THE TN 24 GET DUAL PURPOSE CASK FOR THE TRANSPORT AND STORAGE OF SPENT FUELS FROM TRINO, GARIGLIANO AND ELK RIVER REACTORS

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Abstract

ENEA (Italian National Agency for New Technology, Energy and the Environment) operates the Italian nuclear research centers at the sites of Saluggia and Trisaïa. Both these sites currently store spent fuel pools. In 1999, Transnucléaire was contracted by ENEA to design and license a dual purpose cask for the safe interim storage of the Elk River fuel at the Trisaïa site. The cask had to be designed so that it could be readily adapted for containing the Garigliano and Trino type fuels presently stored at the Saluggia site.

Although the total quantities of fuel is quite modest (1,74 t of heavy metal) their form differs widely: square section assemblies, cruciform section assemblies and some dismantled fuel pins held in special bottles. The Elk River fuel is Thorium based and has a different isotope range from the uranium dioxide based fuels of Trino and Garigliano. Thus the radiation shielding design requirements are not uniform.
Both sites have specific weight and geometrical handling limits. The whole project is a real challenge.

With the close collaboration of ENEA engineers, Transnucléaire was able to propose effective solutions based on the TN 24 dual purpose cask. The TN 24 GET cask weighs 52 t (with fuel assemblies and shock absorbing covers) and can safely handle all the specified fuel types in both transport and storage configurations.

This paper recalls the technical parameters of the fuel and shows how the cask design was developed to suit such diversity. Scale model drop testing was undertaken to demonstrate compliance with IAEA transport regulations and test results are presented together with the programme for in-site interim storage licensing.

Fuel characteristics and interface constraints for the TN24GET design

Table 1 gives the fuel characteristics the TN24GET design was to comply with. These fuel characteristics correspond to two contents :

1. 64 Elk River type fuel assemblies at the Trisaïa research center site with 16 of them dismantled and canned,
2. 52 Trino type fuel assemblies and 1 canned Garigliano type fuel assembly at the Saluggia research center site.

In addition to the fuel characteristics constraints, the TN24GET design had also to comply with the Trisaïa and Saluggia interface constraints.

At the Trisaïa center, the 64 Elk River elements are stored in specific stainless steel cans filled up with water. These storage cans may be handled and are located in vertical position, into racks on the sides of the pool. This area is equipped with an auxiliary crane (capacity 1 ton). At that place, the water height is about 7m. The cask can be installed (after the disassembly of the auxiliary crane beam, that has been foreseen) by the main crane (capacity 50 tons) in the pool, at a place where depth is 11.84m (water height about 11.5 m), and where the cross section is 2.5 x 2.5 m². The carrying capacity of the pool floor is 18 tons/m². A preparation area, located beside the truck path in the pool building, can be used for the cask. This preparation area is also foreseen to be the interim storage location of the TN24GET.

At the Saluggia center, the loading pool is 7.57 m deep so that height of the cask in vertical position is limited to 4.37 m. The pool is equipped with a 2 m high Safety Hydraulic System (SIS) which can be used for supporting and lifting the cask, vertically positioned on it. The loading crane capacity is 48 tons and can translate the cask all over the pool and also move it to the truck area.

	TRISAÏA	**TRINO**	**GARIGLIANO**
Fuel Quantity	64 48 intact & 16 dismantled in cans	52	1
Fuel assembly			
Overall length (mm)	2073	2956	-
Overall section (mm²)	90 x 90	192.4 x 192.4	-
Array	5 x 5	Crucix form	-
Max number of rods	25	28	-
Number of fuel rods	25	26	-
Rods pitch (mm)	19.05	13.9	-
Weight (kg)	28	72.6	-
Fuel can			
Can overall length (mm)	2210	-	3100
Can overall section (mm²)	115 x 115 153 x 153 (on top)	-	161
Array	-	-	17.3 mm
Number of rods	-	-	48 half rods
Loaded can weight (kg)	62.05	-	145.2
Fuel nature	ThO_2-UO_2	UO_2	UO_2
Maximum initial U5 enrichment (%)	5.4	2.72	2.1
Mass of heavy metal per assembly (kg) or (per can for GARIGLIANO case)	27.2	38.9	62.9
	-	8.99	-
Average specific power (MW/tUHM)	13000	-	8580
	-	3560	-
Average burn-up (MWd/tUHM)	33 min	30 min	30 min
Irradiation duration (day)			
Cooling time (year)			

Table 1

TN24GET design

On the basis of all these fuel and interface data, TRANSNUCLEAIRE developed the TN24GET design in order to achieve the following goals:

1. be able to be loaded with a basket for all 64 Elk River fuels,
2. allow the geometric installation of a basket for Trino/Garigliano fuels and provides adequate radiation shielding and heat removal for said fuel,
3. obtain a type B(U)F French transport license in accordance with the IAEA Regulations for the Safe Transport of Radioactive Material [1] and its validation in Italy,
4. be able to be safely stored by ENEA at the Trisaïa center or any other Italian storage site that could be set into operation.

