TN MW® IRE: An application of the TN MW® family for fissile material

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ABSTRACT

In 2015 the Institute for Radioelements (IRE) in Belgium needed a shipment and interim storage solution to manage IRE residue of irradiated material so as to continue the production of radioisotope Molybdenum 99 for medical use. The IRE contracted with Orano TN to deliver two TN MW® packages adapted to this fissile material.

The TN MW® IRE cask is the first application of the TN MW® family. This new generation of casks has been developed by Orano TN (MW for Multi Waste) to provide operators with an all-in-one solution dedicated to waste conditioning, transportation, storage and disposal. The design complies with 2012 IAEA regulations with a total weight of 10 metric tons. The concept of the TN MW® family takes into account Orano TN's know-how acquired through more than 150 heavy cask models licensed by different Authorities in countries including France, Switzerland, Belgium and Germany.

The main challenge was to license a fissile version as a first version of this cask without having carried out any drop tests. Thanks to its 50 years of experience as a cask designer, Orano TN obtained the licensing and completed the manufacturing of the first TN MW® casks and the project which started in 2015 was achieved in less than two years.

1. Introduction

In 2015 the Institute for Radioelements (IRE) in Belgium needed a shipment and interim storage solution to manage IRE residue of irradiated material so as to continue the production of radioisotope Molybdenum 99 for medical use.

At that time no available packaging existed nor licensed to transport this irradiated material due to the high constraints related to its initial enrichment. Moreover, loading and on-site storage areas were limited in size on the IRE site, necessitating restricted dimensions of the packaging. Furthermore, the solution had to be implemented (development, licensing, manufacturing, and testing) in two years to meet the IRE's storage capacities and planning of evacuation for this irradiated material. Thus, in 2015, the IRE contracted with Orano TN to deliver a TN MW® packaging adapted to these fissile residues.

The TN MW® IRE cask is an application of the TN MW® family. This new generation of casks has been developed by Orano TN (MW for Multi Waste) to provide operators with an all-in-one solution dedicated to waste conditioning, transportation, storage and disposal. This highly flexible cask aims to simplify legacy, operational and D&D waste management while optimizing associated costs. The TN MW® is particularly adapted to small facilities, research reactors, and laboratories as a result of its compact dimensions and weight, facilitating the management of diverse waste and the easy handling operations.

The concept of the TN MW® family takes into account Orano TN's know-how acquired through more than 150 heavy cask models licensed by different Authorities in countries including France, Switzerland, Belgium and Germany. The design complies with 2012 IAEA regulations with a total weight of 10 metric tons. The cask is developed based on a flexible concept suitable to nuclear needs for internal transport, IP-2 transport, B(U) transport, interim storage and disposal, even with fissile material (as is the case with the IRE content).

This paper will describe the key challenges of the IRE project from characterization of residue to loading of the new casks including the design and licensing steps.

2. From the drawing board to delivery in record time

2.1 IRE needs

Focused on nuclear medicine, public health, and the environment, the IRE's missions are the production of radioisotopes for diagnostic and therapeutic applications, the measurement and monitoring of radionuclides, and the characterization and management of radioactive waste to support decommissioning activities.

The IRE extracts radionuclides (such as ^{99}Mo) from irradiated targets containing enriched fissile material necessitating the management of residues which are recovered and stored on site in metal cans until evacuation to a treatment site.

In 2015, the IRE evaluated that its on-site storage capacity for this irradiated material would reach the saturation point two years later. At that time, no packaging existed to transport this kind of irradiated material because of the high constraints related to its initial enrichment. Moreover, the IRE's facilities for loading and on-site storage are limited in size.

The initial need was the delivery of 2 casks with their internal components, tools and spare parts.

2.2 Main phases of the project

The different phases of the project were:

A first 6-month phase of feasibility and safety studies to define the preliminary design of the cask: The objective was to define the main dimensions of the cask, in particular the shielding thickness, the capacity of the basket with the number of lodgements, and the quantity of boron required for subcriticality. Also, the materials were selected at this step, and the principle of use was frozen, as for example the transport of the cask in horizontal position. In parallel, a more detailed characterization of the residue was carried out by the IRE to confirm residue compositions and related risk (especially radiolysis).

