THE TNF-XI: A NEW GENERATION PACKAGE FOR U OXIDES

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Abstract

Generally speaking, the existing packages in use for the transport of uranium oxides are quite "old" designs which have been more and more questioned by Competent Authorities worldwide. For some of them, the authorized payload had to be reduced for safety assessment reasons. These packages now need to be replaced.

On behalf of Nuclear Fuel Industries, Ltd., Transnucléaire is in charge of the design of a new generation package: the TNF-XI design.

As for every new type of package, one of the most important requirements is to maximize the payload / production price ratio and to make the operation and maintenance costs as low as possible. The design, which started mid 2000, is thus conducted with three guidelines. The first is to use the most recent Transnucléaire technology: specific non-corrosive foams, high performance criticality control resin and user-friendly closing devices. The second is to demonstrate its safety capability under the most penalizing condition. The third is to benchmark the serial production cost every time the basic design has changed in a way that can impact its price.

Taking into account the existing sites interfaces and UO2 powder conditioning arrangements, the expected performance of the package is to transport six UO2 tons per 20-foot ISO container by loading 20 TNF-XI packagings:

On a safety and licensing point of view, lessons have been learnt from the past. Indeed, it appeared in the last few years that approaches regarding demonstration of compliance with the regulations for fissile packages could vary from one national competent authority to another. Such packages having an extremely international life, the choice has been made to consult the relevant authorities at an early stage of the project. The aim is to consider their experiences and recommendations before the design and the associated methods of demonstration with the regulations have been definitively fixed.

The TNF-XI fleet should be in operation starting end of year 2002.

Content characteristics

The TNF-XI packaging has to allow the transport of powder at any density, scraps and/or pellets of enriched uranium oxides, between the re-conversion manufacturing plants and the NFI fuel assemblies manufacturing plants in Japan. Therefore, approvals and/or validations are requested on the three European, American and Asian continents.

The radioactive content is constituted by uranium oxides (UO_2 or U_3O_8 or UO_3), enriched to a maximum of 5% in uranium 235, according to:

- either usual commercial grade (C.G.U) referring to <2>,
- or slightly polluted uranium, but still compliant with LSA II definition following <1>.

Due to differences in approaches at the international level, these two contents had to be translated into three contents in the safety analysis report, as described here-under.

Content nr.1: the radioactive material is compliant with the standard specification for "Commercial Grade Uranium" (C.G.U) as specified in <2>, and also complies to unirradiated uranium definition (paragraph 245 of <1>). This content is made mainly for the purpose of licensing in France, where the C.G.U is not considered as an equivalent to unirradiated uranium by the competent authority.

Content nr.2: the radioactive material is still C.G.U following <2>, does not comply with the the definition of unirradiated uranium, but complies with the definition of LSA II material following <1>.

Content nr.3: the radioactive material does not comply with the definition of C.G.U, but is still compliant with the definition of LSA II material following <1>.

The application for the package design approval will have to be made for Type IP-2 containing fissile material package and Type A containing fissile material package, following <1>, in Europe and Japan, and Type A containing fissile material package in the US, because an industrial package is not suitable for the transport of fissile material on the view point of the US competent authority.
One can already understand that for the same material to be transported in the same new generation package, the classification of the material will refer to two different applicable standards or regulations, and the package will be registered within two different regulatory categories. We will see that the differences in positions between various competent authorities worldwide are going further, on the demonstration of compliance with the regulations field in particular.

The starting situation

Such material is presently transported with the NT-IX packaging by NFI, which belongs to the "family" of ageing designs of fissile material transport packagings as described in <3>.
The main characteristics of the NT-IX packaging are the following:

- Overall height: 890 mm
- Overall diameter: 600 mm
- Internal useful dimensions of the cavity: ∅ 354 mm * H = 680 mm
- Total weight (for 75 kg payload) ≤ 215 kg.

These packagings, which the 80's design is based on a conventional industrial drum, have been more and more questioned by some competent authorities and have seen their authorized payload reduced with time. In some cases, transports were or still are made possible thanks to special arrangements needing additional safety demonstration including additional official qualification tests, whereas these packagings have been used for years already.

