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**Research Reactor Spent Fuel management: growing needs and
available services**

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ABSTRACT

Identify sustainable spent fuel management solutions is a major challenge faced today by nuclear stakeholders, among them organizations in charge of Research Reactor Spent Fuel (RRSF) management.

Transportation, reprocessing of UAl RRSF and management of post-reprocessing waste have been performed since decades by New AREVA on behalf of international RR operators.

Based on this, New AREVA is able to continuously develop its capabilities in order to meet with the RRSF management market expanding needs. New types of casks for RRSF and waste transportation and storage are being developed; range of RRSF that can be reprocessed has been extended and include now Silicide RRSF and non-intact RRSF; a new Special Fuel Treatment facility is to be implemented in the existing plant opening thus additional reprocessing capacities for special fuel like RRSF.

In terms of RRSF management, New AREVA offers a strong experience in plant operation and adaptability of services.

1. Introduction

Identify sustainable spent fuel management solutions is a major challenge faced today by organizations in charge of Research Reactor Spent Fuel (RRSF) management. In terms of RRSF management up to disposal, two strategies are available (see Fig. 1):

- RRSF conditioning followed by disposal of spent fuel
- RRSF reprocessing and final waste conditioning followed by disposal of non-fissile waste.

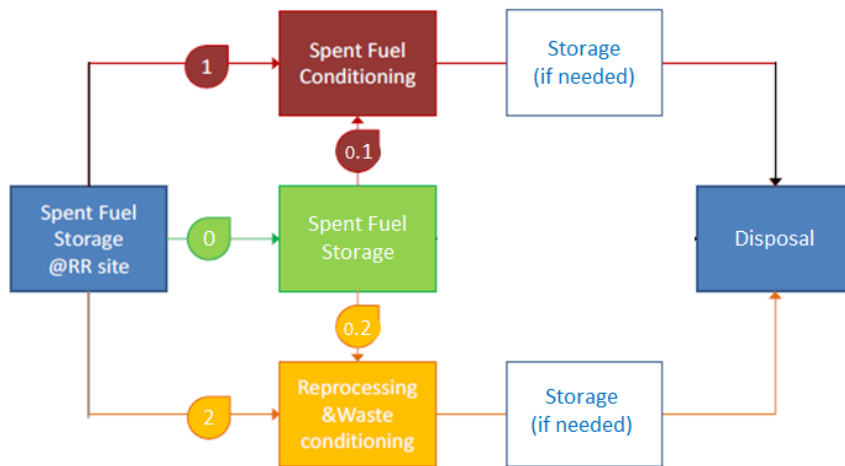


Fig. 1: Two available RRSF management strategies

As technologies for conditioning of RRSF are currently under development, reprocessing of RRSF is today a mature technology implemented since years by several RR operators with New AREVA support. In reprocessing their RRSF the nuclear operators benefit from:

- Reduced volume and radiotoxicity of final waste as compared with unprocessed used fuel
- Waste packaged in form designed for stability for thousands of years
- Final waste exempted of IAEA safeguards.

These combined advantages lead to clear predictability on the RRSF management cost, to reductions of risks with regard to long-term management of nuclear materials and to optimized disposal in terms of design and operations.

Having built a strong industrial experience with RRSF handling, New AREVA is able to continuously develop its capabilities in order to meet with the RRSF management market expanding needs. New types of casks for transportation and storage of RRSF or waste are being developed; range of RRSF that can be reprocessed has been extended and include now Silicide RRSF and non-intact RRSF; a new ‘Special Fuel Treatment’ facility is to be implemented in the existing plant opening thus additional reprocessing capacities for special fuel like RRSF.

This paper presents the existing, new and future services proposed to RR operators for management of their RRSF.

2. Transportation of RRSF

Transportation solutions are implemented for supporting RR operations through RRSF evacuating from site.

2.1. Industrial experience and operations

Since early 1990’s, around 150 MTR-type RRSF transportation casks have been transported to the New AREVA ‘La Hague’ reprocessing plant.

As of today, the ‘TN-MTR’ cask is used for transport of MTR used fuel, especially for transportation to La Hague site. Its main features are as follows:

- Several types of basket, generic or specialized according to the RRSF design
- The highest RRSF transportation capacity worldwide, with a 68-positions basket

- Wet (see Fig. 2) or dry (see Fig. 3) loading at RR site
- Licensed in the USA, Australia, Belgium, France, Indonesia, Portugal, the UK.



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



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

2.2. New services

A new package, the ‘TN-LC’ cask (see Fig. 4), can also be proposed for transportation of used fuel from research reactors, full-length commercial irradiated fuel assemblies, irradiated pins, with following main features:

- Designed for handling of NRU/NRX, TRIGA fuel elements, MTR fuel elements and more
- Loading or unloading in vertical or horizontal position
- Operation in wet or dry conditions
- Licensed in the USA, several foreign validations underway.



