THE TN-MTR PACKAGING

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SUMMARY

The TN-MTR packaging is a type B(U)F cask, specially designed for the transport of irradiated MTR (Material Testing Reactor) and TRIGA fuels. In 1996, Transnucléaire and Transnuclear, Inc. began a cooperative effort to develop a new packaging for the transport of spent Materials Test Reactor fuel. According to the IAEA regulation, this package is a type B(U) containing fissile material. This packaging is intended to replace the IU-04 ("Pegase"), which has been in service since 1967. The TN-MTR packaging will be able to transport MTR fuels in France and abroad. In particular it could be used to transport MTR fuels from research reactors back to the United States. To minimize the number of these transports, Transnuclear has developed a high capacity basket (up to 68 MTR elements) that is adequate for a large variety of MTR and TRIGA fuels.

Since this packaging must be operated in many facilities, it has been especially designed to be easily handled and its operation does not require elaborate equipment.

TN-MTR PACKAGING AND BASKET DESIGN

Packaging design

(See figure 1)

The packaging consists of 3 components: the body, the lid and the impact limiter. The body defines a cylindrical cavity. It is surrounded by 4 layers: an internal layer made of stainless steel, a shielding layer made of lead, an insulation layer and an outer layer made of stainless steel. The lid is made of 3 discs (two stainless steel discs and a lead disc in the middle). The impact limiter is made of wood, encapsulated in stainless steel sheets.

The weight of these 3 components is 20,600 kg. The total mass of the package depends on the basket used and on the MTR fuels transported. The maximum allowable mass in transport is 23,400 kg and the usual mass is around 22,000 kg. In handling conditions, the mass without impact limiter but including handling beam and water inside the cavity is nearly equipment.

