The French Reprocessing Solution And Its Recent Evolution

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ABSTRACT

Used fuel reprocessing offers several benefits for operators, reducing risks and costs, enhancing public support and allowing safe and long-term storage of final waste as well as rationalization of geological repository.

In France, a set of decrees have been recently issued by the government allowing the return of the global inventory of UCC and UCV from two countries of origin using different ratio of UCV and UCC for each country, provided that all metallic mass and radioactive activity of both countries leaves France.

The presentation will focus on this new approach integrating a flexibility in the system of attribution for UCC and UCV providing additional value to reprocessing clients.

Keywords: *fuel reprocessing, French study case*

1 INTRODUCTION

Many utilities and waste management organizations in charge of used fuel management face several challenges such as saturation of pools, delays of final disposal projects, needs of multiple operations related to the management of long term interim storage and downstream steps (Potential issues with fuel integrity for extended dry storage period, ageing management of storage systems with potential required reconditioning, conditioning of used fuel into final disposal canisters…). In this context, taking into consideration requirements from local or international authorities to implement an used fuel management program up to waste disposal, used fuel reprocessing provides a solution to implement a safe, cost effective and sustainable strategy. It allows an optimized conditioning of final waste and the reuse of recyclable materials contained in used fuel, thus saving natural uranium resources, and increasing the energetic independence.

Used fuel reprocessing is a mature technology industrially implemented for decades by international nuclear operators leading to an optimized final waste conditioning.

Reprocessing performed in the Orano La Hague facility for over 40 years includes the extraction of the recyclable materials (U & Pu) from the used fuel, representing 96% of nuclear materials contained in used fuel and conditioning of the non-recyclable materials considered as final waste (fission products, minor actinides and non-soluble metallic parts) in Universal Canisters, respectively vitrified and compacted (Universal Canister of Vitrified Waste, UCV, and Universal canister of Compacted Waste, UCC).

With sustainable development, environment protection, economics and public acceptance in mind, utilities and waste management organizations are evaluating their options for used nuclear fuel (UNF) management.

Generally, there are two approaches for UNF management: open fuel cycle with direct disposal and closed fuel cycle with recycling of UNF.

For both approaches, disposal is the ultimate objective for the radioactive waste management: either direct disposal of UNF or disposal of final residual waste produced after used fuel treatment. It is widely accepted in the technical community that the only currently feasible method to ensure very long-term safety for High Level Waste (HLW) or UNF is isolation in deep, stable geological formations, usually several hundred meters or more below the surface.

In addition, final repositories for UNF require implementation of safeguards in order to comply with non-proliferation objectives aiming at detecting any diversion of declared nuclear material or any undeclared nuclear material activity.

2 THE FRENCH REPROCESSING SOLUTION

Within the closed fuel cycle, used fuel reprocessing is a mature technology implemented since decades by international nuclear operators leading to optimized waste conditioning.

Reprocessing is performed in France at the Orano La Hague facility with the extraction of the recyclable materials (U & Pu) from the used fuel, representing 96% of nuclear materials contained in used fuel and the conditioning of the non-recyclable materials considered as waste. Fission products representing 4% of the nuclear material and non soluble metallic parts are in Vitrified (UCV) and Compacted Universal Canisters (UCC).

Universal Canisters represent several advantages: First there is the reduction of radiotoxicity of the waste by a factor 5 (removal of fissile material); Second, there is long-term stability of the waste (vitrification of fission products) conditioned in a glass matrix specifically designed for durability over thousands of years; Third, it can be mentioned standardization of the waste form with metallic compacted waste conditioned in the same Universal Canister than the vitrified waste; Fourth, it can be stated the waste stability allowing safe storage and transportability to disposal site after storage; Fifth advantage is the compatibility with geological disposal projects such as the Andra's underground radioactive waste repository project (Cigeo) in Bure, France; Sixth, there is an optimization of the design of disposal facilities, simplification of handling operations, reduction by a factor 10 of the volume needed for disposal and minimization of requirements for IAEA safeguards (no fissile material in the waste) including post closure; Seventh, there is the universality of the canisters facilitating compatibility with shared repository solutions such as the ERDO association, which is a multinational association through which organisations from different European countries join forces for shared multinational waste management solutions; And lastly, it can be mentioned a globally strong risk reduction approach for the management of HLW waste.

Orano Reprocessing services of used fuel comprises the following steps: The first step is the used fuel shipment to Orano La Hague reprocessing plant; Then follows the used fuel reprocessing separating the recyclable materials (U& Pu) from the waste; As a third step, recyclable materials (U& Pu) can be returned to the operator or can be recycled under MOX fuel and ERU fuel for the operator reactors or for third party civil nuclear reactors; And as the final fourth step, there is conditioning of the waste in Universal Canisters, stored on Orano's site for cooling before being returned to the country of origin.

It is noted that such steps for reprocessing services require several years of preparation before they can be launched and that an International Governmental Agreement (IGA) needs to be signed before the first UNF shipment between the concerned country of the utility or waste management organization and France.

Used fuel reprocessing has been implemented for several decades within Orano La Hague, for UOX and MOX fuels with more than 36 000 tons of heavy metal reprocessed for several PWR and BWR operators: EDF (France), SOGIN (Italy), EPZ (Netherlands), Synatom (Belgium), and other utilities in Switzerland, Japan and Germany.

