Global Solutions Through Simulation For Better Decommissioning - #16457

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ABSTRACT

Each nuclear facility is different due to their history and there is no rule for choosing a decommissioning strategy. There are three major decommissioning strategies. First, “immediate dismantling”, which means the decommissioning begins immediately after the transfer of waste and nuclear material [1]. Second, “deferred dismantling strategy”, meaning the facility is maintained into a containment zone from thirty to one hundred years before being decommissioned [1]. Finally, “entombment”, referring to the placement of the facility into a reinforced containment until the radionuclides decay and reach a level allowing the site release [1]. When a strategy is decided many factors have to be taken into account.

Into a major project such as a reactor decommissioning, there are many smaller projects and the decommissioning strategy can be different among these smaller projects. Very often, some entry data are not perfectly known, for example, the dosimetric activity has not been updated through time or after specific events. Because of uncertainties and/or hypothesis existing around projects and their high level of interdependency, global solutions are a good way to choose the best decommissioning strategy. Especially since each entry data has consequences on output results whether it is on costs, cumulated dose, waste or delays. Also the dose, delays or waste management, all have impact on costs. To obtain an optimal scenario into a special environment, it is necessary to deal with all these items together.

This global solution can be implemented thanks to simulation in dedicated software which helps define the global strategy, optimize the scenario, and prevent contingencies. For a specific environment, when many scenarios have been developed and simulated, sensitivity studies are really important to choose the optimal decommissioning strategy. Sensitivity studies can be done with simulation tools by comparing results of scenarios directly into the software. This comparison helps to choose the optimal scenario according to which output data is considered as key determinant.

INTRODUCTION

Regular maintenance on active nuclear plants and dismantling operations on the ones that can no longer meet the safety requirements, prevent dangerous accidents. In the nuclear field, decommissioning is inevitable for returning to green but the choice of a dismantling process has exponential consequences on budgets, planning, risks and waste generated. In the specific case of dealing with nuclear facilities, these operations get a particular attention considering the risks of leaks or rejection in the environment. Therefore, it is important to plan in advance these operations, even during the design phase of new built power plants.

When starting a decommissioning project, engineers have to gather entry data needed for planning and creating the best scenario strategy. These scenarios must be done using a global approach which should consider the costs, waste management, received dose, the planning but also the interdependency between these parameters and the entry data. Indeed, the quality of the input data has a strong influence on the risks and should be analyzed with care to reduce all doubts for the study.

Unfortunately, the first generation nuclear plants that are being decommissioned today have poorly documented history resulting in missing or uncertain data. The ambient dose rate is not always well-known as radiological investigations have not been done or updated for many years. An efficient way to reduce contingencies is to do sensitivity studies using simulations in order to select the best scenario strategy for each set of data while evaluating the influence of all uncertainties.

To illustrate this global approach and sensitivity studies, this paper will dive in a decommissioning project conducted by OREKA Solutions using DEMplus®[1], an innovative software which simulates in 3D and compares, manual and robotic operations for new build, maintenance and decommissioning interventions in nuclear facilities.

PRESENTATION OF DEMPLUS®

OREKA Solutions has developed DEMplus®, the first 3D simulation software dedicated to nuclear projects. The software helps you create, optimize, compare scenarios and estimate the cost and the duration of a project taking into account:

- Radioprotection (individual and collective dose calculation,
- Cost and planning of operations,
- Waste management process
- Equipment, Pathway Access…

OREKA Solutions also teamed up with the French CEA (The Atomic Energy and Alternative Energies Commission) to integrate some of their technologies in the software. The first one is the dose calculation engine. Based on the Linear Attenuation Shielding Formula and the Build-Up factor; this engine is recognized by the experts as well adapted for radioprotection calculations. The second technology is an anti-collision engine which insures the accessibility of the workers, equipment or robots and check that no physical obstacle will prevent the realization of the operation.

When using a software such as DEMplus®, the aim is to provide a simple way to simulate an operation and to examine instantaneously its impact on all results. The user successively specifies each operation of a reference scenario, interacting with an interface representing the 3D model of the facility (called the "scene"), the type of operation (cutting, moving, decontamination, radiological inspection…) and outfits. After that, the user can simulate alternative scenarios and compare them. He may change the order of the operations or the operating conditions (for example to do the next operations in contact instead of remote

[1] DEMplus is a copyrighted software by OREKA Solutions.

handling), increase the number of decontamination, add radiation shielding, use specific equipment or tweak the input data…

The user is able to determine the most effective scenario depending on his prior objectives by testing and simulating each action with a specific set of parameters and evaluate the consequences. In addition the software computes results and generates reports.

