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FEED BACK ON THE USE OF THE MX6 AND MX8 MOX FUEL TRANSPORT CASKS

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ABSTRACT

The MX6 and MX8 casks have been developed by TN International to transport fresh MOX fuel assemblies for either BWRs or PWRs. The MX6 is used in nuclear power plants (NPP) in Germany and Switzerland to replace the previous Siemens type II and Siemens BWR casks. In France, the MX8 is used to replace the previous FS69 cask.

Innovative solutions have been applied to each stage of design and manufacturing of the MX casks, which comply with TS-R-1 regulations (IAEA 1996).

The design includes effective neutron shielding for high plutonium content fuel and easy-to-use content restraining systems. The large payload of the MX (6 to 8 PWR MOX fuel assemblies or 16 BWR MOX fuel assemblies) contributes to optimize the dose uptaken during unloading at the NPP.

Moreover, new sequences for dry loading and dry or wet unloading operations were proposed for testing and implementation in nuclear facilities. In all, more than 100 shipments have been performed with these casks since the last five years. During initial operations sequence, TN International worked to improve the casks, for example by reducing operator exposure and optimizing turnaround times.

The MX casks are currently used primarily in French, German and Swiss NPPs. Their use will be extended worldwide, starting with Japan.

INTRODUCTION

The MX6 and MX8 casks have been developed by TN International to transport fresh MOX fuel assemblies for both BWRs and PWRs. They replace the previous Siemens type II, Siemens BWR and FS 69 casks.

These casks comply with TS-R-1 regulations (IAEA 1996).

The MX8 cask was first used to deliver fresh MOX fuel assemblies to the Tricastin nuclear power plant (NPP) in 2002, while the MX6 cask was first used at the Gundremmingen NPP in Germany in 2004.

The MX casks are currently used in France, Germany and Switzerland.

The MOX fuel assemblies are manufactured at the AREVA Melox plant in France and at the FBFC-I plant in Belgium. TN International is in charge of the shipments and uses its subsidiary LMC for shipments to France and Nuclear Cargo and Services for shipments to Germany and Switzerland.

More than 100 shipments have been made since the casks entered in service, including both dry and wet unloading operations.

In this paper, TN International will present its experience in the use of the casks and lessons learned for their optimization.

BACKGROUND ON PREVIOUSLY USED CASKS

FS69 casks

The FS69 cask was used in France from 1996 to 2005 to deliver MOX fuel to EDF power plants.

A new cask had to be developed to:

- Increase load capacity and accommodate assemblies with a thermal output higher than 600 W per fuel assembly,
- allow underwater unloading to limit exposures from new fuel characteristics,
- comply with the requirements of TS-R-1 (IAEA 1996).

Cask development was launched in 1997 for the French market. The design enables transportation up to eight fuel assemblies with a higher Pu content.

Siemens casks

These casks were used in Germany and Switzerland to transport fresh MOX assemblies for both BWRs and PWRs.

A new cask had to be developed to:

- increase cask capacity,
- comply with the requirements of TS-R-1 (IAEA 1996).

MX6 cask development was launched in early 2000 for the European market, focusing first on 16x16 and 18x18 MOX fuel assemblies for PWRs, and on 10x10 MOX fuel assemblies for BWRs. The design enables transportation up to six PWR MOX fuel and up to 16 BWR MOX fuel with a higher Pu content.

DESIGN

Casks design

The MX casks consist of an outer body and internal basket.

The outer body is a double shell cylinder:

- the inner steel shell acts as containment,
- the outer steel shell provides mechanical strength to the cask,
- the area between the shells consists of neutron shielding resin and copper fins for heat dissipation of the contents,
- an upper and lower flange are welded to the inner shell,
- a lid is screwed onto the upper flange and completes the containment,
- wood covers (as shock absorbers) are screwed onto the upper and lower ends to ensure the mechanical integrity of the cask.

To meet the new regulation, the key safety-related change was to no longer consider the fuel cladding as the primary containment barrier.

The internal basket consists of:

- 6, 8 or 16 compartments to maintain the internal geometry of the cask in a criticality-safe configuration in accordance with transportation regulations;
- an assembly clamping system to ensure fuel integrity during routine transportation operations.

Casks characteristics

The MX6 cask was designed for dry loading and unloading; the MX8 cask was designed for dry loading and wet unloading.

