DISMANTLING OF THE HOT CELL Nr 41 AT THE SCK•CEN USING THE ALARA PLANNING TOOL VISIPLAN

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1. Introduction

The Belgian Nuclear Research Centre SCK•CEN is a federal organism for scientific research in the field of safe and peaceful applications of nuclear energy for industrial and medical purpose. Among the installations of this Research Centre, the Laboratories for High and Medium Activities enable to manipulate, inside several Hot Cells, highly radioactive sources in the framework of Reactor Pressure Vessel Surveillance or spent fuels analysis.

2. Description of the cell

Cell nr 41 was already out of service since several years, when the decision was taken in 1999 to dismantle its contents to equip it in the framework of a new program, concerning the reinstrumentation of irradiated fuels. From a historical point of view, this cell was used successively since the years 60 for the reprocessing of ceramic fuels, the manipulation of Pu-fuel and finally for the reprocessing of highly uranium enriched irradiated fuel using chemical extraction techniques. The last manipulations inside this cell dated from October 1990.

All along its utilization, this cell has known several interventions to carry out modifications to the installations and maintenance. In 1999, it was already several years that this cell was unused and left as it was. This cell included then the following elements: steel profiles supporting a working table and a vertical wall, several tanks, lead protection walls, a remote handling arm out of order inside the cell, a travelling crane near the ceiling and several wastes remaining from the last interventions.

Fig. 1 : Outside view of cell 41

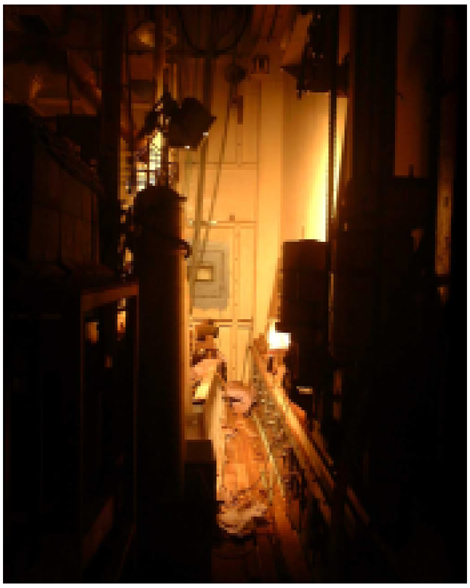

Fig. 2 : Inside view of cell 41

3. ALARA – Use of VISIPLAN

3.1. Measurement campaign

Before to be able to put the dismantling of cell 41 into practice, a detailed ALARA study was carried out. The first step consisted to perform a radiological mapping campaign inside the cell. TLD-dosimeters (thermoluminescent) were used to obtain dose rate values. Smear samples were also taken at several representative points of the cell. These samples were measured afterwards to obtain an estimation of the transferable contamination. Several smear samples were also measured in gamma spectrometry to obtain an estimation of the isotopic composition of the contaminants.

From this first measurement campaign the following conclusions have been drawn:

- The vertical wall of the working surface presented a dose rate of 15 mSv/h
- The dose rate of the working surface varied from 1 to 3 mSv/h with hot-spots of 4 and 20 mSv/h
- The bottom of the α−box of the cell gave an exposition from 3 to 6 mSv/h
- The cylindrical tanks presented a surface dose rate of 1 mSv/h
- The most represented isotopes from the gamma spectrometric measurements were ^{137}Cs (62 %), ^{241}Am (16 %), ^{106}Ru (15 %) and also ^{60}Co, ^{239}Pu, ^{144}Ce,...

3.2. Simulation with VISIPLAN

Based on the measurement results mentioned above an extensive ALARA study was carry out using the software VISIPLAN, developed at the SCK•CEN. This software works on PC. VISIPLAN allows to plan a work in a 3D virtual environment, based on information concerning the geometry, the nature of the materials as well as the radiation field.

The VISIPLAN methodology is characterized by different steps :

- the gathering of information, the construction of the 3D-model representing the place where the work will be done, and the input of the radiological data,
- the general analysis stage,
- the detailed analysis stage followed by
- the work planning and
- the follow-up stage.

