Selection and evaluation of decontamination and dismantling techniques for decommissioning of large NPPs components

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ABSTRACT:
Most nuclear power reactors were built for one purpose – to produce electricity as safely and economically as possible. Plants were not designed for easy decommissioning. Since decommissioning was not taken into account from the beginning, dismantling and decontamination (D&D) activities must be planned individually for each unique facility.
The paper presents main aspects and schemes of the selection and evaluation process used in Lithuania for decommissioning of emergency core cooling system and auxiliary reactor systems at Ignalina NPP. In addition, results of a GRS study on the different factors leading to the selection of dismantling techniques for decommissioning of a reactor pressure vessel in Germany are presented.

1 INTRODUCTION

Decommissioning process involves decontamination, dismantling and waste management. The selection and application of suitable dismantling and decontamination techniques become crucial elements of the successful conduct of decommissioning projects. Practice shows that the selection is performed following an iterative process driven by weighting of a set of different aspects (radiological and conventional worker protection; radiological conditions at the working place; know-how on the nuclear facility; own experiences on the use of the technique; technical work specification; applicability / type of the technique, including dismantling capacity, safety aspects, infrastructure / workspace needed, (de-) installation / maintenance time; aspects of costs; radioactive waste generation; and so on).

Pre-selection of techniques is carried out on basis of general characteristics the techniques have to fulfil, which are driven by more fundamental requirements, like radiation protection aspects or specific conditions at the respective facility. For the final decision, which technique to use, a more detailed analysis is required. Usually simply engineering assessment is used to evaluate the applicability of techniques based on site configuration and equipment type. Following to that the safety issues are analysed using HAZOP (hazard and operability study) or similar approaches and the final step is a cost-benefit analysis. All above factors allow creation an exhaustive list of D&D techniques applicable for the particular site or equipment.

The paper discusses general approaches for the selection and evaluation process of D&D techniques. As well, the paper provides examples of D&D techniques selection and evaluation process implementation in Lithuania for decommissioning of Emergency Core Cooling System and auxiliary reactor systems at Ignalina NPP and a methodology used for selection of dismantling techniques for decommissioning of a reactor pressure vessel in Germany.

2 GENERIC SELECTION PROCESS FOR DECONTAMINATION AND DISMANTLING TECHNIQUES

In this chapter, a generic selection process for decontamination and dismantling techniques is described. The description of this selection process illustrates, which decision aspects are applied during the selection of techniques in practice and which general requirements and principles influence the selection in the framework of the project strategy. Technical features of decontamination and dismantling techniques are described.

2.1 Generic selection process

Planning of decommissioning and dismantling of a nuclear facility is carried out following a complex and iterative process.

Ideally, the decommissioning concept is already developed during construction of a nuclear facility, which demonstrates the principle feasibility of all measures foreseen to reach the desired end-state, including the main measure for dismantling of the nuclear facility and for disposal of the radioactive waste [1]. Possible decontamination and dismantling techniques as well as radiation protection aspects are considered as far as needed to demonstrate the principle feasibility. Generally, a selection of a concrete technique is not part of this project step.

The decommissioning concept is finalized after operation of the facility has ceased, which describes in detail the decommissioning measures foreseen. This decommissioning concept is the basis of the licensing process for decommissioning in Germany and Lithuania. Decommissioning planning contains amongst others a dismantling concept describing the planned steps and measures for dismantling structures, systems and components and, if technically reasonable, the possible decontamination and dismantling techniques and necessary auxiliary systems. Decommissioning planning is done on a much more concrete level than the decommissioning concept, but does not reach in general such a level of detail as to conduct the respective dismantling task. Therefore, before conduct of a certain dismantling task, the respective part of the dismantling concept is concretized and the technique to perform the task selected.

The selection of decontamination and dismantling techniques is one of several decisions made during preparation and conduct of a decommissioning project. As already mentioned earlier, radiation protection aspects are one of the factors considered but not the only one. Other factors, that will be considered are inter alia the needed infrastructure, needed space to operate the technique, time needed for installation / de-installation of a technique, cutting / decontamination capacity, generation of radioactive waste, radiological conditions at the working place, technical requirements set by the system / component to be decontaminated / cut, aspects of safety, costs, dismantling / decontamination strategy. Selection of the technique is performed in a multi-stage, often iterative process. A generic and simplified selection process can be deduced, which is presented in Figure 1.

