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DECOMMISSIONING OF NUCLEAR REPROCESSING PLANTS FRENCH PAST EXPERIENCE AND APPROACH TO FUTURE LARGE SCALE OPERATIONS

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1. INTRODUCTION

Over the years, France has built up significant experience in dismantling nuclear fuel reprocessing facilities.

The dismantling of a complete fast breeder reprocessing pilot plant, AT1 at La Hague, is reaching completion. A number of facilities at Marcoule and La Hague have been dismantled and refurbished, including :

- Plutonium finishing plant MA Pu (La Hague)
- Fuel storage pond (La Hague)
- Batch dissolution unit for metallic fuel at UP1 (Marcoule)
- Liquid Waste Treatment Facility at Marcoule.
- Vitrification pilot plant PIVER.
- Cs 137 source manufacturing facility ELAN II B

These examples clearly show that the operations cover various types of units representative of a modern reprocessing plant.

However, the complete dismantling of industrial plants such as UP1 or UP2 will entail additional constraints. The following aspects in particular must be considered at a larger scale:

- Safety and radiological management of the workers
- Waste management
- Productivity/cost.

These basic constraints must be considered for the future R & D orientations.

2 SUMMARY OF FRENCH EXPERIENCE

TABLE 1 -COGEMA MARCOULE						
	Facility type	**Period of operation**	**Decommissioning objective**	**Duration**	**Waste generated**	**Experience gained from the project**
UP1-line A dissolver	Dissolver of the continuous dissolution line	–	Removal of the dissolver	20 months 1984–1985	–	Decontamination and dismantling of a dissolver.
Room 53–55	Fuel decladding and dissolution facility	58–85	Dismantling of all equipment and pipes–Refurbishment	24 months 1985–1986	Liquid : 250 m^3 Solid : 330 m^3	Total dismantling of HA cells including decontamination of decladding tanks and dissolvers
Room 82–100	Pu purification facility	up to 62 62–85 : used as a storage	Dismantling of all equipments, cleaning of the walls	36 months 1985–1988	Solid : 1658 m^3	Total dismantling of alpha cells
AVM crane	Vitrification facility	–	Replacement of the crane	8 months 1987	–	Dismantling of equipment in a narrow space at a high dose rate (30 R/h)
Refurbishment of the LWTF	Liquid Waste Treatment Facility	–	Cleaning and refurbishment of 28 pools and tanks	1988–1991	Solid : 600 m^3	Sludges collection, large areas of steel liner decontamination, underwater operations by divers.
A1/A2 Vaults	Decladding facility	–	Equipment dismantling, cleaning	12 months 1990	Magnesium: 1200 l Sludges : 4 m^3 Solid : 4 tons	Collection of sludges containing pieces of fuel, underwater dismantling of equipment, underwater decontamination of the steel liner
Fission product evaporator	Pu purification facility	58–65	Removal of the evaporator and decommissioning of the room	9 months 1990	Solid : 20 m^3	Dismantling of HA equipment, concrete decontamination
Magnesium waste conveyor	Decladding facility	~ 83	Dismantling of the conveyor, decontamination of the walls and floor	24 months 1990–1991	Lead : 62 t (recycled) concrete:13 m^3 Other solid : –	Isolation of ducts using thermosetting resins. Dismantling of equipment in an active environment (Up to 20 rad/h)–Decontamination of waste, recycling of lead.

TABLE 2 : COGEMA LA HAGUE						
	Type of facility	Period of operation	Decommissioning objective	Duration	Waste generated	Experience gained from the project
Cell 907	Hulls handling system	–	Removal of process equipment	1976–1977	–	Dismantling of equipment in HA cells
MaPu/UP2	Dry processing, Pu tail end	70–83	Dismantling of all the equipment, floor and wall decontamination	31 months 1984–1986	Solid : 1800 m^3	Extensive dismantling operations in Pu contaminated environement
D1/UP2	Sea discharge pipe of UP2	– 82	Total dismantling of the pipe, onshore and offshore	84–92	Solid : 2400 m^3 (as of 6/91) Liquid : 3 m^3	Underwater dismantling work by divers; remote dismantling in a mobile containment cell onshore
S1/PLH	Hull storage pool	– 80	Cleaning of 3 halls, 6 pools, several cells and refurbishment	87–90	Solid : 4000 m^3	Pool cleaning with extraction of sludges containing fuel fragments, and other activated solid waste
Rotary distributor cell 901/UP2	HALW transfer	65–88	Replacement of the rotary distributor, cleaning of the cell	88	–	Dismantling of equipment in HA cells
Cell 911 HADE/UP2	Intercycle concentrator	– 89	Replacement of an evaporator and two condensers	89	–	Dismantling operations in contaminated cell – Sophisticated techniques have been used : explosive cutting, remote controlled scabbling...
BDH	Decontamination facility	64–90	Refurbishment of the ventilation system, including the dismantling of pipes, tanks, filters...	24 months 90 – 92	Solid : 200 m^3	The operations were carried out without stopping the ventilation system

