Paper
RRFM 2018
March 11-15, Munich, Germany

RESEARCH REACTOR SPENT FUEL TREATMENT PROCESSES AND LICENSING

I. MORLAES, J.F. VALERY, A. TALBI, V. VO VAN
Back-End Sales, Orano
1 Place Jean Millier, 92400 Courbevoie – France

L. STACHETTI
Transportation Business Line, Orano TN
Lieu dit La Tourette, 30204 Bagnols sur Cèze Cedex – France

ABSTRACT

Considering the evolution of international and national regulations, and their request for clarification of spent fuel and radioactive waste management strategy, the identification of sustainable spent fuel management solutions is one of the major challenges faced today by nuclear stakeholders, among them organizations in charge of Research Reactor Spent Fuel (RRSF) management such as Research Reactor (RR) operators and providers of services in the back-end of the fuel cycle.

Treatment of RRSF, being performed at industrial scale since decades and allowing to remove fissile material and IAEA safeguards from final waste to be disposed of, is an answer when sustainable spent fuel management solution is being looked for.

Industrial-scale transportation and reprocessing of RR Uranium-Aluminium (UAl) type spent fuel have been performed since decades by Orano on behalf of international RR operators. Based on this unique operational experience, Orano 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: since 2017, Uranium-Aluminium-Silicium fuel (USi also called Silicide fuel) and also non-intact RRSF can be treated at La Hague.

Furthermore, in order to comply with RRSF management growing needs, Orano is also developing additional RRSF reprocessing capacities based on the current process principles: a new Special Fuel Treatment (Traitement de Combustibles Particuliers, TCP) facility is to be implemented in the La Hague plant opening thus a new reprocessing line for special fuel such as RRSF.

The purpose of the paper is to present the industrial solutions proposed by Orano for management of RRSF, focusing on new services, on management of associated licensing aspects and on first operational results.

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.

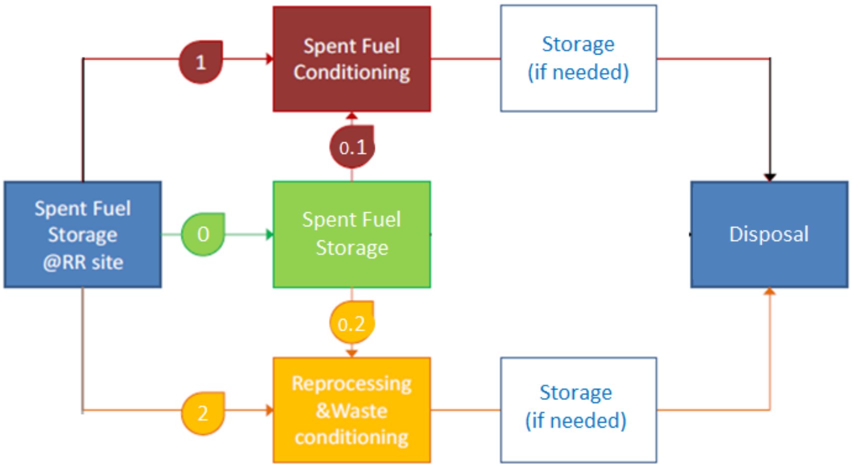

Fig 1. Two available RRSF management strategies

Whereas 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 Orano 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, Orano 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 La Hague plant opening thus additional reprocessing capacities for special fuel like RRSF.

This paper presents the industrial solutions for management of RRSF, focusing on new services, on management of associated licensing aspects and on first operational results.

2. Transportation of RRSF

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

2.1 Industrial operation

Since early 1990's, around 150 MTR-type RRSF transportation casks have been transported to the Orano 'La Hague' reprocessing plant. As of today, the 'TN®-MTR' cask (see Fig 2.) is used for transport of MTR used fuel, especially for transportation to La Hague site. Its main features are as follows:

Fig 2. TN®-MTR cask

- Several types of basket, generic or specialized according to the RRSF design
- The highest RRSF transportation capacity worldwide, with a 68-positions basket
- Wet or dry loading at RR site
- Licensed in the USA, Australia, Belgium, France, Indonesia, Portugal, the UK.

2.2 New services and associated licensing efforts

A new package, the 'TN®-LC' cask (see Fig 3.), 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 3. TN®-LC cask

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

Such cans allow to retain all nuclear material in closed and sealed container and consequently:

- Can be used on research facility site for proper handling operations,
- Are a housing consistent with transport operations (cask loading, transport and unloading),
- Are a housing consistent with operations on reprocessing site (pool storage and reprocessing).