The project strategy is a key aspect of the generic selection process. Project strategic in this context describes the sum of all considerations influencing the principle proceeding in decommissioning. Notably, the term project strategy exceeds what is internationally described by decommissioning strategy, i.e. the decision to dismantle a facility immediately or to dismantle after the facility was kept in a state of safe enclosure. Selection of a project strategy might be driven by more strategic factors and considerations, which are differentiated in general requirements and principles. General requirements comprise of technical (not all techniques are suitable to dismantle all types of materials), regulatory (qualification, i.e. has the technique been demonstrated to be suitable for the foreseen task in former projects, not necessarily at a nuclear installation), and radiological aspects (use of remote techniques in areas with high dose rates). Principle decisions might be taken following strategic considerations of the operator. Examples of principle decision are to use mechanical cutting techniques only or to perform a decontamination of the system before dismantling, which might allow the use of manual cutting techniques not suitable before the chosen measures.

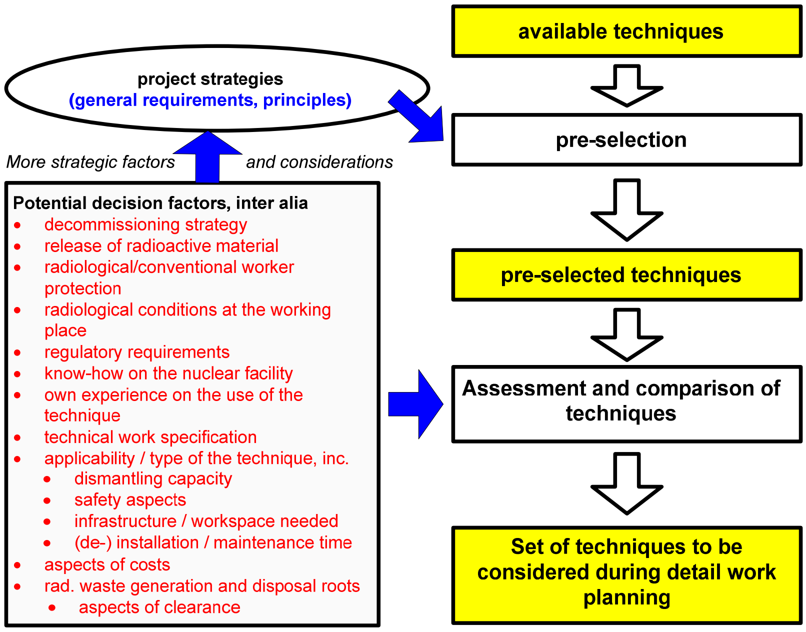

Figure 1: Generic selection process for decontamination and dismantling techniques [2]

Potential decision factors influencing the determination of general requirements and deciding on principles are mentioned in Figure 1. E.g. regulatory requisites are the same for all facilities in one country. But radiological aspects depend amongst others on the operational history and therefore differ from facility to facility. If principle decisions are made, the potential decision factors might lead to additional requisites, which have to be reflected in the dismantling strategy. E.g. do the radiological conditions allow the use of manual dismantling techniques, the principle decision not to use remote techniques might be taken or in case of the principle decision to remove large components in one peace, logistical requisites depend strongly on the geometrical conditions and the operational history.

To summarize, the dismantling strategy is influenced by the combination of general requirements, principles, and potential decision factors.

Starting point for the selection of decontamination or dismantling techniques is a list of all available techniques. A pre-selection of techniques is performed depending on the project strategy. Generally, for the pre-selection no quantitative comparisons between different techniques are performed. Moreover, technical features of the techniques (see chapter 2.2), which comply with the chosen project strategy lead to their pre-selection (e.g. remote handling). The second step in the selection process is performed during planning of the dismantling task leading to a selection after evaluation. Qualitative and quantitative comparisons might be part of the evaluation. This step narrows down the list of pre-selected techniques to a set of techniques to be considered during the detailed work planning.