Fig. 4: TN-LC cask

In 2017, the RRSF transportation service offer was extended: transport (for reprocessing purpose, see §3) of non-intact aluminium-clad fuel is now authorized by the French Safety Authority, based on the use of aluminium cans designed by SCK•CEN [1] with New AREVA support.

3. RRSF reprocessing operations

Through conditioning of final waste under strongly optimized and stable form (see §4), reprocessing of RRSF allows to:

- Obtain clear predictability on the RRSF management cost,
- Reduce the risks with regard to long-term management of nuclear materials and
- In the end move to an optimized disposal in terms of design and operations.

3.1. Industrial experience and operations

Starting at ‘Marcoule’ reprocessing plant and up to the 90’s, 18 tons of UAl-type RRSF from 21 reactors in 11 countries have been reprocessed.

Since 2005 and as of mid-2017, more than 10 additional tons of UAl-type RRSF have been reprocessed at industrial scale at the New AREVA La Hague plant which has been initially designed for reprocessing of LWR used fuel (over 30,000 tHM reprocessed since end of the 70's).

The reprocessing operations on La Hague site [2] are summarized in Fig. 5.

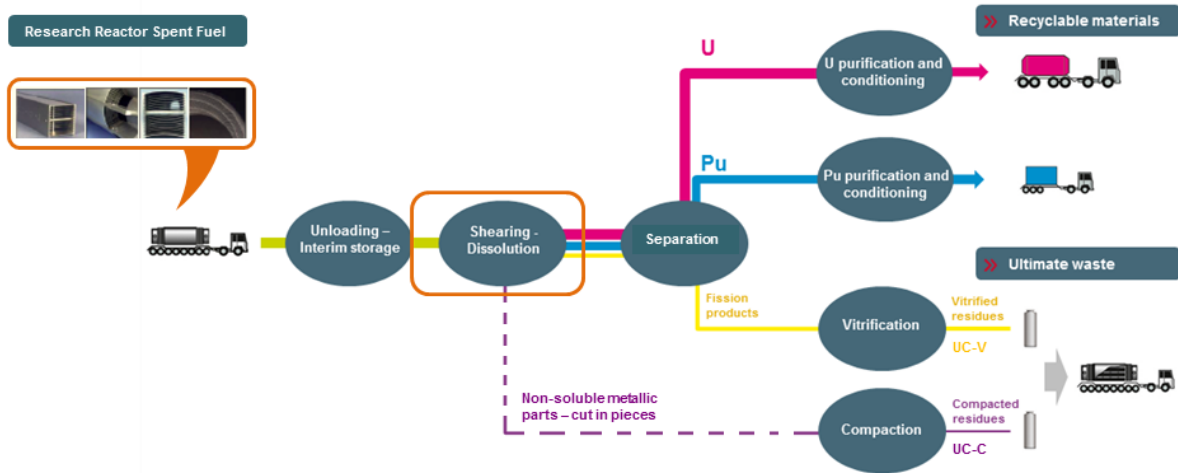


Fig. 5: Process diagram for RRSF reprocessing on La Hague site

The U-Al RRSF specific reprocessing operations mainly take place at the dissolution step.

From wet storage pool to the dissolution facility, the RRSF is transferred with a shuttle basket with operations performed by operators with dedicated cranes and tele-manipulators. The RRSF are then loaded in the dissolution pit one by one by directly dropping them in the boiling nitric acid. The dissolution process is controlled thanks to a dedicated camera placed on the top of the dissolution pit.

Once the RRSF batch is completely dissolved, the solution is mixed with LWR dissolution solution coming from the other dissolution lines.

3.2. New services since 2017

In May 2017, the French Safety Authority granted the authorization for reprocessing of Silicide fuel. The first industrial Silicide fuel reprocessing campaign was performed at La Hague plant in the following months [3]. The process is the same as for U-Al RRSF except for one additional operation performed prior to the mix with the LWR dissolution solution. Such operation consists in separating the Silicon from the dissolution solution because the whole Silicon quantity can not proceed through the standard separation step following dissolution.

Through close collaboration with SCK•CEN, the range of RRSF that can be reprocessed has been extended for including non-intact aluminium-cladded fuel. Also in May 2017, the French Safety Authority granted the authorization for reprocessing of such non-intact RRSF, based on the use of aluminium cans designed by SCK•CEN with New AREVA support.

3.3. Future services

In order to meet with expanding needs in terms of RRSF management, a new Special Fuel Treatment facility is to be implemented in the existing La Hague reprocessing plant opening thus additional reprocessing capacities for special fuel like RRSF and allowing also to extend even more the range of special fuel which can be reprocessed. This future facility, called 'TCP' (see Fig. 6), will benefit from New AREVA's industrial spent fuel reprocessing feedback while taking part in the next steps towards a fast reactor fuel cycle development using innovative treatment solutions.



Fig. 6: Overview of main TCP facility operations

With regard to reprocessing capacities, TCP will bring more flexibility, address a larger range of fuel and facilitate implementation of dedicated solutions for specific features (fuel assembly with specific non soluble metallic structure for instance).

