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Research Reactors Spent Fuel (RRSF) management: transportation and storage solutions

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Abstract

In many countries, Research Reactor (RR) operators are responsible for the safe and sustainable management of their Research Reactor Spent Fuel (RRSF) and associated radioactive waste.
Depending on the strategy employed in the corresponding countries, these management activities may include storage, transportation, and preparation for final disposal of the RRSF or of the corresponding waste after reprocessing.
Since the 1990's, AREVA, and especially its transportation services subsidiary known as AREVA TN, has helped RR operators set up and implement their RRSF management strategies by providing at-reactor-site, transportation, reprocessing, and storage products and services.

This article will describe AREVA's experience with RRSF management, with a special focus on our fleet of transportation casks and associated services (licensing, design, on site assistance,…).

The objective of this paper is to provide RR operators with key drivers to integrate transportation and storage aspects into their RRSF management strategy selection.

Introduction

Reprocessing is one of the today-available options for managing back-end of Research Reactor fuel cycle. Over the past decades, AREVA has been transporting, unloading, storing and reprocessing RRSF in its French facilities.

AREVA has also been involved in a numerous amount of RRSF transportations from RR facilities to cover different management routes.

1. Transportation of RRSF

Since early 1990's, around hundreds of MTR-type RRSF transportation casks have been transported to AREVA La Hague for reprocessing or to another plants, following customers needs.

As described in figure 1 below the RRSF reprocessing offers to RR:
- Non-proliferation: reducing ^{235}U enrichment of RRSF from 20-93% to below 2%,
- Final waste management optimization: standardizing final waste package and reducing volume and radio-toxicity, removing IAEA safeguards on final waste,
- Sustainability of RRSF back-end management: long-lasting solution, re-use of valuable material for civilian purposes i.e. saving natural resources, cost-certainty, cost effective solution,….

Fig. 1: RRSF reprocessing basic scheme and advantages

1.1. Types of transportation cask

The first high-capacity RRSF transportation cask used by AREVA (Cogema Logistics at that time) was the IU04 cask. As of today, AREVA proposes to its customers to use the TN-MTR transportation cask for MTR-types of RRSF, especially for transportation to the La Hague site.
This cask can contain several types of basket, generic or specialized according to the RRSF.
This cask offers the highest RRSF transportation capacity worldwide, with a 68-positions basket.
The TN-MTR cask can be loaded at RR site either under water or using a dry transfer system from pool to cask.

Fig.2: TN-MTR wet loading at RR site

Fig.3: Transfer system for loading TN-MTR at RR site

AREVA can also propose other types of multi-purpose transportation casks, even adapted for non-MTR- type RRSF. As an example a new package, which fabrication will be completed by end 2016, will be proposed by AREVA: the TN-LC package [1].

Fig.4: View of TN-LC transportation cask

Other casks can be considered for transportation of RRSF to AREVA La Hague, after investigating the following:

- Transportation license from RR site to La Hague (i.e. French transportation license, license in the RR country, and all countries involved in this transportation),
- Receipt and unloading at La Hague (see paragraph 1.3. below).

1.2. RRSF transportation experiences

As mentioned before, hundredsMTR-type RRSF transportation casks have been transported to AREVA La Hague and to another plants up to now.
AREVA support international needs for research reactors and has acquired this long-term international experience through multi-modal transportations: maritime, rail and road transportations (see Fig.5 & 6).

Fig.5: RRSF transportation on boat

Fig.6: TN-MTR on a truck

AREVA has notable RRSF transportation experiences in the following countries: Australia, Belgium, Denmark, France, Indonesia, Italy, Portugal, Sweden, Taiwan, United States of America, Uruguay and Venezuela.

Fig.7: Truck with RRSF transportation cask arrival at AREVA La Hague

Fig.8: Control on RRSF transportation truck at AREVA La Hague

Fig.9: Radiological control on RRSF from transportation cask, without shock absorber pool

Fig.10: Cask handling to the preparation cell, before unloading

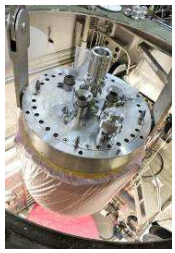

Fig.11: Cask handling preparation cell, to unloading

2. Focus on RRSF reprocessing operations

2.1 Receipt and unloading of RRSF at AREVA La Hague

The AREVA La Hague plant obtained its first authorizations for receiving and unloading RRSF in the late 1990's.
Ever since and until end-of 2014, around 150 MTR-type RRSF transportation casks have been received and unloaded at AREVA La Hague, corresponding to around 5 250 MTR-type RRSF assemblies.
As mentioned before, the transportation casks used for these receipts at La Hague were the IU04 and now the TN-MTR.
But RRSF are not only MTR-type of spent fuels. Thanks to the flexibility of its receipt-workshops, AREVA is also able to receive other types of RRSF, and other types of RRSF transportation casks.

2.2 Current reprocessing operations

Starting at Marcoule plant and up to the 90's, 18 tons of UAl-type RRSF from 21 reactors from 11 countries have been reprocessed with the similar reprocessing operations as the La Hague ones.
Since 2005 and as of mid-2016, over 10 tons of RRSF fuels have already been reprocessed at industrial scale at the AREVA La Hague plant.
AREVA obtained later in 2016 the authorization to reprocess USi-type RRSF from the French Safety Authority (ref. [2]). A first batch is planned to be reprocessed late 2016.

