

Adapting Dismantling and Decommissioning Strategies to a Variety of Nuclear Fuel Cycle Facilities – 12237

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ABSTRACT

AREVA has accumulated over 20 years of experience in managing and operating fuel cycle facilities Decontamination and Decommissioning (D&D) projects of many different types and a variety of scales, both as facility owner (at La Hague for example) and as prime contractor to external customers such as the French Atomic Energy Commission (at Marcoule). A specific Business Unit was created in 2008 to capitalize on this experience and to concentrate - in one division - the specific skills required to be successful and cost effective in decommissioning projects. Indeed one of the key lessons learned in the past decades is that decommissioning is a significantly different business as compared to normal operations of a nuclear facility. Almost all the functions of a project need to be viewed from a different angle, challenged and adapted consequently in order to optimize costs and schedule. Three examples follow to illustrate the point: Safety management needs to take into account the ever changing configuration of a plant under D&D (a quite new situation for the authorities). Production of waste is significantly different in term of volume, activities, conditioning and disposal path. Technology is important but technical issues are often less critical than good management and planning [1]. Further examples and lessons learned are developed through reviewing the projects experience basis.

INTRODUCTION

AREVA is experienced in creating and adapting dismantling and decommissioning (D&D) strategies to a variety of nuclear fuel cycle facilities, processes, and working conditions. These include highly contaminated fuel cycle facilities containing mechanical and chemical processes, hot cells, glove boxes, fuel pools, vaults, tanks (such as used fuel recycling/reprocessing plants, mixed oxide (MOX) fuel fabrication plants, various radio-chemical plants) ; nuclear reactors containing large contaminated and activated equipment (power production reactors, research reactors) and uranium processing facilities (mining sites remediation, uranium enrichment plants, uranium fuel production plants). In addition, various types of legacy waste are often present at the sites that need to be retrieved, repackaged and sent to disposal. Some of the most challenging projects are those involving the presence of very high levels of contamination from fission products (Cs, Sr) as well as actinides (U, Pu).

The involvement in a decommissioning project usually starts long time before the actual

end-of-life of the facility. At this time the preliminary decommissioning scenario is developed and corresponding cost estimates are provided to help the owner / operator to establish its provision for future D&D.

When (or preferably before) the facility shuts down, the first task consists in establishing a detailed diagnostic to first refine the overall scenario, confirm the schedule and cost estimate and then prepare the license application for dismantling. Engineering studies are performed to define the detailed approach, analyzing technologies, processes and equipment that were used in the facility, type and quantity of nuclear materials contained, and waste management strategies. In this phase, a particular attention is devoted to the optimization of the scenario in terms of cost, schedule and risk management, the main two key factors being waste management (final form, volume and destination) and optimization of fixed costs.

The next phase consists in retrieving and recovering any significant quantity of nuclear material remaining in the plant, and then decontaminating / cleaning the rooms and equipment in order to facilitate the subsequent dismantling phase through significantly reducing residual activity and hot spots. The dismantling phase generally consists in cutting piping and other internal equipment and finally demolishing the building if required. The waste produced is very carefully sorted, processed and packaged before being sent to dedicated storage and disposal locations. Then, a special effort is put forth to eliminate residual activity from liquid and solid waste through final cleanup. After final inspection by the authorities, the buildings and recovered areas can be fully decommissioned for re-use of the land and the assets.

These five major steps are implemented consistently throughout our D&D projects, usually in order to bring facilities to contamination levels compatible with International Atomic Energy Agency (IAEA) stage II.

RESULTS

This section detail the approaches developed and results obtained at selected facilities such as the UP1 recycling plant at Marcoule, UP2-400 recycling plant at La Hague and the MOX plant at Cadarache, comparing these D&D projects, with a special focus on the development and application of lessons learned.

MARCOULE UP1 plant

From 1958 to 1997, the UP1 plant at Marcoule – located in the south of France - reprocessed and recycled nearly 20,000 tons of used fuel for special defense applications reactors as well as fuel from the first generation of electricity generating reactors in France (natural uranium fuel, CO₂ cooled, graphite moderated). Cleanup and dismantling of the UP1 plant and the associated units started in 1998. Since 2005, the UP1 facility has been operated by AREVA as a Management & Operation contractor to the CEA (Atomic Energy Commission). This is a huge decommissioning project with 14 main facilities, over 1,000 rooms and cells to dismantle and cleanup, 700 tanks, 21,000

tons of equipment (of which 2% are High Level Waste). The D&D project's end is planned for 2040.

To date the project is well on tracks with more than 85% of the radioactivity already removed from the high level areas through rinsing operation.

To date:

- The vast majority of the fuel decladding facility equipment has been dismantled.
- The entire plutonium and batch dissolution lines have been decontaminated and dismantled.
- Uranium/plutonium separation and continuous dissolution lines are currently being dismantled and detailed design is being conducted for D&D of fission products evaporators. Specific rinsing operations are being conducted on former fission products storage tanks prior to dismantling.

