks were then subsequently delivered and loaded at DOEL from 1995 to 1999. In the meantime, TN developed the TN 24 XL for DOEL 4. A total of 8 TN 24 XL were subsequently delivered and loaded at DOEL from 1996 to 1999. Figure 2 shows the main features of the TN 24 D cask in storage configuration and of the TN 24 XL cask in transport configuration.

The forged carbon steel primary lid bolted to the upper end of the cask ensures the leak tightness of the cavity closure by 2 concentric metallic gaskets. During storage, the inter-space between the primary lid metallic gaskets is pressurized with helium and permanent monitoring of the pressure allows detecting any decrease of leak tightness performance long before any radioactive release becomes possible. The pressurization of the monitored space ensures that no gas can flow from the inner cavity to the atmosphere. The anti-aircraft crash cover is fitted to the top of the flask, over the monitoring system during storage.

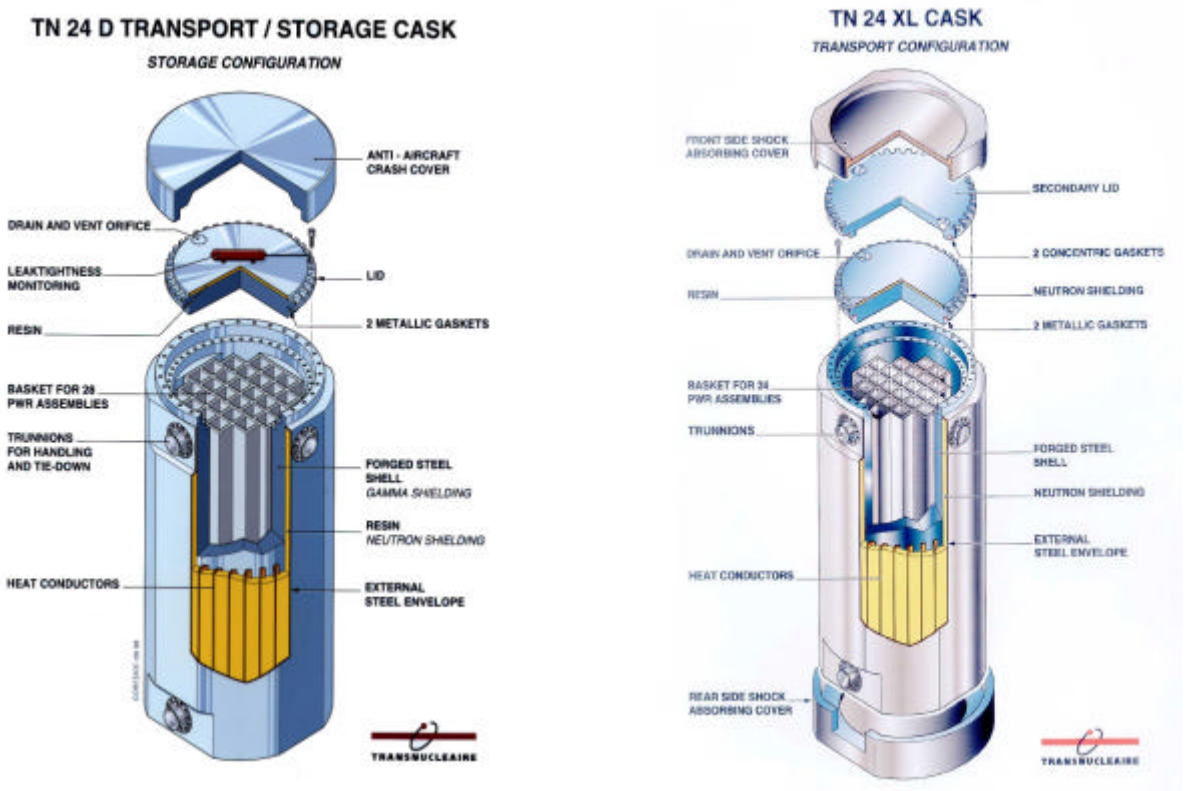


Figure 2

Even though both casks are currently used only for on-site storage at the DOEL facility, they may have to be shipped to another facility at any time. As a consequence, they have a B(U)F license in accordance with IAEA regulations for the allowable contents given in table 1.

Cask	N° of assemblies	Max Burn up (MWd/tU)	Cooling time (years)	Max Enr. (% U5)
TN 24 D	28 PWR	36 000	8	3.4
TN 24 XL	24 PWR	40 000	8	3.3

Table 1

From an operational experience point of view, there were only positive feedback from DOEL operators about TN 24 D and TN 24 XL designs. All 18 cask were loaded and put into storage configuration successfully. The first loaded casks have now been stored for more than 6 years without any technical problem on the casks over this period.