The MX6 cask (see figure 1) is loaded either with 6 PWR MOX fuel assemblies or with 16 BWR MOX fuel assemblies. It has a total gross weight of less than 20 metric tons (MT), a total length of 5,980 mm, a body diameter of 1,340 mm and a shock absorber diameter of 2,130 mm.

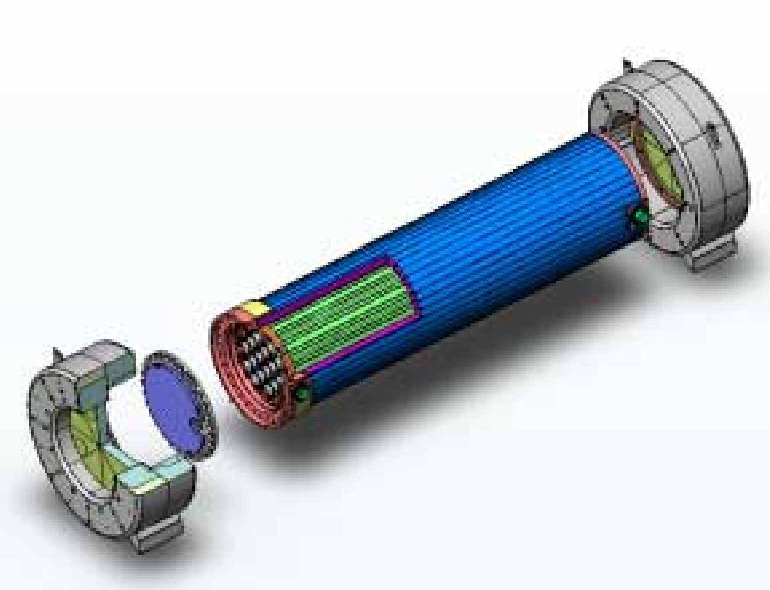

Fig. 1 – MX6 cask with BWR basket

The MX8 cask (see figure 2) is loaded with 8 PWR MOX fuel assemblies. It has a total gross weight of around 22 MT, a total length of 5,183 mm, a body diameter of 1,379 mm and a shock absorber diameter of 2,282 mm.

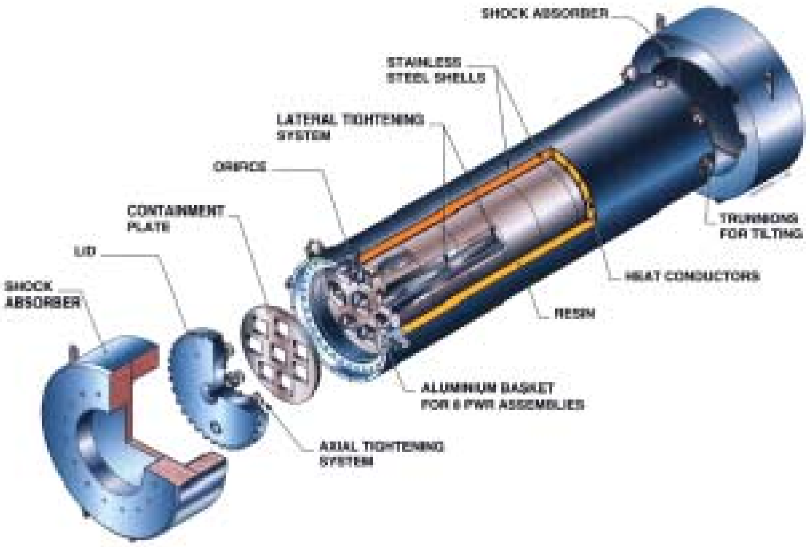

Fig. 2 – MX8 cask with PWR basket

The shielding was optimized to minimize the total dose absorbed by the operators.

The fuel assemblies are transported in horizontal position. TN International designed the content restraining system and the basket. Restraining systems were developed, to comply with the German and French fuel vendors requirements in terms of fuel integrity.

The maximum characteristics of the 16x16 or 18x18 fuel assemblies to be transported in the MX6 cask are as follows: 15% total Pu, 6.5% to 8% fissile Pu, with a maximum heat capacity per fuel assembly of 1,100 W. The maximum characteristics of the 10x10 fuel assemblies to be transported in the MX6 cask are as follows: 10,2% total Pu, 8% fissile Pu, with a maximum heat capacity per fuel assembly of 415 W.