3. RRSF reprocessing

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 operation

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 Orano 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 4.

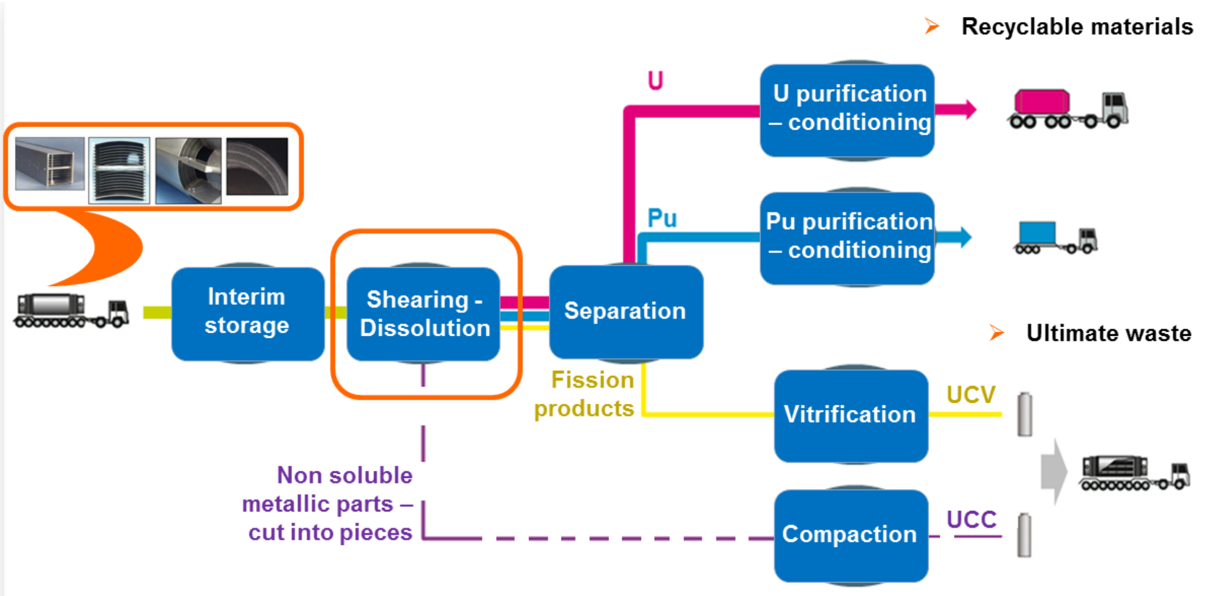

Fig 4. Process diagram for RRSF reprocessing on La Hague site

The UAl 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 monitored 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 and associated licensing efforts

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 UAl RRSF except for one additional operation performed prior to the mix with the LWR dissolution solution. The whole Silicon quantity can indeed not proceed through the standard separation step following dissolution. Therefore the additional operation consists in separating the Silicon from the dissolution solution through centrifugation. The concentrated Silicon is managed through the “fines” line and vitrified with the fission products solutions at the end of the process (see Fig 5.).

As a result, the Silicide RRSF reprocessing capacity is similar to the UAl RRSF reprocessing capacity in terms of tons Al/year.