Following this industrial success, SYNATOM decided to purchase further casks for DOEL 3 and 4 fuels with higher enrichments, higher burn-ups and shorter cooling times. Transnucléaire developed the higher performance TN 24 DH and TN 24 XLH casks within the similar envelope size and weight limits of the TN 24D and TN 24 XL. Sixteen of which were subsequently ordered by SYNATOM. First delivery and loading of those casks occurred in 1999 and the supply is pursuing. Figure 3 shows the main features of the TN 24 XLH and TN 24 DH casks both in transport configuration.

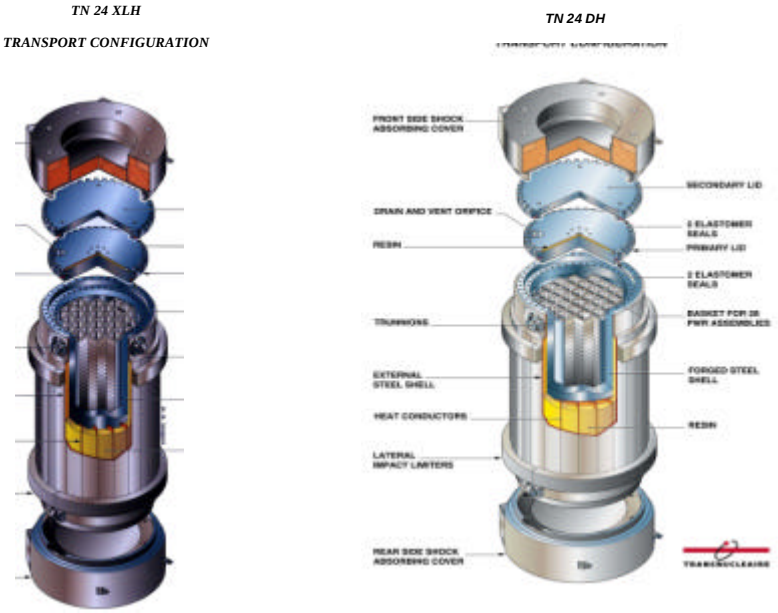


Figure 3

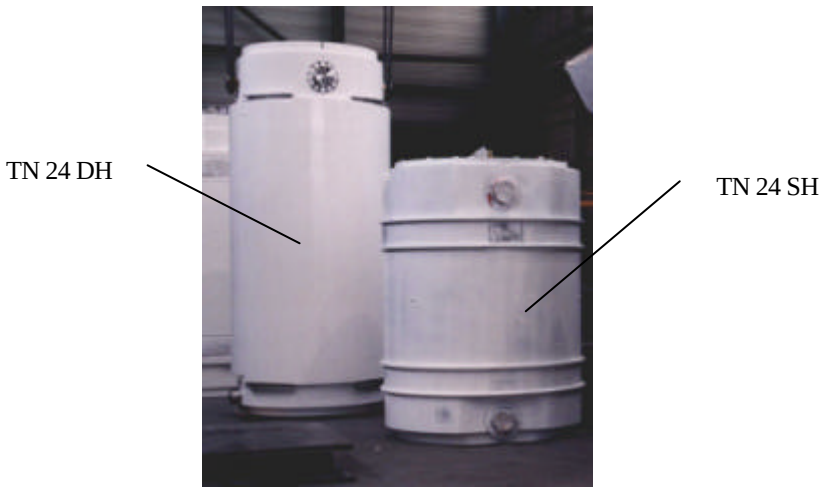
Again and even though both casks are currently used for on-site storage at the DOEL facility, they may have to be transported and have consequently a B(U)F license in accordance with IAEA regulations for the allowable contents given in table 2.

Cask	N° of assemblies	Max Burn up (MWd/tU)	Cooling time (years)	Max Enr. (% U5)
TN 24 DH	28 PWR	55 000	7	4.25
TN 24 XLH	24 PWR	55 000	7	4.25

Table 2

Like the TN 24 D and the TN 24 XL designs, the TN 24 DH and TN 24 XLH designs led to very positive feedback from an operational point of view. Only one problem had to be solved following the first loadings. The dose rates at the level of the top and bottom trunnions were higher than expected due to activation of a higher than expected Co^{59} initial content in top and bottom nozzles of fuel assemblies. This was solved by addition of complementary gamma shielding at this level for both designs on successive units.

As DOEL 1 and 2 units use shorter PWR fuel, another TN 24 model was subsequently ordered by SYNATOM and specifically designed by TRANSNUCLEAIRE for this application. The TN 24 SH is thus the latest model making the TN 24 family for DOEL. A total quantity of nine casks has currently been ordered for a delivery from year 2000 to year 2002. Pictures 1 shows a view of the TN 24 SH dimensions compared to those of a TN 24 DH and is very representative of how TN 24 design can be adapted to suit any fuel characteristic.



