MANAGEMENT OF RADIOACTIVE WASTE (VLLW, LLW AND ILW) PRODUCED BY EDF NUCLEAR POWER PLANTS

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ABSTRACT

EDF's network of operational nuclear power plants includes 58 pressurized water reactors (34 x 900 MW, 20 x 1300 MW and 4 x 1450 MW).
If the waste arising from reprocessing of spent fuel is disregarded, operating waste from nuclear power plants can be categorized as follows:

- Process waste
- Technological waste

Waste package volumes have been driven down considerably thanks to a policy of at-source waste reduction and optimised conditioning introduced in the mid-1980s.
Production of conditioned radioactive waste, in terms of the volume of final storage-ready waste packages, after peaking at almost 400 cubic meters per reactor in 1985, has fallen steadily, stabilizing at around 99 cubic meters in 2003.
Another way of looking at the reduction achieved is to express waste package volumes as a function of net power generation. From a peak of 80 cubic meters/TWh, radioactive waste production fell to 13,6 cubic meters/TWh in 2003.
Incineration and melting facility (started in 1999) of low-level radioactive waste gave a new industrial solution for treating radioactive operating waste, while reducing the volume of final waste packages to be delivered to the Aube surface disposal facility.
In the other hand, new constraints due to the new rules of management of VLLW:

- In 1996, the EDF rule for very low radioactive waste acceptance conventional pathway was repealed
- A new EDF rule (in 2000) makes any waste generated in controlled areas to be considered as radioactive.

The consequences of these new rules induced a large volume of waste which had to be stored on NPP and that had lead to these main problems : safety risks and radioprotection impact. Finally, EDF has decided to define a new concept of Interim On site LLW storage.
The dedicated VLLW (Very Low Level Radioactive Waste) repository, which has opened during the summer 2003 will be able to accommodate a part of volumes of VLLW already stored on site and the waste generated by the decommissioning.
The main actions in the future are:

- Implementation of the new "facility zoning" where "nuclear waste" areas and "conventional" waste areas are defined,
- Segregation of waste according to the facility zoning process,
- Waste treatment on line,
- Optimisation of the waste treatment and conditioning process with a cost approach

INTRODUCTION

The EDF Group is an integrated energy company made up of a network of different companies. A leader in electricity generation and distribution, the Group has an installed capacity of almost 122.6 GWe. The EDF Group supplies energy and services to 41.6 million customers worldwide, including 35.6 million in Europe.

The EDF Group covers all the energy activities: energy management (generation,trading, optimisation), transmission, distribution, supply and energy services.
In all its activities, the EDF Group associates respect for the environment, social responsibility and innovation within a framework of economic performance. The EDF Group's defined the strategic principles it has set to become a showcase in energy and sustainable development.

In France, EDF manages a nuclear fleet of 58 units on 19 sites with continually improved efficiency and no greenhouse gas effect emission. Nuclear energy has been a choice signifying energy independence, economic efficiency and respect for the environment in complete safety. The first reactors were built between 1958 and 1966 and belonged to UNGG technology (Untreated Uranium, Graphite, Gas). These reactors are now being dismantled. EDF then adopted an efficient and low cost technology: the pressurised water reactor.
The French nuclear fleet now includes thirty-four 900-megawatt units (the first to become operational in 1977 was Fessenheim), twenty 1,300-megawatt units and four 1,450-megawatt units.
Over 80% of the electricity generated by EDF in France today is generated at nuclear plants.

Safety and the environment : Two priorities
The safety of our power plants is a key priority. The nuclear industry is governed by very strict regulations and supervised by an independent security authority. Our regular internal controls are reinforced by national and international inspections, enabling us to be sure at all times that our power plants operate at maximum security levels.
Reducing the environmental impact of power plants is another absolute priority. Nuclear energy effluents and emissions are controlled by French and international authorities. Although they cannot be totally cut off, they were reduced by a factor of 15 between 1991 and 2001 (except for tritium).

RADIOACTIVE WASTE MANAGEMENT

Waste Management Principles

Radioactive waste management is based on the following principles :

- The responsibility of the waste producer,
- To assess, manage and prevent the environmental impact of our liquid and solid radioactive waste in respect to regulatory frame,
- Implementation of a quality system and waste traceability,
- Global process in order to take advantage of the standardization of the NPP,
- Public information based on the responsibility of EDF and transparency,
- Cost optimisation

Radioactive Waste Categories and Disposal Channels

The four categories of radioactive waste, VLLW, LLW, ILW and HLW, for which the management is regulated, are determined by the radioactivity, nature, and half-life of the isotopes that they contain.
The table below shows the stage reached in implementation of the different waste management channels, notably the final disposal channel adopted.