Goal 1 & 2

The TN24GET design is based on the TN24 dual purpose cask family. The image in Figure 1 shows the typical design features of a TN24 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 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.
- 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.

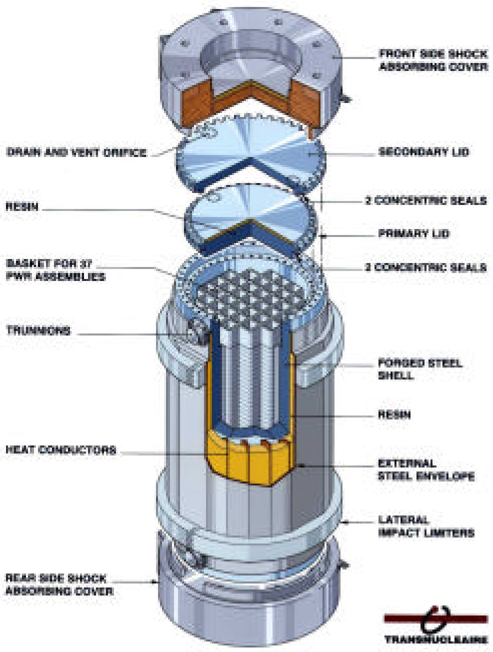


Figure 1

Today, more than fifteen versions of the TN24 have been developed by TN engineers based on the same basic features. Likewise, in the TN24GET case, the typical features had to be adapted in order to integrate the fuel and interface constraints. Main two steps of these adaptations are described hereafter:

1. Two baskets have been designed in order to fit in the TN24GET cask cavity. As the fuel has different geometry characteristics (length, form, etc.), this led to an adaptation of each basket not only to the fuel but also to the cavity dimensions. For example, the Trino fuel were much longer than the Elk River fuel so that a cavity length of 3000 mm has been designed in accordance with the length of Trino fuel. However, this length was still not enough to fit the can containing the Garigliano fuel. It was then agreed between ENEA and Transnucléaire engineers that the Garigliano fuel rods will be removed from the existing cans and placed in 7 cylindrical cans which can fit in 75 mm diameter positions. Such an option allows a most compact spacing Trino/Garigliano basket and thus helps to keep the overall diameter of the cask within the interface constraints. Figure 2 gives a view of the Trino/Garigliano basket for the TN24GET cask.

   With regards to the Elk River basket, the challenge was rather to design a basket which can load all 64 fuel in a limited diameter. In order to gain space, it was then agreed to remove the 48 intact fuel from their existing bottle. An adaptation of the can for the 16 dismantled fuel was designed in order to allow the can draining during the cask draining operations. Thus risks of differential draining and criticality were avoided. This option led to 48 lower position and 16 upper position of the basket.