Cleanup & dismantling operations at Marcoule mainly consist in rinsing the circuits, using conventional reagents (that were used during the operational life of the plant) as well as more specific and aggressive chemical reagents that are more efficient to remove the encrusted material (while ensuring that such new chemicals are still compatible with the effluent and waste processing lines). For example, a program of specific rinsing operations of fission product tanks was developed in order to reach a level of 95% of low level waste when the equipment was subsequently dismantled. Then operations consist in decontaminating, cutting and dismantling the equipment themselves (pumps, filters, tanks, pipes, glove boxes, etc.) to condition them for disposal. Many challenges were faced to operate in such an old and complex facility at Marcoule, it requires the design and/or improvement of specific tools & processes while carefully balancing the pros and cons. The use of plasma torches for cutting scrap metal is a good example of a best practice deployed on our projects after successful trials. It was not obvious to qualify such a high temperature technology in a highly active environment, but the pay-back in efficiency and speed of operation is huge. For example, the highly contaminated dissolvers from the batch dissolution line were dismantled using plasma torch cutting tool (see Fig. 1) with a reduction of a factor 2 of the cutting time while providing significant additional as-low-as-reasonably-achievable (ALARA) benefits. This plasma cutting technology is now spreading out of Marcoule and used in other D&D projects.



Fig. 1 Plasma torch for cutting the bottom of a dissolver from the dissolution line

In another area, the chemical decontamination technologies and methods were systematically adapted to the equipment to be processed. A large number of cells and highly contaminated areas required the development and adaptation of remotely operated devices to conduct decommissioning operations in fully remote conditions for the most complex cases. For example, in a highly contaminated ventilation duct, AREVA has developed a small robot able to scrape and vacuum cleanup the uranium nitrate powder (Pu contaminated) inside the duct (see Fig. 2).



Fig. 2 Remote controlled tool carrier equipped for intervention inside the ventilation duct

One of the keys factor of project success was (and is still today) the “social management” consisting in training the former operators to evolve from an operational culture (40 years of activity) to a decommissioning and project management culture. Former operators are well trained to continue operating the site infrastructure that is still to be used to support the decommissioning activities (such as utility supply, waste conditioning and storage, effluent treatment stations...). The historical knowledge of former operators is also critical to maintain continuity and memory of past activities when the plant was in full operation. However dismantling, cleanup and closure is a very different business than standard operation of a plant. A dedicated project / contract management has been set up and when the workforce cannot be transferred on another plant - extensive training of former operators is mandatory to obtain optimal operational performance while ensuring an irreproachable level of safety. To create a mix team between newcomers/project managers and existing personnel/trainers is a key factor.

Another key factor is to consider safety as a priority. Personnel safety needed serious improvement. An aggressive plan was put in place in 2005 and effectively deployed on the ground with efforts from all the personnel. The team improved its safety results dramatically to achieve a zero-accident rate level over the year 2010. This is part of the despite the significant progress made in the dismantling operations (increase of the working hours by a factor of 3) , the number of radiological events declared to the safety

authorities over the 2005-2010 period remained stable, confirming the efficiency of risk management process implemented at Marcoule.

La HAGUE UP2-400 plant

UP2-400 was AREVA's first commercial used fuel recycling plant (see Fig. 3). Between 1966 and 1998, UP2 400 processed nearly 5,000 tons of natural uranium used fuel from graphite-gas power reactors, 4,500 tons of fuel from pressurized water reactors, and few tons of breeders, as well as research reactors used fuel. UP2 400 was shut down in late 2003 and replaced with two new plants: UP2-800 and UP3.



Fig.3 UP2 400 plant of La Hague

The decommissioning project was launched in 2009 and will be conducted over a 25-year period. This is another large D&D project with significant legacy material to retrieve (hulls, end pieces, resins, sludges ...) prior to starting the actual dismantling operations. There is about 32,000 cubic meter of waste to remove and process. The operation will involve 500 staff at its peak.

The project is today in the detailed planning and licensing phase. Extensive studies were performed to optimize the final scenario. A task force was established in 2008 to systematically challenge the baseline. Indeed the initial strategy developed to decommission the facility was a bit too conservative, leading to high costs. As the owner / operator, AREVA is directly responsible for the dismantling operations that are funded through the provision set aside during its operational life, there is an additional and special interest to save costs. Three major areas of progress were identified that led to reducing by more than 25% the life cycle cost of the project. The first area of progress focused on the management of the waste and its processing. Detailed assessment showed that the past tendency was to use the techniques already in place while the

facility was in operation to process the waste. But dismantling is different; it produces much more waste than standard operations. The induced cost of processing and disposal of D&D waste is a very important contributor to the final cost. New techniques were developed for example to process sludges (drying and pelletizing) instead of immobilizing in a conventional matrix which leads to much larger volume of final waste for disposal. The extent of segmentation of the solid waste was also challenged and optimized. Cutting equipment in small pieces can be very labor intensive, a tradeoff must be made between reducing the volume of the waste - and hence its disposal cost - versus increasing the processing cost in such a way that it may become much more expensive to cut it into pieces.

The second area of major progress was identified in the reduction of the fixed costs. These are the expenses related to the support facilities around the core buildings that are being dismantled (such as the utilities supply, the effluent and waste treatment plants) and the general support functions of the project (maintenance, health physics, procurement, controls ...). When switching from operations to D&D, a number of usual practices can be challenged and streamlined.