2.2 Technical features of decontamination and dismantling techniques

As mentioned in chapter 2.1, principle considerations in the context of the dismantling strategy limit the number of pre-selected techniques in practice. In addition, a set of techniques might be evaluated as being suitable for a certain task according to actual decision factors or might be ruled out. This chapter highlights some technical features, which allow the grouping of techniques and which might be used during the pre-selection process to limit the list of techniques.

2.2.1 Technical qualification

Main feature of a technique is its qualification to fulfil the task (e.g. is the technique suitable to cut a pipe). Requirements for the main feature are therefore mainly defined by technical requisites.

2.2.2 Quantity and type of waste generated

The quantity (primary and secondary) and the type (generation of liquid waste, shavings, aerosols) of waste generated are features of techniques. An evaluation of techniques on the basis of these features is not an easy task, as for a chosen dismantling strategy (e.g. drum-size cutting of components) an increase in the generation of secondary waste might be appropriate if a later disassembling is avoided, which would have caused additional occupational exposures.

2.2.3 Remote handling

Qualification for remote handling is another technical feature, which is of outmost importance for areas, where the dose rate prohibits manual dismantling activities. But additional times for set-up and possible maintenance and repair work have to be considered.

2.2.4 Applicability under water

In close conjunction to the qualification for remote handling is the applicability for operation under water. The necessity to perform dismantling tasks under water is mainly driven by radiological reasons (i.e. necessity for shielding). The list of techniques, which fulfil this technical feature, is quit extensive. Nevertheless, it has to be verified, whether application of a technique changes the water conditions (e.g. haze), causing a derogation of the works or prolonging the time needed to fulfil the task, which might require additional steps in conducting the actual work.

2.2.5 Qualification

Qualified techniques, which are well known by the workers and which application the workers were able to practice, might have a favourable effect on the technical and logistical work planning. In practice, the challenge of evaluating the qualification of a technique lies within the need to verify whether decision factors corresponding to the task, where the techniques has been qualified in the past are also applicable to the actual task. The result of such an evaluation might well be that a technique foreseen has to excluded from the set of techniques to be considered.

2.2.6 Flexibility

Another feature of a technique is its flexibility to be used for different dismantling tasks or different materials. Application of such a technique might lead to an intensified built-up of knowledge among the workers, a reduced need for on-the-job training, and optimization of supply chains. But, when applied in areas with significant contaminations, the tools might need to undergo a decent decontamination campaign before being reused for the next task.

2.2.7 Time for set-up and maintenance

The time needed to set-up equipment and possible maintenance times have to be taken into account especially in areas with high dose rates and areas with high surface contaminations. In case of remote techniques, occupational doses accumulate just during manual interventions. Therefore, the use of robust techniques are recommended, which are often used in conventional demolition projects and which might be replaced without too much costs.

2.2.8 Cutting or decontamination principle

Cutting principles (mechanical, thermal) and decontamination principles (physical, i.e. rinsing, chemical and mechanical) are additional technical features [3].

2.2.9 Special features

Depending on the dismantling task, special features have to be taken into account (e.g. use of remote techniques under inert gas atmosphere).

3 EXAMPLES ON THE SELECTION OF DECONTAMINATION AND DISMANTLING TECHNIQUES FOR THE IGNALINA NPP DECOMMISSIONING PROJECTS

Ignalina Nuclear Power Plant (INPP) was an important part of Lithuania's Energy Sector since 1983 (Unit 1 - 1983, Unit 2 – 1987, design lifetime was projected out to 2013 and 2017, respectively). As a result of the political dialogue leading up to enlargement of the European Union (EU), Lithuania agreed to the early decommissioning of its reactors: Unit 1 shutdown – 2004 and Unit 2 shutdown – 2009. The According to the INPP Final Decommissioning Plan the INPP decommissioning process is split into several decommissioning and dismantling (D&D) projects, generally considering immediate dismantling. Each of these D&D projects covers a particular field of activity for example initial primary circuit decontamination or dismantling of equipment using "room by room" or "system by system" approach. For each project the separate strategy and other licensing documents shall be developed. This means that in the frame of each separate project appropriate D&D techniques shall be selected and evaluated. This chapter presents the D&D selection and evaluation process used for the Ignalina NPP. The multi-stage D&D technique and dismantling strategy selection process applied at Ignalina NPP for decommissioning of emergency core cooling system and auxiliary reactor systems is shown in Figure 2.

