THE OPTIMIZATION OF DECONTAMINATION METHODS EMPLOYED FOR SURFACE AND DEEP CONTAMINATED AREAS USED IN DECOMMISSIONING OF A CANDU-600 NUCLEAR POWER PLANT

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We propose in this paper a method for selection of appropriate decontamination techniques which may be used at Cernavodă NPP decommissioning based on the simulation with ProVision software. Also, we underline in this article the physical decontamination methods. As a basis for selecting the optimum decontamination method, a technology must be able to remove radioactive contaminants. It might be useful to remove non-radioactive contaminants such as organic materials, metals or inorganic materials. Second, the technology should be commercially available by one or more suppliers. Third, the technology must be feasible as demonstrated in the process of contaminants removal in similar installations.

Keywords: decommissioning, decontamination method, software, contaminant

1. Introduction

For nuclear facilities, decommissioning is the final phase in their life cycle after sitting, design, construction, commissioning and operation. It is a complex process involving operations such as detailed surveys, decontamination and dismantling of plant, equipment and facilities, demolition of buildings and structures, site remediation, and the management of resulting waste and other materials. All activities take place under a regulatory framework that takes into account the importance of the health and safety of the operating staff, the general public and protection of the environment.

There is a growing volume of information being published annually and mainly presented at international conferences by specialists in various fields related to decommissioning and decontamination. These present mainly good experiences; however, sometimes mistakes and lessons learned are included. It is important for the collected body of international experience in decommissioning planning and management to be assembled and published for use and interpretation by those engaging in these activities [1].

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The objective of this paper is to provide information for nuclear field specialists and decision makers (ranging from regulators, strategists, planners and designers, to operators) on opportunities for minimizing radioactive wastes arising from the Decontamination & Decommissioning (D&D) of a CANDU 600 nuclear facility. This will allow waste minimization options to be properly planned and assessed as part of National, Site and Plant Radioactive Waste Management Plan.

2. Decontamination techniques selection

In the nuclear installation decommissioning process the decontamination of metal structures and concrete surfaces and buildings is considered.

To facilitate the selection process, each selection criterion is been assigned, in descending order of preference, different levels of performance. The object of decontamination may be the surface of an equipment , a subsystem or an entire process system or in case of concrete structures the wall or floor area, etc. For components whose contamination can be easily removed from the system, the most usual option is to use physical or electrochemical decontamination, unless chemical decontamination is the only feasible method. If pursuant to the evaluation, several techniques are considered acceptable, their characteristics are reviewed to determine which type of technology meets best the constraints set on postulated charge and which offers may be available for analysis.

The net cost of the decontamination process has a role in selecting the methodology because it includes the cost of materials, equipment and activities for the implementation of the method and the cost of processing and storage of the resulted radioactive waste. The lower the value of cost-benefit ration the better, because it signifies the cost per unit of radiation dose reduction for a particular method.

The final choice of the most appropriate decontamination technique is made by comparing the costs with other similar techniques and the method with the most competitive cost is selected [2].

3. Simulation as a step of decontamination techniques choice

A unit cost for each decontamination technique was determined by relating the total cost to the average surface to be decontaminated (i.e. 500 m^2), corresponding to one month work period of a decontamination team.

In order to develop a comparative study on the decontamination techniques, an estimation of the operational parameters corresponding to the work procedures associated to the analyzed decontamination techniques, has been conducted by means of mathematical modeling (Monte Carlo simulation method).

The steps of the simulation (modeling), according to the simulation methodology adopted by the manufacturer of ProVision V.6.1.1. device, involved the following actions:

- the definition of the work procedures specific to the decontamination techniques;
- the parameterization of the work procedures in point of necessary time ;
- the parameterization of the work procedures in point of costs associated to the component activities;
- the simulation of the work procedures by ProVision 6.1.1. by Monte Carlo mathematical method;
- the generation of post-simulation reports on which basis the efficiency of each decontamination technique is assessed.

The definition of the work procedure specific to the decontamination techniques and the parameterization of the work procedures in point of time-consumption and costs related to the component activities were made on basis of the information in the decontamination technique descriptions for to demonstrate their performance [3]. The parameters represented the input data for the soft simulation of the work procedures employing Monte Carlo mathematical modeling method.

4 Decontamination techniques reviewed

In case of nuclear installation decommissioning, decontamination methods relevant for the decontamination of steel structures and equipment, i.e concrete surfaces and buildings are chemically and physically decontaminated.

