THE FS65: A NEW PACKAGING FOR THE TRANSPORT OF FRESH MOX FUEL

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SUMMARY

Considering the development of MOX fabrication and utilization in western continental Europe reactors, and in the framework of MOX return to Japan, with the consequent fluxes of fuel rods and fuel assemblies between the various fabrication, assembling and reactors sites, COGEMA decided in 1994 to develop a new packaging for the land transport of fresh MOX fuel.
This packaging had to accommodate various contents such as either one PWR (900 or 1,300 MW) assembly, or two BWR assemblies, or one rods container. This new design had to meet the IAEA regulations for type B packages, the provisions of ICRP 60 where applicable, and the various requirements of COGEMA's customers, especially those dealing with fuel assembly integrity during transport.
Moreover, these requirements were to be satisfied within a limited weight, in order to avoid the replacement of existing land transport vehicles.
Optimized solutions have been developed, including two versions of the packaging, the FS65 and the FS65-1,300, equipped with internal arrangements allowing to transport various types of fresh MOX assemblies or rods. Currently, four FS65-1,300 packagings are in routine operation and eight FS65 packagings equipped with a BWR basket have been manufactured. Up to now, more than 11,000 fresh MOX fuel rods have thus been transported in FS65-1,300 packagings.

INTRODUCTION

Transnucléaire performed a thorough preliminary study based upon its experience of the design of similar packagings. The major conclusions were that in order to accommodate the various contents, two packagings should be developed:

- the first one named FS65 for one PWR 900 or two BWR assemblies. The different types of fuel assemblies required specific internal arrangements, compatible with the same packaging body,
- the second one named FS65-1,300 for 1,300 MW fuel rods and assemblies, with a longer and smaller diameter cavity, also equipped with specific internal arrangements.

To meet the stringent requirements set forth for fuel assembly integrity after submission to sollicitations resulting from shocks and vibrations, a new high efficiency Anti-Vibration System had to be developed, associated with a fuel tightening system allowing to maintain the contents in the internal arrangement.

PACKAGING DESIGN

The FS65 packagings were designed in compliance with the B(U)F regulatory requirements to which were added specific requirements concerning fuel integrity.
The main characteristics of the FS65 packagings are summarized on the following table :

	FS65	FS65-1300
Contents	1 PWR 900 assembly or 2 BWR 900 assemblies	314 fuel rods max
thermal power	1000 W max	1100 W
useful length of cavity	4670 mm	5000 mm
useful diameter of cavity	500 mm	430 mm
overall cross section	980 mm	930 mm
overall length	5323 mm	5643 mm
weight of the loaded package	5.6 tons	5.6 tons

Table 1: Characteristics of the FS65 packagings

***Description** (refer to figure 1)*

The FS65 packaging is composed of :

- a cylindrical body providing containment and shielding,
- an internal arrangement (basket), in which the contents are tightened,
- an outer frame made of square aluminium tubes,
- an Anti-Vibration System connecting the body to the outer frame.

Body
A cylindrical body has been chosen because this shape offers the best combination of advantages. It allows to withstand constraints such as those induced by drops in transverse directions which improves containment after drops. Also, it is obviously easier to manufacture, especially when high resistance stainless steel is specified.

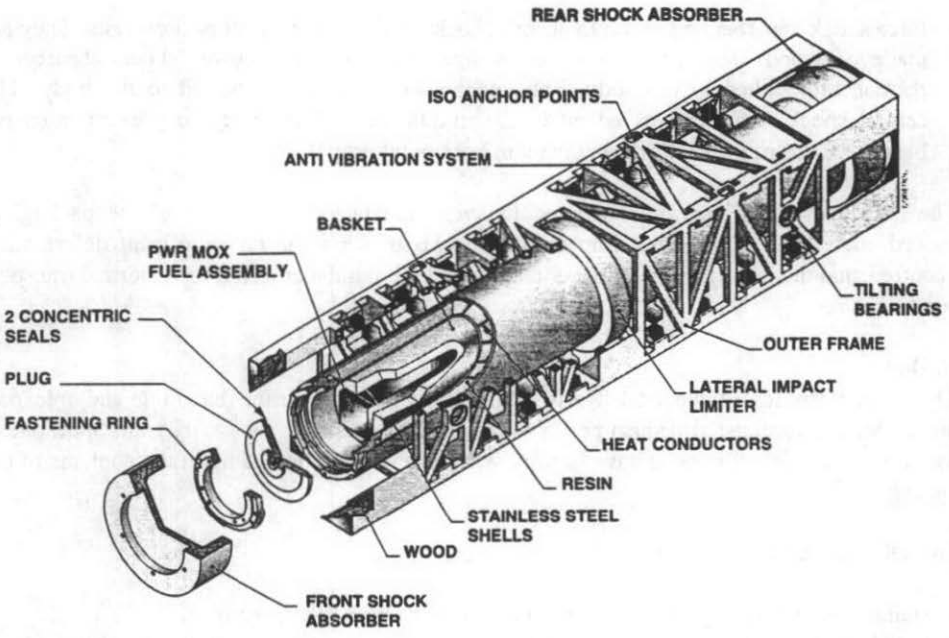

Figure 1: General view of FS65 packaging

The body is made of:

- an internal and external cylindrical shells whose thickness was kept to a minimum in order to meet the overall weight limitation, by using a high grade stainless steel with a twice higher yield strength than common stainless steel such as AISI 304,
- a high strength stainless steel base, welded onto the inner and outer shells at the base of the cavity,
- copper thermal conductors, connecting the two shells all over their length, designed to transfer the heat power of the MOX fuel contents to the external envelope,
- a neutron protection (Transnucléaire proprietary resin), placed between the two shells and 80 to 90 mm thick only thanks to a high neutron attenuation coefficient,
- a closure system which consists in a high strength stainless steel plug, equipped with a fast locking and unlocking patented device with a clamp and a threaded ring. This kind of closure system is currently operational on packagings used for enriched uranium and plutonium. The containment of the radioactive material in normal and accident conditions is performed by the enclosure consisting in the inner shell, the bottom and the closure plug fitted with elastomer « O » rings,

- three shock absorbers designed to absorb shocks during the regulatory drop tests. They are made of wood enclosed in a stainless steel envelope. The lower shock absorber is permanently bolted to the body. The upper shock absorber is bolted to the body. The central shock absorber was added in the middle part of the body to prevent intensive bending stress in the shells during the 9 m horizontal drops.