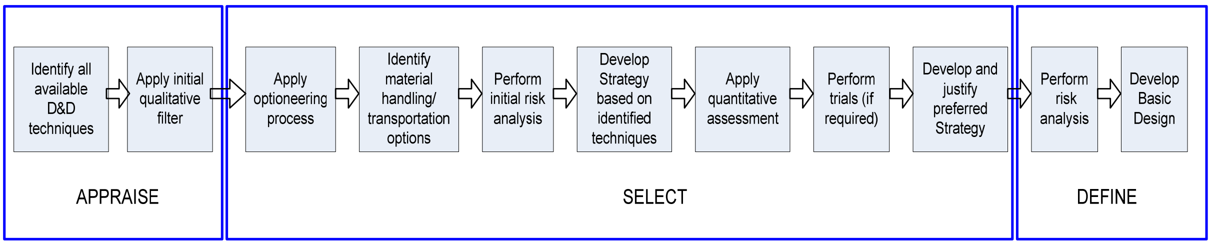

Figure 2: Decommissioning Design Strategy

Before selection of a detailed D&D strategy can take place it is necessary to identify the main options that are available for the facility. Based on previous experience and assessed the viability of each in relation to INPP's desired end state the following options were selected:

- Passive safe storage;

- Intact disposal of equipment without decontamination;
- In-situ size reduction and disposal without decontamination;
- Ex-situ size reduction and decontamination;
- In-situ size reduction and decontamination.

The initial assessment of the overall strategy options reduced the possible options to a single viable strategy and a comparative option for use in financial assessment. In-situ size reduction and decontamination was selected as preferred Strategy option. In order to further detail the preferred D&D strategy, it is necessary to identify the applicable D&D techniques for associated systems.

Selection of the most efficient D&D technique starts from creation of initial list of on market available decontamination and dismantling techniques (as exp. see table below).

For the dismantling	For the decontamination
Flame Cutting	UHP Water Jetting
Plasma Cutting	HP Water Jetting
Thermal Lance	Manual abrasive blasting (dry)
Hydraulic Shears	Manual abrasive blasting (wet)
Diamond Wire Saw	Vacuum blasting
Circular Saw	Centrifugal abrasive blasting (wheel abrator)
Abrasive Disc Cutting	Sponge blasting
Band Saw	Carbon Dioxide blasting
Reciprocating (Sabre) Saw	Wire brushing
UHP Water Jetting	Chemical Foams (in-situ)
Milling Cutter	Chemical Foams (ex-situ)
Explosives	Liquid Chemical processes
Vacuum extraction unit	PHADEC Process
	Strippable coatings
	Metal Melting
	Flame Scarifying

Second step covers application of initial qualitative filter to these techniques. Initial qualitative assessment of the proposed techniques was done by the expert team involving Ignalina NPP staff responsible for D&D operations on the site. Main goal was to crystallize expectation of the Ignalina NPP staff based on existing practice and experience. The initial assessment allow to remove some proposed D&D techniques from the further consideration due to limitation of the wall thickness, production of secondary wet waste, low cutting speed, limited effectiveness based on existing trials, appreciable advantage over less aggressive techniques and significant industrial hazards such as serious asphyxiation hazard.

The remaining options were considered further during the qualitative & quantitative assessment phase, which determines the preferred D&D technique by use of a weighted Multi Attribute Decision Analysis (MADA) type process. The MADA session attendees were selected in order to provide the most appropriate range of input to the process including representatives from Ignalina NPP. It was also recommended at the session that the dismantling selection process be solely applied to the large equipment such as the large emergency core cooling tanks and other tanks from reactor auxiliary system. For all other smaller equipment such as pipes, valves and fabrications would be better suited to the use of a 'tool box' of techniques. This is based on the view that it was not feasible to accurately identify the varying needs of every cut at project development period, hence, some cuts may be best conducted with plasma, some with diamond wire, etc. In light of this, the 'tool box' was established including following techniques:

- Hydraulic shears;
- Reciprocating (sabre) saws;
- Adamant twin disc saws;
- Electric nibblers;

- Angle grinders;
- Bolt croppers;
- Hacksaws;
- Tube cutters;
- Band saw;
- Diamond wire saw;
- Plasma cutter.

