Transport of irradiated fuel rods or activated components

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1. Abstract

The BG 18 packaging started European transport operations in 2002 ; it is designed to transport fresh or irradiated fuel rods or segments, and high activated components. Due to the large quantity of transports and to new emerging contents, TNB needs a second packaging able to continue those transport activities on a long term basis.
At the other side, EDF needed to replace its old R62 packaging, operated to transport irradiated fuel rods from the EDF plants to hotlabs, mainly the CEA Star facility. EDF therefore ordered a new concept to ROBATEL Industries.
Both needs were combined: TNB and ROBATEL Industries jointed, a new packaging named R72 has been developed, based on a ROBATEL Industries concept and the Transnubel transport needs and experiences. This packaging is designed to be loaded or unloaded in a lot of different power plants (France, Belgium, Switzerland, Germany, Spain, ¼) or hotlabs (CEA, SCK Mol, Studsvik, Halden, PSI, ITU, ¼), and uses the same interfaces (handling devices and tools) as the BG18 packaging, in order to avoid additional costs or cold tests.
The use of adequate shielding material, including for neutron shielding, allows a very broad content:
-UO2 and MOX fuel : 120 000 MWd/tM (Burn-up) , 6 months (cooling time)
-Research reactor fuel (MTR fuel, ¼) : Enrichment up to 20% and Burn-up up to 75% (atom %). Extension in progress by the French Authorities.
-Radioactive sources and irradiated reactor core components.
The design has been finished in 2006, and the drop tests have been realized with success in January, allowing the safety file to be introduced to the French Authorities; the validation process in Europe is foreseen during the second half of 2007. The construction of the first packaging will be finished early 2008.

2. Introduction

The purpose of this presentation is to share the information's regarding the transport of irradiated fuel rods executed up to now, and to give more view on the future of these transports, mainly focussing on the B(U)F type package necessary for these operations.

3. Historical review

The BG 18 is owned and operated by TNB since 2002. Designed to transport full length fuel rods or fuel segments, this package has been already presented during the Patram 2004.

4. The BG 18 packaging : the proof of safe operation

To summarize the characteristics of the BG 18, it has a cylindrical form; the construction is based on a steel/lead/thermal insulation/steel double envelope, protected by 2 shock absorbers in the front and in the rear. The cavity is closed by means of a turning lock in the front, and a massive plug in the rear. Inside the cavity, the containment system consists of a tube closed by a bolted lid.
One of our last transports, executed between Spain and Belgium, has raised questions about the danger of the transports of irradiated fuel rods. As answer to this, the BG 18 is in operation for 6 years without any incident; the loading, unloading and transport activities have been in several cases verified by competent authorities, without any request for corrective action up to now. The reference list of the transports has been updated :

Transport		Date	Content		Observation
from	to		Quantity	Type	
Gundremmingen (D)	SCK-CEN (B)	April 2002	3 rods	MOX - BWR	
Gundremmingen (D)	SCK-CEN (B)	April 2002	3 rods	MOX - BWR	
Gundremmingen (D)	SCK-CEN (B)	September 2002	3 rods	MOX - BWR	
Gundremmingen (D)	SCK-CEN (B)	September 2002	2 rods	MOX - BWR	
Tihange 1 (B)	SCK-CEN (B)	January 2003	2 rods	UO2 - PWR	
Gundremmingen (D)	SCK-CEN (B)	February 2003	3 rods	MOX - BWR	
Neckarwestheim (D)	SCK-CEN (B)	July 2003	16 rods	UO2 - PWR	
SCK-CEN (B)	ITU (D)	December 2003	samples		
SCK-CEN (B)	Studsvik (S)	March 2004	samples		
PSI (CH)	Gösgen (CH)	April 2004	14 rods	MOX - PWR	
Gösgen (CH)	PSI (CH)	May 2004	7 rods	UO2 - PWR	
PSI (CH)	SCK-CEN (B)	June 2004	4 samples	MOX/UO2 - BWR	
SCK-CEN (B)	PSI (CH)	June 2004	3 samples	MOX - BWR	
ITU (D)	Gundremmingen (D)	June 2004	8 rods	UO2 - BWR	
ITU (D)	Gundremmingen (D)	April 2005	7 rods	UO2 - BWR	
Gundremmingen (D)	ITU (D)	April 2005	17 rods	UO2 - BWR	
Beznau (CH)	ITU (D)	April 2005	7 rods	MOX - PWR	
ITU (D)	Gösgen (CH)	October 2005	7 rods	UO2 - PWR	
Gösgen (CH)	PSI (CH)	October 2005	11 rods	UO2 - PWR	
Gösgen / PSI (CH)	ITU (D)	October 2005	6 rods	MOX/UO2 - PWR	
Tihange 1 (B)	SCK-CEN (B)	November 2005	2 rods	UO2 - PWR	leaking rods
SCK-CEN (B)	Halden (N)	December 2005	2 samples	MOX - BWR	
PSI (CH)	Gösgen (CH)	May 2006	16 rods	MOX/UO2 - PWR	
Leibstadt (CH)	PSI (CH)	June 2006	10 rods	UO2 - BWR	
PSI (CH)	ITU (D)	June 2006	samples		
Obrigheim (D)	ITU (D)	September 2006	1 sample	ThO2/PuO2 MOX	
ITU (D)	Gösgen (CH)	November 2006	6 rods	UO2 - PWR	
Gösgen (CH)	ITU (D)	December 2006	4 rods	UO2 - PWR	
CNA Almaraz (E)	SCK-CEN (B)	September 2007	2 rods	UO2 - PWR	
ITU (D)	Studsvik (S)	October 2007	6 segments	UO2	