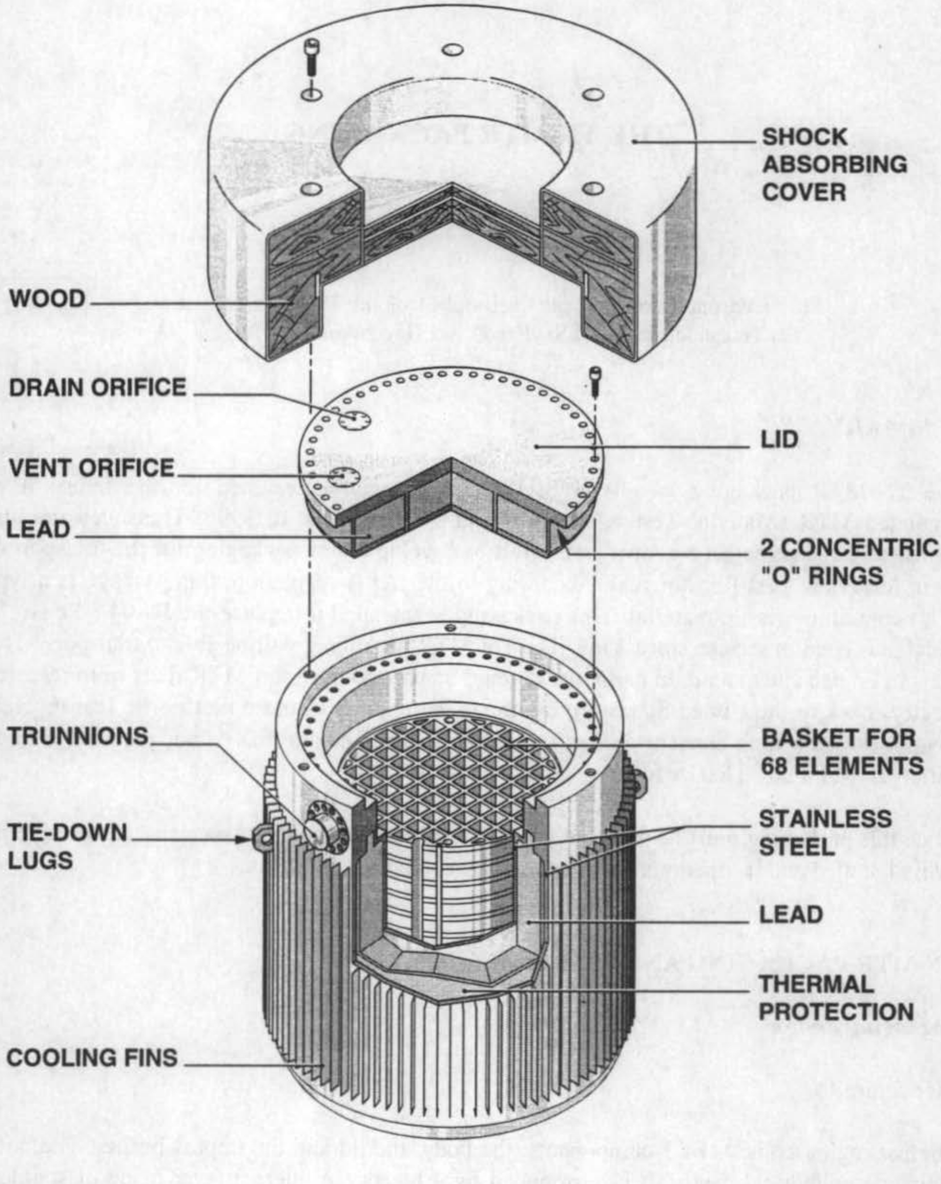

Figure 1: General view of the TN-MTR cask

The cavity is 1,080 mm high and 960 mm in diameter. The outer dimensions of the packaging including impact limiter are 2,008 mm in height and 2,080 mm in diameter. Without impact limiter, 1,610 mm in height and 1,600 mm in diameter.The TN-MTR has a single impact limiter on the top end and the cask can therefore be transported vertically.

To save weight and minimize accelerations in case of vertical drop, the bottom end of the cask has a chamfered shape, forming a conical section.

The packaging is equipped with two orifices allowing to perform all loading operations (water filling and draining, air inlet and vacuum). In order to improve packaging safety, both orifices are fitted on the lid so that they are protected by the impact limiter and not damageable under the conditions of a punch test.

The lead shielding is surrounded by a thermal insulation layer protecting it in case of fire.

MTR-68 basket design

(See figure 2)

This basket has 68 full sized compartments 87 mm square, and 8 smaller compartments. The capacity of each full compartment is one or several elements with a total weight of 19.4 kg, a decay heat of 118 watts, and a fissile content up to 866 g at 95% enrichment.

The challenge of the basket design was to support the heaviest MTR fuel under accelerations greater than 250 g, to maximize the allowable decay heat, and to provide criticality control for high-enrichment, high fissile content fuels. The difficulty was compounded by the dimensional constraints entailed by a high payload, which leave only 6 mm between compartments.

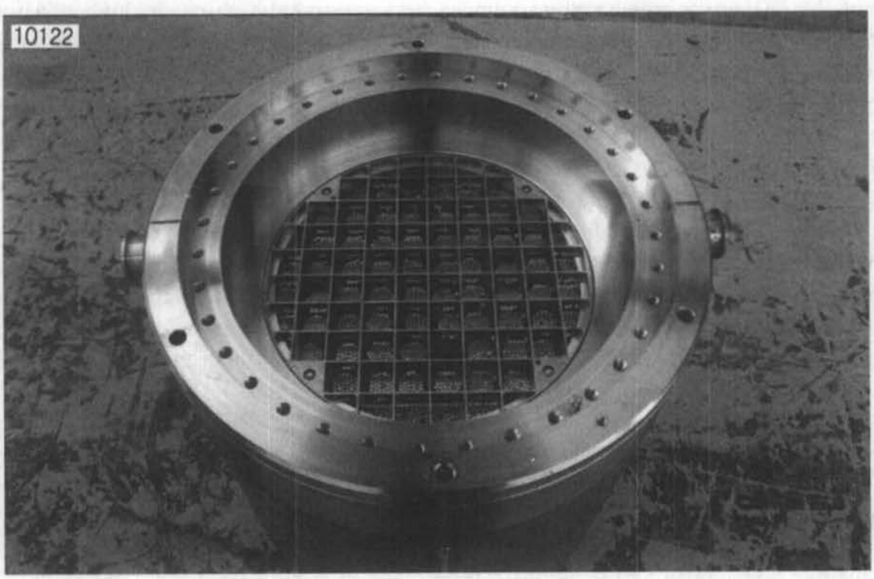

Figure 2: Dummy fuel assemblies in the half scale model

Early in the design process, it became clear that all attempts to use laminated structural and the thermal/criticality control materials across the 6 mm compartment wall would result in both buckling of the basket under 9-meter side drop conditions and inadequate heat transfer. The solution was to segregate the basket functions along the axis of the basket by stacking thin structural discs alternating with thicker thermal/criticality control discs. The fuel compartments are machined from solid discs and the discs are assembled with 4 tie rods. Differential thermal expansion between the precipitation-hardened stainless steel and borated aluminum discs is accommodated by oversized tie-rod holes and disc springs, while alignment is maintained by floating keys at the basket perimeter. The borated aluminum discs carry compressive loads under end drops, and under a conservative approach, are not assumed to support the fuel elements, but analysis and testing verify that the stainless steel discs alone can support the fuel in the 9-meter side drop.