The third area of progress was to optimize the supply chain. It was demonstrated – from past experience - that simplifying the procurement process, reviewing the work packages allocation and involving the subcontractors very early in the strategy would lead to another set of significant cost reductions.

The project is currently waiting for administrative authorizations to enter into the operating phase.

CADARACHE MOX plant

Between 1962 and 2003, the Cadarache plant first fabricated fuel for fast neutrons reactors, and then it manufactured recycled MOX fuel for French, Swiss and German electrical utilities. It was shutdown in 2003 mainly due to obsolescence of the design with respect to seismic constraints.

Following 5 years of preparatory studies and material retrieval / cleanup, the dismantling operations began in 2009. Since that date, AREVA has been conducting these activities as Management & Operation contractor to the CEA, which owns the facilities. As part of this project, 422 glove boxes or glove box equivalents and 38 tanks are to be dismantled over a period of 10 years. The dismantling activities are mostly manually-operated and therefore primarily depend on worker reliability, operating expertise and training. To date, more than 60% of the glove boxes have been actually dismantled (see Fig. 4).



Fig. 4 Cell 1 of the ATPu facility of Cadarache (before and after)

The challenges faced can be summarized in the following 5 points: Manage safety; Maintain cost and schedule while working on a first of a kind D&D project; Manage Human Resources; Manage Waste and Manage Contractors. Specific approaches were successfully developed to handle these challenges.

Nuclear safety in a decommissioning project is challenging by essence. The configuration of the facility is changing almost every day when the D&D operations are in actual progress. Safety authorities are not used to this ever changing / continuously evolving situation. The key to obtain authorizations in due time is to prepare the D&D plan very early and to share it with the regulators as soon as possible. The plan shall especially be flexible enough to accommodate for unexpected events as far as possible (such as the discovery of material inventory, retained in areas impossible to investigate accurately without actually dismantling the glove box). The scenario should avoid a monolithic technical approach, plan A and plan B should be developed concurrently in order to prepare for the unexpected. Once the license is granted on the basis of one approach only it is difficult and costly to change later.

Maintaining project life cycle cost is a constant concern for such first of a kind project. The estimated cost has been stabilized thanks to exhaustive diagnostics and good knowledge of the plant history. The other important factors to avoid surprises are the preparation of the work, training of the operators, waste management and integration of the supply chain.

Managing human resources was (and is still) quite challenging in this project as it had to integrate the entire existing workforce from day one. This was recognized and taken into account as a high priority in the project from day one. Specific measures were taken to transition staff from operation to dismantling culture and skills. The strategy implemented was to start with the cleanup / material recovery step, which is very similar to normal operation with which plants operators are familiar. In the mean time a systematic training program was setup to qualify and certify operators (to become dismantlers) including coaching, a “plutonium school” and long hours working on scale-one mock-ups. Finally a thorough re-allocation plan was put in place to progressively transfer former operators to other operating plants within the AREVA complex and

switch to specialized workers for the main part of the decommissioning activities.

Waste management is crucial to maintain the cost target. Costs related to waste management and disposal (once it is removed from the glove boxes) represent more than 50% of the total project costs. Efforts are made continuously in order to minimize the quantity of High Level or “geological” waste (the packages that are too active to be disposed of in a surface repository) as compared to the Low Level and Very Low Level category. This HLW has successfully been limited to date to less than 10% of the total quantity of waste for disposal.

Managing the supply chain is also an important factor of success. Integration of the subs is a key point to ensure their appropriate level of training and safety culture. However, the contractualization is still competitive and reward is still based on performance, inducing the sub-contractors to challenge themselves and contribute to the continuous improvement of the global project performance.

Lessons learned summary

- The management of safety and personnel people in a continuously changing environment is critical to success
- The management of such D&D program requires the creation of specific project management tools and processes as well as the creation of dedicated skills and disciplines. Relevant training program must be developed.
- The facility utilities and infrastructure must be maintained in operation after the shut down, especially ventilation system and handling devices are crucial for D&D works.
- The knowledge of the initial conditions is crucial to define a credible D&D scenario however difficult to obtain. Additional investigations are often necessary but the constraints surrounding operations in a nuclear facility lead to limitations on the ability to conduct them. So, based on technical complexity, feasibility, return on investment, ALARA principle and safety case, a compromise must be found on how far we should go by weighing costs and benefits.
- The definition, production, flow, transportation, interim storage, evacuation and final storage of waste package from a facility under D&D is the backbone of D&D projects

CONCLUSION

AREVA has a long and vast experience in the cleanup and dismantling of a number of very large and complex nuclear facilities. This effort focused initially on AREVA's own plants and is expanding now to other customers. The setup of a specific Business Unit in 2008 to takeover this business allowed concentration of the skills and the lessons learned in a dedicated division so as to provide the best means to optimize safety, performance, costs and schedules. Indeed transitioning from operations to D&D of a nuclear facility is a quantum leap. The assistance from specialized teams can bring significant cost savings.

REFERENCES

1. IAEA D&D Workshop, Manila 2006