The description of the cask with the safety principles were presented to the Competent Authorities at the end of this period.

During the 9 subsequent months, all detailed studies were conducted while the safety analysis report was being compiled by a dedicated Orano TN "task force". The application request was sent in April 2016, first to the French Competent Authority (ASN) and one month later to the Belgian Competent Authority (AFCN).

In parallel, the manufacturing of the two casks, with their internal components (basket, canisters and internal shock absorber), and the tools to operate the casks was launched.

Orano TN managed the transport licensing process for one year until the French and Belgium Type B(U)F certificate was issued in May 2017.

The delivery of the casks was made successively in July then in August 2017. Orano TN brought complementary technical assistance services throughout the process, before the loading (documentation, package loading, transport preparation, interface test, theoretical and practical training of IRE operators…) and during the loading of the casks itself in September 2017 (assistance during the loading of the first cask, operations of lid closure, vacuum drying/helium filling of the cask cavity and leak-tightness tests).

Two more casks were ordered in 2017 and delivered to the IRE at end of 2018.

Furthermore, the TN MW® design supports an increase in the quantity of radioactive material loaded due to its robustness. A request for such an extension of the initial certificate was set to ASN and AFCN in May 209.

3. TN MW® IRE: the first version of the TN® MW family Type B(U)

3.1 Main characteristics of TN®MW

The TN MW® cask was designed using the most cost-effective solutions in terms of both investment and operating costs with common materials and common standard procedures. It is intended to be used for packaging, transportation, and long-term storage and disposal of intermediate- and high-level waste.

The design basis includes the following:

- Ensured containment of the radioactive contents under any condition (normal and accidental transportation conditions, and storage conditions);
- Ensured occupational exposure protection of workers and public.

The TN MW® cask can be transported by road, rail or ocean vessel inside a standard 20' ISO container. A few of the major features of the TN MW® are provided below (please see full description in the 2016 paper [1]):

- Weight of 10 metric tons;
- Easy to handle with a forklift or a hoist;
- Dry or underwater loading/unloading;
- Openings to facilitate draining/drying of the package cavity;
- On-site transfer and interim storage of the package without shock absorbers in vertical position;
- Interim on-site storage for up to 40/50 years (no gasket replacement, possibility of leak-tightness monitoring if required);
- Compatible with final disposal.

3.2 Adaptation to IRE needs

Initially designed for non-fissile material, the TN MW® has been adapted to the IRE's fissile content.

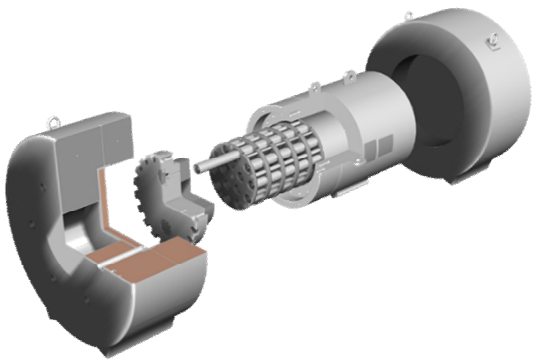


Fig. 1: TN MW® IRE Type B(U) Fissile with its dedicated basket and shock absorbers

The TN MW® IRE cask is composed of the following parts:

- A thick (200 mm) stainless steel forged body with welded lifting lugs;
- A closure system composed of a thick lid closed by screws and two concentric gaskets
    - Two orifices are located on the lid for inert gas in the cask cavity;
    - A leak test plug is located between the concentric gaskets to check leak tightness of the seal during storage;
    - An internal shock absorber is foreseen for resistance to delayed impact of content during accidental conditions (9-m drop test);
- A dedicated basket constructed with Boron to ensure subcriticality of the content during normal and accidental transport conditions. Lodgments of the basket received canisters in which are loaded IRE cans;
- Two shock absorbers (top and bottom) required in transportation configuration only.

