Radioactive Waste Management in a Treatability and Optimisation Perspective – 17527

Arne Larsson *, Maria Lindberg *, Gregor Krause*
Jean-Francois Rives**, Jeremy Buttin ***

* Cyclife Sweden, ** Socodei, ***EDF DPD2

ABSTRACT

In order to meet recycling criteria or to fulfil Waste Acceptance Criteria (WAC) for disposal there are many different management concepts for radioactive waste that can be applied. Which concept or set of concepts to use to optimize waste management depends on several factors, among them, the regulatory framework for recycling, the availability of a disposal facility and the acceptance criteria for disposal.

The required pre-treatment and other pre-disposal activities should be carefully analyzed for each of the disposal options, as they are significant contributors to the total cost for managing the waste.

Waste Acceptance Criteria are living documents that should be updated when regulatory framework changes as well as when new treatment methods and new packaging and barrier systems develop.

Each waste treatment facility, has its own specific limitations and therefore its own WAC/CFA (conditions for acceptance), which depends both on the plant design and national legislation.

Many waste owners, countries or licensees, have their preferred, and in some cases well established, waste routes for certain waste streams. In some countries, the full chain from waste treatment through to disposal of radioactive waste is in place, whilst other countries still are in the process of establishing their repository program.

The worst case scenario for any licensee or waste owner is waste which is not possible to qualify for disposal. This can be due to poor or degraded waste containers, unspecified content in waste packages, or wastes that are not suitable for disposal in their current form. Such deficiencies result in expensive actions related to waste retrieval, new characterisation and/or costly investigations.

The EDF Group has a fleet of waste treatment facilities and has, for decades, provided waste treatment services to domestic and international customers. This paper will discuss important waste owner considerations and EDF experiences related to the optimization of the waste management process. This will be from both a treatment and an end-state perspective.

INTRODUCTION

EDF is a large electricity generator with operating nuclear reactors in France and in the UK. One important sector in the EDF nuclear operations chain is the efficient and safe management radioactive waste.

The EDF Group has the unique advantage of being both a large NPP fleet operator and, in parallel, a decommissioning and waste management specialist. In 2016 the waste management capabilities within the EDF Group were further strengthened by the acquisition of the Studsvik waste treatment organisation. The acquisition included Studsvik’s facilities for waste conditioning and the recycling of materials suitable for clearance after treatment.

Development of innovative cost effective solutions for waste treatment and decommissioning is becoming an increasing focus both within the EDF Group and globally.

RADIOACTIVE WASTE MANAGEMENT IN A LIFE CYCLE PERSPECTIVE

Waste composition characteristics through the life cycle

Throughout the life cycle of a nuclear facility, the waste composition, as well as the volumes of radioactive waste generated, excluding nuclear fuel, differs significantly.

During the normal operating phase, significant amounts of dry active wastes (e.g. protective clothing and plastics) are produced. Different types of water treatment residues such as ion exchange resins (IER), sludge and filters are also a significant waste stream. The radioactive dose rate of the regular operational waste spans from potential contamination up to hundreds of mSv/h. The vast majority of the waste has a typical dose rate of less than 1 mSv/h.

Another waste stream arising during the operational phase is waste related to maintenance and facility changes, for example, replaced components. During outages for upgrades or modernization the volumes of waste can be significant, up to several thousands of tonnes. The radioactivity of maintenance waste also spans from potential contamination up to hundreds of mSv/h of dose rate. The dose rate of the maintenance waste entirely depends on which part of the facility the work is carried out in. During operational life, the vast majority of the waste mass has a dose rate below 1 mSv/h.

During the decommissioning phase, the waste proportions will to a large extent be totally different, and the waste volumes generated annually, in an efficient project, will be significantly larger. A large portion of the waste or material can be classified as potentially radioactive. Only a small part of the waste has a dose rate above 1 mSv/h.

A comparison of the typical waste compositions during normal operations, upgrades/modernizations and decommissioning is given in figure 1. It should be noted that there can be significant variations due to plant and project properties.