3 RECENT EVOLUTION OF THE FRENCH REPROCESSING SOLUTION

In France, three decrees have been recently issued by the government allowing the return of the global inventory of UCC and UCV from two countries of origin using different ratio of UCV and UCC for each country, provided that all metallic mass and radioactive activity of both countries leaves France. This flexibility is based on the calculation of the "Integrated Toxic Potential" representative of the waste canisters radiotoxicity which needs to be agreed between the two countries and Orano.

The evolution of the French regulation:

The first decree for the return of foreign waste waste state in the 2006 Law « Programme Act on the sustainable management of radioactive materials and wastes » stating: The disposal in France of foreign radioactive wastes is forbidden (Art. L542-2.).

This decree than was complemented in 2008 by the no 2008-209: Residues from reprocessing have to be returned to the country of origin. Therefore, Orano put in place an accounting system

(EXPER system) that allocates to a client the mass and activity of his spent fuel introduced into France. This mass and activity shall be returned under the form of UCV and UCC. A third decree was added in 2017 with no 2017-1309: This is an amendment to the previous one. It allows to derogate from the above attribution rules and to return to one specific client/country only UCCs and to another client/country only UCVs or a mixture of UCV and UCC provided that all mass and activity of both clients leave France. An equivalence system shall be agreed upon between all parties.

Among existing methods to define a measure of equivalence for comparing radioactive wastes such as UCV and UCC, Orano has been proposing to its clients to use the “Integrated Toxic Potential” (ITP). The ITP method has been used before in government-sponsored programs, specifically in the United Kingdom to accelerate the returns of residues to foreign customers of the British reprocessing industry, including the German Utilities.

The ITP method has first been proposed by British Nuclear Fuels Limited (BNFL) to optimize the return of residues to their overseas customers, among various alternative approaches. The ITP has been described in the 1997 European Union report [1] EUR-17241EN “Elements for Assessing the Equivalence between Radioactive Waste Materials” and the ITP approach has been publicly reviewed in 2004 by NAC International [2]. “Consultation Paper on Proposals for intermediate level radioactive waste substitution”.

The equivalence principle is based on the calculation of a theoretical quantity named “Integrated Toxic Potential” (ITP). This quantity aims to assess the radiotoxicity of waste packages. According to this method, at a time t, the radiotoxicity can be quantified by its "Toxic Potential" (TP) which is defined as “the volume of water into which the activity of a given nuclide i (Bq) present in the waste package considered must be diluted so that the annual ingestion of this water leads to an absorbed dose of 1 mSv”. Therefore, TP can be understood as an activity weighted by a coefficient depending of annual intake of the nuclide.

4 ADVANTAGES FOR UTILITIES AND WASTE MANAGEMENT ORGANIZATIONS

Enabled by the latest French decree, provided that a consenting third party is found, Orano can return to one specific client/country only UCCs and to another client/country only UCVs or a mixture of UCV and UCC. For the client/country managing only UCCs, there are several advantages provided that Intermediate Level Waste (ILW) such as UCC does not require the same constraints such as HLW by the safety authority of this country:

Firstly, there is no heat generation of UCC leading to compacted storage/disposal facility with reduced footprint compared to UCV and no necessity for forced ventilation in the interim storage; Secondly, there is the simplification of the storage/disposal facility concept; Third advantage is the

reduced depth of the geological disposal facility with reduced costs (capital and operating expenditure); And lastly there is the advantage of reduced required provisions.

The above advantages will result in an additional benefit for the concerned country since managing only ILW can favour acceptability and public acceptance for the final waste repository. Depending on the overall purpose of the repository no safeguards may be required.

For utilities and waste management organizations participating in shared multinational disposal facility concepts such as the ERDO association, this can facilitate and accelerate their discussions there since UCC and UCV are standard waste packages licensed already by 9 safety authorities for storage & disposal which have accepeted the HLW vitrified canister confinement durability for several thousand years.

5 CONCLUSION

Within the two approaches of UNF management, open fuel cycle with direct disposal and closed fuel cycle, the latter has recently benefited in France from a significant evolution following the issue of 3 governmental decrees.

All foreign waste resulting from reprocessing in France needs to be sent to their country of origin, however the latest decree allows to return to one specific client/country only UCCs and to another client/country only UCVs or a mixture of UCV and UCC provided that all mass and activity of both clients leave France.

With an equivalence system such as the ITP agreed between all parties, it becomes possible that one country / waste management organization receives only UCC which can lead to several benefits provided that ILW does not have the same stringent disposal facility requirements such as HLW by the respective safety authority of the country.

The direct benefits of receiving only UCC are that reduced footprint with reduced depth will be needed for the geological disposal facility leading to reduced capital and operating expenditure accompanied by lower requirements of provisions.

Furthermore, the concerned country receiving only UCC can benefit from a facility of public acceptance for the final waste repository given only ILW waste in a standardized form already accepted by the safety authorities of 9 other countries.

Finally, for utilities and waste management organizations involved in shared multinational disposal facility concepts, receiving only UCC can further accelerate discussions and ease public acceptance of the country or countries willing to receive such standard canisters.

REFERENCES

[1] European Union, EUR-17241EN “Elements for Assessing the Equivalence between Radioactive Waste Materials”, 1997.

[2] NAC International, “Consultation Paper on Proposals for intermediate level radioactive waste substitution”, 2004.