5. The growing need

Based on the need of EDF to examine yearly some fuel rods, mainly in the hotcels of CEA Star facility in Cadarache, and due to the fact that the existing packaging (the R 62) is an old design, EDF investigated alternatives.
It was soon clear that the BG 18 was not able to answer the need of EDF for different reasons: availability (the BG 18 is a unique package), feasibility of the loading under the pool, maximum transport weight of 40 tons in France for example.

EDF decided to order the transports of their fuel rods, including the obligation for the contractor to own a suitable package.

In order to answer this specific transport need, Robatel Industries and Transnubel joined their forces: Robatel Industries with the concept of the R72, Transnubel with the BG18 experience and transport experience.

6. The R 72 packaging : the challenge

The challenge of the R72 is based on the following inputs :

- A maximum total weight of the package allowing road transport within the allowed maximum road mass limits, no special permit necessary and no special vehicle necessary;

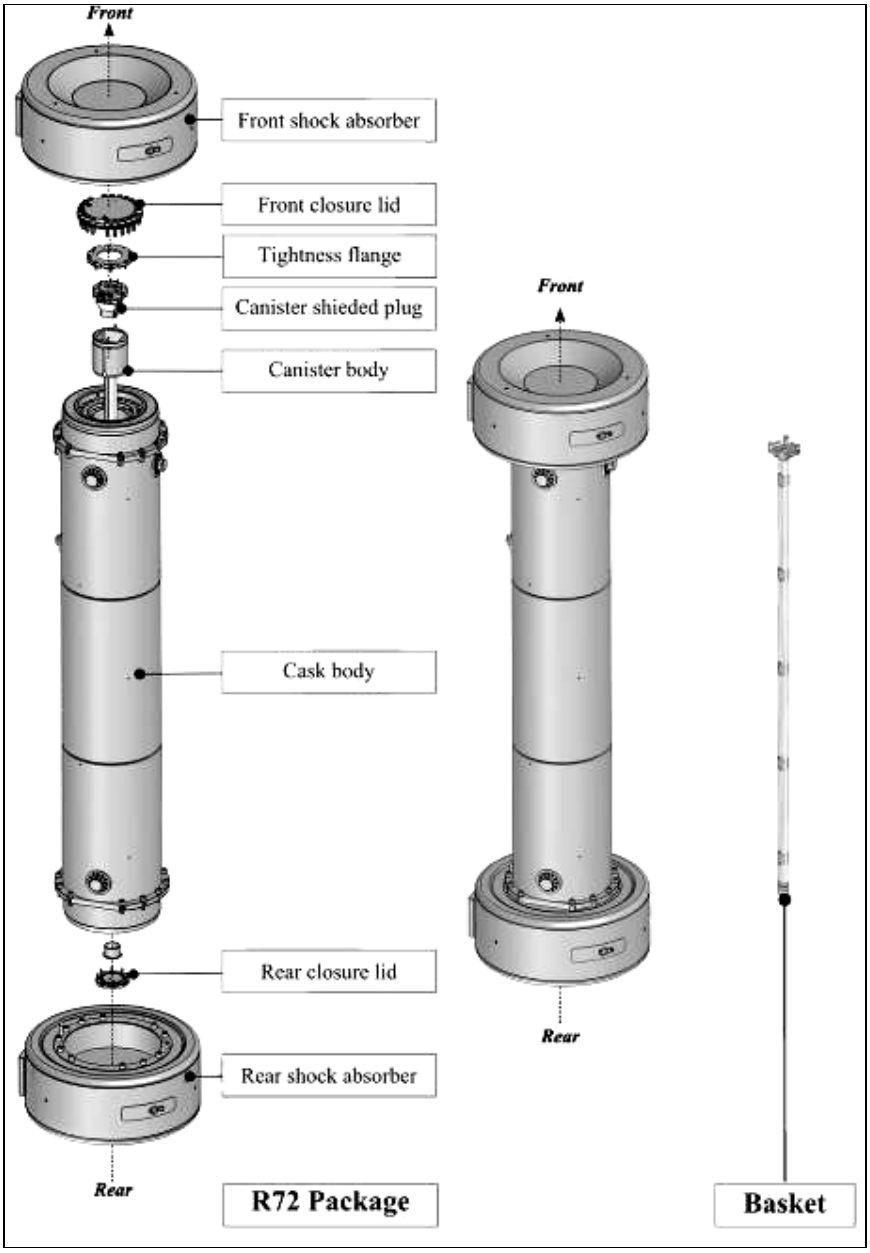
Belgium	44 T
Denmark	42 T
Germany	40 T
Finland	48 T
France	40 T
United Kingdom	40 T
Italy	44 T
Netherlands	50 T
Norway	40 T
Spain	40 T
Sweden	40 T
Swiss	40 T

