Transport of irradiated fuel pins

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1. Abstract

The transport of irradiated fuel pins is important to be able to investigate the behavior of the fuel after irradiation; in the Western Europe, these transports are using the BG 18 since 2001. The R 72 packaging has been taken in operation in 2009.
The presentation will focus on different aspects :

- Experience gained with the BG 18 packaging. This aspect will give more information about the lessons learned during the last 3 years of transports, mainly related to the organization of international transports and the associated difficulties, but also the loading and unloading on-site activities.
- The use of the new R 72, approved in 2009, from cold testing to transport operations. More information will be given on the broad possibilities offered by this new packaging for loading and unloading.
- The difficulty of leaking fuel pins. When utilities encounter situations of leaking fuel, it is important to investigate the causes leading to the leak, and therefore transport the leaking fuel pins to hotlabs. The difficulty to obtain an approval for leaking fuel pins will be explained, leading today to a situation where these transports are not possible with the R 72 packaging.
- The specific case of the first use of the R 72 packaging will be outlined; due to the old infrastructures, the loading of the R 72 in Avogadro (Italy) was in a first step considered as impossible. After all, the loading has been done in a very unusual way, by means of a upside-down shielding, taking the fuel pins with a pneumatic gripping device trough an opening on the shielding. This shielding as been docked to the R 72 packaging in vertical position, allowing the fuel pins to be lowered in the R 72 with minimal gaps. The story of one year preparation for one week on-site work ...

2. Introduction

The purpose of this presentation is to share the information's regarding the transport of irradiated fuel rods using two different packagings, the BG18, already in use for more than 20 years, and the R72, recently put in operation.

3. Historical review

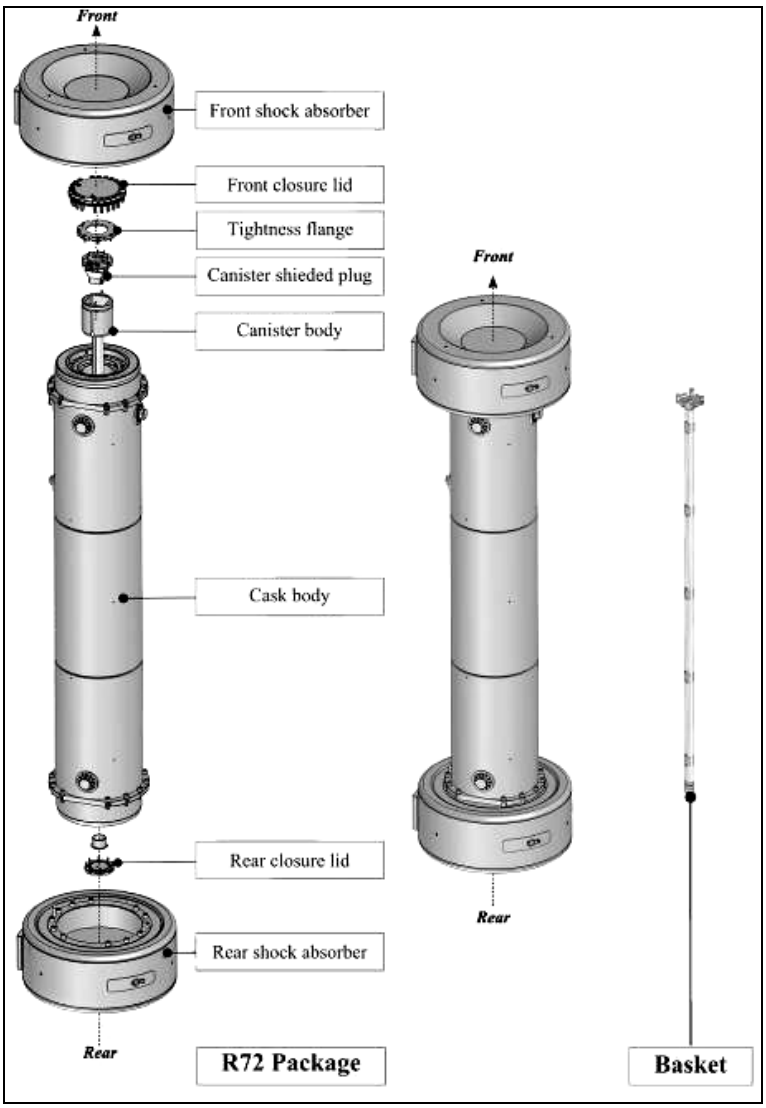
The BG 18 is in use for more than 20 years. Designed to transport full length fuel rods or fuel segments, this package has been already presented during the Patram 2004 and 2007. This packaging is still in use.
Regarding the R 72, Robatel Industries and Transnubel joined their forces in order to answer this specific transport need : Robatel Industries with the concept of the R72, Transnubel with the BG18 experience and transport experience. The R72 has also been presented to the Patram in 2007; the packaging was at this time in a licensing process and construction process.