Table I. Existing or future disposal channels for the main solid wastes and for residues resulting from radioactive effluent treatment

<table>
<tr><td>Activity \ Period</td><td>Short lived</td><td>Long -lived</td></tr>
<tr><td>Very Low Level (VLLW)</td><td>Surface disposal at the Morvilliers repository (ANDRA)</td><td>Conversion of current storage areas into disposal facilities under investigation</td></tr>
<tr><td>Low Level (LLW)</td><td rowspan="2">Surface disposal at the Aube repository (ANDRA)</td><td>Dedicated disposal facilities planned for waste containing radium and graphite</td></tr>
<tr><td>Intermediate Level (ILW)</td><td>Waste management channels being devised in the framework of law 91-1381 of December 30, 1991</td></tr>
<tr><td>High Level (HLW)</td><td colspan="2">Waste management channels being devised in the framework of law 91-1381 of December 30, 1991</td></tr>
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Category VLLW:

Until 2003, the situation was problematic for substances with less than 100 Bq/g of radioactivity for artificial radionuclides or 500 Bq/g for natural radionuclides (called waste of very low activity, TFA), no disposal site for these particular wastes existed. Now, the VLLW can be disposed in the surface disposal at the Morvilliers repository (managed by the French radioactive waste management agency, ANDRA).

The definition of VLLW in France is independent of any dose constraint or minimum activity level. The prime criterion for VLLW segregation from conventional waste is not measurement results but primarily, the origin of the waste in the facility. French regulations require all nuclear facility to undergo a "facility zoning" process, where "nuclear waste" zones and conventional waste "zones" rare defined. A "nuclear waste zone" is a zone where items or may have been contaminated or activated.

Category LLW and ILW :

The limit between VLLW and LLW is set by the acceptance criteria in the VLLW disposal facility. These waste can be disposed of at the Centre de l'Aube (managed by the French radioactive waste management agency, ANDRA).

Category HLW:

EDF is playing an active role in the research programme, established by law in 1991, which aims at developing best practices for radioactive waste management. As planned in the French law, the possible solutions will be debated in Parliament before becoming law in 2006.

EDF provides technical and financial support for the CEA (Atomic Energy Commission), developing solutions for the disposal of highly radioactive waste, or for the ANDRA (National Agency for the Management of Radioactive Waste) which is building an underground laboratory at Bure (Marne) to conduct waste storage research into deep geological strata.

EDF RADIOACTIVE WASTE

General Overview

Production of conditioned radioactive waste, in terms of the volume of final storage-ready waste packages, after peaking at almost 400 cubic meters per reactor in 1985, has fallen steadily, stabilizing at around 99 cubic meters in 2003. This achievement is reflected in the graph of waste generation (see Figure 1).

Another way of looking at the reduction achieved is to express waste package volumes as a function of net power generation. From a peak of 80 m^3/TWh, radioactive waste production fell to 13,6 m^3/TWh in 2003.

The total volume of radioactive waste delivered at the Centre de l'Aube is 7100m^3 in 2003.