During the first stage, the model of cell 41 was built based on the drawings of the cell and the nature of materials of the several present elements. When the sources and their activities are known, a calculation of the radiation field can be carried out directly. In our case a supplementary step had to be followed. Based on the nature of the isotopes determined by gamma spectrometry and on the measures of dose rates inside the cell, an algorithm of VISIPLAN has allowed to determine the mean activity of the different elements (i.e. recalculate the sources).

In the general analysis stage, the calculated field is used and suggestions, concerning the way to reduce the doses are tested (for instance use of a shield), recalculating for each option the values of the radiation field. In the framework of the dismantling of cell 41, different shielding options of the hot-spots were analysed.

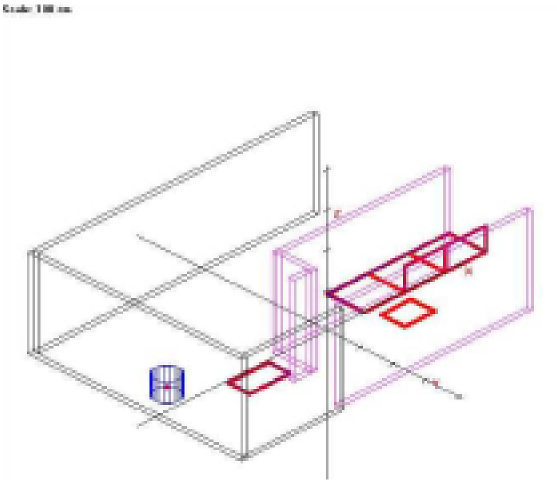

Fig. 3 : VISIPLAN Modelization cell 41

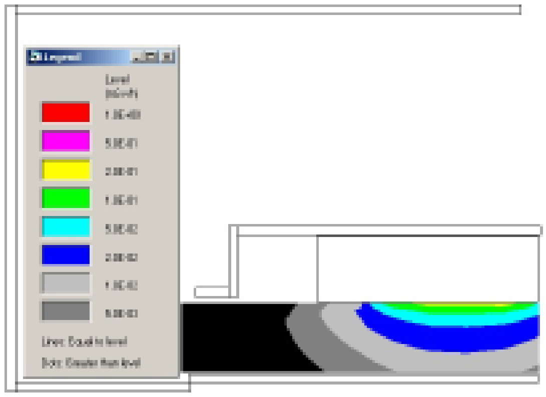

Fig. 4 : Estimation of dose rates inside the cell, via a grid, at the working place

In the detailed analysis stage a dose calculation is carried out following a trajectory, made of a series of tasks, each characterized by a position, a task description and task duration. For cell 41 examples of tasks are the installation of material in the cell, the cut of each part of the vertical wall, the cut of the different parts of the working surface, the cut of the tanks,... For each tasks, the software take account of the disappeared activities further to the evacuation of the cut pieces.

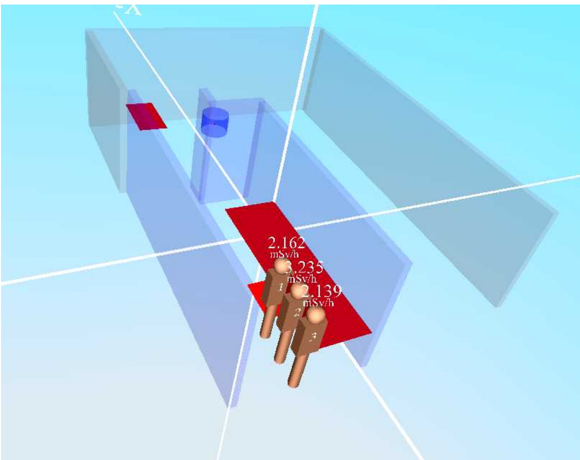

Fig. 5 : VRML Conversion of one of the trajectories

Cut of the third part of the vertical wall

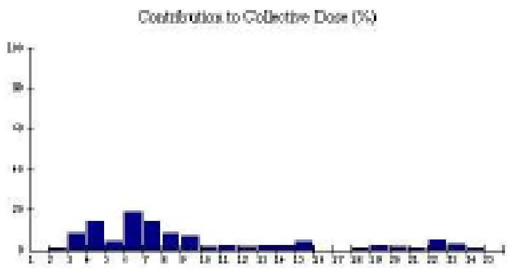

Fig. 6 : Collective dose repartition between the different trajectories.