4. The BG 18 packaging

The BG 18 is able to be loaded with 30 fuel pins, including UO2, MOX, and leaking fuel pins. It has been used for 14 transports in the last 3 years in different countries, mainly Germany, Switzerland, and Spain.

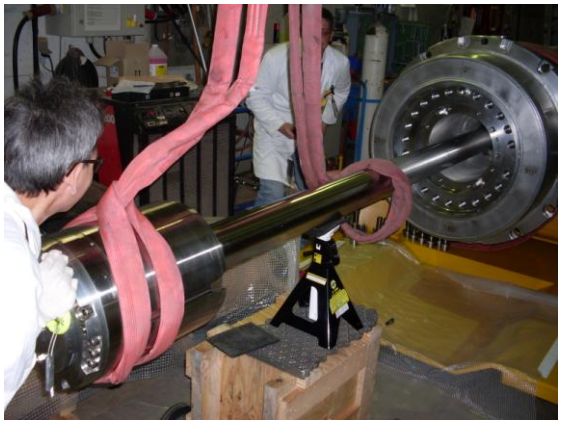
5. The R 72 packaging

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

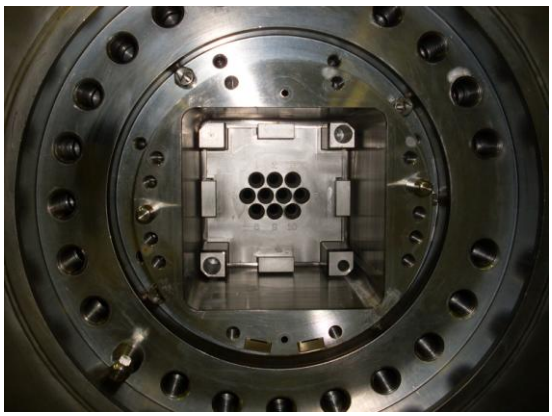


All included, it's a 21.5 tons cylindrical package of around 6.3 meter length, a diameter of 1.7m and 2 shock absorbers of 1 ton each. The package inner cavity is a 5.3m x 0.14m cylinder; it allows up to 10 fuel rods and tolerates a weight up to 650 kg.

In order to be fully compatible with all labs where the fuel pins are loaded or unloaded, two different types of canister is existing; both canisters differ by the way of handling (one can be handled by existing fuel handling devices) and by their diameter of the head (the smallest one can be pushed through an opening of 250 mm)



The R 72 is able to load 10 fuel pins :



At the present time, two different types of content have been approved for the R72 package.