Fig 1. Simulating an operation on DEMplus® is done by selecting the equipment, choosing the type of operation to be simulated and the tool and team to be used. The results are provided in term of cost, dose, duration, and waste generated.

Its also very important to study how to structure and normalize these feedback data. One of DEMplus® primary objectives is to standardize a costs grid to improve the acquisition of what was learnt from experience, record and exploit it. The estimated values of the study phase and figures obtained from the realization should be cross-checked to better understand why some actions were under or over-estimated. It is necessary to increase our dismantling intelligence. As for oil and gas industry, we established structured cost codes with the goals to get them normalized by safety authorities and to standardize dismantling frameworks.

DEMplus® is based on a global approach that helps implement an ALARA (As Low As Reasonably Achievable) method. The software allows a better preparation and control over your projects during the entire life cycle of your nuclear installation: new build, maintenance, life time extension, decommissioning. It is a real decision-support tool which responds to current work challenges and assists engineering companies defining their operation strategies.

CASE STUDY

To better understand the importance of a global approach and sensitivity studies, we will dive in a specific case study conducted by OREKA Solutions using DEMplus®. The goal of this project was to simulate a decommissioning scenario for the lower part of a Reactor. The parameters of this project included: Setting up the physical inventory, the simulation of several environments and radiological configurations, the simulation of several dismantling, the comparison between scenarios. This study aimed to reduce the dose, cost and duration of the project.

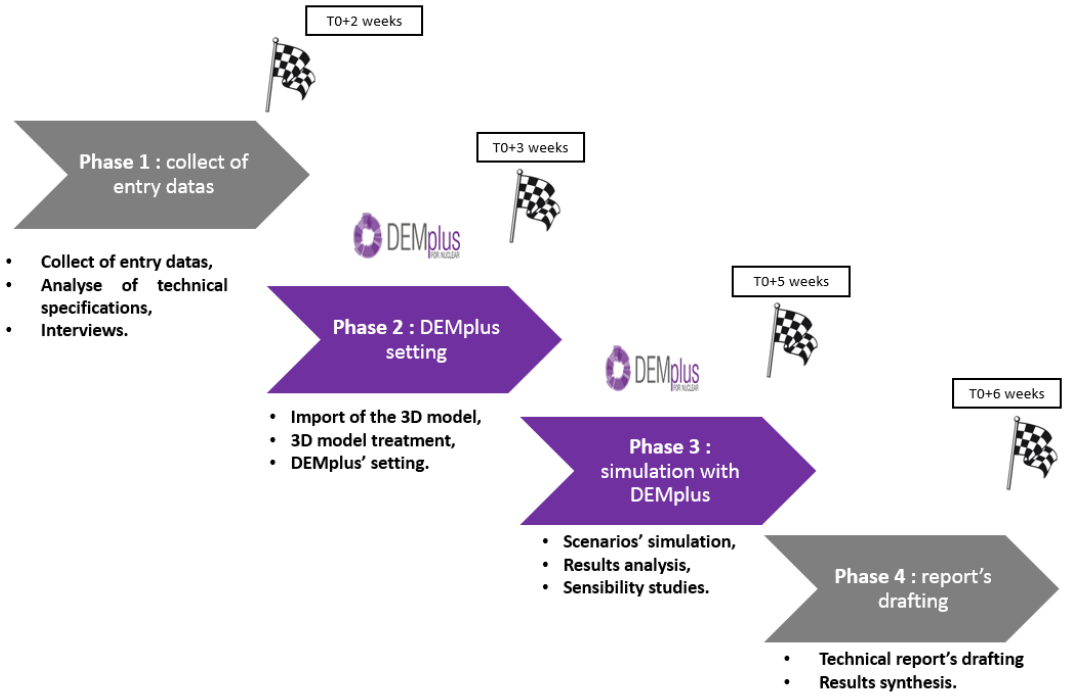

Fig 2. The project was completed in 6 weeks.