The sketch of NT-IX is shown in Figure 1.

Considering such situation, added to increasing needs for transportation of reconverted UO2 powder from abroad due to the criticality accident that occurred in Japanese re-conversion plant, NFI decided to invest in the development and manufacturing of a new generation packaging, able to increase the transport capacities compared to NT-IX packaging, relying on up to date sound demonstrations of compliance with the regulations, and expecting full approvals in Europe, the US and Japan.

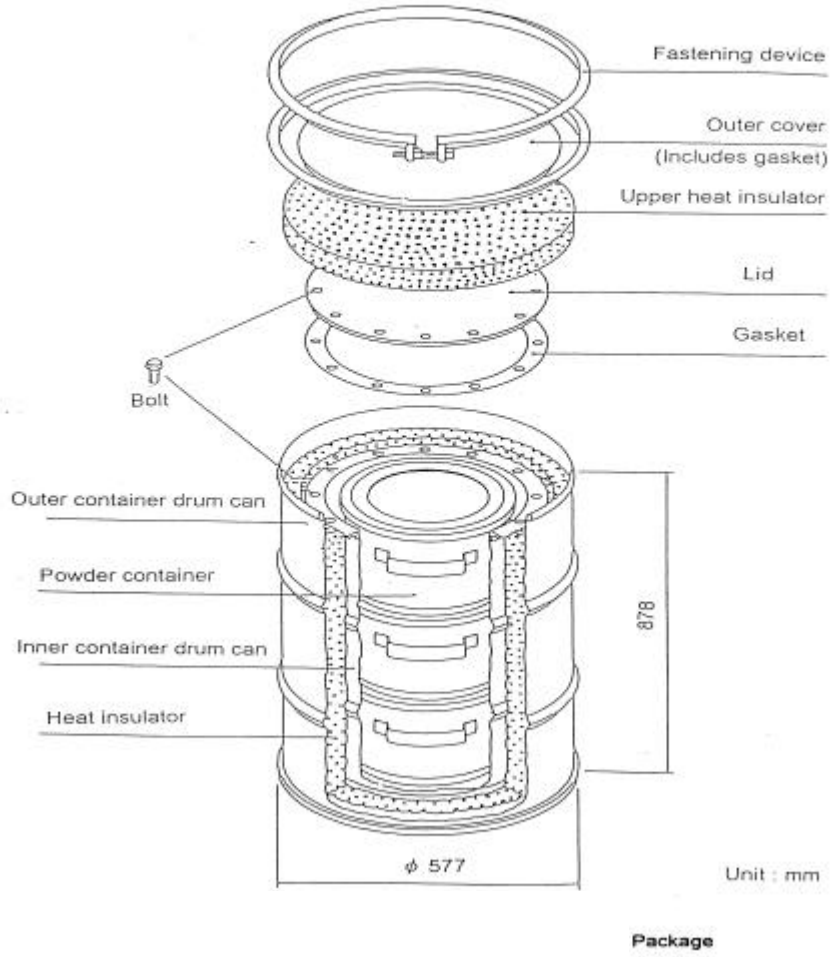

Figure 1 – the NT-IX packaging

Operational constraints

The TNF-XI packages can be grouped by 20 for transportation in standard 20-foot ISO dry containers (maximum gross weight: 24 t).

It is requested that the existing handling operations in plants are modified by the minimum with this new packaging. In particular:

- The radioactive material is placed in stainless steel existing NFI pails, which are compatible with the internal dimensions of the cavity of the NT-IX packaging. The reason why to use existing NFI pails is that these pails are used in a safety analysis of fuel manufacturing plants. Such requirement has a direct impact on the requested performance of the new package, because it is well known that the reactivity of the package is a deep function of the fissile section diameter.

Preliminary design
Based on these material and operational requirements, a basic solution has been designed, which leaded to the main features and sketch here-under.