1st content:

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

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

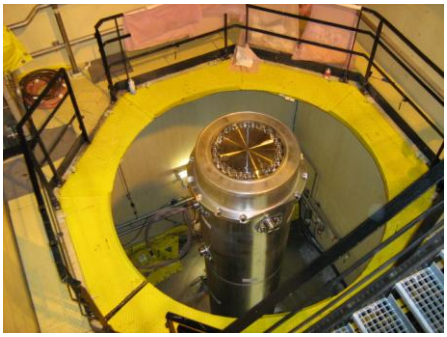
2nd content:

The second content has been 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 and MOX 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 (MWd/tihm)	100 000	100 000
enrichment % ^{235}U	≤ 10	≤ 1.5
% of Pu	-	≤ 15
Minimum Cooling Time	6 month	6 month

Before using the packaging, two different cold tests have been executed :

- cold testing in Paluel (F), in order to demonstrate the loading of the R 72 by placing the packaging under water in the pool,



- cold testing in Nogent (F), in order to demonstrate the loading of the R 72 by placing the packaging docked under the pool.

Both tests concluded that the packaging, the associated tooling, and the procedures can be used.
As result, the R 72 has been declared operational in December 2009, and immediately used in Italy (see more details hereunder). In April, a second transport of fuel pins has taken place between Cruas (F) and CEA Cadarache (F)

6. Transport of high burn-up irradiated fuel rods. (story of a snake that eats its own tail)

The evolution of the burn-up rates in nuclear power plants leads to a need of transport of fuel pins with higher burn-up. The European laboratories need to receive such high burn-up fuel pins to evaluate the fuel's behaviour at high burn-up and to collect radiological data in order to obtain a sufficient Benchmark for the qualification of calculation codes.
To perform the safety studies on packagings intended for the transport of high burn-up irradiated fuel, designers need to describe the content from the radiological point of view, to be loaded in the packaging; calculation codes need to be used out of the range of their validation.
However, the competent authorities in charge of the approval of packagings request the content to be precisely known; the usual way is to make calculations of the isotopes and activities on basis of calculation codes, but these codes need to be validated by the authorities. As the validation is not granted for high burn-ups, long, hard and expensive discussions start about the way used for the characterization of the content and about the justification of safety margins, without possibility of demonstration.

The laboratories need to receive high burn-up fuel rod to validate the calculation codes, those fuels rods need to be transported, but the packaging will only be validated if the calculation codes are validated …