2.3 Towards a specific dissolution facility for treatment of specific fuels

In order to reprocess diverse fuel types, an innovative and polyvalent shearing and dissolving cell is planned to be put in operation in about 10 years at La Hague. This installation, called TCP (French abbreviation for polyvalent fuel treatment), will be set up at the La Hague reprocessing plant. The TCP shearing tool and dissolving equipment will benefit from AREVA's industrial feedback, while taking part in the next steps towards a fast reactor fuel cycle development using innovative treatment solutions. Feasibility studies and R&D trials on dissolution and shearing are currently ongoing. This new installation will allow AREVA to propose new services to their customers, in particular in term of Fast Reactors and Research Reactors fuel treatment. In addition to current reprocessing process at UP3, TCP will bring more flexibility, address a larger quantity of fuels and open the door to dedicated solutions for specific features (i.e. innovative Al or Si management).

2.4 Final waste production and management

2.4.1 Final waste attribution to customers

According to the applicable European Directive [3] and to French law [4], the introduction on French territory of spent nuclear fuels for a reprocessing purpose has to be framed by an intergovernmental agreement (IGA) between France and the SF country of origin. This agreement settles "a forecasted schedule for reception and processing of the material and, if any, the later planned use of the material separated during reprocessing". Article L542-2 of the French Environmental Code specifies also that disposal in France of radioactive waste from abroad is forbidden, including waste resulting from RRSF reprocessing.
In regards to spent fuel reprocessing at the AREVA La Hague plants, France already signed IGAs with Italy, the Netherlands and Belgium. Another in under preparation with Australia.

2.4.2 Final waste production and interim storage

After the reprocessing operations, the concentrated fission products solutions are vitrified in the AREVA La Hague plant and the resulting glass matrix poured in universal canisters.

The interim storage of vitrified residues is performed in pits with ventilation by natural convection in the AREVA NC La Hague plant (EEVSE and EEVLH facilities).

Fig. 28: Universal Waste Canister (CSD) – Vitrified wastes

Fig.29: Outside view of La Hague EEVSE facility

As mentioned in paragraph VI.A, the duration of interim storage of vitrified residues coming from foreign RRSF reprocessing is agreed between France and the RR's country before starting importation in France of the RRSF, through an IGA.
De-storage of the residues and preparation for transportation, including loading in the dedicated transportation cask are performed in the *DRV* facility in AREVA La Hague. AREVA customers can witness these de-storage and preparation for transportation operations.

Fig.30: De-storage facility control room

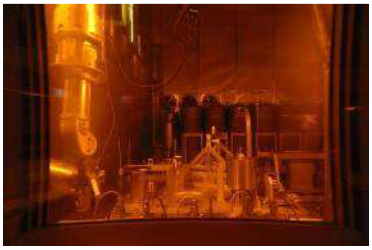

Fig.31: De-storage operations for CSD-V

2.5 Final waste transportation and management in the RR country

Transportation casks that can be used for the transport vary according to the customer's final waste interim storage policy: storage in pits/vaults, or storage in the transportation cask itself on a storage area

2.5.1 Solutions for waste transportation

If the dedicated RR country makes the choice of interim waste management in pit/vaults, like in the AREVA La Hague plant, the TN-28 and the TN-81 residue transportation casks can be used to ship CSD to the customers with a maximum of 28 universal canisters per cask. This choice has been made by Belgium for management of its final waste after RRSF reprocessing at La Hague.
In the case of an interim storage in cask, the TN-81 cask can be used as a "dual-purpose" cask ie for both residue transportation and interim storage, with a maximum of 28 universal canisters per cask. This choice has been made by Australia for management of its final waste after RRSF reprocessing at La Hague.

If needed, other types of transportation casks can be considered by AREVA for loading CSD-U, according to customers' needs. Nevertheless, as for RRSF receipt, feasibility studies, safety report application to Safety Authority /authorization, design and fabrication of new equipment and possible modifications to the workshop are necessary.

Fig.32: AREVA TN-81 dual purpose cask

Fig.33: AREVA TN-28 transportation cask

2.5.2 Experience

AREVA has a wide experience in residues shipment to foreign customers.
In the case of residues return related to RRSF reprocessing, AREVA has already returned small quantities of CSD to RRSF customers, based on a joint residues management with NPP and RRSF customers (Belgian feed-back). Indeed, in case of a nuclear power country that made the choice of reprocessing its NPP spent fuels in France, a joint return is efficient, cost effective, and reduces the number of nuclear transportations. When there is no NPP spent fuel reprocessing in France in the RR country, and no associated return of vitrified waste, another solution can also consist in performing a CSD shipment CSD with a dedicated transport program (Australia), and benefiting from the associated advantages.
AREVA has also experience in designing, licensing and constructing the facilities dedicated to interim storage of final waste.

3. Conclusion

AREVA acquired a long-term experience on RRSF management, encompassing international and multi- modal transportation, reprocessing and waste management.
Thanks to its experience, and thanks to the high-quality of its operators, its plants and equipment, AREVA is ready to set up sustainable partnerships with its RR customers in order to robustly manage the back-end of their fuel cycle.

4. References

[1] N. Guibert, J. Thomas, V. Laloy “AREVA TN Transports and Logistics Activities - Fleet of Transport Casks for International Shipments in Support of Research Reactor and Laboratories”, Transactions of RRFM2015, p. 488-492, Bucharest, Romania, April, 19-23, 2015.

[2] J.F. Valery, X. Domingo, P. Landau, C. Alameda-Angulo, C. Pechard, V .Laloy, “Status on silicide fuel reprocessing at AREVA La Hague”, Transactions of RRFM2015, p. 453-463, Bucharest, Romania, April, 19-23, 2015.

[3] Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:199:0048:0056:EN:PDF

[4] French Environmental Code resulting from the law of June 28, 2006 on the sustainable management of radioactive materials and waste, and application decree no. 2008-209 of March 3, 2008 on procedures applicable to the reprocessing and recycling of foreign spent fuel and radioactive waste specifies certain conditions