As well special attention was paid on the specific equipment such as aerosol filters, zeolite and perlite filters and asbestos containing materials. Such equipment requires special techniques for dismantling due to high activity and high industrial hazard. Availability of such equipment was one of the main differences between two presented projects at Ignalina NPP. For the aerosol filters dismantling existing filters maintenance practise at Ignalina NPP was adopted. Due to that it was not necessary to take into account any other options which possibly would lead to purchasing of some new equipment and trainings of personnel. Dismantling of zeolite and perlite filters requires new approach because there was no existing experience at Ignalina NPP. For that purpose a special vacuum extraction system was proposed.

Due to the use of an initial qualitative assessment, all the remaining decontamination options were considered to have sufficient decontamination factors to be robust techniques for this application.

At the beginning of the MADA session the high level criteria and attribute to be considered for each option was discussed and agreed and in this case it was decided that different attributes were important for decontamination than for dismantling hence a differing selection of attributes was identified. It was identified attributes that would be a significant differentiator between the techniques under consideration. For the dismantling techniques following high level criteria and attributes were identified:

High Level Criteria	Selected Attributes	Weighted Score	Justification
Safety	Operator Dose and Radiological Hazards	**10**	Low levels of activity associated with each option. None of the proposed options would lead to doses that are unsafe or that exceed legal limits. All of the options would be managed to ensure that operator doses are acceptable, therefore this attribute was allocated the lowest weighting.
	Conventional Safety	**100**	Conventional safety risks were considered to be a significant differentiator between the dismantling techniques. The difference between the techniques in relation to this attribute has the potential to impact the delivery of the project, hence the allocation of the highest weighting.
Technical	Process / System Robustness	**50**	Each of the technique assessed involve the application of proven technology. There is some differentiation between the techniques in terms of experience using the equipment, however this was not deemed to have significant implications with regards to the delivery of the project.
	Utilisation of / Compatibility with Existing Plant and Processes	**50**	The technology associated with each of the assessed technique will utilise existing operator skills. Some options will require operator training, however this was not deemed to have significant implications with regards to the delivery of the project.
	Ease of Deployment	**40**	It was agreed that each of the assessed technique adopt simple, proven equipment, therefore technique differentiation with regards to deployment was not considered to be significant.
Economic	Lifetime Costs	**100**	The differences between the techniques in terms of cost were deemed to be core project drivers and

High Level Criteria	Selected Attributes	Weighted Score	Justification
			therefore this attribute was allocated the highest weighting.
	Programme	**100**	The differences between the techniques in relation to project delivery timescales were agreed to be core project drivers and therefore this attribute was allocated the highest weighting.

For the decontamination techniques following high level criteria and attributes were identified:

High Level Criteria	Selected Attributes	Weighted Score	Justification
Safety	Operator Dose and Radiological Hazards	**10**	The 'worst-case' routine operator dose was not considered to be a significant differentiator. None of the proposed techniques would lead to doses that are unsafe or that exceed legal limits. All of the options would be managed to ensure that operator doses are acceptable; therefore this attribute was allocated the lowest weighting.
	Conventional Safety	**100**	Conventional safety risks were considered to be a significant differentiator between the decontamination equipment options. The difference between the techniques in relation to this attribute has the potential to impact the delivery of the project, hence the allocation of the highest weighting.
Technical	Process / System Robustness	**50**	Each of the techniques assessed involve the application of proven technology. There is some differentiation between the techniques in terms of equipment effectiveness and reliability; however this was not deemed to have significant implications with regards to the delivery of the project.
	Waste Form Acceptability	**50**	As each of the techniques assessed involve the application of proven technology, there is a reasonable understanding of the waste forms that will be produced. On this basis, this attribute was not deemed to have significant implications with regards to the delivery of the project.
	Interfaces	**75**	All of the options assessed are independent of external factors. It was agreed that external dependency was a potential 'show stopper' for the project, therefore this attribute was allocated a high weighting factor.
Environ-mental	Chemical Discharges	**50**	Potential chemical discharges associated with each of the techniques have been identified. Although some waste disposal routes will be easier to establish than others, it was agreed that this attribute would not have significant implications with regards to the delivery of the project.
Political / Regulatory	Public Acceptability	**75**	All of the options assessed in relation to this attribute involve on-site operations. It was agreed that on-site activities tend to be more publicly acceptable. This attribute was deemed to be a potential show stopper and was therefore allocated a high weighting factor.
	Permissions	**75**	This attribute was considered in terms of potential regulatory risks, political risks and authorisations associated with each of the options. It was agreed that of all the options therefore would present a significant risk to the project's programme. On this basis, this attribute was allocated a high weighting

