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Guide to enhance reliability of the dose estimates in dismantling

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1. Introduction

The pre-studies, the studies and the realization of works associated with the dismantling of nuclear power plants show important gaps between the dose estimates before the start of the work and the doses really collected during the work. Most of the time, predicted doses are overestimating the actual doses, which induces a non-adequate allocation of human, technical and financial resources (wrong classification of the radiation protection stakes of the jobs, highly formalized ALARA analysis to be validated by an ALARA Committee, etc.).

On the basis of these observations, EDF/CIDEN launched a study, in collaboration with CEPN, to analyze the whole process since the initialization of a dismantling project until its complete achievement in order to identify the reasons of the gaps between predicted and actual doses.

2. Decommissioning at EDF

In 2009, 9 EDF units are under decommissioning (see Figure 1).

- One pressurized water reactor (PWR): Chooz A (300 MWe) in operation between 1967 and 1991. The particularity of the unit is that it was built in a cavern, which acted as a natural containment building.
- One heavy water reactor (HWR): Brennilis (70 MWe) in operation between 1967 and 1985.
- Six graphite gas cooled reactors (GCR):
  - Chinon A1 (70 MWe) in operation between 1963 and 1973,
  - Chinon A2 (200 MWe) in operation between 1965 and 1985,
  - Chinon A3 (480 MWe) in operation between 1966 and 1990,
  - Saint-Laurent A1 (480 MWe) in operation between 1969 and 1990,
  - Saint-Laurent A2 (515 MWe) in operation between 1971 and 1992,
  - Bugey 1 (540 MWe) in operation between 1972 and 1994.
- One fast breeder reactor (FBR): Creys-Malville (1240 MWe) in operation between 1986 and 1997.

Figure 1. EDF units under decommissioning in 2009

3. Specificities of dismantling activities

Dismantling activities present specificities in comparison with activities during reactor operation and outages:

- Lack of feedback experience: most of the time, dismantling activities are new or even unique tasks, for which there is no feedback experience, while most of the outage activities are performed every year in each unit.
- Difficulties to accurately evaluate radiological conditions for dismantling activities, in particular due to:
  - The lack of knowledge about the history of reactor operation,
  - The impossibility to perform direct measurements on the field or because only old radiological maps, not adapted to the work to be performed, are available,
  - The constant evolution of the source term: the decrease of the source term during the work following the removal of equipments or because of radioactive decay,
  - The changing of doses rates in radioactive waste storage.
- Difficulties to accurately evaluate the exposed workload, in particular for tasks, which last months or even years.
- Waste management: many waste of different natures and types (VLLW, LLW, ILW), in particular waste that are not present during reactor operation, must be managed.

These specificities induce that the approach for preparing dismantling jobs from the radiation protection point of view should slightly differ from the preparation of routine jobs. For instance, in some cases, criteria used during outage to evaluate radiological stakes of activities are not adapted to dismantling activities.

4. Analysis of dismantling projects

In the scope of the project launched by EDF/CIDEN in collaboration with CEPN, three case studies of dismantling projects were analyzed. The objective was to identify the main causes, which could explain the important difference between estimated doses and actual doses at the end of the activities. In a second step, these observations were used to prepare the guide, which will be described later in the paper. The three cases chose by EDF/CIDEN were the following:

- Extraction of the lateral neutron protections (PNL) at Creys-Malville,
- Extraction of shells and waste packages at Chinon A3,
- Dismantling of the HK cavern (nuclear auxiliary building) at Chooz A.

We can note that the three case studies are not in high dose rate area, but in the future, from 2012 the dose estimate is between 300 and 900 H.mSv for the dismantling activities.

4.1. Extraction of the lateral neutron protections at Creys-Malville

The objectives of this project were first to extract the PNL, which were around the reactor vessel, then to put them into containers, specifically developed for the PNL, and finally to store these containers in another building of the plant. The duration of the project was 15 months.

The first dose estimate performed by EDF/CIDEN (before the contractor was chosen) was 185 H.mSv. After an optimization process, the second dose estimate of EDF/CIDEN was 84.4 H.mSv. The first dose estimate by the contractor, based on the radiological data given by EDF/CIDEN (mainly computer modelled dose rates), was 66.4 H.mSv. The final contractor dose estimate before the start of the work was 50 H.mSv.

At the end of the task, the total collective dose received by the workers was 8.4 H.mSv.

4.2. Extraction of shells and waste packages at Chinon A3

At Chinon A3, many shells and waste packages were store in the heat exchanger rooms. The objective of this project was to transfer the waste from the heat exchanger rooms to the ANDRA LLW disposal. The duration of the project was 18 months.
The first global dose estimate performed by EDF/CIDEN (before the contractor was chosen) was 90 H.mSv. The first dose estimate by the contractor, based on the radiological data given by EDF/CIDEN, was 87.4 H.mSv. After an optimization process, the final contractor dose estimate before the start of the work was 78.1 H.mSv.

