INRA Integrated Fuel Recycling Facility Solid Waste Management - 9468

G.H. Senentz, F. Drain
SGN
1, rue des Hérons, 78182 Montigny Le Bretonneux, France

C. Veyer
Consultant, 21 rue du May, 59570 Saint Waast la Vallée, France

P. Murray
AREVA FS
4800 Hampden Lane, Bethesda, MD 20814, USA

F. Bailly
AREVA NC
33, rue La Fayette, 75 442 Paris Cedex 09, France

Jimmy Angelos
URS – Washington Division
2131 Centennial Drive, Aiken, SC 29803

Toshiyuki Zama
JAPAN NUCLEAR FUEL LIMITED
Rokkasho-mura, Aomori-Ken 039-3212 Japan

ABSTRACT

This paper presents an overview of the Integrated Fuel Recycling Facility solid waste management process for the Pre-Conceptual Design of the facility proposed by the International Nuclear Recycling Alliance (INRA) Team. Wastes estimates and expected activity level are provided. The low volume of expected produced waste benefits from years of experience and feedback from La Hague operations, where a determined waste management strategy has been implemented. All waste management information presented in this paper is based on existing industrial experience in AREVA facilities in France. Specific US and site specific local requirements that are not fully assessed yet may impact waste forms and quantities. Some process optimizations are still possible that would decrease the number of residues (most notably for low level waste), dependent on potential disposal paths in the U.S. and the associated waste acceptance criteria of the receiving facilities.

INTRODUCTION

According to the recently published DOE/EIA report" *International Energy Outlook 2008*" (IEO 2008) [1], the share of nuclear power in the world electrical output is projected to increase from 2.6 trillion kWh in 2005 to 3.8 trillion kWh in 2030, as concerns about increasing fossil fuel prices, energy security and greenhouse emissions are rising; in at least three countries (China, India and the United States), nuclear power is positioned for strong growth.

In the United States, in the EIA 2008 reference case, 17 GW of new nuclear capacity are projected to come online by 2030. Such an expansion of nuclear power will require a complete, mature, and sustainable nuclear fuel cycle, which ensures safety for the public, enhanced non-proliferation, efficient use of resources, and minimal impact from waste management and disposal.

The Global Nuclear Energy Partnership, or GNEP, initiative has been launched to provide a framework for both international and domestic use of nuclear power to reduce the risks associated with nuclear proliferation and the impacts associated with waste disposal. Internationally, GNEP comprises a partnership of countries working toward establishing international structures intended to prevent the uncontrolled spread of nuclear technologies

and materials. Domestically, the Advanced Fuel Cycle Initiative (AFCI) program focuses on options for changing the U.S. fuel cycle to reduce the High Level Waste (HLW) radiotoxicity, volume and heat and supports the international GNEP vision.

Recently, the US-DOE has published the Programmatic Environmental Impact Statement (PEIS) which analyzes several alternatives for accomplishing the GNEP objectives [2]. This document establishes that the DOE's preferred approach would be a change to a closed fuel cycle, although it evaluates several alternative pathways.

As part of the Department of Energy Global Nuclear Energy Partnership (GNEP), AREVA leads a team consisting of recognized world leading companies in the area of used nuclear fuel recycling (UNF). The team prepared a pre-conceptual design for an upgradeable engineering-scale recycling plant with a nominal through put of 800 tHM/y. The pre-conceptual design of this leading edge facility was based upon the team's extensive experience in recycling plant design and real world "lessons learned" from actually building and operating recycling facilities in both France and Japan. The conceptual flowsheet proposes to separate the useful products for recycling into new fuel and sentences the high level waste, (HLW) for vitrification in an inert glass matrix.

As part of the next implementation step for a closed fuel cycle, and to ensure a minimal impact from waste management and disposal, it is necessary to design a completely integrated waste management strategy for all the waste forms produced by the facilities.

ORIGIN OF WASTE

Waste arising in a recycling plant can be sorted in three broad categories:

- Conventional waste
- Nuclear waste:
    - Technological waste
    - Process waste

Conventional, non nuclear wastes are produced in the non active, conventional area of the plant. Examples are wastes coming from reagent or utility buildings. They can be common industrial waste or special industrial waste, depending on their nature and toxicity, and must be properly disposed of. These waste are not addressed further in the present paper.

Nuclear wastes are subdivided in technological wastes and process wastes. Technological wastes are those arising from plant operation, but not produced as part of the recycling process itself. Failed and discarded pumps, gloves, protective clothing, and other wastes from maintenance activities fall in that category. Most of them are of low activity, except for process equipment that has been in contact with fuel nuclear material or process solutions from the dissolution to the first cycle. Process waste nature and quantity are a direct result of the processes implemented in the plant. Vitrified glass canisters, hulls and end pieces compacted waste, but also cemented mineralized solvent and air filters are considered to be part of this category. Their activity goes from low (mineralized solvent) to high (vitrified fission products).

