NEW PACKAGE SYSTEMS FOR EDF RECYCLING POLICY

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ABSTRACT

Since the beginning of the nineties, EDF (Electricité de France) has been carrying out a policy towards increasing burn-up. As a consequence and to keep energetic performances of the MOX (Mixed OXide uranium and plutonium) fresh fuel assemblies at parity with UO2 fuel, the concentration in plutonium increased up to 7.1%, soon up to 8.65% and even more.

To take into account the increased dose rate and the increased thermal power of these MOX fresh fuels in the transportation system, COGEMA LOGISTICS designed, manufactured and licensed the MX8 package to replace the previous packaging.
Simultaneously new high-secured transport system was developed.

Due to the capacity of the reactor pool, the spent fuel assemblies must be evacuated with a short cooling time and high residual power. Because of the neutron source of these future MOX spent fuel assemblies, the TN™12/2 packaging, which has been in operation since 1980's to transport UO2 or MOX spent fuel to COGEMA La Hague, from EDF, other European and Japanese NPP lacks flexibility.

COGEMA LOGISTICS is designing a new cask (TN™112) to transport the future EDF MOX spent fuel assemblies. The TN™112 has to comply with the 1996 edition of the IAEA transport regulations and with the transport and handling equipment presently used for the transport of spent fuel in France. It can be loaded with 12 assemblies, either MOX or UO2.

This paper gives a description of two packages belonging to the new generation:

- one for fresh MOX fuel assemblies transportation, used on EDF's power plants for MOX reloads,
- one for spent MOX fuel assemblies transportation, presently under development with a first transport planned for mid-2007.

I . EDF fuel cycle policy

With its 58 reactors ensuring 80 % of the power supply in France, EDF has faced over the last decade and solved a real challenge: increase its NPPs contribution to the grid, ensured with a high level of safety and reliability, while increasing plutonium recycled and reducing dose uptake.

The fuel cycle management also corresponds to a sustainable development policy:

- from an economical point of view to increase fuel assemblies power production and reinforce the profitability of nuclear power, synonym of a higher confidence in this source of supply and giving EDF a strong economical advantage
- from an environmental point of view to manage high level and long life waste and preserve long term resources for future generations, as well as contributing significantly to limit the global warming
- from a social point of view to reduce dose rate for workers, develop more user-friendly interfaces reducing time of exposure and create job opportunities for a significant number of highly qualified people to recycle these products.

The present EDF's strategy aims at increasing fuel performances in this decade and is built upon reprocessing of spent fuel and recycling of all the plutonium under MOX fuel assemblies.
This strategy is developed according to the following steps, that is balance of plutonium separated and recycled, named :

- "MOX parity", which requires a plutonium content of 8,65% in MOX fuels for a balance with UO2 fuels of 45 GWd/t,
- "MOX post parity", which requires a plutonium content of 9,3% in MOX fuels for a balance with UO2 fuels of 54 GWd/t

The rising neutron dose rate resulting from this higher plutonium content led COGEMA LOGISTICS to develop two new packages, the MX8 for fresh MOX fuel assemblies and the TN 112 for MOX and/or UO2 spent fuel assemblies, with the following fundamental principles:

- MX8 had to accept a higher plutonium content, and thus a higher heat output while decreasing dose uptake by operators
- TN 112 had to accept exponential neutron source and increased thermal output of spent fuel.

Implementing those principles, while developing a closed cycle policy means adapting each step of the fuel cycle to this pattern. Thus transportation means have to offer better shielding and higher flexibility.

II . MX8

To take into account the increased dose rate and the increased thermal power of the fresh MOX Fuels COGEMA LOGISTICS designed, manufactured and licensed for their transport, a new generation of casks beginning with the MX8 packaging for PWR fuel assemblies. It replaces FS 69 (2 MOX assemblies per packaging). MX8 has been designed for EDF 17x17 PWR fuel assemblies for 900 MW NPP units type, which are running with both MOX and UO2 fuel assemblies.

As a new package, the MX8 has taken into account the evolution of MOX fuel management in EDF's units, moving from current 12 assemblies per reload presently to 16 in the coming years, which explains the choice of 8 assemblies to be transported per cask.

