The Importance of Experience Based Decommissioning Planning – 16242

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ABSTRACT

Decommissioning of a nuclear facility is an extensive and multidisciplinary task which involves the management and technical actions associated with ceasing operation and thereafter the step by step transfer of the facility from an operating plant to an object under decommissioning. The decommissioning phase includes dismantling of systems and components, decontamination and clearance, demolition of buildings, remediation of any contaminated ground and finally a survey of the site. Several of these activities generate radioactive or potentially radioactive waste which has to be managed properly prior to clearance or disposal.

What makes decommissioning of nuclear installations unique is to a large extent the radioactive waste management. No other industries have that complex regulatory frameworks for waste management. If a decommissioning project in the nuclear industry does not consider the waste aspects to the extent required, there is a large risk of failure causing a reduced trust by the regulators and other stakeholders as well as cost and schedule overruns.

This paper will give an overview of important aspects and findings gathered during decades of planning and conducting decommissioning and nuclear facility modernization projects.

INTRODUCTION

Studsvik and Westinghouse, who cooperate in the name ndcon in the area of nuclear decommissioning on selected markets, have developed a decommissioning concept consisting of eight major steps covering the activities from decommissioning planning up to delicensing of the site.

The first step, the decommissioning planning and preparations, is considered as the most critical in several perspectives, in particular regarding consequences related to schedule and costs.

The ndcon main focus when conducting planning and preparation activities is safety and efficiency through well proven processes. Our concept relies on in-house experience from conducted decommissioning projects as well as extensive NPP power upgrade and modernization projects. By involvement of partners strong in conventional non-nuclear decommissioning projects, especially the ones involving hazardous waste and complex systems, the total experience has been extended to the benefit for planning future projects. Success stories as well as lessons learned from decommissioning of large industrial installations have been analysed. Innovations and new technologies are successively incorporated to further optimize the decommissioning process.

THE STEPS OF DECOMMISSIONING

A NPP decommissioning project could be divided into phases in different ways. The ndcon concept divides decommissioning into eight major steps and certain sub-steps.

I – Initial planning

- Decommissioning strategy
- Dismantling and Waste Management Strategies including disposition routes
- Licensing documentation
- Material flow optimization
- Detailed planning

II – Defueling

- Fuel leakage detection
- Management of intact and failed fuel

III – Inventory and characterisation

- Inventory assessment – theoretical calculations verified by in-situ measurements
- Radiological characterisation of systems, installations, structures and site
- Waste and material categorisation based on risk for contamination
- Building and site categorisation based on risk for contamination

IV – Decontamination

- Selection of decontamination techniques (to fit with the Dismantling and Waste Management Strategies)
- Chemical decontamination of systems and components
- Mechanical decontamination of materials and structures

V – Dismantling

- Segmentation of internals and reactor pressure vessel
- Dismantling of systems and installations in a waste led process

VI – Waste management

- Development of a Waste Management Plan implementing the Waste Management Strategy
- Establish the required in-situ Waste Treatment and Material Clearance Systems
- Implement waste transportation and off-site treatment routes
- Implement waste conditioning for disposal in accordance with WMP
- Implement the waste documentation systems

VII – Clearance and demolition of structures

- Characterisation and categorisation of structures upon completion of dismantling
- Decontamination and demolition of contaminated structures, as necessary
- Clearance measurements

- Clearance documentation
- Demolition of remaining structures after clearance

VIII – Site clearance

- Site characterisation (surface/sub-surface)
- Site remediation
- Site clearance

More or less all the different steps have multiple interfaces and dependencies with most of the other steps in the process.

EXPERIENCE PLATFORM

Examples of experiences that build the ndcon knowledge platform:

- Planning
  Extensive decommissioning planning experience for NPPs and other nuclear installations. Also planning related to the extensive modernization projects conducted in Sweden over the last decade has is beneficial for further work. Especially the projects which have already been fully realized generates a lot of experience.

Fig. 1. Left: BWR Reference Plant Decommissioning Study (Sweden).
Right: Concept Selection Study for decommissioning (Norway).