	Diameter	Height
External dimensions without shock absorber (mm)	1,080	1,475
Cavity dimensions (mm)	680	950
Maximum weight when loaded without shock absorber (MT)	10	
Maximum weight when loaded with shock absorbers (MT)	12	

Table 1: TN MW® characteristics

Orano TN also delivered all ancillary equipment and tools necessary to operate the cask in IRE facilities including:

- 1 transport frame
- 2 transport chairs for vertical on-site transfer
- 1 tilting frame
- 2 lifting beams
- 1 lid chair
- 1 protection plate
- 1 operational lid
- Tool box
- Canister handling tools
- Leak-tightness test module & screwing tools
- Spare parts

Fig. 2: TN MW® IRE Type B(U) Fissile in transport configuration (stowed on its transport frame) and storage configuration with its transport chair for vertical transfer

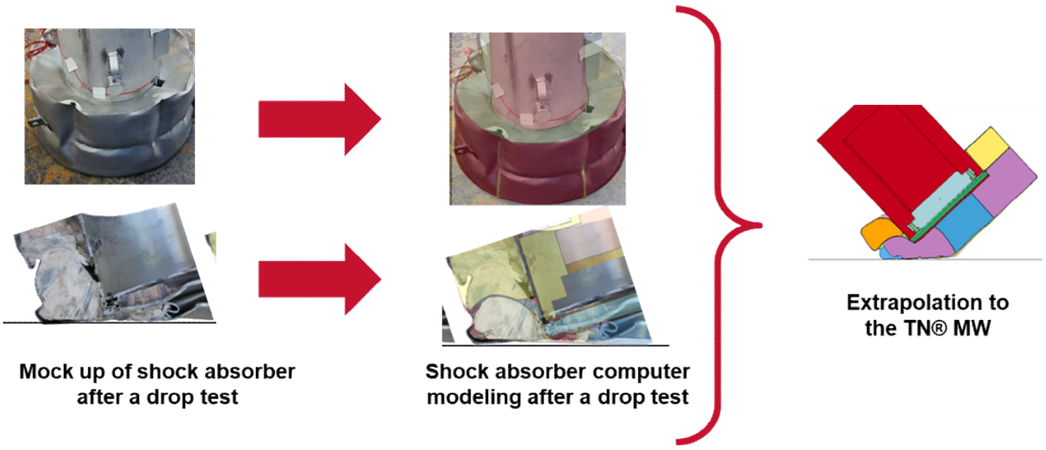
4. Key to Success

4.1 Proven technical choices

A 2-year period is highly uncommon and remains exceptional for such a project of design and licensing of a new Type B(U) Fissile cask. The Type B proof of concept usually follows different steps leading, necessarily, to several years. First, the proof of concept for accidental conditions (9-meter drop test in particular) is made on the basis of a drop test conducted on a reduced-scale prototype under the most penalizing conditions. The leak tightness obtained after the drop test guarantees compliance with regulatory criteria. These drop tests are complemented by numerical simulations on the basis of the detailed 3D model of the cask to confirm the leak tightness in various conditions (variations of parameters such as gap or temperature…).

To reach the time objective, the TN MW® proof of concept was based exclusively on numerical simulations, mastered by Orano TN, for the benchmark of drop tests and completed by a high robustness of the design by using proven materials and technologies, already qualified and implemented products on others type B(U) Fissile casks.
In fact the behavior of the shock absorbers constituted by wood encapsulated by steel are well-known and validated by safety authorities and Orano TN mastered the benchmark of drop test of such product with numerical simulations. For this reason, the TN MW® shock absorbers are derived from those designed for the TN®106 cask, the drop tests of which were conducted in the year 2000 and the weight and dimensions of which are quite similar to that of the TN®MW. The results of the deformation and acceleration benchmarks on the TN®106 numerical simulation were almost identical to the real measurements taken from the reduced-scale physical prototype. These results could be extrapolated the TN®MW, eliminating the need for the physical drop test. In addition, the increased robustness of the TN MW® shock absorbers, with increased capacity of energy absorption (increase of the thickness), was tested via 19 drop test simulation cases corresponding to the most penalizing drop test configurations depending on various parameters (angle of drop, temperature, material properties, torque tightening, gaps…).