These wastes will require specific treatments in dedicated facilities included in the preconceptual design of the Integrated Fuel Recycling Facility proposed by INRA.

REDUCTION OF QUANTITY AND RADIOTOXICITY

Thanks in part to high performance of the plant, implementation of a consistent and determined waste management strategy at the La Hague plant has led to a considerable reduction of the quantity and radiotoxicity of final waste from this facility to be stored in surface or deep repositories. This considerable reduction has not been achieved only compared to previous, older generation plants, but also compared to the quantity of waste originally generated by the newest plants after commissioning.

Efficient reduction of volume and radiotoxicity of generated solid waste relies on a multi-prong strategy. Some key elements of this strategy are:

- Excellent decontamination performance of the first extraction cycle, leading to a significant reduction of solid waste activity arising from downstream units
- Equipment design, where sub-assemblies considered replaceable (motors…) are located outside active areas, whenever possible, and are always easily accessible, so that only the replaced part is discarded
- High reliability of equipment, thanks to an extensive development program during plant design and to the operator’s continuous effort to improve operability
- Decontamination and repair of equipments that can be recycled, reducing both operating costs and amount of waste
- Optimized management of aqueous effluents, allowing routing activity to the glass, with its high waste loading
- Compaction of waste, including hulls, fuel end-pieces, and technological waste is an integral part of the waste volume reduction strategy [3]

However, waste minimization is not only a matter of design [4]. The reduction of the quantity and radiotoxicity of final waste compared to the quantity of waste originally generated by the newest plants highlights the importance for the plant performance of not only a good design but also of good operations. As seen previously, the plant and maintenance operator is responsible for operating the plant at the highest performance possible, and is quite often instrumental in process performance improvements. He is also actively involved in continuous efforts to improve equipment reliability. However, his necessary involvement does not stop there. For example, minimization of material, tools, and equipment entering controlled areas and liable of becoming radioactive waste can only be achieved if plant and maintenance operators take ownership of waste management goals and policy.

Due to its current level of development, the current preliminary design proposed by INRA for the Integrated Fuel Recycling Facility does not explicitly incorporate this part of the waste management. Experience and lessons learned from La Hague and similar facility in Japan (Rokkasho plant) will be a critical asset to effectively deploy this waste reduction strategy, from the design to the operation stage of the plant.

SORTING AND CONDITIONING

All of the above contributes to reducing both the volume and the activity of the waste generated by a recycling facility. Waste generation is however unavoidable, and waste arising from plant production and operation must be appropriately conditioned, depending on their nature and their toxicity.

First of all, two types of waste generating zones are defined in the facility [4]. In the first type, inactive waste only is generated (even though the zone is in the controlled area of the plant) and treated as such. In the second type, generated wastes are considered nuclear waste. The facility zoning, coupled with optimization of control measures, reduces the quantity of nuclear waste.

Generated wastes (untreated at this point) need to be characterized before being routed to the appropriate centralized treatment process. Wastes are characterized initially before leaving the generating facility in their primary container (drum, bag…). Untreated waste packages are characterized by material content (metal, organic…), expected radionuclides composition, based on the corresponding process step, and of course external dose rate and surface contamination required for transfer operations. Before conditioning, the activity is measured through a non destructive measurement that can be coupled with the expected radionuclides composition.

Considerable work has been performed to select the best treatment for waste, determined on the basis of its properties, to guarantee the long term stability of waste while minimizing its volume. A range of technologies is available to condition waste in line with their production during plant operation. Figure 1 shows the treatment technologies planned in the INRA preliminary design for the Integrated Fuel Recycling Facility and expected waste streams, for a 800 MTHM/yr facility. For convenience, names of similar containers used at La Hague are provided between parenthesis.