TABLE 3 : CEA CENTERS						
	Facility type	**Period of operation**	**Decommissioning objectives**	**Duration**	**Waste generated**	**Experience gained from the project**
ELAN II B	Fabrication of Cs 137 and Sr 90 sources		Removal of all equipment, decontamination of the cells			Remote dismantling operations in HA cells using sophisticated robot equipment
ATI	Fast breeder fuel reprocessing pilot plant	69 – 79	Removal of all equipment, decontamination of the cells	85 –	Solid : 400 m^3 (as of 1991)	Dismantling of all the cells – HA cells – MA cells – alpha cells Development and use of sophisticated tools and robot equipment. Decontamination of the process pipes and tanks.
PIVER	Pilot vitrification facility	69 – 80	Removal of the main equipment, decontamination of the cell	87 – 91	Liquid : 22 m^3 Solid : 250 m^3	Dismantling using the existing remote handling equipment, and additional manipulators to increase the area covered, while keeping HALW transfer pipes active.
ATTILA	Dry reprocessing pilot cell	68 – 75	Removal of all equipment, decontamination of the cell	83 – 85	–	Remote decontamination and dismantling using the robots and tools handled by the cell crane.Removal of shielding walls
RM2	Radiometallurgy laboratory–13 cells	67 – 85	Removal of all equipment, decontamination of the cells	90 –	–	Decontamination of alpha waste by the PROLIXE (Ag II) process – Dismantling of HA cells

3 TWO LARGE-SCALE OPERATIONS : MA Pu (La Hague) and RM2 (CEA FAR)

3.1 MA Pu

MA Pu is the Pu finishing facility of the UP2–400 plant at La Hague.

Objectives of Decontamination and Dismantling (D & D)

The decommissioned units belonged to the MA Pu facility. They were in operation from 1970 to 1983.

They included solvent extraction process, oxalic mother liquor concentration, precipitation, drying, calcination, storage and packaging of Pu oxide.

The units included a total of 14 ventilated enclosures, 30 glove boxes, 2 sampling benches, and associated piping.

The final objective was the refurbishing of the above mentioned units for capacity increase, and the decontamination of the premises so as to obtain a surface contamination lower than 0.074 Bq/cm^2. Operations took place from March 1984 to October 1986.

D & D methodology

1. *Preparation phase* :

- Organizational preparation including regulatory aspects.
- Inventory of equipment to be dismantled.
- Radiological measurements.
- Drawing up of operating procedures detailing the methodology used for each glove box or enclosure and including the requisite preparatory works.
- Selection of cutting tools (electrical alternating saw, nibbling machine, hydraulic shears...).
- Installation of handling tools.
- Arrangement of working areas : implementation of plastic, ventilated air locks, and additional shieldings.
- Draining the vessels and rinsing the circuits.
- Preliminary works and cleaning the cells and glove boxes to recover the residual Pu and to reduce the activity level.

2 *Dismantling phase* :

Dismantling was performed room by room according to the following general methodology :

- Overhauling of the glove box if necessary (new gloves and filters).
- Decontamination of internal equipment and fixation with varnish.
- Transfer in vinyl bags to a glove box for cutting of equipment and structure.
- Waste removal in vinyl bags after radiological monitoring.
- Sandblasting of concrete walls and final decontamination.

3 *Final contamination control phase*

Waste management methods

The wastes are systematically inspected in an alpha room by overall neutron counting and then placed in standard ANDRA containers (1.7 x 1.7 x 1.7 m).

Results of operations

Duration :

The preliminary studies lasted 1 year (1983 – 1984), the D & D operation 2½ years (1984 – 1986).

Total wastes produced :

1312 m^3 of wastes in ANDRA caissons with an average activity level of 2.6 10^{10} Bq (0.7 Ci) per caisson.

126 m^3 of wastes in 100 liter drums containing a total of 5.8 10^{13} Bq (1566 Ci) of Pu.

Doses, manpower :

The total manpower was 94.000 hours, and the total integrated dose 29.4 rems.

3.2 RM2 Radiometallurgical Laboratory

RM2 is a radiometallurgical laboratory located in the CEA – Fontenay– aux– Roses Research center.

Objectives of D & D and present decommissioning status

Radiometallurgical Laboratory N° 2 of the Fontenay-aux-Roses Research Centre was intended to study Pu-Base fuel for fast breeder reactors. Operations started in 1967 and ended in 1985 when the laboratory was shut down to be decommissioned. D & D operations took place from April 1990 through today.

The laboratory has 13 cells of various sizes arranged in a L-configuration. Cells 7-11 constitute the "short line" and cells 1-6 form the "long line". The cell walls are made of baryte concrete 1 m thick (39 inches). Some of the cells are lined with stainless steel. All remote handling and ventilation equipment were in working order and all openings were accessible, so that the cells could be fully decontaminated and dismantled.

D & D methodology

The cells in the short line were completely emptied. The working surfaces were removed. Process equipment adjacent to the cells was disassembled. The stainless steel liners in cells 10 and 11 were removed. In the other cells, the epoxy paint on the concrete surfaces was removed using different abrasive processes. Dry ice decontamination was implemented for the walls in cell N° 9. Radioactivity mappings performed revealed that contamination did not migrate into the concrete structure of the cells. This will be confirmed by more precise measurements.