The maximum characteristics of the 17x17 fuel assemblies to be transported in the MX8 cask are as follows: 10,2% total Pu, 8% fissile Pu, with a maximum heat capacity per fuel assembly of 1,100 W and a total maximum heat capacity per cask of 6,800 W.

Safety Requirements

The casks comply with TS-R-1 requirements as Type B(U)F packages and the corresponding international modal regulations ADR, RID and IMDG-Code.

The MX8 cask design has been fully approved by the French authorities (ASN) in France in November 2001, and fully extended since December 2006.

The MX6 cask design has been fully approved by the French authorities (ASN) in France in December 2002 and in Germany by the German authorities (BAM) since October 2003. It is also undergoing validation in Switzerland.

DEPLOYMENT

Transportation means

TN International has developed a new high-security system for the MX8 cask, which complies with international road transportation requirements and French security regulations.
For the MX6 cask, TN International has worked with NCS to develop a new high-security system called SIFA2/2, which complies with international road transportation requirements and German security regulations.

Tools

The tools developed for loading and unloading operations are mainly:

- a radiological shield plate,
- clamping/unclamping tools (independent module in the case of the MX8 cask).

For wet unloading,

- a cooling-drying module was developed.

Dry run

For each plant, dry runs have successfully been performed before the first shipment to certify the whole system, with all parties involved participating. In some cases, preliminary tests were performed on a mock-up.

Operating protocols, an operations manual and a handling manual have been used for the tests. The primary purpose of this preparation was to certify the manuals (general and in-plant manuals) before proceeding with the test themselves; six months were necessary to reach this goal. Plant improvements required one year before the first loading.

The tests provided key feedback:

- loading and unloading sequences have complied with the operator's safety requirements;
- the duration of each step has not been as long as originally estimated, meaning that operator exposure during normal operations has been overestimated;
- fuel assembly integrity during loading and unloading operations have been demonstrated;
- heavy equipment and tooling have been qualified for use in the plants.

Return of empty casks

All parties involved, including the health physics sections, have agreed on specific conditions for the return of empty casks. Accordingly, casks returning to the manufacturing plant have to meet non-contamination conditions of less than 0.4 Bq/cm2 for beta and gamma and less than 0.04 Bq/cm2 for alpha.