Physical decontamination methods are based on some form of physical or mechanical abrasion of the surface contaminants or host material to get the effect of contaminant removal.

Figure 1 shows the diagram of the decontamination methods applicable to nuclear installation decommissioning, in accordance with those described above.

Starting with the scope of applicability, i.e. imposed limitations, and evidencing the special considerations for each decontamination technique the efficiency of each decontamination technique was determined on basis of the professional decision and available information in the literature [3].

The decontamination techniques that are best for certain areas of the CANDU 600 NPP were determined and for each selected technique, the estimated concrete or metal surfaces which are to be decontaminated by that technique,were established.

On the other hand , on basis of the detailed studies in the previous stages

[4], the total areas requiring decontamination were estimated , namely: 85000 m^2 metal surfaces and 65000 m^2 concrete surfaces.

The capacity of each decontamination technology characterizing a decontamination technique , function of the type of contaminated surface (metal, concrete) is shown in table 1**,** structured on methods of physical decontamination.

5 Conclusions

It was considered that all surfaces identified in the contaminated areas must be decontaminated either for the license release or for to pass to an inferior contamination category.

The following physical decontamination techniques were considered relevant and selected for the decontamination of the Nuclear Power Plant in Cernavodă: **Strippable coatings , Centrifugal Shot Blasting, Concrete shaver, En-vac robotic wall scabbler, Grit Blasting, Soft media blast cleaning, Steam vacuum cleaning, Piston scabbler.**

A unit cost for each decontamination technique was determined by relating the total cost to the average surface to be decontaminated (i.e. 500 m^2), corresponding to one month work period (see table 1).

In figure 2 we illustrate the En-vac Robotic Wall Scabbler (physical method) workflow, which is the input for ProVision simulation. The En-vac Robotic Wall Scabbler (ERWS) is really a remote-controlled grit blasting unit specifically designed to work on flat-surfaced walls. The ERWS is able to decontaminate much deeper than comparable baseline technologies. The En-vac Robotic Wall Scabbler is a mature technology that performed well during demonstration. Operating the robot unit required no special skills; however, the En-vac system required the user to be trained to operate the equipment. According to the operators, this technology completed a large surface area much more easily and faster than the baseline technology. The system was user-friendly and able to remove paint at a faster rate than the baseline technology. It was noted that anchor points are needed to support the robot in case of emergency power shutdown.

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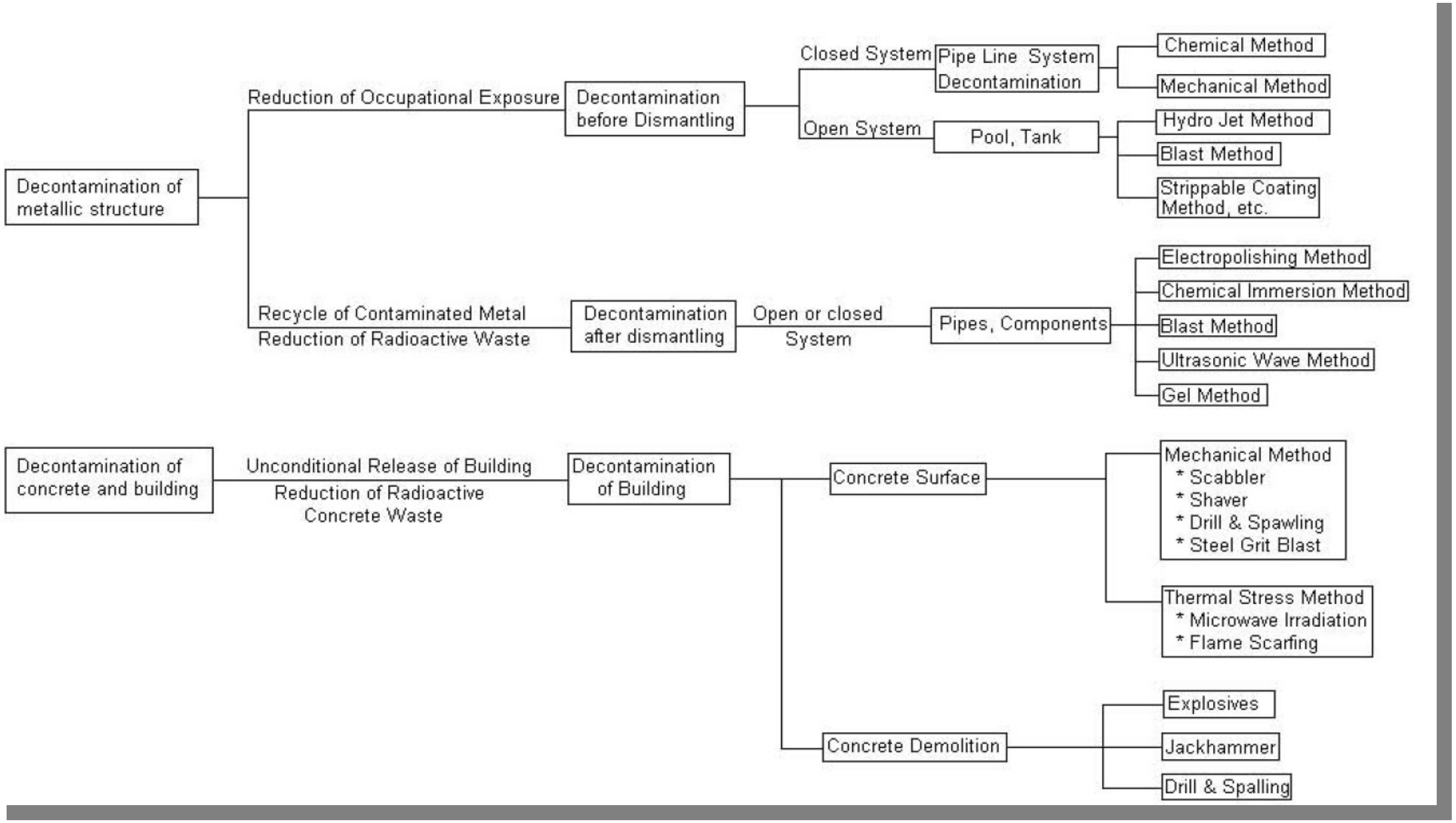