During the work, it appeared that the dose estimate was overestimated. It was then evaluated again three times:

- After 3 months, 21.67 H.mSv: even if radioactive decay was taken into account in the assessments, dose rates were still overestimated,
- After 8 months, 15.6 H.mSv: decrease of exposed time and staff, due to improvement of operational procedure,
- After 16 months, 7.94 H.mSv: good operational practices (in particular biological shields when detecting hot spots) not taken into account during the preparation, improvement of the exposure factor values depending on the worker specialties.

At the end of the task, the total collective dose received by the workers was about 4 H.mSv.

4.3. Dismantling of the HK cavern at Chooz A

Contrary to the two other case studies, only the preparation phase of this project was analyzed as it just started at the end of 2008.

The objective of this project is to dismantle all the electro-mechanical systems of the nuclear auxiliary nuclear building (HK cavern), except operational systems needed for other activities (lighting, telephony, sound, etc.). The removal of some systems will induce an important risk of alpha contamination. The duration of the project was initially 15 months: it was extended to 24 months because alpha risk was initially underestimated.

EDF/CIDEN did not provide to the contractors with a first dose estimate, but only with a dose collective objective: less than 200 H.mSv. The first dose estimate by the contractor was 181.2 H.mSv (base on a 15-month duration). After the optimization process, the final dose estimate was 172.3 H.mSv (based on a 24-month duration).

The work started at the end of 2008. Contrary to the two other case studies, it seems that the dose rates were not overestimated, mainly due to the fact that radiological maps were realized consistent with the expected workstations. However, the first data already showed slight differences with the final estimated collective dose. A new assessment was made in the first semester of 2009: about 145 H.mSv.

5. Analysis of the causes explaining gaps between estimated dose and actual doses

First of all, it has to be underlined that, due to the specificities of dismantling jobs (see paragraph 3), the fact that dose estimates are not as accurate as for outage jobs does not mean that dismantling jobs are not as well managed. However, improvements in the preparation of dose estimates are possible.

According to the analyze of the three study cases, different points can explained the important differences between estimated doses and actual doses:

- Evaluation of dose rates:
  - The Creys-Malville's case showed that, when dose rates must be modelled by computer, this favours their overestimation, as the main penalizing hypothesis are used.
  - Old or inadequate radioactive maps are often used to prepare dose assessment: in particular, the measurement points do not generally fit with the workstations.
  - Radioactive decay is not always taken into account: this is in particular penalizing for long-duration works when Co-60 (half-life of 5.3 years) is the main isotope.

- Evaluation of exposed time: it is difficult to make an accurate evaluation of the workload for long jobs. In particular, the decrease of exposed times due to the repetition of the same gestures can generally not be evaluated prior the start of the work.

- Evaluation of the exposure factor:
  - This factor is difficult to evaluate for dismantling tasks as these are often new activities without any feedback experience,
  - A value of 0.7, which is a common value for outage activities, is often used for the activities, whereas it may not be adapted,
  - More generally, this factor is sometimes not well understood (and then misused) by the persons preparing the job.

- ALARA culture:
  - A conservative dose estimate is often preferred to prevent unexpected exposure: a tricky justification for exceeding the dose estimate can then be avoided.
  - There is often a lack of dialogue between different actors, in particular between engineers, who prepare dose estimates, and operators, who will perform the activities and often know very well work conditions.

- Dose and dose rate measurements: the accuracy and coherence of measurements between dose measurement device and dose rate measurement devices are questioned for low dose rates (below 1 μSv/h), which are quite common during (actual) dismantling activities.

6. Orientations of the guide

Following the analysis of the case studies, a methodological guide was written for CIDEN and contractors. The objective of this guide is to improve dose estimates and, more generally, the content of the radiation protection studies related to the activity. It is important to underline that this guide cannot be the only answer to the gaps between dose estimates and actual doses.

The guide integrates and takes into account the specificities of dismantling jobs and good radiation protection practices to be considered. It is not only focused on dose estimates but on the complete ALARA procedure: preparation, follow-up and feedback experience. For each of these steps, it details the objectives, the questions to be considered and the outputs.

The guide describes precisely how to prepare dose estimates at each step and in particular, the importance of the preciseness of initial data (dose rates, contamination risks, etc.). Moreover it underlines the importance of the follow-up step to adapt radiation protection to real conditions. It is advised that dose estimates and optimisation actions should evolve if necessary during the activity, especially for long-duration jobs. To allow this evolution, it is important to perform a sensibility analysis on the initial data and actions.

Finally, one of the main problems for dismantling activities is the lack of feedback experience. The guide insists on the need for feedback and proposes methodology for getting and analyzing the activity, when it is performed and when it is finished.

The methodology for collecting feed-back experience will notably be applied to the works associated with the dismantling of the HK cavern at Chooz A, with the appointment of a dedicated person. Moreover, another guide will be soon elaborated, including more precised recommendations for the radiation protection follow-up of jobs as well as fee-back analysis.