- Primary systems
  The extensive experience in inventory determination, segmentation, removal and packaging of reactor internals has proven that there are methods and tools available for safe and cost efficient management of reactor internals. These methods and tools can be applied as is on most reactor types. The experiences from segmentation of reactor pressure vessels has proven that it is an efficient method. The experience in the alternative solution to remove

the reactor pressure vessel as one piece is less. Removal of RPVs has several common challenges with handling of other large components with a significant inventory like PWR steam generators in which there is significant experience.

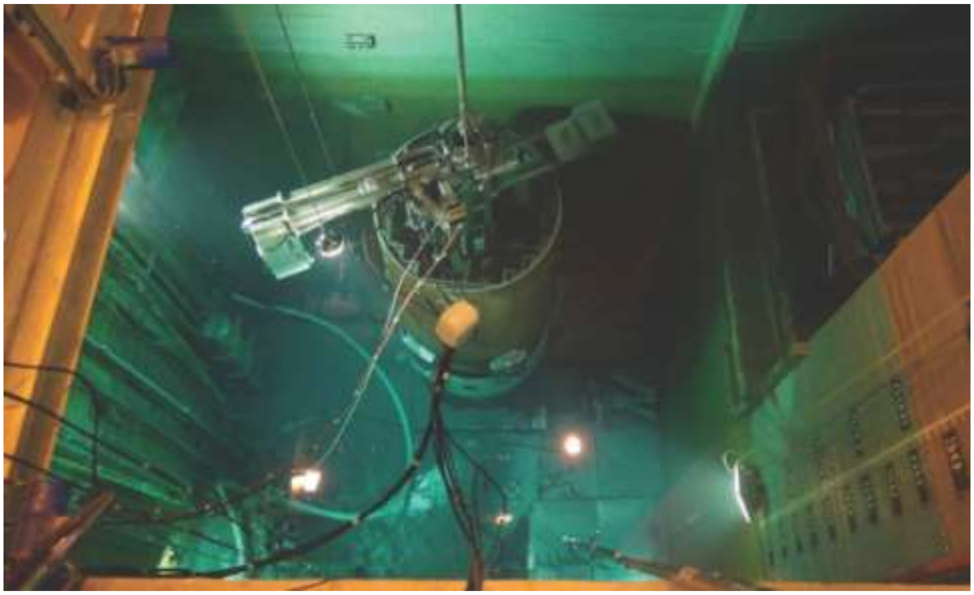

Fig. 2. In pool cutting of Reactor Pressure Vessel.

- Large components
  Handling, transport and off-site treatment of large heat exchangers and other components has been performed for more than a decade. Dozens of large components with a weight in the range of 300 tonnes have been managed for treatment at the Studsvik facility by decontamination, segmentation and melting aiming for clearance to the open market.

Fig. 3. Magnox Boiler entering Studsvik Melting Facility.

- Full scope services
  Planning, characterisation, dismantling and waste management of large systems like the BWR turbine island and other installations on controlled area. The experience includes on- and off-site waste treatment, clearance and recycling as well as conditioning, packaging and return transport of all residues for interim storage or disposal.

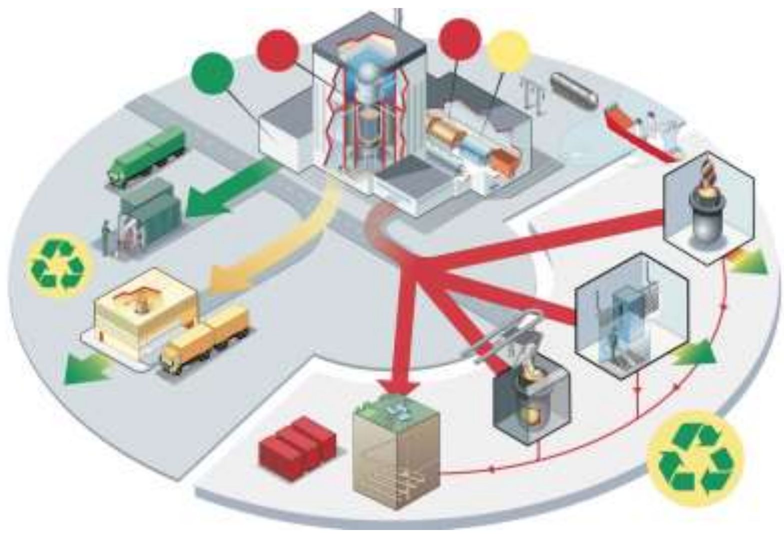

Fig. 4. Schematic Waste Flow Overview based on radioactivity content/risk for contamination.