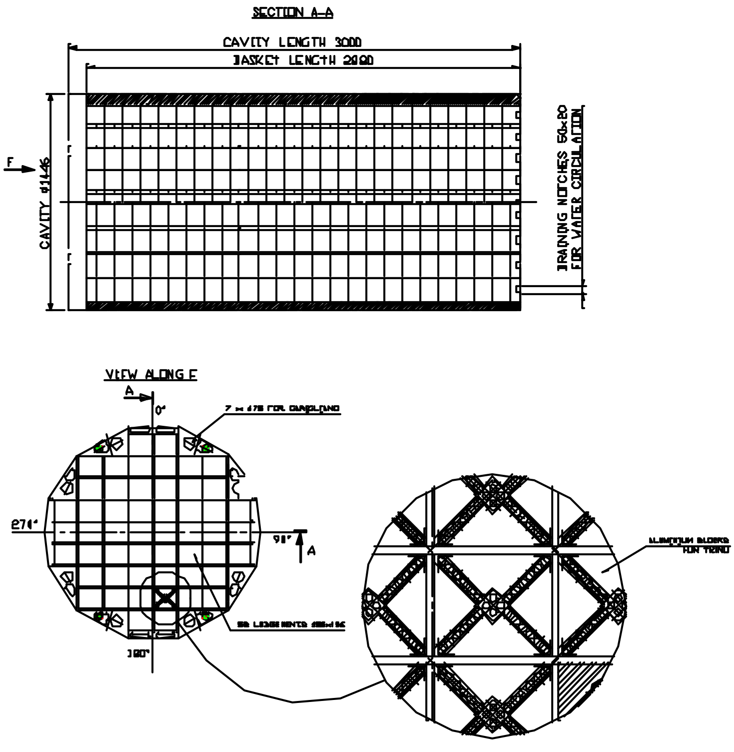


Figure 2

Figure 3 gives a view of the Elk River basket for the TN24GET cask with all 64 positions. The basket length is 2244 mm and it is installed on 9 cylindrical steel supports of 745 mm length.

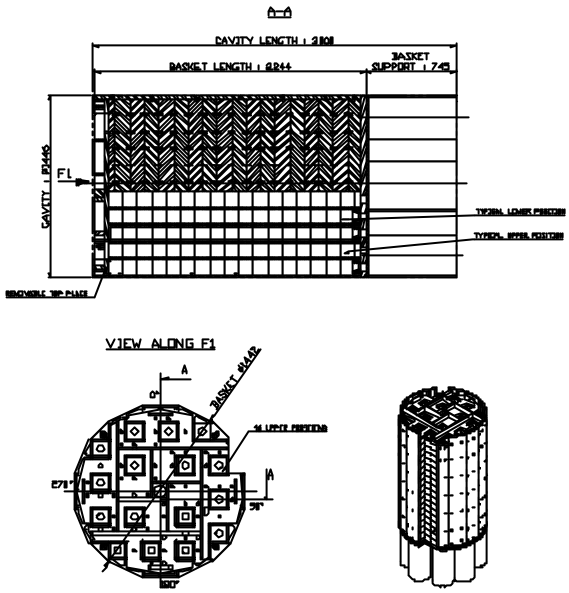


Figure 3

2. One advantage of the TN24 design casks is that their shielding characteristics can be easily adapted and optimized to the fuel characteristics by playing on the forged shell (gamma shielding) and outer resin shell (neutron shielding) thicknesses. In the TN24GET case, such an adaptation was not so straight forward as the 64 Elk River fuel were mainly gamma emitters (no neutron shielding needed) and the 52 Trino + 1 Garigliano can were gamma + neutron emitters. The Trino/Garigliano source was thus much more important than the Elk River source. In order to optimize TN24GET shielding to the fuel content in both cases, it was then opted that the TN24GET will have two configuration: one with only the main forged steel shell which corresponds to the Elk River content and one with resin shielding on the outer shell which corresponds to the Trino/Garigliano content. Both shielding configurations comply with all dose rate criteria (transport and storage) and all interface constraints.

The achievement of these two major steps led to the definition of the main features of the TN24GET cask in transport configuration and which are shown in figure 4:

- An overall length of 6010 mm and a maximum diameter of 2800 mm at the level of the shock absorbing cover.
- A cavity length of 3000 mm with an inner diameter of 1446 mm.
- A distance between trunnion flats of 2198 mm.
- A weight of the loaded cask in transport configuration of 52 tons.
- A weight of the cask during handling over the pool of 42 tons for Elk River content and 47.9 tons for Trino/Garigliano content.

