SPENT FUEL STRATEGY FOR THE BR2 REACTOR

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ABSTRACT

The Belgian MTR reactor is fuelled with HEU UAlx elements and the fuel cycle was normally closed by reprocessing consecutively in Belgium (Eurochemic), France (Marcoule) and finally in the U.S.A. (Idaho Falls and Savannah River). When the acceptance of spent fuel by the U.S. was terminated, the facility was left with a huge backlog of used elements stored under water. After a few years, urgent and mandatory actions were required to maintain the BR2 facility operating. Later the accent was put on the evaluation of an optimum long term solution for the BR2 spent fuel during the projected 15 years life extension after the refurbishment executed between 1995 and 1997. The paper gives an overview of these successive actions taken during the last years as well as the handled various criteria for comparing and evaluating the available long-term alternatives. After commitment to reprocessing in existing facilities operated for aluminium fuels the focus of the BR2 fuel cycle strategy is now moving to the procurement of the necessary HEU fuel for securing the long term operation of the facility.

1. Introduction

The BR2 reactor of the Belgian Nuclear Research Center (SCK•CEN) at Mol, Belgium, was put into operation in January 1963. The BR2 reactor - figure 1 - is the SCK•CEN's most important nuclear facility and was operated in the framework of many international programmes concerning the development of structural materials and nuclear fuels both of the various types of nuclear fission reactors and for fusion reactors. The qualities and particular features of the reactor also designated it for performing experiments aiming to assess and demonstrate the safety of nuclear cores.

The facility was shutdown end of June 1995 for an extensive refurbishment programme after more than 30 years utilisation. The beryllium matrix was replaced and the aluminium vessel inspected and requalified for the envisaged 15 years life extension. Other aspects of the refurbishment programme aimed at reliability and availability of the installations, safety of operation and compliance with modern safety standards.

The reactor was restarted in April 1997.

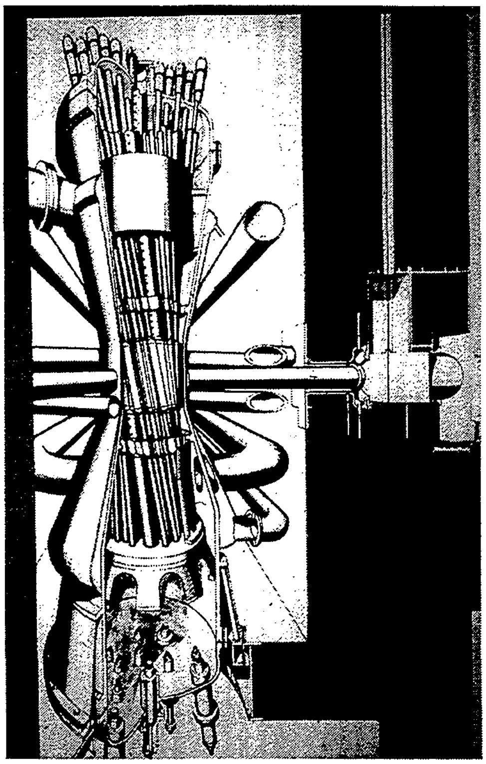

Fig 1. BR2 reactor.

2. BR2 conventional fuel cycle

From the first start-up in 1963, the BR2 reactor is using standard MTR fuel plates - 1.27 mm thick, 0,508 mm meat thickness - cladded with aluminium. Uranium-aluminium alloy fuel was first utilised. Change to cermet fuel material, obtained by blending UAlx powder with Al powder, occurred at the beginning of the 1970's.

The enrichment was and is still in the range 89 - 93 %. Small variations in the enrichment level are allowed and compensated by adjustments of the uranium density in the meat - 1.27 gU/cm^3 nominal -.

A standard BR2 fuel element consist of several concentric tubular shells (up to 6) - figure 2 - . Uranium loading was first 200 g U235 for a 6 plate fuel element, and is now 400 gU235 with the cermet type UAlx core.

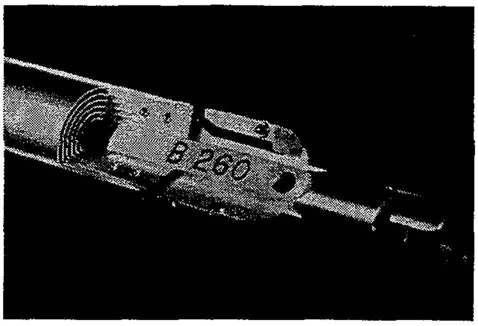

Fig 2. BR2 fuel element.

The procurement of the highly enriched Uranium (H.E.U.) occurred up to now only through the U.S.A.