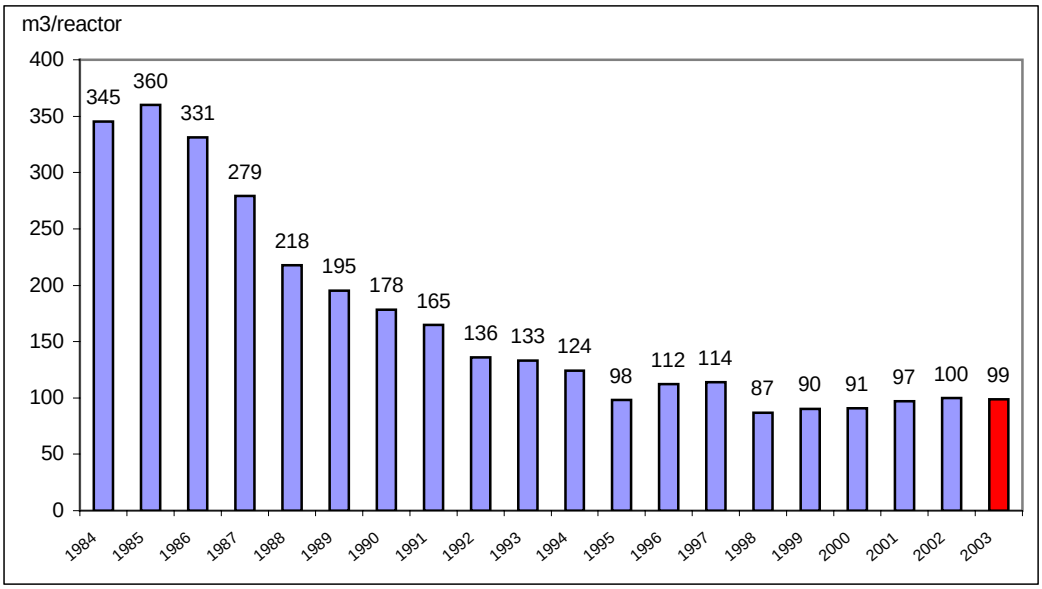

Fig. 1. Graph showing reduction in total volume of radioactive waste package (LLW and ILW) produced by 900 MW and 1300 MW reactors.

Waste reduction at sources has been obtained mainly thanks to a good overview of liquid treatment means and limiting contaminable materials (PVC films...) in controlled areas. Good practices pointed out for efficient sorting and compaction of maintenance wastes and dismantling or shredding of ventilation filters have been promoted and generalized. To avoid generating « hazardous wastes » during particular operations, everybody is invited to wonder whether a suitable outcome for this waste exists or not.

Incineration and melting of low level radioactive waste in Centraco since 1999 unit have brought a reduction in the volume of waste packages disposed of at the Aube surface repository.

If the waste arising from reprocessing of spent fuel at Cogema's plants and activated materials (ILW, long lived emitters) are disregarded, operating waste from nuclear power plants can be categorized as follows:

. 'Process' waste, mainly comprising:
- Ion exchange resins,
- Evaporator bottoms, sludge,
- Water circuit filters,
- Air filters (including iodine traps),

. 'Technological' waste:
- A wide range of solid waste, including rags, paper, cardboard, plastic sheets and bags, polyethylene, rubber, glass, clothing, wood, small scrap metal parts, rubble, small shot, sand, etc.
- In liquid form, comprising mainly oil and small volumes of lubricants and organic solvents used for decontamination.

Among these waste, some of them have only one treatment/disposal option, other two and the last none.
In 2004, The operating channels are the following :
- Direct disposal of at Centre de Morvilliers (VLLW),
- Direct disposal of at Centre de l'Aube (LLW and ILW),
- Treatment (incineration or melting units) in Centraco before final disposal.

Of course, in all the waste management steps the cost have to be taken into account. The average cost (conditioning, transportation and disposal) for VLLW is about 1 k€/ton and for LLW/ILW between a few k€/t and 60 k€/t. For LLW/ILW the most important costs are the conditioning of active resins by the mobile unit.

Only One Option

The waste that has only one option for treatment and disposal are the waste with:
- High activities (ion exchange resins, filters and irradiated solid waste) and disposed of at Centre de l'Aube,
- Physical characteristics not compatible for direct disposal without a previous treatment, these waste are mainly oils and solvents

<u>The ion exchange resins</u> (ILW):
Ion exchange resins generated by the primary circuits considered as ILW are the second main source of NPP beta gamma activity (45 % of NPP beta gamma activity delivered at the Centre de l'Aube), the average production is 140 m^3/year.
By now, EDF uses the MERCURE mobile unit (designed by SOCODEI) since 1996. The spent resins are mixed with a polymer, this matrix ensures the containment of the radionuclides. The containers are concrete container with steel shielding. In 2004, a second MERCURE unit has been come into service.

<u>The water filters and the irradiated solid waste (ILW)</u>

The concerned solid waste has a dose rate greater than 2 mGy/h. Waste is conditioned in concrete container and immobilized with a hydraulic binder. If necessary, biological protections are introduced into the container. The process must ensure the containment of the radionuclides moreover containers used are concrete containers with high performances. These waste packages represent 45 % of NPP beta gamma activity delivered at the Centre de l'Aube, and about 1000 waste packages per year.

Oils and solvents (VLLW)
Since 1999, oils (2.5 cubic meters per reactor per year) and solvents (3 to 10 cubic meters per year for all NPP) with low levels of contamination are incinerated in Centraco units. After immobilization with hydraulic binder the ashes are disposed of at the Centre de l'Aube.

Several Options

Solid waste (VLLW and LLW)
Low level solid waste coming from maintenance operations and represents the most part of the total NPP waste volumes. Waste is precompacted on site and conditioned in 200 litres steel drums. At the Centre de l'Aube, the waste packages are treated at the compaction facility with a 2000 tons press and concreted in 485 litres drums before disposal. Since 1999, a great part of the waste are treated in the incineration and melting facility. Then the ultimate waste, ashes and ingots, are disposed of at the Centre de l'Aube.
The opening of VLLW disposal centre and the sorting of waste will permit to use this new route.