The regulatory drop tests demonstrated the very satisfactory behaviour of the packaging. Indeed, after three nine metre drop tests, and two punch tests, no significant deformation occurred, and the leaktightness of the containment still met the criterion for « normal transport conditions ».

Basket

The main purposes of the basket is to tighten the content during handling and transport operations and to transfer the heat power of the fuel assemblies to the cavity wall. Short dated, four different types of baskets have been or will be developed according to the contents of the package.

From the centre to the outside, the basket consists in:

- stainless steel housings to hold either one PWR or two BWR assemblies,
- radial aluminium gussets used to centre the housings and to ensure the strength and the cohesion of the basket and the evacuation of the heat flux from the housing tubes towards the cavity wall.

The basket is fixed to the cavity of the body to guarantee a rigid link.
To prevent vibrations, the content is tightened in the housing tubes of the basket by pads which are operated thanks to Transnucléaire patented tigthening system.

Outer frame

The packaging has a transport and handling parallelepipedic outer frame. The main purposes of this equipment is :

- to support the Anti-Vibration System and the body,
- to tie-down the packaging in the security container,
- to handle the packaging during loading and unloading operations,
- to protect the body against shocks during these operations.

This outer frame is mainly made of aluminium.

Anti-Vibration System

The Anti-Vibration System has been placed as an interface between the external frame and the cylindrical body. The Anti-Vibration System has been especially designed according customers specifications for acceptable dynamic response of fuel assemblies. So it must guarantee the fuel assembly integrity during handling and land transportation in normal and incidental conditions.
Its natural frequency, a few hertz, has been selected to be just above the truck suspension frequency, known from previous tests, and low enough to obtain an almost perfect frequency filtration on the FS65 body.

Two aspects have been considered in the design:

- vibrations due to land transport on the security container,
- shocks occurring during the handling operations.

The Anti-Vibration System consists of elastomer pads placed around the body at the four edges of the outer frame in eight different places along the outer frame.

Interface considerations

As a multi-content packaging, the FS65 can be used in every MOX facility operated by COGEMA and its partners.

According to the contents and the facilities involved, several modes of loading the contents can be used (in horizontal or vertical position).

A special attention has been devoted to handling conditions. The upper face of the outer frame is equipped with four ISO anchor points, enabling horizontal handling thanks to a spreader used for loading and unloading the packaging into the security land transport container.

Four bearings are incorporated on the two lateral faces of the external frame. These bronze-lined bearings in which the corresponding trunnions fitted on a handling beam can be inserted are also designed to handle the packaging. The FS65 can be lifted by means of the front side pair of bearings, tilted from the horizontal position to the vertical position around the rear side bearings, and handled vertically.

The FS65 packagings are transported horizontally by batch of 4 in a security land transport container.

LICENSING

The type B certificate approval of the FS65-1,300 packaging has already been granted by the French competent authority on the basis of the Safety Analysis Report while licensing of the FS65 model is currently in progress.

The fuel characteristics considered in the Safety Analysis Reports are shown on table 2:

	FS 65-1,300	**FS 65 (BWR)**	**FS 65 (PWR)**
number of Rods or Assemblies	314 rods max.	2 assemblies	1 assembly
thermal power (W)	1,100	2 x 300	1,000
Pu content, max. average per assembly (or rod for FS 65-1,300) (%(U+Pu))	8.71	8	13.0
Pu_f content (% total (U+Pu)) for criticality assessment	5.4	9	10.5

Table 2: Fuel characteristics

PERFORMANCES

Anti-Vibration System

Qualification of the Anti-Vibration System was performed, thanks to a handling and transport test. Demanding conditions were imposed, such as a pitch plate test and hard brakings.
All of the specified criteria were fulfilled, the maximum acceleration on fuel being most of time lower than 0.5 g. This result was confirmed after transport tests, which used inactive dummy fuel bundles that were thoroughly inspected after transport and dissassembling.

Reduction of integrated doses rates

By comparison with the former generation of packagings for fresh MOX fuel, the FS65 offers a large reduction of integrated doses to the personnel. It is due to the mode of loading where neutron shielding is held in position while operating.

Immersion

The FS65 concept provides a large margin regarding immersion in water. Although the regulatory depth to be considered is 15 m, tests have been performed, which have shown that the leaktigthness of the FS65 packagings is kept under a 500 m immersion as a minimum minimorum.

CONCLUSION

Following COGEMA's decision to proceed with the second generation of fresh MOX fuel packagings, an optimized solution has been developed, including associated internal arrangements allowing to transport various types of fresh MOX assemblies or rods, the whole being tested and qualified according to transport regulations as well as stringent requirements for integrity set by fuel designers.

Currently, four FS65-1,300 packagings are in routine operation and eight FS65 packagings equipped with a BWR basket have been manufactured. Up to now, more than 11,000 fresh MOX fuel rods have thus been transported in FS65-1,300 packagings.