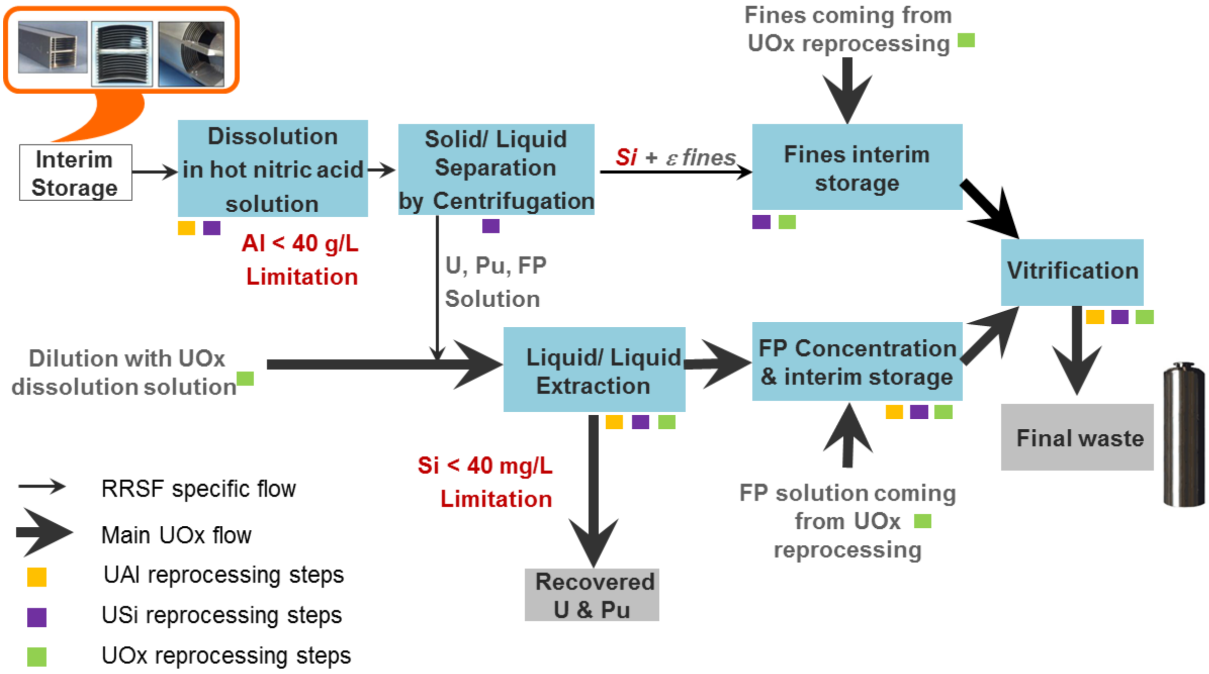

Fig 5. UAl and Silicide RRSF reprocessing at La Hague, process diagram

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 Orano support, as mentioned in §2.

3.3 Future service

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 Orano’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 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 Orano 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. 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 - with the same external geometry as vitrified residues canister.

Fig 7. Vitrified and Compacted residues Universal Canisters, with height 1.3 m

Conditioning of final waste into Universal Canisters (UC) 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 Industrial operation

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, Switzerland, and the UK.

Fig 8. TN®28 cask

Fig 9. TN®81 cask

4.3 New services and associated licensing efforts

For management of small quantities of residues, Orano is working on a solution adapted for transportation and long-term storage of one UC (see Fig 10.). Such solution is based on the 'TN®MW' cask design (see §5) which has been licensed by the French and Belgian Safety Authorities for transport of nuclear waste.

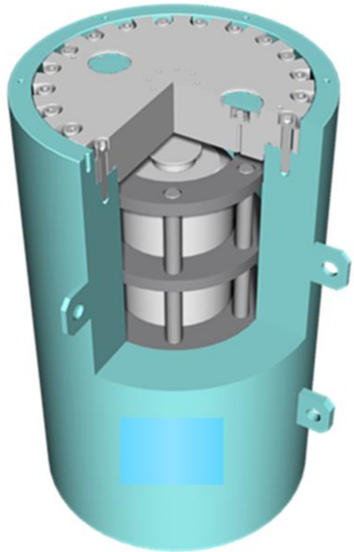

Fig 10. Future TN®MW cask design for one UC

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.

Orano 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, Orano is able to offer the RR operators up-to-date and adapted services, always fully in line with competent authorities requirements. Continuously meeting the evolving market needs, Orano 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	Universal Canister (packaging for post-reprocessing residues)
UMR	Residue Mass Unit

8. References

[1] https://www.sckcen.be/en

[2] Overview on RRSF reprocessing, from spent fuel transportation to vitrified residues storage – RERTR 2015 – by: JF Valery, X. Domingo, P. Landau, M. Launay, P. Deschamps, C. Pechard, V. Laloy, M. Kalifa

[3] Research Reactor silicide fuel reprocessing at La Hague plant – RERTR 2017 – by: C. Lavalette, JF Valery, V. Vo Van, A. Talbi, L. Halle, C. Pechard, X. Renault

[4] Act No.2006-739, dated 28 June 2006, on the Sustainable Management of Radioactive Materials and Waste and Decree 2008-209, dated 3 March 2008

[5] Reprocessing of research reactor spent fuel and management of the arising waste – RERTR 2016 – by: X. Domingo, V. Vo Van, JF Valery, F. Lefort-Mary

[6] The TN®MW, a new optimized cask for research reactor’s waste management – RERTR 2017 – by: A. Talbi, M. Ghobrini, JF Valery, V. Vo Van, C. Lamouroux, C. Grandhomme, B. Kerr