- Buildings
  Characterisation after dismantling of systems and installations, decontamination of building structures and clearance measurements prior to facility demolition or unrestricted reuse.

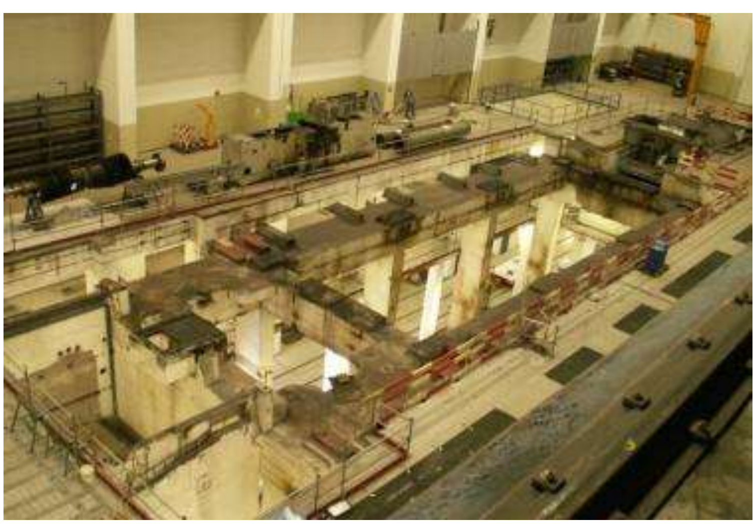

Fig. 5. Turbine hall after dismantling of equipment and associated piping.

PLANNING OBJECTIVES

Two types of planning projects are typically performed

- Planning for funding and national infrastructure
- Planning for implementation

Planning for funding and national infrastructure

The objective with this planning activity is mainly to form a basis for funding, to initiate the decommissioning process and to provide input for the national infrastructure. Infrastructure to be considered in this planning phase can be inventory and waste volume need in the national repositories.

Planning for implementation

The planning for implementation is a follow up activity to the previous planning activities. Typically this planning activity is started up a few years prior to the permanent shutdown of a nuclear facility. This planning activity is equal to the first step in the ndcon decommissioning concept described above.

THE PROCESS OF PERFORMING DECOMMISSIONING PLANNING

As mentioned above decommissioning planning should be experience based but not discriminating new technologies proven to be reliable. A too conservative approach will most likely have a negative impact on a project.

Decommissioning should preferably be conducted in a structured process from initial planning to site release and license termination. Let us call it a process from "A to Z".

Decommissioning planning should of course be performed in the same way but it is important to think somewhat different especially when setting strategies and plans. The end state conditions and some other major parameters has to be defined very early in the planning process. A methodology called the "Z to A" approach has been developed.

The "Z to A" process covers among other activities:

Define end state

- Free release criteria for materials, structures and site
- Reuse and recycling options
- Repository requirements (WAC) and availability

Define the required material and waste management processes

Select and optimize the material and waste management processes to meet approved end states. Quantify volumes per category. Define what should be done inside the facility, at other locations on the site and off-site.

Plan the dismantling procedures
Dismantling planning to facilitate a safe and cost efficient process respecting ALARA and the waste management strategy.

Implement decontamination measures
Optimize the decontamination efforts to secure workers environment during dismantling (low dose rates) and the relevant waste management objectives like re-categorisation of waste (for example from ILW to LLW).

Define the Characterization and categorisation efforts required
Definition of the characterization objectives efforts to establish a reliable categorization for systems, installations, structures and site areas.

Tailor the planning activities
Proceed with the planning to facilitate a safe, fast and cost efficient decommissioning process.