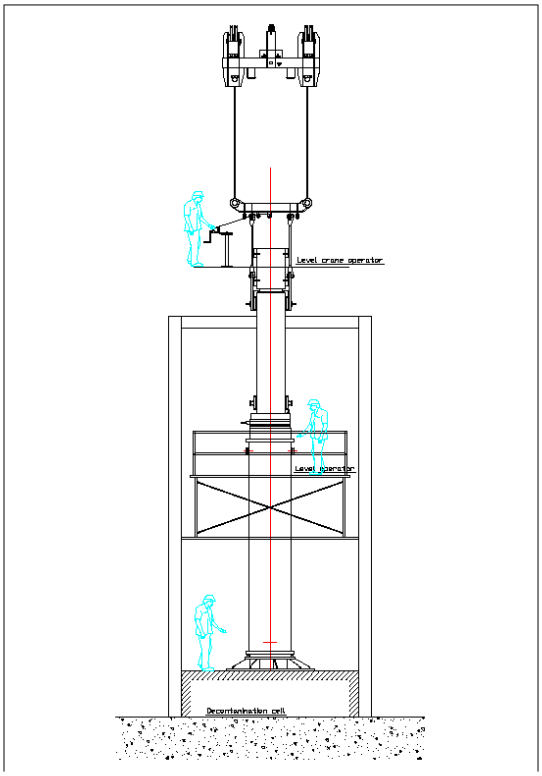
7. The transport of leaking fuel pins

Lots of nuclear power plants over the world have been or will be concerned by the presence of leaking irradiated fuel pins in their pool. The wish of everyone is to understand the reasons of the ruptures in order to be able to take actions and avoid as much as possible the leaking fuel pins in the future.
The BG18 packaging is authorized to transport leaking fuel rods. However, its approval will expire soon. The R72 package is foreseen to take over the transports performed with the BG18. The studies presented in its safety analysis report show that the packaging is able to transport leaking fuel pins, but the certificate of approval don't allow it. Once the BG18 approval will be expired, there will be no possibility to transport leaking fuel pins again.
The concern of the authorities deals with the possible presence of water in the packaging during the transport, leading to radiolysis and risk of explosion. The cavity of the packaging is dried by use of vacuum, and the absence of water is checked by the pressure evolution. The authorities consider as possible that the water penetrates into the leaking fuel pin during its presence under water, and will remain in the fuel pin, even if the pin is in the high vacuum created into the cavity which is the usual method used to dry a container. But they consider the release of the water as possible during the transport …

The answer to this point has to be found in the experience gained during the years with the BG18, but this way of demonstration generate more questions than evidences.

8. The first use of the R 72 : the Avogadro case

The R 72 has been used the first time at the Avogadro site (Italy). Due to the old infrastructures and the limited dimensions on the site, the loading of the R 72 in Avogadro was in a first step considered as impossible, as it was impossible to position the packaging in the pool for the loading of the fuel pins.
On basis of a previous experience with other packagings and after some engineering work, the loading has been foreseen using a upside-down transfer cask, transferring the fuel pins each by each.



A footplate has been placed on the floor plate of the decontamination cell in the reactor building. This was done very carefully, as the total height of the combination R72 + transfer cask is about 10 meters high. Furthermore, the verticality was an important aspect, as the fuel pin had to be lowered in the basket of the R72 with very little gap.

The R72 ,on his transport frame, was brought into the building on the trailer.
From here on, the preparation of the packaging started: the front and rear shock absorbers were removed, the R72 was tilted vertically and placed on the footplate. Once the R72 was fixed, it was prepared to receive all the other parts that should be used in a further stage, mostly designed for shielding and interface between both R72 and transfer cask.

As the R72 packaging has no ball valve, the first part mounted on top of the R72 was placed in order to remotely open and close the cavity of the packaging. This was necessary to get the possibility to lift the plug of the R72, which is foreseen to provide the necessary shielding for the operators. In case of loading under water, the plug can be removed without any additional device, as the water provides the necessary shielding. In this case, the loading was in dry condition; a special designed gate valve ,with radiation protection inside, was mounted on the R72.This gate valve was used to assure that there was always sufficient radiation protection for the operators working around this gate valve.

On top of this gate valve a tool was placed to get the possibility to remove the plug. The plug stays in the tool ready to be used again when closing the package after the loading of the fuel pins.
Another tool was necessary: an eccentric disc was placed to receive the transfer cask; this eccentric disc made it possible to load the fuel pins in the different positions of the basket of the R72 by rotating the disc.

The transfer cask was placed upside-down in the pool water. This transfer cask was foreseen of a pneumatic gripping device mounted on a winch; once above the first fuel pin, the gripping device was lowered and the pin was taken. The fuel pin was then lifted in the transfer cask. The ball valve of the transfer cask was closed, allowing the transfer cask to be lifted out of the water and to be transferred above the R72 packaging. It was then docked on the R72 in a predefined position (coordinates), as each fuel pin had to be inserted in the correct position in the inner basket.

After docking of the transfer cask, the fuel pin was lowered in the R72 packaging, using the winch, and with the help of a camera to verify the correct insertion before undocking the transfer cask

After the loading of the rods all the regular testing was done and the R72 was prepared for transportation by road to his unloading site.

9. The future of both packagings

The R72 packaging is a new concept, fully operational, with a recent safety file. This packaging will step by step be used for the transports done today by the BG18, as the BG18 is an older concept.

10. Conclusion

The transports of irradiated fuel pins require in most of the situations a case by case analysis of the loading and unloading possibilities, leading to adapted procedures or specific tooling; these transports remain punctual operations.
The transport of leaking fuel pins and high burnup fuel is a challenge regarding the demonstration to the competent authorities.