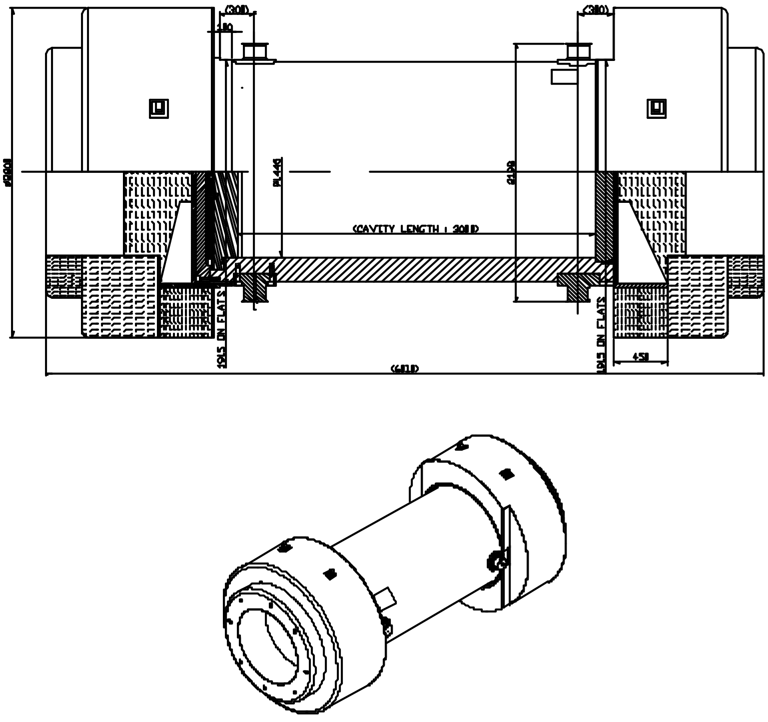


Figure 4

Goal 3

The TN24GET main features being defined in compliance with all fuel characteristics and interface constraints (goal 1 and 2 achieved), it has been shown with usual methods proven on TN24 casks that the TN24GET can then respect in normal and accidental transport or storage conditions:

- the sub-criticality of each content,
- the limitation of the dose rate within criteria,
- the containment of the radioactive content,
- the heat dissipation.

In particular, 1/3 scale model drop testing was undertaken to demonstrate compliance with IAEA transport regulations of the TN24GET design fitted with two 2800 mm diameter wood shock absorbing covers. Table 2 gives the four drop testing performed with the 1/3 TN24GET scale model.

Following the performance of these most penalizing drop tests, as defined in the IAEA regulations [1], it has been demonstrated:

- the good behaviour of the shock absorbers,
- g-loads considered for the mechanical analysis of the package and its baskets are in accordance with calculations: maximal g-loads were found to be 67g during the 9m axial drop test on lid shock absorber, 55g during the slap-down drop test, 26g during the 9m drop test at 25.1°.
- the efficiency of the TN24GET containment system which respects the IAEA criteria: leak rate after drop tests below $2,1.10^{-7}$ $Pa.m^3.s^{-1}$ SLR.

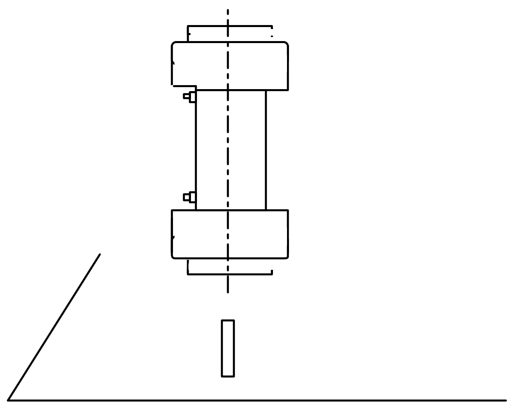
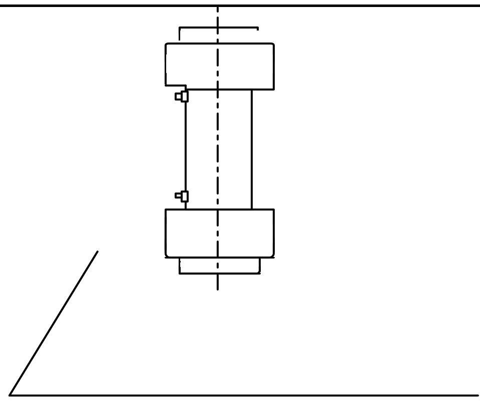
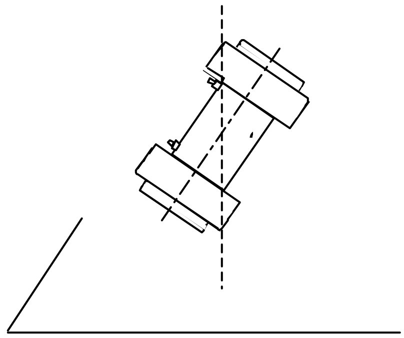
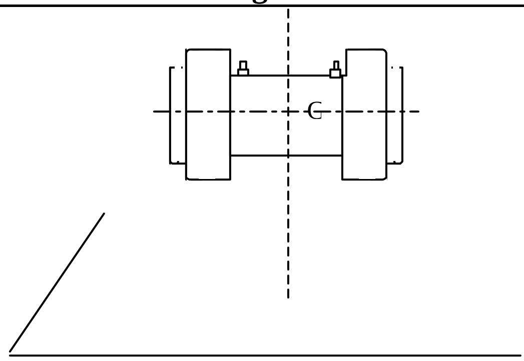
 **1m axial puncture drop test on lid shock absorbing cover**	 **9m axial drop test on lid shock absorbing cover**
 **9m drop test at 25.1° on lid shock absorbing cover**	 **9m lateral drop test (slap down at 8.3°) on bottom shock absorbing cover**