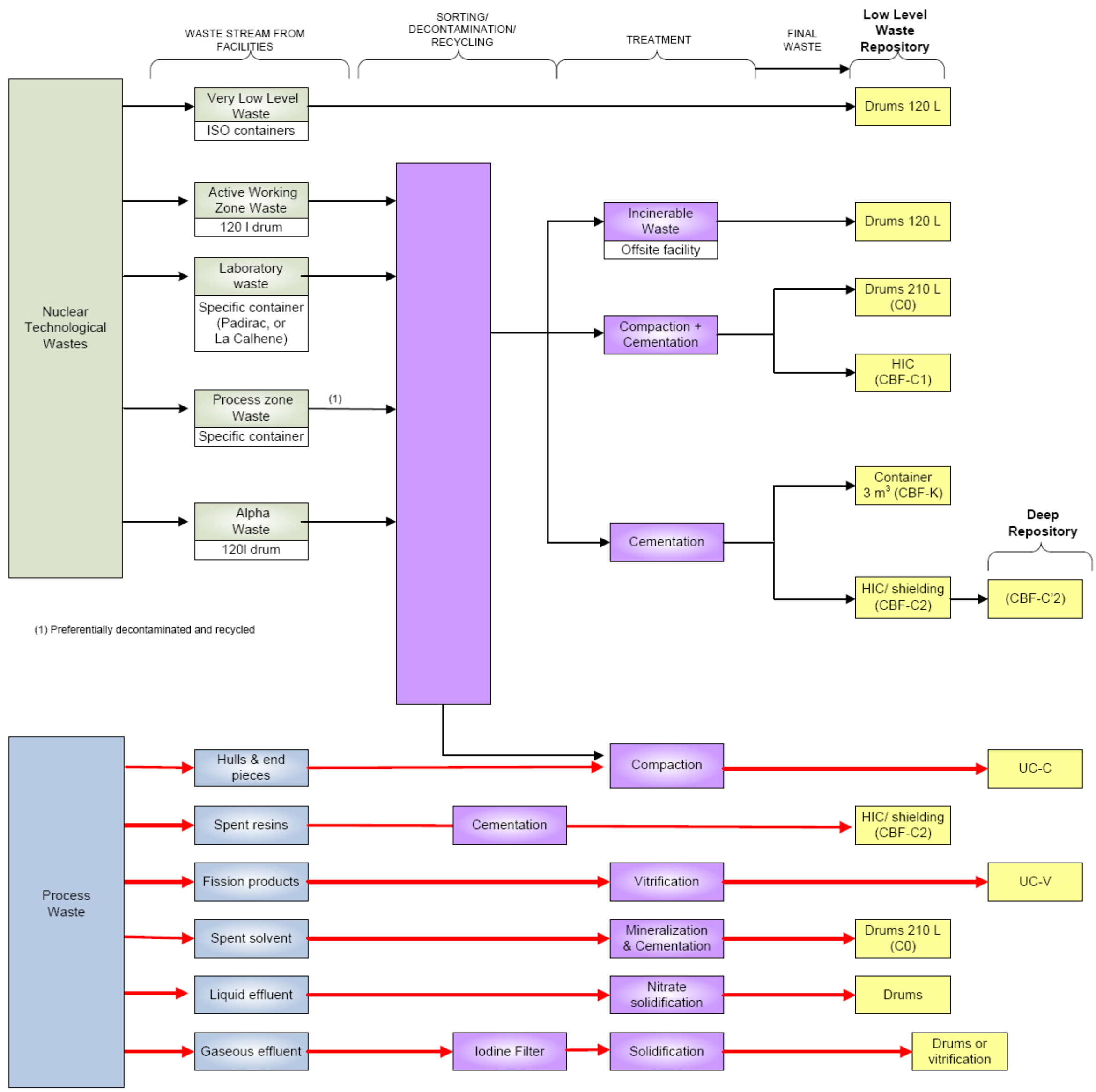

Figure 1- Waste Management Diagram

More than 99% of the beta and gamma activity from the fuels is conditioned in glass canisters along with the fission products responsible for those radiations. Hulls and end pieces are compacted in a 25,000 kN press, then inserted into universal canisters geometrically identical to vitrified glass canisters.

Additional process wastes are those arising from solidification of excess nitrates, and conditioning of iodine as a solid waste. Nitric acid is used throughout the recycling process. Although it is recovered from the effluents and reused in the process, it is expected that more nitric acid or nitrous oxide will be used than can be recycled, effectively generating an excess of nitric acid that will have to be disposed of. The INRA preliminary design of the Integrated Fuel Recycling Facility provides for neutralization and solidification of this excess nitric acid. Since the plant is assumed to be located inland, iodine has to be trapped and conditioned as solid waste. The most adequate waste form is under investigation and development in Japan, to be implemented at Rokkasho plant. For the same reason, tritium will also have to be trapped and conditioned. Existing tritium trapping and conditioning technologies are being evaluated.