The design of the packaging (see Figure 2) is mainly composed of an external protection body including the shock absorber and the thermal protection (protections against mechanical and thermal tests following <1>), surrounding the four neutron absorbing layers which enclose the inner cavities.

- General characteristics of the packaging:
  - Overall height: 1040 mm
  - Overall section: 1100 * 1100 mm
  - Internal useful dimensions of each cavity: ∅ 354 mm * H = 675 mm
  - Net weight ≈ 660 kg
  - Total weight (for 300 kg payload, pails included) ≤ 1050 kg.

- Easy closing system of the inner cavities: twist-off lids on a bayonet basis.

- Internal and external sheets made of stainless steel.

- Upper face of the package equipped with a specific polymer cover, allowing the stacking on three levels during storage of the package, and interlocking with specific pins.

- Easy handling of the package thanks to integrated forklift paths (crossed directions) which are located on its lower face. Lifting of the package with a crane by ropes.

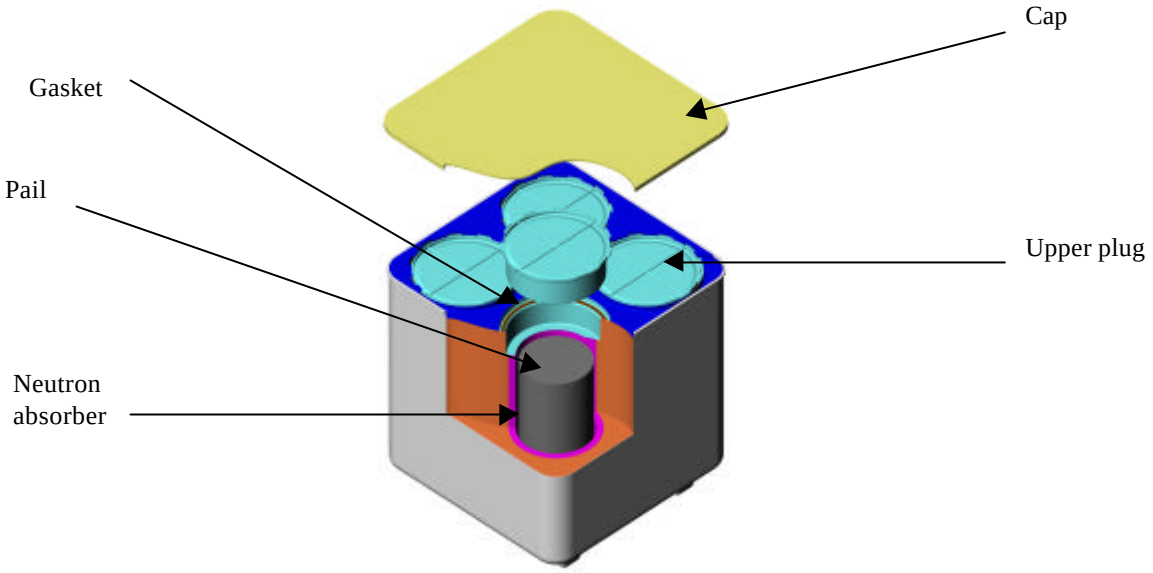

Figure 2 – Preliminary design

Development and qualification

It is now well known that national competent authorities may behave differently in front of a newly developed package, especially for fissile material.

In a world governed by exchanges and information, it is also common sense to take into account the operational feedback of existing packages a new one can be compared to.

These two statements led Transnucléaire to:

- First, consider the most recent technology for the development of TNF-XI package. In particular, a highly efficient and recently developed neutron absorbing resin and an advanced thermal protection made of phenolic foam, chloride free, have been used, engulfed inside stainless steel sheets. The first one contains a high and optimized hydrogen / boron ratio content, and the second one contains as low as possible chloride elements, in order to avoid any life-time corrosion risk and to minimize the maintenance costs.

- Second, introduce its preliminary concept and the envisaged methods of demonstration of compliance with regulations to two of the most demanding competent authorities, which territories will be crossed by the foreseen transports: the US-NRC, and the French DSIN.