Based on the different trajectories that were calculated, a scenario can then be build allowing having a global view of the different operations to be carry out and of the dose levels that will be received by the different workers. Based on the different available information's at the moment of the execution of the calculations, a global collective dose of 21 man.mSv was foreseen (taking into account the uncertainties defined in the system, between 15 and 28 man.mSv).

3.3. Procedures

Before to begin the intervention, different procedures and working instructions were written. They concerned among other things the placement of an intervention zone in front of the cell, the evacuation ways of the wastes, the cutting means, the protection equipments for the workforce,... The intervention zone in front of the cell was composed of different parts : a working zone and a waste docking station built with wooden panels covered with plastic sheets and a double door system for the entrance of the workforce.

Due to the high risks of contamination (also α)), the workforce was equipped with ventilated suits in overpressure, including an independent mask with a filter type P3. To control the internal contamination risk of the different workers, a nose-blow of each of the persons was taken at the end of each intervention. One of the persons having carried out the intervention underwent also a measure at the "Whole Body Counter". It was also foreseen that in case of incident (for instance. crack in the ventilated suit), the concerned person would leave immediately the cell and would undergo a control as well by nose-blow, as by direct measurement at the "Whole Body Counter".

Each worker carried a dosimeter, type TLD, a wrist dosimeter also type TLD, an electronic dosimeter Siemens EPD and an electronic dosimeter with remote reading type Xetec, allowing the Radiation Control agent, outside the cell, to follow directly the evolution of the doses of the worker.

Before to begin the operations, the availability of 3D dosimetric maps for the operators has also allowed to improve the communication towards them and to highlight the ALARA problematic.

Fig. 7 and 8 : Intervention in overpressure suits

4. Realization of the dismantling

4.1. Difficulties

Different difficulties were encountered mainly at the beginning of the cutting operations. Before to be able to open the cell, several uncertainties remained on the nature of the materials inside. Indeed, due to the fact that the cell was not used anymore since several years, the available information's were limited. It has had an impact on the choice of the dismantling techniques. At the origin, a circular saw with two contra-rotating blades was selected. The goal was to cut big surfaces, in a first time inside the cell and afterwards to bring them towards the working zone outside the cell to cut them into smaller pieces. However at the time of the first cuts, it appeared that the structures to dismantle were more resistant than foreseen. The cutting technique had to be review. An angle grinder machine was then chosen. This technique, that allows cutting bigger profiles, has however the disadvantage to produce sparks, what brought a higher fire risk in the working zone. The reduction in smaller pieces had from then on to be carried out inside the cell in a higher dose ambiance.


Fig. 9: Cutting with the angle grinder machine

4.2. Dismantling stages

From a general point of view, three big stages can be distinguished in the dismantling of cell 41 (between 2000-02-07 and 2001-10-31): 1. cut of the working table, of the profiles, of the tanks and of the lead castle, 2. decontamination of the cell, dismantling of the remote handling arm, of the travelling crane and of the remaining lead wall, 3. different decontamination stages and fixation of the remaining contamination by different painting layers.

The collective dose resulting from these different operations is 26,4 man.mSv (distributed on 19 persons). This dose is spread in the following manner: 19,4 man.mSv for the first stage, 5,3 man.mSv for the second one and 1,7 man.mSv for the third one. This result can be compared with the prediction of 21±7 man.Sv. As we can see the foreseen collective dose was underestimated, what is not generally the case in VISIPLAN calculations. The main reasons for this underestimation can be found in the uncertainties about the nature of the elements to dismantle inside the cell before to open it and consequently in the encountered cutting problems. For some operations, such as the dismantling of the travelling crane, the resolution of classical safety problems has also contributed to the increase of the foreseen collective dose.

5. Conclusion

The content of cell 41 of the installation LHMA from the Belgian Nuclear Research Centre SCK•CEN has been dismantled with success on a period of one and half year. The VISIPLAN software, developed at the SCK•CEN has allowed to carry out an ALARA optimization of the doses and to improve the communication towards the operators in charge with the dismantling. This software allows to simulate a 3D working environment in presence of several sources. A collective dose of 26,4 man.mSv, for an evaluated one of 21±7 man.mSv, was received from the beginning of the dismantling up to the last stage consisting in the fixation of the individual contamination.