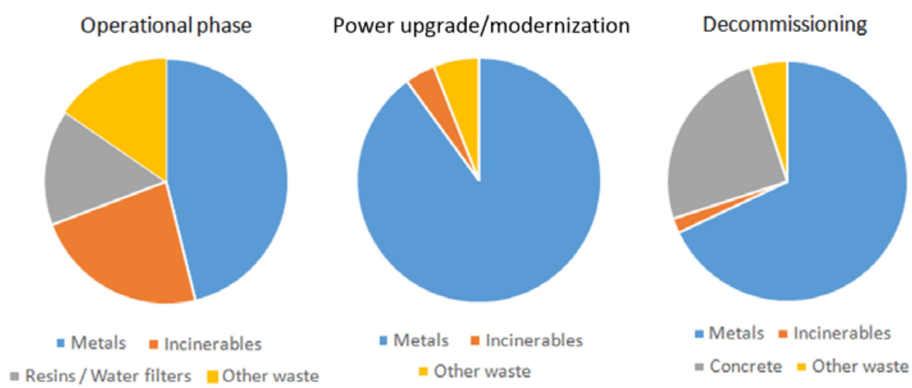

Fig. 1. Composition of waste.

As seen in Figure 1 the compositions for the upgrade and the decommissioning phases have some similarities while the normal operation phase differs significantly.

Waste owner considerations

EDF as a plant owner and therefore a significant waste producer, has implemented or is planning to implement safe and optimized management routes for all waste types that are or will be produced. In addition, all waste routes are constantly scrutinized and enhanced as needed, taking benefit from technological developments and experience.

Through experience, EDF has learnt that managing radioactive waste is essential in all phases of the facility lifecycle. In order to optimize waste management, proper characterization, careful segregation and efficient treatment are key factors. Other important tasks include planning and recording of data and knowledge management, which is of great importance.

The most cost efficient approach to radioactive waste management is “avoidance”, i.e. to implement routines that make avoiding generating unnecessary waste volumes the easiest option. Operational changes to reduce the generation of waste can be done in any facility, while physical modifications to reduce the waste generation are more challenging and expensive. This becomes obvious in older facilities designed decades ago when back-end issues were less in focus.

When it comes to new build, EDF is committed to optimizing the design of the nuclear power plant in order to minimize, as is reasonably possible, the amount of radioactive waste generated throughout the facility life cycle. This includes the decommissioning phase, many decades in the future. Designs generating waste that cannot be managed and disposed of using an existing or known process are not accepted.

EDF GROUP WASTE MANAGEMENT CAPABILITIES

To meet the needs within EDF Group along with providing other waste generators with efficient waste treatment services, investments have been made in treatment facilities, methods and above all in competence. Below are the management possibilities for some example waste streams described.

Dry Active Waste (DAW)

As Dry Active Waste (plastics, paper/cardboard, wood, fabrics etc.) normally has a low density as well as properties (content of complexing and chelating agents etc.) that are likely to be restrictive for disposal, treating DAW is Good Practice. Due to its low density, DAW will also take up a large volume in any repository and as repositories are finite resources, treatment is again Good Practice.

DAW can be compacted to reduce the volume, however, a larger volume reduction can be achieved through incineration which also ensures the destruction of unwanted properties.

EDF group operates two incineration facilities for its own needs and for providing services to other waste generators.

In France the Socodei facility Centre for treatment and conditioning (CENTRACO) has a capacity of 3,000 tons/year for solid waste but can also treat liquids with a capacity of 3,000 tons/year. The radiological limitation for total beta and gamma emitters are < 40,000 Bq/g and for total alpha emitters < 370 Bq/g.

In addition to the CENTRACO facility, EDF group operates a facility in Sweden. The Swedish facility (on the Studsvik site) has an incineration capacity of 500 tons/year and limitation on total beta and gamma emitters of < 8,000 Bq/g and total alpha emitters < 80 Bq/g. The Swedish facility is specialized in closed, customer specific, campaign operation.

In addition a pyrolysis facility with a licensed capacity of 100 tons/year is available for certain waste streams.

Liquid waste

During the operational phase of NPPs and other nuclear facilities, liquid waste streams like water based solutions, oils and solvents are generated. Some of these liquid waste streams cannot be treated and released by the operator.

Waste packages containing free liquids, in most cases, cannot be disposed of in a radiological waste repository. Typically the WAC prescribes that all liquid waste forms have to be transformed into a solid state.