The parts embedded in biological shieldings remained in place (ventilation ducts etc). They will be removed later.

Cell 7a was completely cleaned up. This cell was a continuation of cell 7b, the partition wall being made of lead bricks. This cell was cluttered with bulky equipment (press, reciprocating saw etc) with high dose rates (2 Gy/h). Since no direct access to cell 7a was provided, remote techniques had to be used. The lead partitioning wall between cells 7a and 7b was dismantled to form a single cell arranged as a waste treatment facility to cut, decontaminate and condition equipment from other cells of the long line. The cell roof slabs were removed to extract large units. These were transferred to cell 7 through a tunnel installed above the long line to ensure alpha containment. A complementary 7000 m3/h ventilation system was started up when removing a slab in the roof or opening a cell door.

Cell 6 was used to store fuels before inspection in storage pits. It was fully emptied.The STMI dry ice process was used to roughly decontaminate the working surface and the walls. Operations were remotely controlled (MT 200 type remote manipulator).

Process equipment in cell 4 was remotely disassembled. A part of the resulting waste was conditioned in baskets intended for SIDS/SACLAY (Solid Waste Management Department of the Saclay Nuclear Research Centre). The glove box associated with this cell was decontaminated, disassembled and placed of in an ANDRA container.

Waste management methods

Waste generated during clean-up was sorted by type and activity and managed accordingly.Waste intended for ANDRA was conditioned in 200 l drums and 5-10 m3 containers.

Waste treated in the PROLIXE facility(silver dissolution of the Pu powder) or at SIDS/Saclay will be decontaminated to satisfy ANDRA's acceptance criteria (alpha activity < 3.7 MBq/kg).

4 LESSONS FROM EXPERIENCE

The operations summarized in the tables above clearly cover all kinds of units making up a reprocessing plant. The experience gained served to draw the following conclusions.

- In case of immediate decommissioning, the D & D studies must start as early as possible to allow a smooth transition between the operating and decommissioning phases.
- Overlapping of operation and dismantling is not unfeasible.
- The initial radiological and physical inventory is of utmost importance. It should be compiled during the preparatory work.
- The residual activity in the facility should be removed as much as possible prior to dismantling in order to limit the contamination dispersion risk.
- The radiological status to be reached for the building must be defined very carefully. Decontamination operations may last longer than expected and are therefore difficult to schedule. Equipment for monitoring the residual contamination on surfaces of walls, floors or equipment should be improved.
- Waste management should be planned from the start. Waste segregation and packaging should be organized according to the activity and the type of the materials to maximize the waste packages produced going to surface disposal.
- In planning the operations, priority should be given to the mecanical cells equiped with handling devices (telemanipulators, cranes) to use them for dismantling purposes. Special attention must be paid to the reliability and maintenability of the handling devices.

5 APPROACH TO FUTURE LARGE SCALE OPERATIONS

The development of new technologies for decommissioning large scale plants should be guided by three main considerations : safety, waste management and cost.

- **Safety :**

  The risk of contamination spreading is a feature of fuel reprocessing plants as compared to reactors. Dismantling operations further increase this risk (dust generating by cutting or demolition, removal of parts of the containment barriers). It can be controlled by several means : extensive decontamination of process equipment and process cells, restoring of the containment by implementation of mobile modular locks, fixation of the labile contamination by strippable varnish, adapted ventilation systems.

  Dismantling work is usually very labour intensive, and therefore means a large potential integration by the personnel. The individual dose could be reduced by limiting the presence of operators in the work area. Robots could be used or at least automated equipment, such as the SCOUTER semi–automatic cutting unit developed for large diameter pipes.These units can be installed manually in the cells but are remotely operated. However, their cost should be taken into consideration.

  Another benefit of reducing hands–on work would be to decrease the risk of accidents specific to construction sites such as load dropping, falls, burns.

- **Waste management :**

  Large quantities of waste, most of them of very low activity, are generated on dismantling sites. Cross contamination should be avoided as much as possible by proper containment, sorting and control. Waste must be segregated by type of material and activity as early as possible, at the work area.

  To avoid excessive final disposal costs, some of the waste will have to be recycled and/or returned for public reuse. Melting of low activity contaminated metal is under development in France. A 15 ton furnace has been built by CEA in MARCOULE. The production of steel waste containers is a possibility. Another final product could be shielding plates.

Technologies to reduce waste volume, such as compaction and incineration, to decontaminate as much as possible of the material for recycling, and produce waste packages adapted to final disposal requirements, must be developed or improved.

- **Cost**

  Cutting operating cost requires developing advanced decontamination techniques that would produce the lowest achievable volume of secondary wastes and allow waste recycling. Productivity could be increased by higher robotization/automation levels for some tasks.

6 CONCLUSION

French experience in decommissioning nuclear fuel reprocessing facilities is extensive, but only small or medium scale operations have been carried out so far. To prepare the future decommissioning of large size industrial facilities such as UP1 and UP2, new technologies must be developed to maximize waste recycling and optimize direct operations by operators, taking the integrated dose and cost aspects into account.