Figure 1, The diagram of the decontamination methods

Table 1

Physical Decontamination Techniques

Tech-nical code	Techniques	Strengths	Quality of Performance Data	Type of surface	Degree of use [%]/surface [m^2]	Unit Cost [€/m^2]	Total Cost [€/month]
2.1	**Strippable Coating**	Produce a single solid waste. No airborn contamination. No secondary liquid waste	Good	Metal Concrete	10 / 8500 1 / 650	34,275	17.137,43
2.2	**Centrifugal Shot Blasting**	Especially good for removing paint and light coating from concrete surfaces in open areas, away from wall-floor interfaces	Good	Concrete	10 / 6500	68,579	34.289,28
2.3	**Concrete Grinder**	Fast and mobile. Less vibration	Good	Concrete	1 / 650	33,403	16.701,36
2.4	**Concrete Shaver**	Good for large, flat , open concrete floors and slabs. Fast and efficient.	Good	Concrete	7 / 4550	17,646	8.823,11
2.5	**Concrete Spaller**	Good for in-depth contamination. Fast.	Good	Concrete	0,5 / 325	28,530	14.265,22
2.6	**Dry Ice Blasting**	CO_2 gas generates very little extra waste. Very good for surface contamination.	Proper	-	-		
2.7	**Dry Vacuum Cleaning**	Quick available. Compatible with other physical decontamination techniques	Proper	Concrete	10 / 6500	15,590	7.795,43
2.8	**Electro-Hydraulic Scabbling**	Generates less secondary wastes than other techniques using wather. Very efficient. Removes deep contamination.	Poor	Concrete	1 / 650	135,666	67.833,28

Tech-nical code	Techniques	Strengths	Quality of Performance Data	Type of surface	Degree of use [%]/surface [m^2]	Unit Cost [€/m^2]	Total Cost [€/month]
2.9	**En-vac Robotic Wall Scabbler**	Works well on large , open spaces, including wallsand ceiling. Worker exposure to contaminants is limited; remote operation and integrated vacuum system	Good	Concrete	35 / 22750	11,887	5.943,61
2.10	**Grid Blasting**	Well-established technology.Different Types of grid and blasting equipment are available for a variety of applications.	Good	Metal Concrete	10 / 8500 20 / 13000	11,152	5.575,98
2.11	**Hight Pressure Water**	High pressure systems are available	Proper	Metal	10 / 8500	109,206	54.603,28
2.12	**Soft Media Blast Cleaning (Sponge Blasting)**	Removes actually all the contamination from the surface	Good	Metal	20 / 17000	17,960	8.980,43
2.13	**Steam Vacuum Cleaning**	Easy to use.Wasted surfaces dry quickly. Good for large flat surfaces	Good	Metal	5 / 8500	59,738	29.869,28
2.14	**Piston Scabbler**	Remote operated and standard units are available. Good for open flat concrete floors .	Good	Concrete	1	103,615	51.807,45