4. Final waste production and management

4.1. Final waste production

As per French law [4], any introduction of spent fuel or radioactive waste from abroad onto the French territory shall only be authorized pursuant to intergovernmental agreements and provided that no residual radioactive waste resulting from the processing of such substances shall be stored in France beyond the term prescribed by such agreements.

Compliant with the French law, the New AREVA La Hague waste accountancy system is the EXPER system used to determine the equivalence of final waste that needs to be returned to the country of origin after reprocessing.

The equivalence is determined with two units being the residue activity unit (UAR) based on neodymium content (in dg, because it is a representative indicator that can be effectively measured), and the residue mass unit (UMR) based on weight of non-soluble metallic structural components of the spent fuel (in kg). The UAR and UMR are credited into accounts at the time of reprocessing independently of any conditioning of the waste. They are then debited from the accounts at the time of expedition of the residues from La Hague, the objective being to set both UAR and UMR accounts to zero.

UAR and UMR are sent out of France under the form of Universal vitrified residues Canister and Universal compacted residues Canister respectively (see Fig. 7):

- Vitrified residues. The fission products and minors actinides are vitrified in a homogeneous glass matrix and conditioned in Universal Canister (high activity UC-V or intermediate activity UC-U). This type of conditioning is very stable and ensures containment over thousands of years.
- Compacted residues. Structural waste coming from non-soluble-cladded fuels are compacted and conditioned in Universal Canister (UC-C) with the same external geometry as UC-V/U.



Fig. 7: UC-V (or U) and UC-C with height 1.3 m / 4.3 feet

Conditioning of final waste into Universal Canisters leads to multiple benefits:

- Simplified transport and on-site handling conditions thanks to standardization,
- Volume saving in storage/disposal facilities,
- High stability of the residues demonstrated for the very long term,
- Exemption of IAEA safeguards and
- Rationalization of the ultimate waste policy through standardized type of waste.

4.2. Final waste management

UCs are managed today in Australia, Belgium, France, Germany, Japan, the Netherlands, Switzerland and the UK [5].

Transportation of large quantities of UCs (up to 28 UCs, vitrified type or up to 20 UCs, compacted type) is performed today on routine basis, using the TN[®]28 cask (see Fig. 8), licensed in Belgium, France, Japan, the Netherlands and the UK.

Transportation and storage of large quantities of UCs (up to 28 UCs, vitrified type) is successfully implemented, using the TN[®]81 cask (see Fig. 9), licensed in Australia, France, Spain, Switzerland, and the UK.



Fig. 8: TN[®]28 cask



Fig. 9: TN[®]81 cask

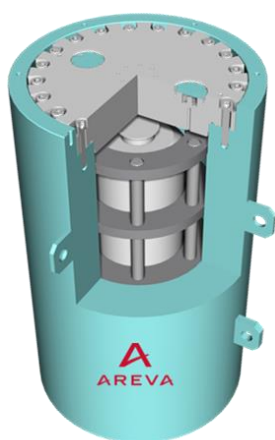


Fig. 10: Future TN[®]MW cask design for one UC

5. RRSF dry storage

Decision can be made for putting in place an intermediary step before implementation of one or the other available RRSF management strategies. In such a case, RR operators may need modular dry storage solutions.

New AREVA will be able to propose in the near future a cask for transport and storage of radioactive material with fissile content such as RRSF. This cask will be based on existing TN[®]MW cask design [6]:

- it has been licensed in 2017 by the French and Belgian Safety Authorities for transport of material resulting from production of Molybdenum 99
- two first units have been successfully delivered and loaded on client's site in the following months (see Fig. 11).



Fig. 11: Future TN[®]MW cask for transport and storage of RRSF

Such solution presents following advantages in terms of support to RR operations:

- Modularity
- Flexibility keeping door open to both RRSF management strategies
- Support to management of spent fuel storage pool capacity.

6. Conclusion

Considering the evolution of international and national regulations, and their request for clarification of used fuel and radioactive waste management, the identification of a used fuel management sustainable strategy is one of the major challenges nuclear reactor operators are facing today.

A sustainable management path for such material implies a set of different options, from on-site management to management in the disposal facility, encompassing transportation, storage or reprocessing activities.

Based on its long-term and international experience on RRSF management, New AREVA is able to offer the RR operators up-to-date and adapted services. Continuously meeting the evolving market needs, New AREVA is ready to set up sustainable partnerships with its RR customers in order to robustly manage the back-end of their fuel cycle.

7. Acronyms

LWR	Light Water power Reactor
MTR	Material Testing Reactor
RR	Research Reactor
RRSF	Research Reactor Spent Fuel
TRIGA	“Training, Research, Isotopes, General Atomics” type RR
UAR	Residue Activity Unit
UC (-V/U/C)	Universal Canister (high activity vitrified residues/intermediate activity vitrified residues/compacted residues)
UMR	Residue Mass Unit

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