High Level Criteria	Selected Attributes	Weighted Score	Justification
			factor.
Economic	Lifetime Costs	**100**	The differences between the options in terms of cost were deemed to be core project drivers and therefore this attribute was allocated the highest weighting.
	Programme	**100**	The differences between the options in relation to project delivery timescales were agreed to be core project drivers and therefore this attribute was allocated the highest weighting.

As a result of MADA section the 3 options for dismantling and 3 options for decontamination with the top scoring were selected to be taken forward to the quantitative assessment phase for the both projects at Ignalina NPP. Additionally for the zeolite and perlite filters removal the vacuum extraction unit was selected.

In order to accurately determine the most effective D&D Strategy for both projects, the remaining options were subjected to a quantitative analysis. The remaining options (including cost comparators) were as below;

- In-situ size reduction with decontamination
  - Flame cutting + Vacuum Blasting
  - Flame cutting + Wheel abrator
  - Flame cutting + Wire Brushing ***(cost comparator only)***
  - Plasma cutting + Vacuum Blasting
  - Plasma cutting + Wheel abrator
  - Plasma cutting + Wire Brushing ***(cost comparator only)***
  - Milling cutting + Vacuum Blasting
  - Milling cutting + Wheel abrator
  - Milling cutting + Wire Brushing ***(cost comparator only)***
- In situ size reduction with no decontamination ***(cost comparator only)***

In the interests of completeness, the above presented criteria considered in this quantitative assessment incorporated, amongst others, the recommendations of Ignalina NPP on their particular areas of interest. The factors considered were as shown below:

Cost • Capital cost of D&D tools (taking into account possible re-use of tools) • Capital cost of auxiliary equipment • Cost of tools and equipment installation/commissioning • Cost of tools and equipment maintenance • Cost of tools and equipment removal • Cost of preparatory works • Costs of consumables • Cost of service requirements • Cost of manpower • Dose up-take equivalent cost • Cost of primary waste management • Cost of secondary waste management
Waste Management • Primary waste volume • Secondary waste volume • Secondary waste form • Waste compatibility with INPP routes
Schedule • Procurement of equipment

• Size reduction duration cycle • Decontamination of cycle duration • Other processes (handling, radiological control)
Manpower • Size reduction cycle duration • Decontamination cycle duration • Other processes (handling, radiological control) cycle duration
ALARA Criteria
Conventional Safety

As the result of quantitative assessment the flame cutting technique was selected for the dismantling of the emergency core cooling tanks. But for the dismantling of reactor auxiliary system equipment higher score gets plasma cutting techniques. This difference was mainly related to the metal type of the equipment. In the first project for D&D of ECCS equipment main part of equipment was made of carbon steel. In the second project main part of equipment was made of stainless steel. Due to that the cutting speed trough different type of steel plays one of the main roles during selection of cutting method.

For the equipment decontamination in both projects manual vacuum blasting was selected. The other proposed decontamination technique – automatic abrasive blasting known as wheel abrator gets very similar score. Therefore the cost of automatic system is much higher than manual vacuum blasting if we consider amount of metal directed to decontamination only form one particular project.