In France, this has been resolved by EDF in two ways. At the CENTRACO facility there is a centralized storage for liquids which are then treated at the onsite incineration facility. EDF also has the opportunity to use a mobile unit for concentrate stabilization locally at the NPPs. The Swedish facility also treats certain liquids by incineration.

Ion Exchange resins (IER)

As the variation in dose rates and activity content in ion exchange resins is large, treatment and disposal, as well as transport on public road, is challenging. In order to meet these criteria, mainly in France but also in other countries, the "Mercure" system was developed. The "Mercure" is a mobile treatment system, see figure 2, which can be transported by road in a set of ISO containers. It is designed mainly for IER's with higher dose rates (primary circuit cleaning of NPP) and using this process, high dose resins are embedded in a stable polymer matrix. The final waste package is qualified for road transport and disposal at the Centre de l'Aube facility in France.

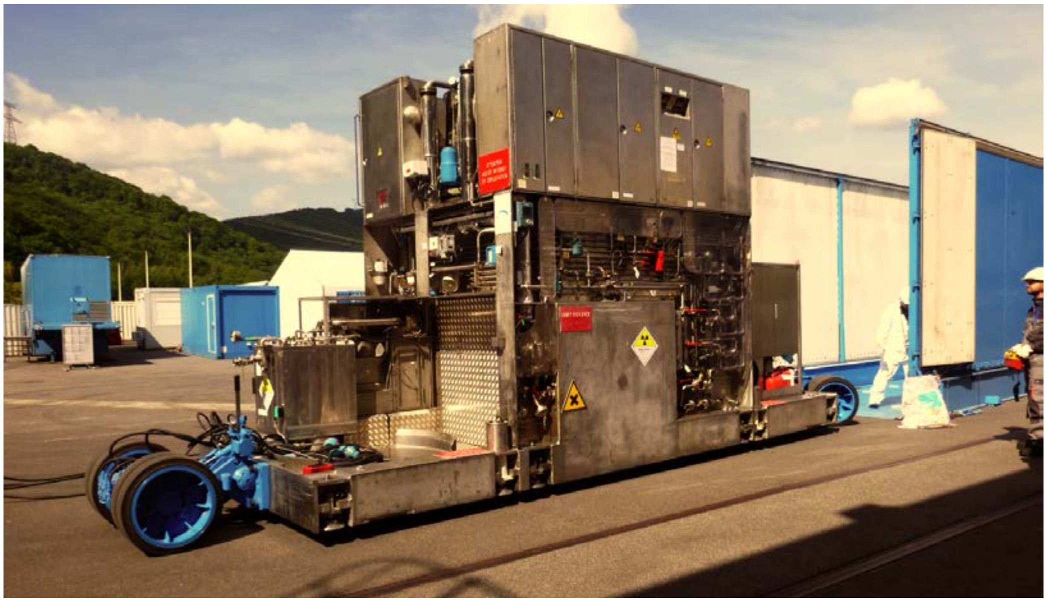

Fig. 2. MERCURE resin treatment equipment.

Both the French and Swedish facilities can treat Low Level resins by incineration.

Metallic scrap and large components

The metal waste arising during operation, maintenance and upgrades can be categorised into metallic scrap and large components. In order to minimize metallic waste, decontamination with subsequent recycling through to clearance, with or without a melting step, is Good Practice. Recycling of metals is subject to regulatory frameworks that are country specific.

EDF Group treats metals at three locations, France, UK and Sweden. Two of these sites, in Sweden and France, have melting facilities. In the UK, EDF operates a Metals Recycling Facility, applying processes for decontamination and clearance. At the facilities carbon steel, stainless steel, aluminium, brass, copper and lead are treated. In Sweden and in the UK the aim is to recycle the metals outside the nuclear industry whilst in France, the aim is volume reduction for disposal as well recycling within the nuclear industry.

Waste acceptance criteria for the two melting facilities are:

Swedish facility:	50-100 Bq/g for beta/gamma emitters (aiming for recycling by clearance) 100 Bq/g for alpha emitters
French facility:	20,000 Bq/g for beta/gamma emitters 370 Bq/g for alpha emitters

Large components

Treatment of large components results in a significant reduction of the disposal volume and it may also have a major impact on the repository infrastructure and safety case (reduction of void etc.). Over the last 25 years, several large components originating from European NPPs have been treated at the specialized facility for large components located at the melting facility in Sweden. Transporting large components off-site for treatment in a specialized facility, has been proven to be an efficient alternative to on-site treatment and direct disposal. Magnox boilers, see figure 3, PWR steam generators, BWR re-heaters and turbines, fuel casks and reactor vessel heads are all examples of large components that has been treated during the last 25 years.