In addition to analyses of several specific fuels, the basket criticality safety was analyzed with non-geometry-specific models which verify that any aluminum-clad MTR fuel up to 462 g U^{235} at 93.5% enrichment can be carried safely. While this understates the criticality safety capability of the basket, it qualifies the basket for nearly all of the great variety of MTR fuels. The basket can also carry up to 220 high-enrichment TRIGA elements. All criticality analyses demonstrate that $k_{eff} + 3\sigma < 0.95$ for both accident and normal conditions. The transport index for criticality safety is 0. Criticality analysis takes into account the tolerances of the plates and hypothetical deformations of the fuel elements.

MTR-52 basket design

This basket has 52 compartment, 98 mm square. The capacity of each compartment is an element with a weight of 8.5 kg, a decay heat of 154 watts, and a fissile content up to 550 g U^{235} at 20% enrichment. The design is similar to that of the MTR-68 basket with a number of exceptions. The compartment walls are thicker and the structural discs are thinner. Alignment of the discs is maintained by a central pin and a single key. Lastly, the thermal/criticality control discs may be fabricated from either borated aluminum or from a boron-carbide aluminum metal matrix composite ; the analyses support either material.

RHF basket design

This basket consists of a stainless steel cylinder, including 3 compartments for the RHF elements. Each compartment is equipped with rolled borated stainless steel sheets, one in the center of the fuel element and the other surrounding it. The basket can be easily extracted from the cavity by means of 3 removable lifting eye bolts screwed to the top face. The TN-MTR equipped with the RHF basket accommodates 3 RHF fuel elements.

TN-MTR OPERATIONS

Loading and unloading

The loading and unloading operations can be made in either dry or wet conditions. During transport the cavity is under a slight vacuum. One orifice of the lid is used to evacuate air during water filling or to pulse air during water extraction. The other orifice is used to fill the cavity with water or to extract it, and finally to vacuum dry the cavity.

Handling and tie-down

The TN-MTR is easy to handle since two trunnions are bolted on the packaging body and handling operations require no tilting. Note that the trunnions are protected by the impact limiter during a lateral drop and that they can be used with the impact limiter installed. Every component (lid, impact limiter...) of the packaging that has to be removed during operations, can be lifted easily either by handling beam or lifting eye bolts. Because loading and transport orientations are the same, no tilting is required, and the packaging can be used with low overhead clearance.
The TN-MTR tie down is simple and can be easily adapted to the transport means (container, flat bed...). It consists of four steel blocks placed under the conical section and four chains attached both to the TN-MTR lugs and to the transport vehicle or container.

DROP TESTING

Drop test program

The drop test program was developed to be representative of the worst drop condition, and was presented to the French authorities before the testing. It resulted in a drop test program including 5 nine-meter drops (two lateral, two end drops and one corner drop), and 2 punch tests (one on the cask body, one on the lid aiming at one of the orifices). Two 0.3 meter drops were added on site.

Scale model

(See figure 3)

The model was an accurate half scale representation of the packaging. In fact, only small items have not been modeled such as the fins or the drain tube in the cavity. One of the baskets was modeled to test its mechanical strength, and it was carefully chosen to be intentionally more damageable than the real basket which is particularly conservative on the following points:

- yield strength at temperature,
- web thickness,
- loading, both for load distribution and total load.

Results and conclusion

The test campaign was carried out in March and April 1997 and demonstrated that only local deformations are caused on the cask and that the containment leaktightness is maintained under all postulated accident conditions. Furthermore, the mechanical strength of the basket was confirmed under very conservative assumptions.

Figure 3: Scale model of the TN-MTR cask after 7 drops

CONCLUSION

The TN-MTR packaging has been developed taking advantage of the operational experience gained with the Pegase cask and special attention has been paid to every safety consideration. The cask Safety Analysis Report has been submitted to the French Competent Authority and the operating license is expected by mid 1998. In the meantime, the fabrication of 3 cask units has been started with a view to perform increased MTR spent fuel transports in the coming years.