Table 2

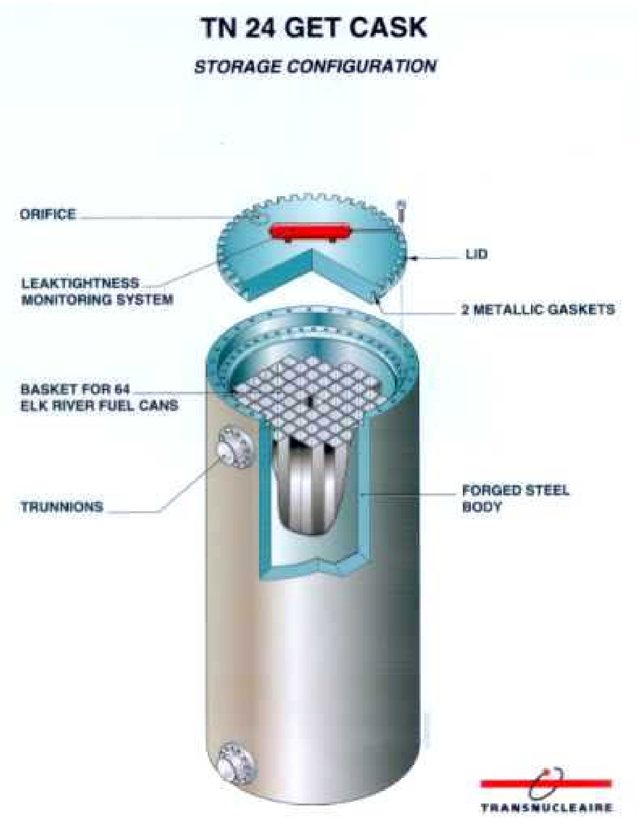
The drop testing put an end to the design effort of the TN24GET with regards to the goal 3: obtain a type B(U)F French transport license in accordance with the IAEA Regulations for the Safe Transport of Radioactive Material [1] and its validation in Italy. Transnucléaire applied for the license in September 2000 and the TN24GET design is currently under review by French authority DSIN.

Goal 4

However, as a dual-purpose cask, the TN24GET had also to fulfil ENEA requirements for the in-site interim storage licensing. Transnucléaire had to provide ENEA with a Topical Safety Analysis Report (TSAR) for the TN24GET storage license. As it was the first time a dual-purpose cask was going to store spent fuel in Italy, no particular requirements were existing from Italian authorities. As it was the first time a dual-purpose cask was going to store spent fuel in Italy, the TSAR and the analysis contained in were based on those of the TN24 design casks already stored in Belgium at the DOEL interim storage facility.

Figure 5 shows the TN24GET cask in storage configuration resulting from the analysis in TSAR. The cask is in vertical position without its transport shock absorbing covers. A monitoring system ensures the continuous monitoring of the leak tightness of the primary lid gaskets.

The next step is then the technical assistance to ENEA for the inclusion of the TN24GET TSAR in the storage license application to the Italian Authority and for the discussion with them in order to obtain the in-site storage license at Trisaïa. The design requirements for cask and storage facility for the dry storage of Elk River spent fuel are currently under discussion between ENEA and Italian Competent Authority ANPA. As a



result of these discussions, the final design of the TN24GET cask shall be then issued, thus reaching goal 4.

Figure 5

Conclusion

The design of the TN24GET dual purpose cask for the transport and storage of spent fuels from Trino, Garigliano and Elk River reactors was a real challenge for ENEA and Transnucléaire engineers. The interface constraints of two totally different sites and the three different type of fuel to be loaded were entry data not so simple to comply with. Effective solutions based on the TN24 dual purpose cask were found so that main goals of the project are on the verge of being achieved.

The two final steps are to obtain type B(U)F French transport license in accordance with the IAEA Regulations for the Safe Transport of Radioactive Material [1] with its validation in Italy, and the in-site storage license at Trisaïa. In order to facilitate this licensing process, it would be very helpful to have in the near future an international standard focussing on the general design criteria for dry spent fuel interim storage facility, in particular on dual purpose casks design requirements in connection with those of the IAEA Regulations for the Safe Transport of Radioactive Material [1].

References

1. International Atomic Energy Agency. *Regulations for the Safe Transport of Radioactive Materials, IAEA n°ST-1, 1996.*