Picture 1

Like the other TN 24 of the DOEL family, the TN 24 SH is B(U)F licensed in accordance with IAEA regulations for the allowable contents given in table 3.

Cask	N° of assemblies	Max Burn up (MWd/tU)	Cooling time (years)	Max Enr. (% U5)
TN 24 SH	37 PWR	55 000	5	4.25

Table 3

As the other members of the DOEL family, TN 24 SH design also led to very positive feedback from an operational point of view.

From a general point of view, the operational experience of TN 24 design casks in Belgium can be summarized in the three following points:

- The cumulated dose rate (gamma and neutron) per loading operation (TN 24 XL/ D / XLH / DH) taking into account 2 x 8 hour shifts of 6 persons during 5 days proved to be quite low with an

average of 0.25 mSv/p (1/200 of authorized dose) for operators, all packaging being AIEA compliant,

- The high efficiency of the containment barrier is demonstrated through the permanent monitoring system with no leak tightness problem on all the loaded casks,
- The Client's point of view is very positive as shows this statement of Michel Valkeneer, Tractebel, during Belgatom seminar of 17 October 2000: "Before the end of 2000 more than 30 TN 24 casks will have been loaded in the fuel buildings of the DOEL units and transferred to the dry storage facility without any technical problem."

TN 24 operational experience in Switzerland

A group of Swiss utilities have opted to ship spent fuel to a central interim storage facility called ZWILAG. Following international tender invitations, Transnucléaire were awarded contracts for the supply of dual purpose transport and storage TN 24 casks for both PWR and BWR fuel types for the nuclear power plants of GOESGEN and LEIBSTADT.

The first of these casks was the TN 24 G cask developed for the PWR nuclear power plant of GOESGEN. In 1995, GOESGEN decided to purchase four casks of this type. All four casks have been presently delivered by TRANSNUCLEAIRE and the first cask loading is expected to occur late year 2001 or early year 2002. Picture 2 gives a view of three empty TN 24 G casks in the brand new storage hall of.

Picture 2 -Zwilag

In order to be transported from the GOESGEN nuclear power station to the ZWILAG interim storage facility, the TN 24 G has a B(U)F license in France in accordance with IAEA regulations, with a validation of the packaging approval license in Switzerland. The allowable content is given in table 4.

Cask	N° of assemblies	Max Burn up (MWd/tU)	Cooling time (years)	Max Enr. (% U5)
TN 24 G	37 PWR	Average 42 000	10	3.8

Table 4

The TN 24 G is so far the heaviest and largest TN 24 cask constructed by TRANSNUCLEAIRE in Europe with a total weight in transport configuration of 135 tons and a maximum diameter in transport

configuration of 2990 mm. As a consequence, several cold trials have been performed with this cask in order to validate all interfaces and operations:

- a cold transport between GOESGEN and ZWILAG was realized in year 2000 with the new TRANSNUCLEAIRE wagon Q76 specifically designed to transport heavy casks up to 140 tons such as the TN24G. All handling and transport operations of the cask from the nuclear power station to the interim storage facility (approximately 50 km far) were realized successfully.
- a cold loading simulation of the cask was realized in the nuclear power station in Spring 2001. Again, all handling and loading operations of the cask were realized successfully. These operations were the most critical ones as the TN 24 G was tailored to the need of GOESGEN so that its weight and dimensions were very close to the plant limits.

At the present time, the cold trials within the ZWILAG interim storage facility are still pending for the TN 24 G. Such trials should occur in Autumn 2001. Their completion will allow to start the loadings of TN 24 G casks.

In 1996, the BWR nuclear power station of LEIBSTADT decided to purchase the TN 52 L cask. This TN 24 dual purpose transport and storage cask was designed to answer the needs of LEIBSTADT to first perform routine transport of spent fuel from the nuclear power station to the European reprocessing facilities of La Hague or Sellafield, and next to store spent fuel at the ZWILAG interim storage facility.

The TN 52 L was then designed to comply with all the associated handling, transport and storage requirements. In particular and although the intermediate storage facility of ZWILAG is similar to that in Belgium, the cask design requirements for storage were differing in some details. Main requirement on the cask design was the request of a double lid system with a permanent monitoring of the pressure in the inter-lid space. The design of all TN 24 casks for Switzerland (TN 24 G included) was thus adapted in order to comply with such a requirement. Figure 3 gives a view of the TN 52 L cask in storage configuration. As on TN 24 casks for Belgium, the carbon steel primary lid is bolted to the upper end of the cask. It ensures the leak tightness of the cavity closure by one inner metallic gasket checkable thanks to one outer elastomer gasket. The secondary lid is also equipped with one metallic gasket checkable thanks to one elastomer gasket. During storage, it is the inter-lid space which is pressurized with helium and the permanent monitoring of the pressure allows detecting any decrease of leak tightness performance.