4 EXAMPLES ON THE SELECTION OF DISMANTLING TECHNIQUES IN GERMAN DECOMMISSIONING PROJECTS

The following examples from German decommissioning projects [4] demonstrate how different decision factors have influenced the selection of dismantling techniques. Moreover, practice shows that for a specific task like “dismantling of a reactor pressure vessel (RPV) and its internals” a set of suitable techniques might exists and where the decision, which one to use is taken during the detailed work planning.

4.1.1 Dismantling of RPV internals at the nuclear power plant Gundremmingen-A (KRB-A)

Dismantling of the nuclear power plant Gundremmingen-A (KRB-A) was the first larger decommissioning project in Germany (1st license applied for in 1980). At this point of time, hardly any knowledge on decontamination of systems existed and respective techniques could not be regarded as qualified. Because of the dose rates present, a principle decision was made to dismantle the RPV under water making use of its shielding capabilities and by using remotely controlled thermal cutting techniques (plasma arc cutting, contact arc metal cutting) [5].

4.1.2 Dismantling of the RPV and its internals at the Experimental Nuclear Power Plant Kahl (VAK)

During the decommissioning of the Experimental Nuclear Power Plant Kahl (VAK), which commenced in 1988, it was decided not only to rely on qualified techniques but due to its experimental character make use of innovative techniques (water abrasive suspension jet cutting) [5]

4.1.3 Dismantling of the RPV and its internals at the Multi-Purpose Research Reactor (MZFR)

Because of the geometrical conditions and limit space, the RPV of the Multi-Purpose Research Reactor (MZFR) had to be dismantled in-situ. To retain flexibility, application of different techniques in different steps was chosen: The components above the RPV were dismantled manually. Then, the RPV top and the rod-shaped RPV internals were dismantled remotely without water coverage; the moderator tank and the thermal shielding were dismantled remotely under water by using contact arc metal cutting and plasma arc cutting techniques. Dismantling of the RPV bottom was performed remotely in air using a band saw [6], [7].

4.1.4 Dismantling of RPVs at the nuclear power plant Greifswald (KGR)

Dismantling of the nuclear power plant Greifswald (KGR) is mainly driven by the strategic decision to remove the five RPVs, who were in operation in one piece and transfer them for decay storage to the interim storage facility Zwischenlager Nord (ZLN) on the site. With this, a significant reduction of the amount of radioactive waste to be disposed after the decay storage is expected. It seems quite obvious that the repeatable character of five similar decommissioning projects lead to a qualification of procedures including the selected dismantling techniques. Furthermore, the later dismantling of the large components after decay storage allows the use of conventional and therefore qualified dismantling techniques, like band saws, which could not be used for in-situ dismantling because of the lack of space needed for installation. At ZLN, such dismantling equipment is set up [8], [9].

4.1.5 Dismantling of RPV internals at the nuclear power plant Würgassen (KWW)

The situation at the nuclear power plant Würgassen (KWW) is similar as in KRB-A, but due to the later decision for decommissioning (in 1995 compared to 1980) a wide range of techniques could be regarded as qualified [10].

4.1.6 Dismantling of RPV internals at the nuclear power plant Stade (KKS)

At the beginning of the decommissioning of the nuclear power plant Stade (KKS), system decontamination was performed, which lead to significant reduction of the dose rates in the respective areas of the power plant. The RPV and its internals were included in the decontamination process. Their dismantling was performed with remote techniques, mainly under water [11].

5 CONCLUSIONS

Analysis of decommissioning projects in Lithuania and Germany shows that the selection process for decontamination and dismantling techniques is a multi-step process, where in a first step the list of all available techniques is narrowed done following general more strategic decisions, which are influence by general requirements (like technical, regulatory or radiological aspects) and principle decision (like use of mechanical cutting techniques only or to perform a decontamination of the system).

A further reduction of the list of techniques is done during planning of the decontamination or dismantling task, performing an evaluating on basis of qualitative and / or quantitative analysis. This leads to a “tool-box” of techniques, which allows enough flexibility during the detailed work planning for optimization in relation to aspects of e.g. radiation protection, radioactive waste generation, costs.

In addition, with such a “tool-box” the operator is able to react on unforeseeable situation during conduct of the actual dismantling task questioning the chosen technique, without significantly delaying the dismantling process and limiting the generation of additional decommissioning costs.

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