- Increased content regarding the BG 18 content, taking in account Uranium and MOX fuel rods, PWR, BWR, FBR and MTR fuel but also other specific contents like sources and activated material;
- Requirements of EDF regarding the loading : the packaging has to be loaded on all EDF units; this means the possibility to load the packaging immerged in the pool, like most 900 MW units, or the packaging positioned under the pool like most 1300 and 1450 MW units;
- The nuclear plants where the package will possibly be loaded in the future present a lot of differences, ranging from detail to basic differences. The input for the new concept takes in account that it has to be possible to load the package, eventually with minor additional tooling;
- Necessity to take in account the unloading in different hotlabs : all European hotlabs have different configurations. The reference hotlabs taken in consideration were SCK Mol, ITU Karlsruhe, CEA Star Cadarache, PSI and Studsvik;
- Necessity to take also in account the unloading in power plants, in case of return of the fuel rods to the place of origin;
- Using as much as possible the same interface tooling as for the BG 18 to avoid the repetition of cold tests and feasibility studies and to reduce the costs associated with the tooling.

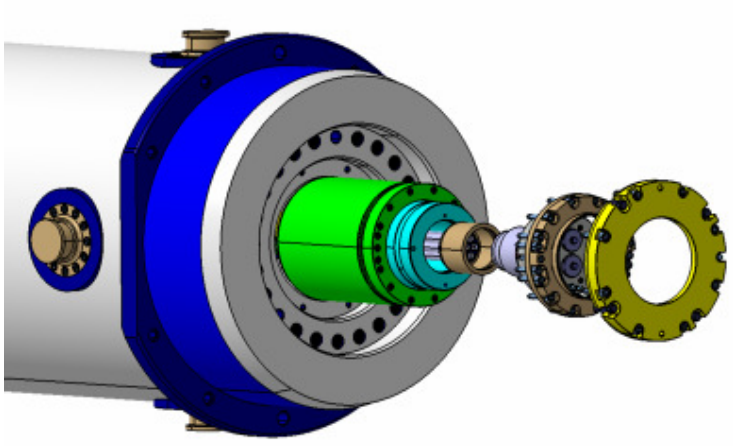
This challenge has been raised, the concept today exists.

7. The R 72 package : the design

The R 72 is a type B(U) F package designed for the transportation of fresh and/or irradiated fuel rods as well as non fissile irradiated material like activated metal pieces and sources.