Fig. 3. Magnox Boilers (310 t each) for treatment.

In the last few years, several large components from France have been treated at CENTRACO such as fuels racks, heat exchangers and tanks.

In Sweden, large components of up to 400 tons in weight and 25 meters in length can be safely transported and treated by decontamination, size reduction and melting for recycling. The current limitation at CENTRACO is 200 tons in weight and 19 meters in length.

Volume reduction of up to 98% and a recycling degree of the metal of 95% has been demonstrated [1, 2].

Slightly or potentially contaminated waste

During the life cycle of a nuclear facility significant volumes of waste which are potentially contaminated or contaminated below the threshold values for recycling by clearance are generated. Especially in the decommissioning phase, large volumes of waste in these categories will be generated.

A dedicated facility for clearance measurements with a heavily shielded measurement cell at the Swedish waste treatment facility serves both the domestic and international customer needs.

DISCUSSION

The track record from decades of waste treatment in EDF's facilities incorporating new facilities and methods over time shows the benefit applying diversified and optimised methods in pre-treatment, treatment and conditioning.

Significant volume reduction can be achieved as illustrated in figure 4.

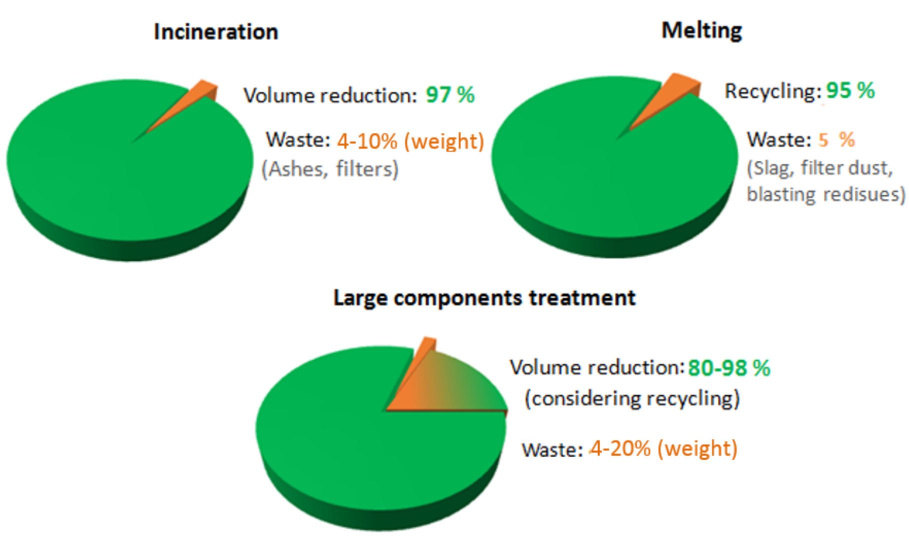

Fig. 4. Volume reduction by waste treatment.

In addition to cost savings, volume reduction and recycling within the nuclear sector or to open market (clearance) saves disposal volume in the limited resource of repositories and limits environmental impacts.

We are fully convinced that the same basic approach can be applied on waste from decommissioning as has been done during the operational phase. Some services may not be needed during decommissioning while others will have to be added or scaled up. Research and development activities in new technologies and services are performed based on in house needs as well as external requests.

The lessons learned from large modernisation projects are considered very helpful for us both as a facility owner and as a waste treatment organisation.

CONCLUSION

Waste volume reduction, conditioning for safe disposal and treatment for recycling is found to be sustainable, as well as attractive, from several perspectives.

To guarantee success in material management and waste conditioning, the following well known factors are given priority:

- Secure Experience, Competence and Understanding
- Secure access to specialized treatment facilities
- Secure access to recycling and alternative disposal routes
- Focus on Structure and Logistics
- Implement Safe, Effective and Robust processes
- Do not forget Stakeholder dialogue and involvement

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