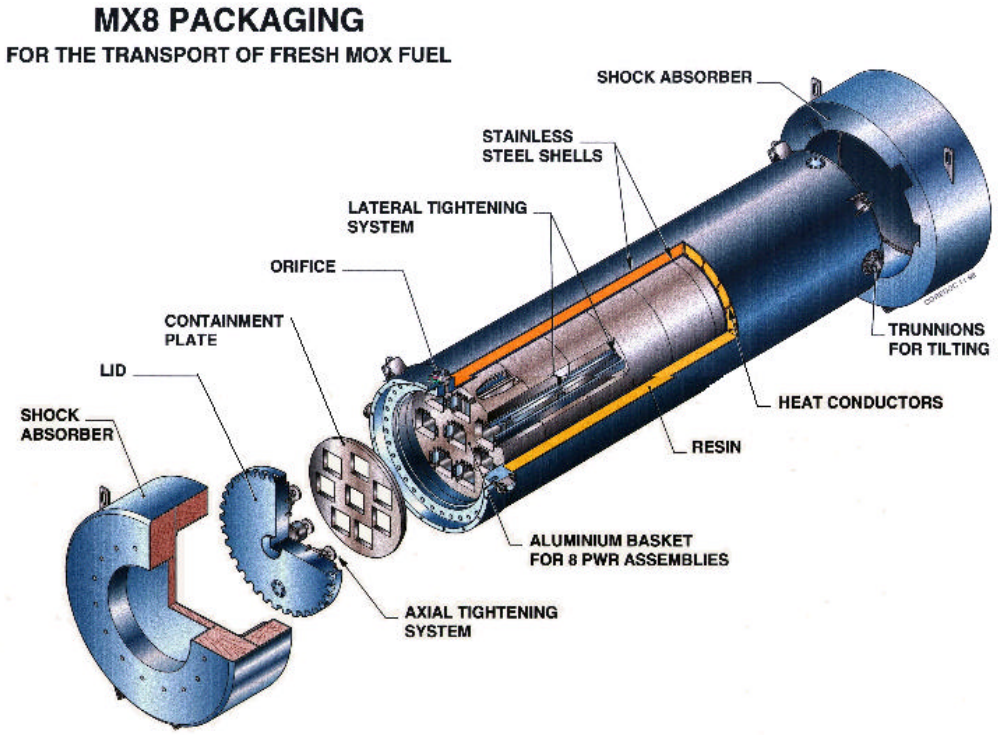
MX8 has been developed as a "mid-weight" packaging in order to be loaded easily in MELOX plant and limit the number of constraints, for road transports. It benefits from all COGEMA LOGISTICS experience and R&D gained on spent fuel packaging development, as well as specific characteristics due to the necessity to guarantee the integrity of the fuel during the transport for fresh fuel assemblies.

The MX8 has been designed according to requirements of the 1996 IAEA transport recommendations TS-R-1. It has been designed for vertical remote loading/unloading, dry loading in MELOX plant and underwater unloading in EDF's NPP.

II.1 - MX8 packaging description

The MX8 is made of two main components:

- a body with one closure system and two shock absorbers,
- a basket designed for restraining the fuel assemblies to guaranty the fuel integrity



II.1.1 - Description of the body

The body of the MX8 packaging is made out of two coaxial stainless steel cylinders linked with copper heat conductors and separated by resin. The copper heat conductors are used for the evacuation of the internal heat coming from the fuel assemblies. The resin is a shielding and a neutron absorber.

The body is equipped with a closure system so that the packaging stays leak tight under normal and accidental conditions of transport.

Orifices allow the packaging to be depressurised and to be filled with water during the unloading operations, then emptied, once fuel assemblies have been unloaded, and dried before closure for the return back from the power plant.

For leaktightness, the cavity lid and orifices are equipped with EPDM seals. An interseals space is provided for the checking of the leaktightness of the cavity.

In order to absorb the energy of impacts under regulatory test conditions, shock absorbers made out of wood inserted in titanium or stainless steel casings are bolted on top and bottom of the body.

The loaded MX8 with its 8 fuel assemblies has a total gross weight of 22 tons, a total length of 5180 mm, a body diameter of 1380 mm and a shock absorber diameter of 2280 mm.

This remarkably low tonnage allows transport on a legal weight truck system.

II.1.2 - Description of the basket of the MX8

Even more than for spent fuel assemblies, the characteristics of the basket are an essential part of the safety demonstration and the capacity to meet EDF long term needs on MOX fuel properties.

The basket is made of several sections out of aluminium corresponding to the 8 positions in the basket. These sections are connected and support boronated stainless steel sleeves in order to control criticality.

The lateral tie down system is pneumatically controlled. The lateral tie down system and the axial tie down system tie the fuel assemblies in the lodgement during the transport with a controlled force; the tie down system can also be manually operated if needed.

This tie down system has been tested and validated by the fuel vendor both under dry and wet conditions, meeting the fuel vendor requirements and thus ensuring the integrity of the fuel assemblies.