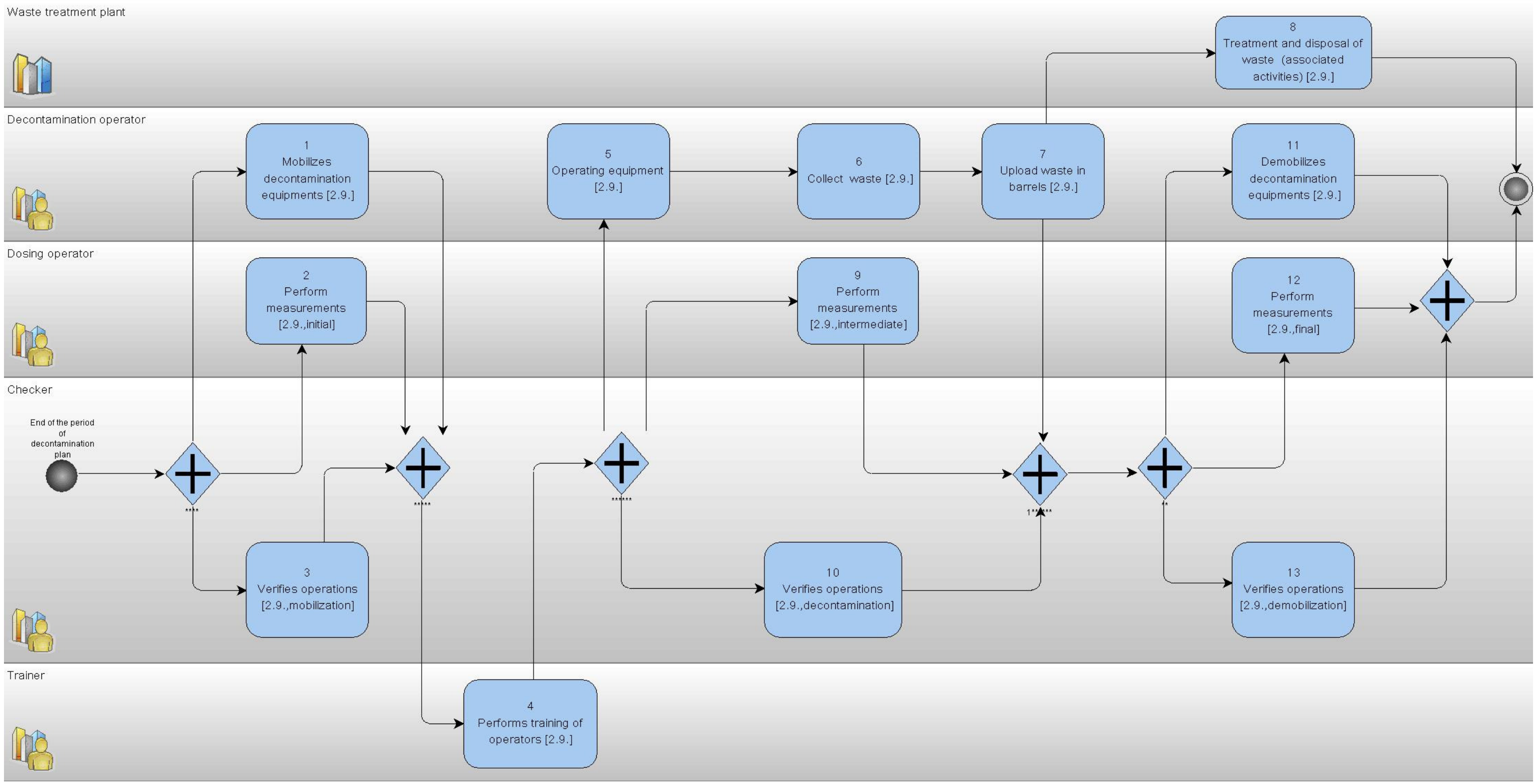

Figure 2, En-vac Robotic Wall Scabbler (Workflow)