How did Orano TN to validate the numerical simulation results with no physical measurement of the leak tightness? Orano TN benefited from its past experience in designing and licensing a dual-purpose cask for spent fuel (TN®24 type), with applying the same methodology (demonstrated only by numerical calculations) that had led to define and fulfill more stringent mechanical criteria based on stress or strain of body, basket and screw material.



In addition to the exclusive use of numerical simulations to gain time, the cask was designed with standard materials and technologies previously qualified and implemented on other Orano TN Type B(U) Fissile casks. Likewise, the metallic gaskets, used to ensure long-term interim storage without maintenance for a period of at least 50 years, had already been licensed for all dual-purpose Orano TN cask series. The metallic gaskets on the TN MW® cask satisfy tightness specifications for the primary lid and covers that give access to the cavity. These high-performance metallic gaskets are fully qualified and have high temperature resistance, that are more stringent than the conditions of IRE's on-site storage.

Finally, the materials selected had also been proven as robust. The body and lid are made in forged stainless steel (no brittle fracture at low temperatures) which prevents any corrosion during long-term storage thus minimizing maintenance (no coating) and facilitating manufacturing by limiting the number of operations (no coating).

Such optimization of time was also extended to the manufacturing process which was based on proven specifications, standardization of the components. Moreover, the choice of forged stainless steel provided cost savings and manufacturing schedule optimization by avoiding coating/overlaying operations.

4.2 Innovative technical points as well

To meet the latest regulatory requirements, Orano TN implemented several innovations:

- The internal shock absorbers inside the cavity (for delayed impact) are made of new materials which increase the energy absorbed improving the safety margin and avoid any additional constraints in the lid screws
- The basket incorporates a new boron material to increase margin in criticality conditions requiring a specific qualification, and its geometry was designed to optimize the loading capacity.
- The canisters into which the IRE's cans of residues are loaded are equipped with porous filters that required qualification to ensure that the inert gas is able to fill the canisters for radiolysis management.

4.3 Risk management of the design & licensing phase

The main challenge of the TN MW®IRE project was the schedule. To avoid any delays, Orano TN launched early the first procurement of critical components to be qualified: boron in the basket, and the new material for the internal shock absorber.

The SAR review was done by a close partnership of all Competent Authorities, ASN/IRSN and AFCN: Safety options were presented to ASN and AFCN at the same time. Thanks to the quality and robustness of the design, ASN and AFCN both agreed to the schedule of one year to conduct the expertise without a drop test. The characterization of the content was one important issue challenged by AFCN in relationship with the IRE.

Both Competent Authorities exchanged information continuously throughout the licensing process. The quality of these exchanges helped all involved parties reach a common understanding of the project. Belgian multi-lateral approval of license was granted only one month after the French license approval. Thus, discussing with the two Competent Authorities at the same time was a real opportunity for an efficient SAR review from both sides.

Inspection of the cask manufacturing was carried out by both Competent Authorities as it was a first-of-a-kind design.

5. Conclusion

TN MW® IRE is a first-of-a-kind cask for the interim storage and transportation of irradiated residues originating from the IRE. Part of the TN MW® family, it is a Type B(U) Fissile version with a specially designed basket for criticality. Following the design process that lasted only 2 years from start to finish, the loading and transport license was successfully granted by the French and Belgium Safety Authorities in May 2017, after a one-year collaborative review process. Since then, 4 casks have been successfully delivered and loaded on the customer’s site.

The ability to manufacture the product is such a short period was mainly due to Orano TN’s vast experience in the design of Type B(U) Fissile casks. The numerous drop tests mastered by Orano TN in the past on similar shock absorbers made it possible to license the TN MW® without a physical drop test.

This success is also due to the innovative thinking and meticulous project management of the Orano TN; its engineering team was able to find and implement new solutions improving the safety margin without any impact on the schedule.

With earned confidence, the TN MW® family is currently under development applying the same principles for various types of non-fissile waste.

6. References

[1] F. Lefort-Mary, C. Lamouroux, M. Ghobrini, C. Hervé, B. Kerr, “TN MW® Cask Family – A New Packaging System Focused on Waste Management from Operational Stage to End-of-Life of Nuclear Facilities.” Paper N°6003 presented at the bi-annual meeting of the Patram symposium, Kobe, Japan, September, 2016.