EXPERIENCES AND LESSONS LEARNED

The ndcon companies have an extensive experience in conducting decommissioning projects as well as in planning. In total has the two organisations participated in more than 250 decommissioning projects. Even though the type, size and prerequisite for the projects differs significantly several common factors, which may have a massive impact on both schedule and costs, can be identified.

Identify and mitigate potential bottle necks and showstoppers
The first and most important parameter is to perform the planning in a way that bottlenecks and showstoppers for activities already started up are avoided. Secure that all activities are properly planned, that the organisation is in place and that all tools and procedures are fit for purpose before the activities are started up. Do not forget to secure the complete path to the end-state and that alternative pathways are available and suitable.

Examples of bottle necks/failures:

- Undersized material and waste pathways and storage areas
- Failure, low performance or low capacity for material decontamination and clearance systems
- Unexpected radiological inventory causing stop in processes and require re-characterization, further decontamination efforts and consultancy with regulators

Proposed mitigation activities:

- Perform a material and waste simulation throughout the different phases of the project.
- Benchmark with decommissioning projects which have proceeded further. Typically both owners and contractors are pleased to support.

Avoid sub-optimizations
Ensure that the different projects will be aware of the full picture to secure that sub-optimization (i.e. focus on an activity not taking the global impact into account) not will take place. To a large extent a decommissioning project is like a relay race. Each project or activity will get the "baton" from the previous runner, will do its best to perform the task well to put the next team in a position that will allow them to succeed. The final result is depending on the performance of all participants. A later participants can to certain extent repair an early failure but if the failure is grave it will not be possible to repair. It is therefore of large importance to secure quality throughout all steps and to have a "helicopter view" when making decisions.

Examples of bottle necks/failures:

- The end product of an individual project within a decommissioning project is not compatible with the later steps or the final end-state conditions like super compaction or grouting of waste without clear disposition route.
- Focus on fast dismantling without considering the material and waste optimization and other aspects in an administrative (for example improper gathering and recording of information) or physical perspective (not respecting the material categorisation). A typical mistake is mixing of material subject to clearance with contaminated material.
- Staff is not properly informed and are making shortcuts because they do not understand the consequences.

Proposed mitigation activities:

- Proper planning and efficient communication of the plans to all involved function holders.
- Make sure all staff are properly trained and informed as well as aware of the full picture.
- Avoid incentives which will generate a silo mentality (i.e. inward looking and resistance/low priority on sharing information).

Minimize waste amounts for disposal
Disposal of radioactive waste is expensive in most countries. In addition, the requirements for qualifying the waste for disposal and fulfilment of the Waste Acceptance Criteria could be rigorous. Since a large percentage of the repository programs are delayed, the facility owners may have to defer their decommissioning program or build up intermediate storage capacities.

All together the above are good incentives to minimize the waste amounts for disposal. The cheapest waste is the waste never generated. Waste categorisation, clearance and volume reduction are ways to reduce waste for disposal.

Examples of bottle necks/failures:

- Limited understanding of the radiological status of the facility causing stops or ad hoc decisions in waste management.
- Poor or incorrect categorisation of materials, systems and installations

causing lack of confidence and significant mitigation requests
- Dismantling teams do not respect or understand the importance of waste categorisation and by then causing elevated volumes of radioactive waste.

Proposed mitigation activities:
- Consider the radiological characterisation and the categorisation activities as some of the most important activities in a decommissioning program.
- Make sure all staff are properly trained, motivated and informed about the consequences of a poor waste management.

CONCLUSIONS

Decommissioning projects are complex activities which involves a lot of stakeholders, contractors and specialists over several years. The importance of experience, competence and understanding in planning as well as in implementation cannot be underlined enough. Do not hesitate to consult experienced experts. It is a good investment.

Other important parameters are structure and logistics i.e. to do both planning and implementation activities in a structured and transparent way. Furthermore a decommissioning project must rely on safe, effective and robust processes. Violation of safety will in the best way just cause delays. Poor efficiency will most likely have an impact on both schedule and cost. Make sure back-up solutions and alternative routes are available.

If the above is well implemented in the planning process there will be good conditions for a Safe, Fast and Cost Efficient decommissioning project.