

Software VISIPLAN : a powerful tool for optimisation

F.Vermeersch and C.Vanbosstraeten
SCK•CEN
The Belgian Nuclear Research Centre
Boeretang 200
B-2400 Mol
Belgium

Abstract

The VISIPLAN 3D ALARA planning tool is developed to assist the person responsible for ALARA on a nuclear site. The tool provides the possibility to plan the work in a 3D environment taking into account the geometry, material and radioactive source specifications. It allows assessing the individual and collective dose uptake for a defined work scenario and enables through comparison of work scenario's the optimisation needed for efficient ALARA planning. The system is currently being used at the SCK•CEN, different application will be addressed in this paper.

Introduction

The optimization of radiological protection of the workers in nuclear industry is an important part of the safety culture. However the application of the ALARA concept (As low as reasonably Achievable) is not always straightforward. The first part of ALARA, the "As Low As" part, concerns the reduction of the dose. In order to investigate this part the ALARA-analyst must be able to predict dose in the work area and must also be able to investigate the effects of geometry, material or source changes. Another important part in the dose assessment is also the work organisation i.e. the distribution of the work force over the different tasks.

In order to be able to handle this information the SCK•CEN developed the VISIPLAN 3D ALARA planning tool. This PC-based tool makes it possible to create and edit work scenarii taking into account worker positions and subsequent geometry and source distribution changes in a 3D environment. The dose calculation within the tool are base on the point-kernel technique with build-up correction. This method has proven to be fast and sufficient for most application in the field of dose assessment.

In the following section we give a detailed description of the current VISIPLAN tool. Section 3 covers some of the applications of the tool at the SCK•CEN. In the 4th section we describe some new developments that we are implementing in the VISIPLAN software in order to communicate the results of the analysis in an efficient way.

The VISIPLAN tool

The VISIPLAN tool is based on the following methodology for assessing an ALARA case from the radiological point of view. The steps to take in an ALARA-analysis of an intervention or a routine work in a nuclear environment are :

- Information gathering and model building
- General analysis
- Detailed planning
- Follow-up

Each of these steps will be described in the following sections in relation to the tools available in the VISIPLAN software.

UNCONTROLLED COPY

Model building stage

A set of model building tools is provided to translate the geometrical model and associated materials information of the work area into a VISIPLAN model by using primitive volumes such as boxes, spheres, cylinders and tubes. The material information is entered in the model as standard materials such as concrete, water, iron... and is attributed to the different volumes. The density of these materials can be changed according to the model needs. Mixtures of materials can also be attributed to a volume in order to simulate the attenuation by complex internal structures. Attenuation and build-up data of user defined materials can also be entered in the materials databases. Source position, source strength, source geometry and source composition can be defined directly in the model. The source spectrum is selected from an isotope list or can be defined by the user. Source strengths can be determined from a measured dose rate set with a source inference tool. The effectiveness of this method will depend on the number and quality of the measurements on site.

A VISIPLAN model of an environment is given in figure 1.

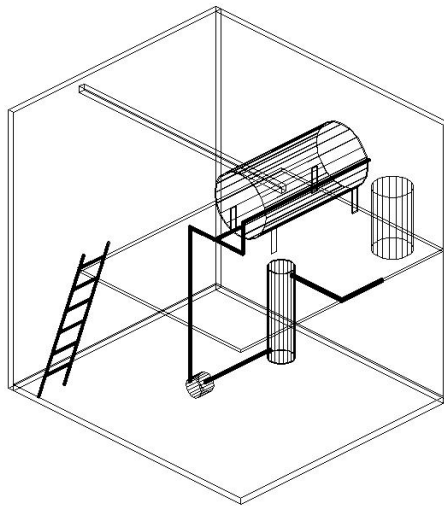


Fig.1. Example of a VISIPLAN model with a tank, a pump and a circuit. A material specification is associated to every volume in the model.

General analysis stage

Once the model is defined tools become available for the general analysis stage. This involves the calculation of dose maps of the working areas. The dose rates can be displayed as contours or as colour patterns on grids perpendicular to the x-, y- and z-axes of the model. This allows a quick detection of the high dose rate areas. A graphical interface is provided to display the contribution of each source to the dose at each location on a grid. This tool helps the analyst to suggest and test possible shielding before going to the detailed work planning.

Source sensitivity analysis tools are available to modify source strengths enabling a quick assessment of operation such as chemical cleaning or contamination removal.

UNCONTROLLED COPY

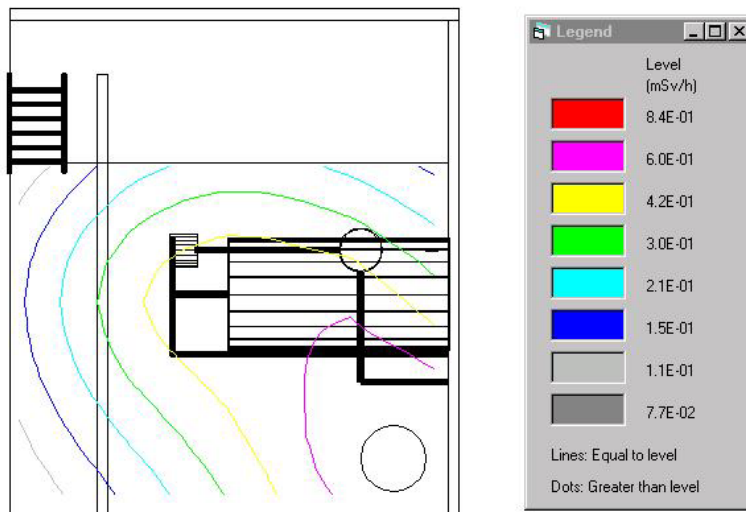


Fig.2. Dose pattern on a grid above the tank calculated with VISIPLAN.