Once the physical inventory done, 3 radiological configurations were simulated because of an existing uncertainty concerning the position of the radiological sources.

Several scenarios were created by varying different parameters such as:

- The approach of the dismantling in itself,
- The dose configuration,
- The operating conditions, in contact or tele-operation,
- The protection suits used,
- The equipment used.

Compared with the scenario considered optimal at the beginning of the project, alternative solutions were recommended in terms of equipment to use considering the environment having constraints of limitation of dusts and effluents.

Four scenarios using different strategies of decommissioning have stood out and they have been developed and simulated in the software: the first scenario was a manual intervention; the second used radioprotection shields to reduce the dose received by the workers; the third simulated the intervention using remote controlled robots and the fourth used handling equipment to carry out big dismantled equipment's outside the facility and into a less radioactive environment, in order to cut them into smaller part and sent into proper waste treatment processes.

Solutions in term of waste management were also brought in sense that the cut of equipment could be outsourced, allowing to reduce the duration of the operation inside the radioactive cell.

Fig. 3. Choose the best strategy by changing some entry data.

In addition, various waste management strategies were simulated using the software DEMplus® and the results showed that, for this particular environment, a decontamination of equipment prior to their dismantling resulted in a de-classification of the waste categories into less radioactive waste which drastically reduced the cost of the waste management.

All these scenarios have been compared to each other. For this specific project and environment, the comparison showed that decontamination prior to decommissioning operations using mostly handling equipment resulted in an optimized scenario which balanced a cost effective project, a low and reasonable dose received by the worker and a shorter duration of the project.

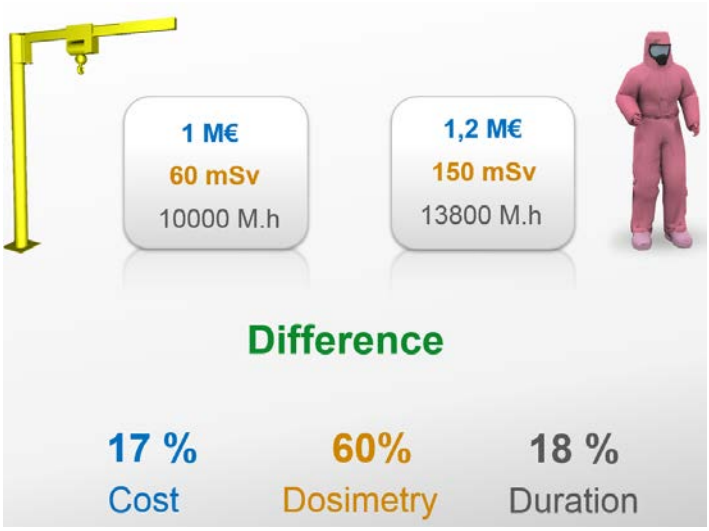

Fig. 4. Results of the comparaison between the initial reference scenario and the optimized scenario.

CONCLUSION

In order to keep that energy at a low-level price, all operations along the plant lifetime have to be well managed: maintenance, upgrades for increasing its lifetime, dismantling... An inefficient control of these costs could challenge the sustainability of the civil nuclear industry.

As a complete simulation of nuclear interventions can be done quickly and efficiently using simulation software like DEMplus®, many strategies can be tested, analyzed and compared on all output parameters in a total accordance with the ALARA approach. Then, contingencies can be prevented by trying a number of situations depending on various uncertainties. This enables to determine the best scenario strategy for each set of data. In addition; simulations can verify not only access issues into some environment but also radiological access. By testing different dosimetric configurations or hot spot location, simulation allows you to test them and so reduce risks.

Simulation offers a very good return on investment in the sense that several scenarios simulating different strategies and/or variations in the entry data can be created in short time. And the different simulations quantifies risks, reduces hazard and therefore reduces costs.

Some simulations tools enable to collect output data for future decommissioning projects. This improve the feedback acquisition, very important in the decommissioning field in which we do not have a lot of feedback.

Moreover the knowledge and approach used in DEMplus® for nuclear which was initially designed for nuclear industries is transferable to other fields as oil and gas, transportation and industry.

REFERENCES

[1] OCDE 2006, NEA n°6038, “Selecting strategies for the decommissioning of nuclear facilities”