The fuel cycle has been traditionally closed by reprocessing of the used fuel elements : in total 2326 fuel elements were sent first at Eurochemic (Mol, Belgium) from 1967 to 1974, then at Marcoule (Cogéma, France) and then finally in the U.S. (Idaho Falls and Savannah). Another batch of 144 fuel elements were ready for shipment to Savannah, early in 1989, when the USDOE decided not to renew its Off-Site Fuel Policy and despite the fact that an import Certificate for these 144 fuel elements was signed by the U.S. in June 1988.

3. Short term consequences and actions following the U.S. decision

Following the U.S. decision to halt the return of U.S. origin irradiated fuel, the BR2 facility was left with a huge backlog (± 670 fuel elements) of spent fuel elements resulting from the operation between 1982 and 1988.
Since then, the continued operation of the reactor required early in 1991 a limited expansion (2x56 F.E.) of the storage capacity to 800 standard fuel elements.
By the end of 1991, however, it became clear that a large expansion of the storage capacity was required to maintain the facility operating. Indeed, a renewal by the USDOE of its Off-Site Fuel Policy was evaluated as very improbable in the short term (2 ... 3 years). Moreover because of contractual irradiation obligations the BR2 reactor had to be operated until mid-1995 when it should be shutdown for a major refurbishment.
Thus early in 1992 a project started to expand the wet storage capacity. The objective was to increase the storage capacity to 1550 fuel elements. Such a large storage expansion involves a complete reshuffling of the storage channel with new designed high density storage racks. It means also a complete reanalysis of possible internal and external accidents. The project was approved in 1993 by the Licensing Authorities with two conditions:

- the storage channel should be inspected and refurbished;
- an alternate solution to underwater storage at the BR2 site should be available for the operation of the facility after refurbishment.

The first condition necessitated an urgent relief of ± 10 % of the total inventory in storage. The only readily achievable solution was at that time the reprocessing in the UKAEA-Dounreay facility. After the necessary contractual arrangements, 240 fuel elements - in total 10 shipments with the UKAEA Unifetch casks - were transferred successfully between November 1993 and April 1994.

Table 1 shows the evolution of capacity and occupation in the BR2 storage channel; variation in capacity is due to the replacement of old racks by high density racks and to the refurbishment of the storage channel.

	23-aug-93	1-nov-93	21-jan-94	9-aug-94	1-jan-95	1-jul-95
Actual storage capacity	895	895	1015	831	831	831
Planned evacuation of fuel	-	96	48	-	-	-
Actual occupation	845	860	728	656	676	676

Table 1. Evolution of capacity and occupation in BR2 Storage Channel (for standard fuel elements only).

4. Evaluation of possible long term solution for the end of the fuel cycle

The decision in 1994 by the SCK•CEN Board to refurbish the BR2 facility between mid-1995 and 1997, and the requirement of the Licensing Authorities to have in-time, thus in 1997, an alternate solution to the on-site underwater storage, created the necessary motivation to finalize the on going studies.

These studies were initiated early in 1992. The objective was to have a broad evaluation of all possible scenarios in the country and abroad: dry storage in containers, dry storage in canisters, reprocessing with and without reutilization of the recovered HEU, compared against the reference solution, being the evacuation/return of the fuel back to the U.S.

These different options are briefly characterized as follows:

- Dry storage in thick containers

The storage is foreseen in CASTOR-like containers filled with each 12 or 28 standard fuel elements. The casks are stored in an extension - to build on the Belgoprocess site - of the building foreseen as interim storage of vitrified waste from the belgian power plants. After an interim storage of 40 ... 50 years, the fuel should be reconditioned for geological disposal or reprocessed.

- Dry storage in thin canisters

The fuel is conditioned in thin canisters which are stored for 40 ... 50 years in an extension - to build - of a building foreseen for vitrified waste, on the Belgoprocess site.
After an interim storage, the canisters are disposed off underground or the fuel is reprocessed.

- Reprocessing with recovery of the uranium

After processing, the fuel is recovered, reutilized as H.E.U (~ 72 % enrichment) or blend down to < 20 % enrichment.
Cemented waste is returned to Belgium, stored for 40 ... 50 years in a dedicated building - to build - on the Belgoprocess-site and finally disposed off underground.

- Reprocessing without recovery of the uranium
After processing, the recovered uranium is diluted to 1 % enrichment. Waste is returned in Belgium and stored in an existing building - foreseen for vitrified waste from power plants - on the Belgoprocess site for 40 ... 50 years before final disposal underground.
These various alternate solutions were successively evaluated against various criteria : available techniques and safety, waste return, uranium recovery, overall costs, timing, availability in the future, politics.