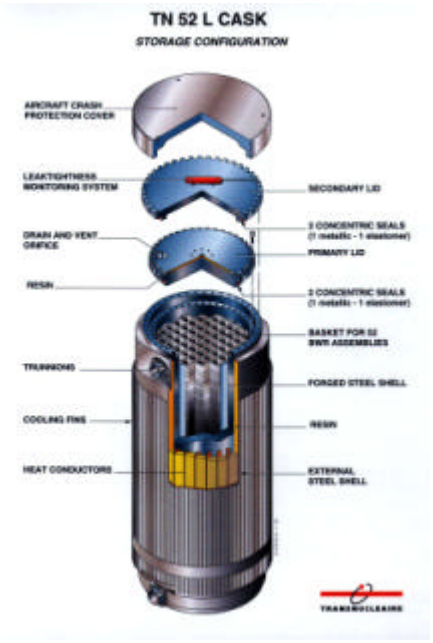


Figure 4

Like the TN 24 G, the TN 52 L is B(U)F licensed in France with a validation of the packaging approval license in Switzerland. The allowable content is given in table 5.

Cask	N° of assemblies	Max Burn up (MWd/tU)	Cooling time (years)	Max Enr. (% U5)
TN 52 L	52 BWR	53 000	2.5	4.95

Table 5

The TN 52 L cask was actually the first TN 24 cask used for routine transport. The cask was delivered in 1999. Cold trials were performed subsequently at La Hague reprocessing facility and LEIBSTADT nuclear power station. Following the completion of these cold trials, two transports have taken place from the LEIBSTADT nuclear power station to the La Hague reprocessing facility. All loading, transport and unloading operations were realized without any technical problem. The TN 52 L thus demonstrated the true dual purpose capability of the TN 24 design casks. Especially, the following new operations for a TN 24 design cask were performed: cask handling with shock absorbing covers and impact limiters, water refilling of the cavity and unloading of spent fuel assembly.

The LEIBSTADT nuclear power station subsequently ordered in 1997 another TN 24 cask design to cover its needs of spent fuel storage at ZWILAG: the TN 97 L cask. The delivery of six casks were to take place from year 1999 to year 2001. With a capacity of 97 spent fuel assemblies compared to the capacity of 52 for the TN 52 L, the TN 97 L was a true optimization of the payload for fuel assemblies to be stored. The TN97L is so far the heaviest and largest TN 24 cask for BWR spent fuel constructed by TRANSNUCLEAIRE with a total weight of 134.5 tons and a maximum diameter of 2990 mm.

As all TN 24 casks designed for Switzerland, the TN 97 L has to be transported to ZWILAG and is B(U)F licensed in France with a validation of the packaging approval license in Switzerland. The allowable content is given in table 6.

Cask	N° of assemblies	Max Burn up (MWd/tU)	Cooling time (years)	Max Enr. (% U5)
TN 97 L	97 BWR	Average 26 000	10	3.95

Table 6

To date, three TN 97 L casks have been delivered and one of them was loaded in July 2001. The cask was transported successfully from the LEIBSTADT nuclear power station to the ZWILAG interim storage facility and put into storage configuration. Picture 3 shows the loaded TN 97 L cask on its way from LEIBSTADT to ZWILAG. The TN 97 L was the first cask shipped to ZWILAG so that the interim spent fuel storage facility was successfully put into operation. The storage of this cask followed several cold trials which validated all operations: cask loading at LEIBSTADT nuclear power station, transport from LEIBSTADT to ZWILAG, preparation of the cask for storage at ZWILAG. Again, all these tests led to very positive operational feedback of the cask.

Picture 3

Conclusion

Although cask designers focus very often on the licensing and manufacturing aspects of casks, operational feedback is the key of the success of a design. Actually, operators as final customers are mainly interested in operational reliability, flexibility and efficiency of the casks.

So far, more than thirty casks based on the TN 24 design have been loaded and stored in Europe without any technical problem. Having a look at the situation in the United-States, more than thirty additional TN 24 design based casks have been loaded and stored. This sample is large enough to confirm conclusively the reliability of the TN 24 design.

TRANSNUCLEAIRE proved also the flexibility of its TN 24 design casks by adapting the design to the actual needs of the customers in terms of fuel characteristics, interface constraints and transport needs. The payload was thus optimized and special requirements of the utilities and the interim storage facilities were taken into account too.

As a consequence, the TN 24 solution proved to be in Europe a very efficient solution when utilities were looking for dual purpose transport and storage systems for their spent fuel management.