Metallic nuclear technological wastes are mixed with hulls and end pieces and compacted together. Most of the other technological waste will be condition in a centralized grouting facility, using different waste package (called C0, CBF-C1, CBF-C2, CBF-K, CBF-C’2) depending on their nature and their toxicity, to provide adequate waste package characteristics with respect to transportation regulation and final repository criteria:

- C0 are essentially 55-gallon drums (210 L), where 5 120-L compacted drums are immobilized in concrete. They provide adequate conditioning for low level waste technological waste (gloves, overboots, valves, etc…).
- CBF-C1 are containers with high durability and mechanical resistance similar to U.S. High Integrity Container (HIC). They provide a fiber concrete shell to C0 packages when required by transportation or final repository criteria.
- CBF-C2 are similar but larger version of the C1 package. They typically receive irradiating technological wastes from the most active parts of the facility, or spent resin from pool water treatment.
- CBF-K, with their 3.1 m^3 internal capacity, provides room for large, low activity technological waste that would not fit in previous waste packages.

The choice and implementation of those waste packages in existing facilities have been supported by an extensive R&D program in order to acquire thorough knowledge of long-term waste package behavior [5]. Those waste packages have been designed to provide not only a high mechanical integrity but also good radionuclide containment.

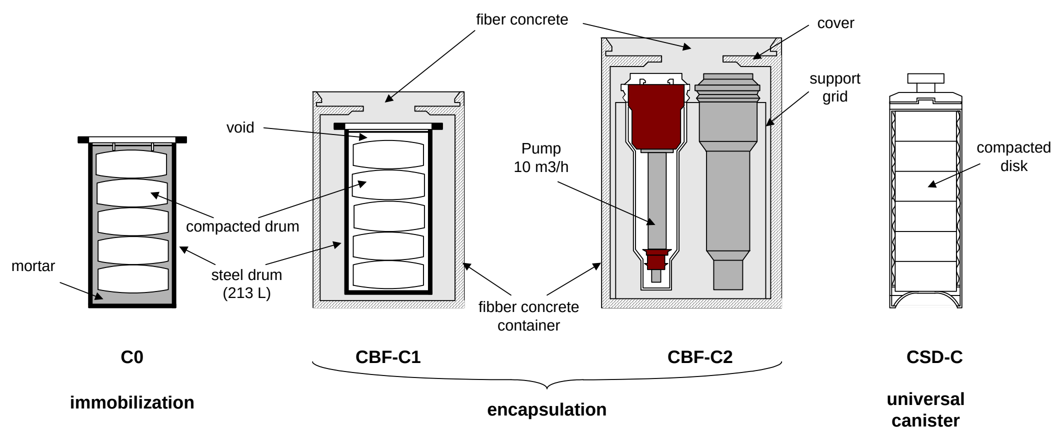

Figure 2- Solid Waste Conditioning

CONCLUSION

Knowledge, design, and operational know-how accumulated by AREVA in its existing nuclear activities have already been put to good use in its existing facilities, especially its reprocessing and recycling facilities, to reduce both the volume and the radiotoxicity of the waste. This experience and the step by step improvement it made possible are the result of a comprehensive waste management approach.

As part of a sustainable fuel cycle, and to ensure a minimal impact from nuclear waste, this accumulated experience is made available as a starting point for the preliminary design of the Integrated Fuel

Recycling Facility. Within the frame of the US regulatory and infrastructure context, the potential for further optimization will be studied in the next design steps. It has been emphasized by all the participants to the GNEP tender that the implementation of recycling would require some reorganization of the national regulatory and waste management schemes, and that wasteform qualification should be integrated into the early licensing activities for a recycling facility [6], [7], [8].

REFERENCES

[1] Energy Information Administration, “Annual Energy Outlook”, DOE/EIA-0383 (2008), 2008

[2] Department od Energy, “Draft Global Nuclear Energy Partnership Programmatic Environmental Statement”, Oct. 2008

[3] P. Pradel, P. Fournier, P. Miquel, C. Veyer, “Waste Minimization and Management along Processing and Recycling of Nuclear Material”, *Waste Management, 1998*

[4] G. Neliaz, J.C. Dumont, F. Drain, V. Londres, “Management of Solid Waste in the Nuclear Fuel Cycle: COGEMA’s Solution”, *European Nuclear Congress 2002*

[5] V. Londres, P. Fournier, R. Do Quang, “Management of Waste from the French Nuclear Fuel Cycle : What are the Key Issues ?”, *International Youth Nuclear Congress, 2000*

[6] K. McCARTHY, “*The future of the Nuclear Cycle*”, WM’08, Phoenix, 2008

[7] A. DOBSON, “*Advanced Fuel Cycle Waste Management – Challlenges and Issues*”, WM’08, Phoenix, 2008

[8] D. DAVIDSON, “*Waste Management Approach – INRA findings for GNEP studies*”, WM’08, Phoenix, 2008