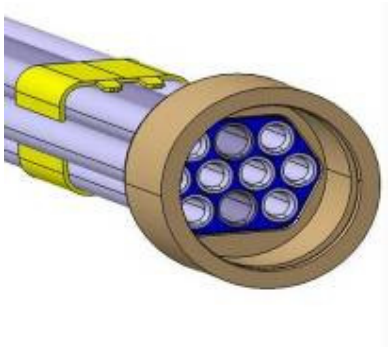


All included, it's a 21.5 tons cylindrical package of around 6.3 meter length, a diameter of 1.7m and 2 shock absorbers of 1 ton each. The package inner cavity is a 5.3m x 0.14m cylinder; it allows up to 10 fuel rods and tolerates a weight up to 650 kg.



The accessories and peripherals that are necessary were created to permit its use with a large range of installations. Most of them were made compatible with the BG 18.

The R 72 can be equipped with different inner arrangements, which might be customized, depending of the needs or wishes of the plants installations.



Finally, the R72 offer the last generation neutron protection.

The package can be loaded or unloaded :

- vertically in a pool, in wet conditions,
- vertically under the pool,
- horizontally, docked to a hotcell, in dry condition.
- upside down in dry or wet condition.

Agreements and validations are already foreseen for most European countries; other countries can be considered depending on the needs.

8. The R 72 package : the content

At the present time, three different types of content have been defined for the R72 package.

1st content:

The first content was requested by EDF for its own needs. It allows UO2, MOX and defect rods as well as parts of fuel rods enclosed in appropriate caps.

	UOX-A	MOX-A
Maximum Burn up (MWj/tmli)	85000	75000
enrichment % ^{235}U	≤ 5	≤ 0,7
% of Pu	-	≤ 11
Minimum Cooling Time	6 month	6 month

2nd content:

The second content has defined by TNB. This content has been introduced on basis of TNB experience: the values were set by comparison of our BG18 transport experience and a survey of the evolution of the needs for the coming years.
The internal customized arrangement combined with the capacities of the R72 offer the ability to carry UO2, MOX and defect rods. Rods like PWR and BWR are supported as well as non fissile irradiated material: irradiated reactor core components, control rods, guide tubes, spacers, …

	UOX-B	MOX-B
Maximum Burn up (MWj/tmli)	120 000	120 000
enrichment % ^{235}U	≤ 10	≤ 1.5
% of Pu	-	≤ 15
Minimum Cooling Time	6 month	6 month

3rd content:

This content is currently still under investigation. It is intended to cover as much as possible future needs on long term basis. The contents considered are for example :

	UOX-C	MOX-C
Maximum Burn up (MWj/tmli)	150 000	150 000
enrichment % ^{235}U	≤ 10	≤ 1.5
% of Pu	-	≤ 20
Minimum Cooling Time	3 month	3 month

Radioactive gamma and neutron sources (Co-60, Am-241, Cs-137, XBe, …)
Research reactor fuel (LEU, enrichment up to 20 %), like U3O8-Al, UZrHx, UMo, U3Si2-Al
High enriched research reactor fuel (HEU, enrichment up to 100 %)
Fast reactor fuel with a total Pu content up to 28 %
High temperature reactor fuel

9. The R 72 package : situation of the project

The drop tests took place from 9th to 11th of January 2007 at the Robatel facilities in Genas, using 1 mock-up foreseen for 6 droptests; the French authorities were present and approved previously the sequences.
The drop tests were :

- Sequence 1 : maximizing the efforts on the bolts used for closing the lid of the containment system and the main closing lid
  1st drop test : drop onto a bar to the centre of the main lid
  2nd drop test : vertical drop on the front shock absorber

- Sequence 2 : maximizing the deformation of the front shock absorber, previously heated
  3rd drop test : drop with 15° angle, temperature 65°C

4th drop test : drop onto a bar, 4,5° angle, temperature 65°C

- Sequence 3 : maximizing the deformation of the body (flexion) and the deformation due to the punch tests
  - 5th drop test : slap-down, 80° angle
  - 6th drop test : drop onto a bar in the centre of the body

The results of the drop tests were within the expectations, no additional drop tests are necessary. The results were introduced in the safety file.

The safety file has been introduced to the French authorities on the 21 of December 2006.

The construction started in January 2007; it is expected to be completed in March 2008. Cold tests will then be realized in the factory before taking the package in operation. Anyone interested in these cold tests can take contact with us.

10. Conclusion

Although the transports of irradiated fuel rods remain punctual operations, the efforts are existing to provide safe transport solutions for the short term but also long term needs. The experience acquired with the years is used to optimize the design of new concept and to increase the reliability. Efforts are made to take in account future needs as soon as those needs are expressed.