The basket allows transportation of MOX assemblies with the following characteristics:

- maximum total plutonium content of 10,2 %
- maximum fissile plutonium content of 6,8 %
- maximum power per fuel assembly of 1100 W
- maximum power for the 8 assemblies of 6016 W

Besides, COGEMA LOGISTICS is working on adaptations in order to anticipate further increase in plutonium content.

II.2 - Safety requirements

MX8 system has been designed as a type B(U)F package for fissile radioactive materials according to IAEA requirements and the corresponding international modal regulations ADR, RID and IMDG-Code. Still, MX8 should be mainly concerned by road transports.

In order to demonstrate adequate containment under normal and accidental conditions, several drop tests on representative models (scale ½) of MX8 have been performed. So drop tests from 9 m high in the worst configurations, with puncture test conditions have been performed. A leaktightness of the containment was controlled as well as deformation after drop tests. The fuel assemblies were represented by mock-up assemblies.

Confirmation of containment and criticality were calculated taking into account the results of the drop test, thermal assessment and previous tests concerning fire resistance of the resin under accidental conditions.

II.3 – Operating conditions

Two deliveries of MOX fuels to Tricastin NPP with one MX8 have already been performed successfully, one in November 2001, the second one in December 2002.

Specific tools have also been designed but limited to the minimum required in order to use as much as possible existing interfaces and tools already developed for TN 12 family packages.

Four MX8 packages have been manufactured by COGEMA LOGISTICS for the global need for MOX fuels deliveries. Their respective set of tools are currently under fabrication in order to be able to deliver MOX fuel to 900 MW EDF's power plants on a routine basis at the end of 2004.

Besides conditions of operations in EDF's 900 MW with this package, these two deliveries have been important to follow carefully dose rate and achieve the target of reducing significantly the dose undertaken. Once practical procedures had been perfected during the first operation, the second one was closer to routine conditions and showed a reduction by more than a factor two of the dose uptake compared to the previous package FS 69. It demonstrates that even with plutonium content of more than 9% in MOX fuels, the dose uptake with the MX8 should be half of the one for operations with 4 FS 69, transporting MOX fuels with 7% of plutonium content.

Furthermore, 4 MX8 will replace 18 FS 69 because time-consuming and costly inspections needed after each rotation of FS 69 will be replaced by in situ control in the MX8. MX8 is equipped with a redundant system, two "Monilog" tipping alarms in case of high acceleration of the fuel in the package during transport.

With the MX8, COGEMA LOGISTICS is achieving the target of reducing dose rate while meeting EDF needs for further plutonium content in MOX fuels. Designing MX8 with the in situ control systems and tie down system guaranting the fuel integrity for 8 assemblies in the same package was a real challenge that COGEMA LOGISTICS has successfully faced.