FEEDBACK FROM THE FIRST CAMPAIGNS

MX8 cask

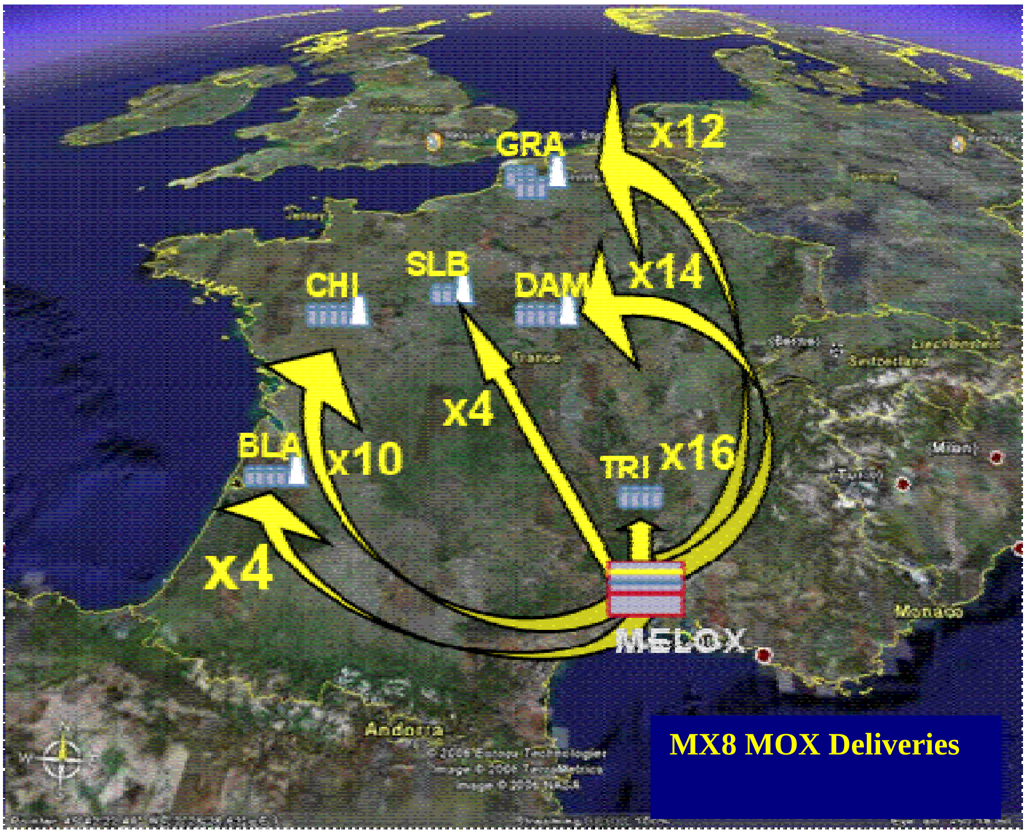

Fig. 3 – MX8 Deliveries in France

Shipments: 60 shipments from 2005 to 2007

Loading duration: 48 hours - Unloading duration: 5 days

Dose: 0.8 mSv per unloading

Feedback: - clamping controlled by the automated system ;

- contamination prevention under control.

MX6 cask

The first shipments of fresh 10x10 MOX fuel assemblies using the MX6 transportation system from the FBFC-I plant to the Gundremmingen NPP have been performed from mid-March 2004 to mid-April 2004 at a rate of one shipment per week. Subsequently, more than 40 shipments were made to German and Swiss NPPs (Isar, Emsland, Grafenrheinfeld, Brokdorf, Beznau, and Philipsburg in 2008).

The preparation period is longer, but all fuel assemblies are loaded or unloaded in a shorter period of time.

The reduced time schedule for loading or unloading, along with the presence of resin layer between the shells, minimized the total dose.

EVOLUTION

Design evolution

The design of the MX cask is conducive to other applications in two ways:

- by changing the basket (or inner fittings) within the same body, or

- by changing the basket and body sizes.

In the first case, a new basket has been designed to take into account the MOX fuel characteristics. Dimensional studies have been performed to accommodate a maximum number of fuel assemblies. The mains constraints taken into account were:

- fuel weight
- thermal capacity
- dose and criticality

The main advantage of this solution is that it doesn't require new regulatory drop tests.

In a second hand, the body can be modified as necessary to take into account customer requirements, such as :

- a given number of fuel assemblies,

- a specific size,

- the handling process.

The design of the body would be maintained, but tests would need to be performed due to changes in cask weight.

Worldwide extension

MX6 cask for Japanese BWR plants

For land transportation of fresh MOX fuel for BWRs from the manufacturing plant (Melox in France and SMP in the UK) to the AREVA NC La Hague plant, a lightweight MX 6-type cask weighing about 20 MT would need to be used. A new basket was developed that can be loaded with 10 fresh 8x8 BWR MOX fuel assemblies.

This MX6 cask is also used for Japanese plants with no heavy lifting capabilities used for the TN 12/2 casks.

This capability was achieved with:

- a new type of fuel holder capable of grasping 2 sides of a basket compartment during loading,

- assemblies placed horizontally in the cask at a 45° angle(see fig.4) so that they rest naturally on 2 sides of the compartment,

- a new clamping system to immobilize the fuel in the radial and axial position with the head of the fuel holder, instead of a line of tightening pads that press the fuel holder against 2 sides of the compartment.

Others

Development prospects have been identified for Belgium and the Netherlands, and for South Africa at a later date.

CONCLUSION

The MX casks were successfully developed as TS-R-1 containers to replace the old fresh MOX fuel shipping casks.

Using an innovative design and dry loading and dry or wet unloading sequences, the MX casks help optimize loading and unloading time duration and reduce the dose uptake during operations.

The design also includes easy to use content restraining systems.

As part of this development, TN International provided a wide range of services, from development of documentation to preparation of testing to support during loading and unloading operations to optimize every aspect of the loading and unloading sequence. The success of the operation is directly attributable to the cooperation of all parties.

Based on the experience of more than 100 transportation operations in Europe, the use of the MX cask will be extended worldwide, beginning with Japan.