Ion exchange resins (VLLW and LLW)
Low-level radioactive ion exchange resins (from treatment of steam generators blow downs) are incinerated or disposed of at the VLLW disposal. The annual production is about 400 m^3 per year.

Evaporator bottoms and sludges (VLLW and LLW)
Waste coming from liquid treatment effluent of NPP is treated by evaporation. The concentrates average production about 260 m^3 per year) are immobilized with a hydraulic binder in a concrete container, for the sludge the same process is carried out. Since 1999, a second route is available for this waste, the incineration unit and became the main option.

No Options

Outside the scope of the operating waste currently conditioned and delivered to the disposal centre, certain specific waste types are placed in interim storage at power plant sites or at national facilities, either to enable radioactive decay, or due to the current absence of treatment/disposal solutions. These comprise mainly the following operating wastes

Waste with asbestos
In NPP, only a few quantity of asbestos is used. Only few technical materials (seal, valve, fire barrier...) contain asbestos. The potential final disposals are the Centre de l'Aube (LLW) and the Centre de Morvilliers (VLLW) but today no final approval for disposal has been given.

Hazardous waste:
Some of the waste produced, generally VLW, contain toxic elements as mercury, cadmium. It's the case of electronic compounds, batteries, fluorescent light tubes. The disposal of these type of waste is under study.

Sealed sources:
The disposal of sources is forbidden and a national project relative to the elimination of sources is under progress. The final option will be a direct disposal according to the radionuclide and the level of activity or destruction before disposal of.

Activated materials:
This waste category includes large or highly-radioactive reactor components (control rod assemblies, flux thimble….) currently in interim storage in spent fuel pits, and destined for deep repository due to their high levels of activity

INTERIM ON SITE STORAGE FACILITY

The lack of free release criteria and the new constraints due to the new rules of management of VLLW:

- In 1996, the EDF rule for very low radioactive waste acceptance in conventional pathways was repealed (VLLW ion exchange resins, water/air filters, oils and solvents were concerned),
- The new EDF rule (2000) makes all waste generated in controlled areas to be considered as radioactive,
- The delays of incineration and melting (only started in 1999) previously, since 1995,
- The delays of VLLW final disposal (only started in 2003),

Have the consequences to accumulate a big quantity of waste on site: 10,000 tons of waste had to be stored on NPP sites with a lot of difficulties to decrease quickly this stock. . EDF had to find a solution in order to manage properly waste on site.

In order to limit the safety risks due the « congestion » of interim storage buildings initially designed for metallic drums and concrete casks:

- Safety (risk of fire due to the presence of oils and solvents),
- Radioprotection (high dose rates in and outside buildings)

EDF has decided upon the concept of an open on-site containers storage facility by following hard conditions of radiological cleanness.
In 2004, 19 storage facilities are in operation and the waste has been transferred to these storage sites.
The main requirements into the storage facility:

- The limitation of waste activity according to the type of waste,
- « Two barriers ": most of waste are conditioned in metallic drums or boxes then in containers IP2 – 20' (one exception: « watertight » boxes for scraps)
- No activity inside the facility except shipping of closed casks generally filled when they enter the facility
- Containers with tanks or drums inside are equipped with their own retentions
- Before shipping to the facility all casks (containers: internal/external; drums, boxes, tanks: external) are controlled at 0,4 Bq/cm^2
- Parts of ground are controlled by taking smears or quarterly with a specific device,
- Absence of water in containers' retentions,

FUTURE PERSPECTIVES AND CONCLUSIONS

Number of improvements has been introduced in relation to conditioning processes and installations during EDF's 30 years of radioactive waste management experience.

In the future, the main concerns will focus around the following axes:

- For the waste without pathway, to continue the study of the potential pathway with ANDRA and Safety authorities. For the waste with existing channels, the efforts must be carried out the optimisation (economical and technical) of the complete process and the search of channels in some cases.
- Another topic is a better sorting of waste according to the "nuclear waste" zones and conventional waste "zones" implemented in all NPP.

In making sustainable development a priority, the EDF Group is committed to responsible industrial behaviour and to taking every measure to identify and reduce the impact of its power generating plants on the environment. This has been achieved by the ISO 14001 certification of all the sites

At least and because a suitable issue for VLLW, LLW and ILW (short live) are by now available the next challenge is to assess the best outcome for ILW (long live) and HLW.