Detailed planning stage

The tools available for the *detailed planning phase* involve trajectory calculation and a scenario building tools. A trajectory is defined as a sequence of tasks to be performed in a fixed geometry and source distribution. These trajectories contain information involving the task description, the location and the duration of the sequential tasks to be performed. The dose account is then calculated for the trajectory based on the radiological and geometrical information of the model. Uncertainties on the work duration can be taken into account making it possible to calculate an upper and lower limit for the acquired doses. A calculated trajectory contains information on the accumulated dose versus time, the dose rate and the dose per task. Details are given per task on the contribution of each source to the accumulated dose. This information supports the analyst in decision to introduce new shielding solutions or to reduce the source strength by other techniques.

From a set of trajectories the analyst can build a scenario. The scenario is defined by selecting a set of calculated trajectories and associating each to a worker or a group of workers. The scenario results include collective dose for the work as well as the individual dose specified for each worker.

The scenarii can be compared on the bases of collective dose, maximum individual dose, collective time (man*h) and intervention time.

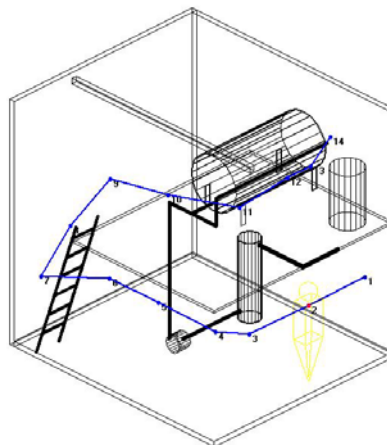


Fig.3. Trajectory definition in the work environment

UNCONTROLLED COPY

Follow-up stage

The graphs and task lists produced in the detailed planning stage make it possible to perform a thorough *follow up* of the dose account during the work. This is achieved through comparison of the predicted and the received dose. Large deviations between both are an indication that risks which were not foreseen in the planning stage are present on the work floor. An appropriate answer and new prognoses can then be formulated based on new measurements and an adaptation of the model including the detected risks. This approach makes it possible to update the model during the work progression and to suggest scenarios with a lower dose account for future activities.

Applications

The VISIPLAN tool was applied to several ALARA studies at the SCK•CEN. The applications ranged from decommissioning, maintenance to the installation of new experimental devices. A sample of some applications is given below.

BR3 decommissioning

The VISIPLAN ALARA planning tool was first applied to perform dose prognoses for the decommissioning activities at the BR3 PWR-reactor at the SCK•CEN [1]. A dose assessment was made for work planned near the primary circuit (see Fig.1a). The source strengths were estimated based on the combination of a dose mapping and source inference technique. The analysis of the radiation field helped us to pinpoint the sources with a large contribution to the dose for the planned operations. By adapting the model we were able to study different scenarios with the aim to reduce the dose for further work. This scenario's involved shielding but also the reduction of the contamination in some vessels through chemical cleaning. The predicted and actual doses for the work performed at the BR3 agreed within 20%.

Hot cell decommissioning

The VISIPLAN tool was also used to perform a dose assessment for the decommission of a Hot cell. The source distribution a contaminated workflow in the hot cell was calculated with the source inference tool. The dismantling of the hot cell walls and the removal of the workflow with the contamination was simulated. Predicted and measured collective dose agreed within 30%.

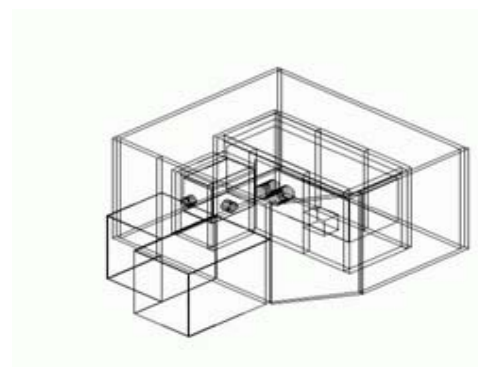
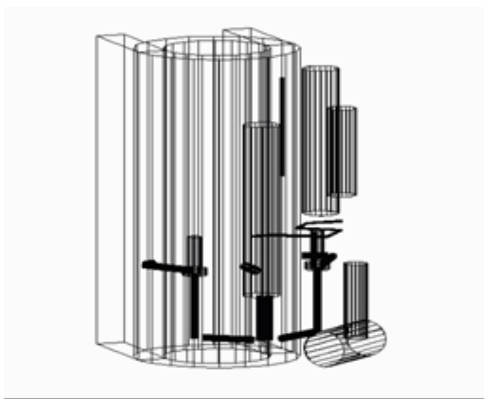


Fig.4. Model of the BR3 and the hot cell decommissioning site.