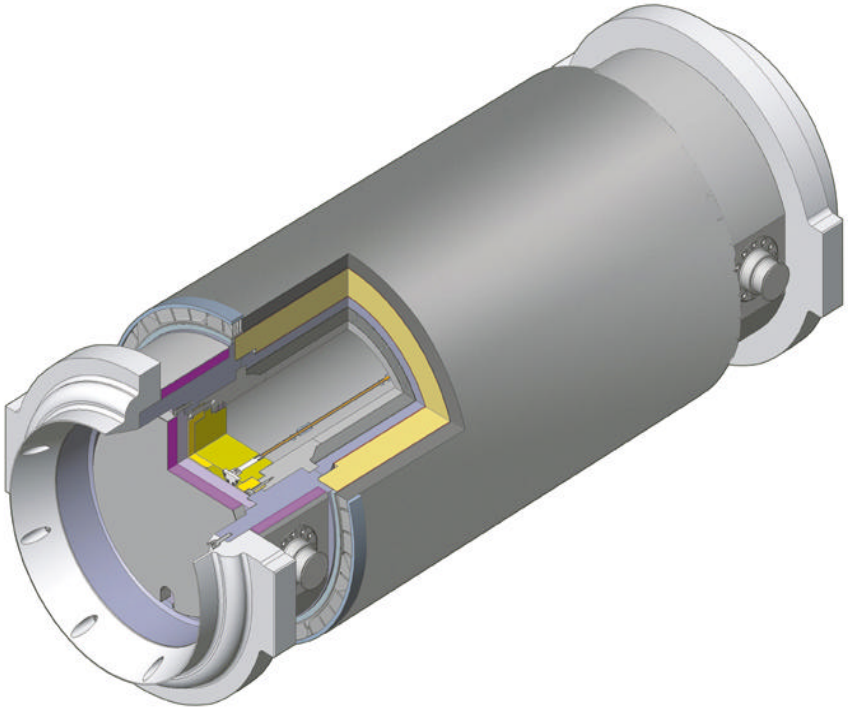
III .TNä 112

The TN12/2 packagings have been in operation since 1980's to transport spent fuels to COGEMA La Hague reprocessing plant, from EDF 900MW units, European and Japanese NPP. Spent MOX fuel are also transported in the TN12 packagings, with the condition to mix 4 MOX fuels and 8 UOX fuels, in compliance with authorisations of the TN12.
In EDF NPP, the spent fuel assemblies must be evacuated with a short cooling time and high residual power. This induced some constraints in the management of MOX spent fuels in EDF's pools which will be more and more severe as far as EDF implements its policy of rising burn-up. In order to allow evacuation of spent MOX fuel assemblies with the same flexibility as for UO2 assemblies, COGEMA LOGISTICS is currently developing and will manufacture from 2005 a new packaging system enabling transportation of up to 12 spent MOX (or 12 UO2 or any combination of 12 spent MOX or UO2) fuel assemblies per loading.
The TN112 will be loaded under water in EDF's 900 MW units pools and can be unloaded in dry or underwater conditions after reception in La Hague reprocessing plant.

The TN112 has been designed according to requirements of the 1996 AIEA transport recommendations TS-R-1. The TN112 allows transportation of 12 MOX fuel assemblies with a burn-up of up to 50 GWj/t and a cooling time of 3 to 4 years.

The key features of the design are the very thick compound layer to attenuate the neutron flux, the double water barrier according to IAEA 1996 regulations and a unique orifice to reduce the operating time and dose uptake.

The development of this new package design started in 2003. Drop tests are foreseen in 2005, and the first loaded transport is scheduled in 2007 in accordance with EDF needs.



TNä 112 cask

III.1 - TNä 112 packaging description

The TN112 is made of two parts :

- a body with a double closure system and two shock absorbers,
- a basket designed to receive 12 fuel assemblies.

III.1.1 - Description of the body

The body of the TN112 is made out of two coaxial stainless steel cylinders delimiting the shielding materials and surrounded by fins.

The body is equipped with a closure system so that the packaging stays leak tight under normal and accidental conditions of transport.

Orifices allow the packaging to be pressurised and to be filled with water during the loading operations, then emptied, once loaded with the fuel assemblies and dried before closure for expedition to La Hague reprocessing plant.

For leaktightness, the cavity lid and orifices are equipped with EPDM seals. An interseals space is provided for the control of the leaktightness of the cavity.

In order to absorb the energy of impacts under regulatory test conditions, shock absorbers made out of aluminium are bolted on top and bottom of the body.

The loaded TN112 with its 12 fuel assemblies has a total gross weight of 112 tons, a total length of 6670 mm, a body diameter of 2540 mm and a shock absorber diameter of 2590 to 2790 mm.

III.1.2 - Description of the basket of the TNä 112

The internal basket designed specifically for a high decay heatload allows individual assemblies with up to 6 kW and a total power of 50 kW (for the 12 fuel assemblies).

The basket is made of modules of H profile with a neutron absorber material allowing also satisfactory heat exchange conditions.

III.2 - Safety requirements

TN112 system has been designed as a type B(U)F package for fissile radioactive materials according to IAEA 96 requirements and the corresponding international modal regulations ADR, RID and IMDG-Code. TN 112 will be transported by rail and road. Its design takes into account the double high standard water barrier according to § 677 of IAEA 96.

In order to demonstrate adequate containment under normal and accidental conditions, drop tests on representative models (scale 1/3) of TN112 will be performed during the first quarter of 2005 and a mock-up will be used to validate the fire resistance.
TN112 will be manufactured from 2005 for first loading operations in EDF NPPs from mid-2007.

III.3 Operating conditions

Some tests with a mock-up have validated interfaces in La Hague reprocessing plant and the same approach will be performed in EDF St-Laurent NPP in September.
The corresponding set of tools has been defined taking into account existing tools for TN 12 and new required ones to benefit from innovations and improvements of specific concepts.

IV. Conclusion

Thanks to his challenging customer, EDF, COGEMA LOGISTICS has designed a new generation of packages answering to a sustainable development policy and with improved performances. A close cooperation between EDF and COGEMA LOGISTICS enables to validate each step of the project successfully, from definition of the database to the test of the package and in close future the implementation of transports with this new generation of packages.