These criteria are commented and evaluated here below:

Techniques and Safety

* Some doubts remain about the long term stability of aluminium fuels during interim storage;
* Underground disposal in clay - reference solution in Belgium - for HEU aluminium fuel was evaluated and excluded : indeed there is a non negligable risk for criticality.
  Underground disposal in clay does not foresee the presence of large amounts of metal, thus excluding the disposal of large casks;
* Availability of reprocessing facilities for aluminium fuels within 40 ... 50 years look very uncertain;
* Long term stability of cemented waste for underground disposal needs further evaluation;
* Characteristics and specifications of waste from power plants reprocessing wastes are very well known and accepted.

- Waste return

* The expected volume of cemented waste is very important (1 cemented 500 l drum for 3 ... 4 fuel elements).
* The expected volume of vitrified waste is very low (2 canisters of 180 l per Ton total metal)
* There is no waste return for the U.S. alternative.

- Uranium recovery
HEU recovery and recycling looks attractive. Certainly because of a lack of secure supply from the U.S.•HEU recycling has been positively demonstrated at BR2 in 1994-1995 with the irradiation of 6 test fuel assemblies. There are however penalties (lack of reactivity, short operation cycles ...) which can eventually be offset by alternate refuelling strategies using mixed HEU cores [1].

HEU. dilution and reuse for fabrication of LEU. fuel elements looked very speculative because there were no agreed specifications for fabrication.

- Timing of evacuation
A guaranteed planning of evacuation is mandatory, to demonstrate to the Licensing Authorities our commitment of reducing the on-site spent fuel inventory.
Also there is a need to continue efforts to refurbish the storage channel.

- Availability in the future
Ideally the choosen option should be available for a period covering the foreseen operation of the reactor after refurbishment.

- Overall costs
Certainly one of the most important weighing factors, not only because the large amount of fuel now in storage (± 4 T total metal) but also for all these spent fuels generated during the expected life of the facility.

- Politics

Uncertainties due to politics do exist in our European countries. They looked however much more reasonable than those associated with the situation in the U.S.•Politics can influence directly the level of costs, the timing of evacuation, the availability .... .

5. Final choice and long term commitment for the end of fuel cycle

In November-December 1996, the SCK•CEN Board of Directors and the Technical Liability Fund decided to opt for an optimal long term commitment on basis of the evaluations and criteria cited above.

The dry storage option, in casks or thin canisters, was at that time already abandoned, for its high costs and large uncertainties after an interim storage of 40 ... 50 years.

Even with a slightly higher overall cost than the U.S. solution, the reprocessing option offered by COGEMA was choosen mainly for its long term commitment (in principle, contract for the whole life of the reactor), the firm contractual arrangements (price, timing) and the low risks associated. The reprocessing option offered by the UKAEA was a lot more expensive, mostly due to the storage cost of the large volume of waste. Reutilization of the recovered uranium could not offset this disadvantage.

Date	U.S.D.O.E.	COGEMA	UKAEA
Nov-Dec. 1996	1.00	1.15	1.75
Feb. 1998	1.21	1.17	1.93

Table 2. Relative cost comparison of the available options.

The table 2 shows the relative overall cost comparison for the available options at two dates : end of 1996 when the decision was made and in February 1998. Cost comparison is done on the whole process: transport, processing, conditioning of waste, interim storage and final disposal of waste. Clearly the slight economic advantage for the U.S.-option disappeared with the higher cost of the U.S. dollar.

Evacuation of the BR2 fuel to COGEMA (La Hague) is planned to begin in July 1998. Seven transports in 1998 and 13 transports in 1999 are scheduled using the IU04 container (Pegase). Later on, the additional transfers will use the new TN-MTR container designed by TRANSNUCLEAIRE.

6. Conclusion

Following the U.S. decision not to renew its Off-Site Fuel Policy, the BR2 reactor was forced to expand its underwater storage capacity to secure the operation until the foreseen mid-1995 shutdown for refurbishment. Meanwhile, the different long term options for the back-end of the fuel cycle necessary for the life extension of the facility were examined. End of 1996, a final decision was taken for a reprocessing by COGEMA in its La Hague facility.

The focus of the BR2 fuel cycle strategy will now move to the procurement of the necessary HEU fuel for securing the long term operation of the facility. In this perspective the new high density fuels using LEU now under development to replace HEU, can only compete with the present UAlx fuels if they can be processed in existing facilities at an equivalent price.

7. Reference

[1] B. Ponsard, Trans. Conf. Research Reactor Fuel Management (RRFM '97) Bruges, Belgium, February 5-7, 1997, p. 74.