It has to be noticed that, thanks to its international network, the TN group was aware of practical differences in applicable standards or regulations between the US and France from the beginning of TNF-XI design, and had introduced both approaches in its development. For example, the philosophy to be used for sub-criticality demonstration differ between both countries: an Upper Superior Limit (USL) for the K_{eff} has to be determined on the US side, considering the type of material to be transported, prior to criticality calculation. In a different manner, fixed "universal" superior limits can be used in France, but they are different whether a single package is considered, or a packages array is considered.

Despite this, the reaction of interviewed competent authorities has been quite different, both on the design itself and on the provisional methods of demonstration of compliance with the regulations.

The main items having direct consequences on the project were:

- a suggestion made on the US side to put in place an additional item for reinforcement of the powder containment in accident transport conditions.
- an extension of the provisional drop tests sequence. Indeed, the IAEA regulations call for a sequence of punch and 9m free drop tests. The sequence should be performed in the most penalizing way. For the one, the punch test prior to the free drop was most damaging, but for the other one, the punch test had to be performed further to the 9m free drop. An "international sequence" has thus been created : punch test / free drop / punch test was the final cocktail.

The tests sequences on two different prototypes are provided below.

QUALIFICATION TESTS SEQUENCES

SPECIMEN A		SPECIMEN B	
DEFINITION OF TEST	**ATTITUDE**	**DEFINITION OF TEST**	**ATTITUDE**
1 free drop 1,20 m	Impact on: - Corner of the upper face of the package	1 free drop 1,20 m	Impact on : - lateral face
Penetration test of 6 kg bar	Impact bar on : - lateral side - center of plug - plug bayonet	Penetration test of 6 kg bar	Impact bar on : - center of bottom - center of head
1 m puncture test	Impact of bar on : - 1 lateral side 0°	1 m puncture test	Impact of bar on : - center bottom 25°
9 m free drop test	Impact on : - corner (the same as in previous free drop)	9 m free drop test	Impact on : - lateral face (the same as in the previous free drop)
1 m puncture test	Impact of bar on : upper plug nearest to the corner impacted in the previous free drop tests	1 m puncture test	Impact of bar on : - lateral side 25° impacted in the previous free drop tests
Thermal test 800 °C 30 min. : on both specimens			

An example of a drop test sequence is presented on the pictures here-under:

Corner drop test preparation

Corner drop test result

Preparation of serial manufacturing

Working as industrial partners, NFI and Transnucléaire fixed, at the earliest stage of the project, a target manufacturing serial price. Consequently, each sub-part manufacturer has been closely involved in the definition of the packaging, on the viewpoint of manufacturing and serial production prices.

By the organization of the project team, the design cannot be changed without an effective bench-marking to the serial production price parameter. Manufacturing hundreds of packagings of this type needs to be prepared: this requires to work with professionals, who are able to imagine the best industrial solution for such kind of design change vs. serial manufacturing. And it is a fact that the optimized industrial solution may be impacted or modified with design modifications which sometimes seem so simple.

Conclusion

It is generally recognized among the nuclear industry that some of the front-end materials packages need to be redesigned and replaced. Such is NFI opinion when financing the development and manufacturing of TNF-XI, using the most recent technology.

But the international operators, even when they know the rules and take preliminary precautions, are still facing multi-way of applying rules by authorities, as soon as the considered package has to obtain several approvals. They would not understand the interest to replace ageing but amortized designs which are sometimes difficult to re-license by newer and safer concepts, which cost thus more, but which would still be difficult to license *because* they are needed for international use.

References

<1> Regulations for the Safe Transport of Radioactive Material - 1996 Edition – Requirements n° ST-1, IAEA Vienna.

<2> ASTM C 996-96 : Standard Specification for Uranium Hexafluoride Enriched to Less Than 5% ^{235}U.

<3> "Uranium oxides (UO2) / transporting an industry staple" prepared by Melissa Mann – TLI, on behalf of the WNTI. Patram 2001.