Sampling in a linear accelerator target room

The program was also applied for the dose assessment for sampling activities at the target room of a linear accelerator. The working area covered a rectangular area of 6 by 14 m [2]. No information was available for the multiple sources present in the target room. The source strengths were estimated, with the source inference technique available in the software, based on

UNCONTROLLED COPY

a detailed dose mapping of the target room on a 3D grid of 1 m interval and information on the location of the main sources.

The predicted values for the accumulated dose agreed with the measured ones within 30%.

Construction works near BR2 research reactor Heat Exchangers

Another ALARA study concerns the construction works near the BR2 heat exchangers. The model is used to determine the most suitable technique considering dose uptake, the need for supplementary shielding and cost. During this study we examined the combined use of VISIPLAN and a gamma scanner for remote hot spot mapping "RadScan 700" from BNFL Instruments. The combined use provided us with a more detailed radiological model of the heat exchangers.

The results of the scanning are represented in a pan tilt plot but also in a 3D representation in the VISIPLAN geometry. The latter enabled us to view the positions of the hotspots with respect to the model and define equivalent sources in the VISIPLAN model.

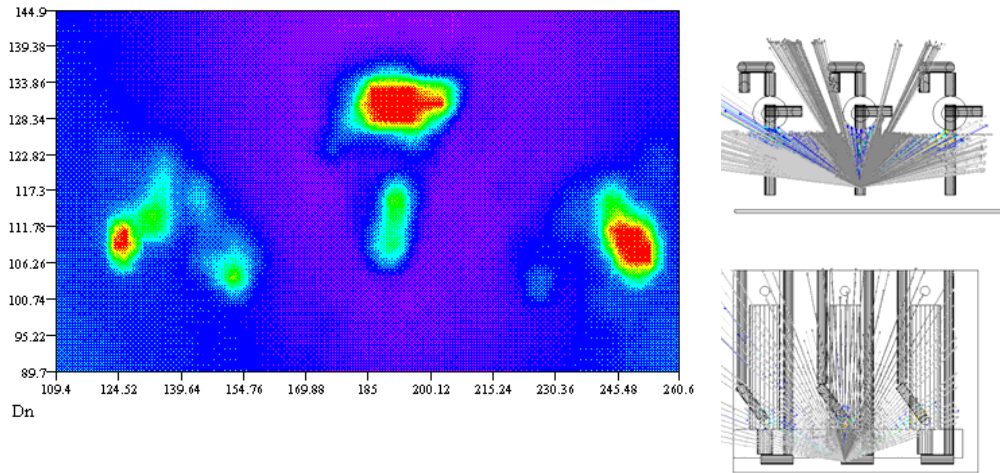


Fig.5. Pan and tilt map of the gamma scanning with the RadScan 700. The inset on the right shows the directions of the scan

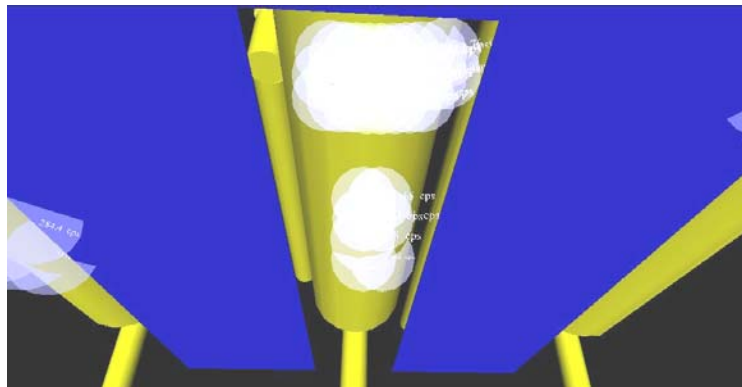


Fig.6. Projection of the scanning results on the VISIPLAN model of the heat exchangers enabling to pinpoint the hotspots in the 3D environment.

Future developments

The VISIPLAN tool is operational and allows a fast optimisation of the dose uptake for a planned work in a complex environment. The further developments are aimed to improve the communication of the results to the planners and the workers. Therefore we are developing a

UNCONTROLLED COPY

VRML (Virtual Reality Modelling Language)-HTML interface to the program that will enable an improved representation of complex geometry's and results of the simulations. The next figure shows an example of a VRML-HTML trajectory output of VISIPLAN. The intensity of the dummy is a measure for the dose rate and allows the user to immediately detect the important dose positions. The user can then further examine the results by clicking on the dummy in the VRML representation. This action creates a popup window with information on the task, task duration, dose rate and dose uptake. A further HTML-link in the window allows examining the contribution of different sources to the dose rate at this position.

The choice to use VRML-HTML technology is obvious. This technology allows an easy 3D representation of an environment and an easy link to text information on dose rates and task descriptions. Furthermore the information can be explored with the standard internet browsers.

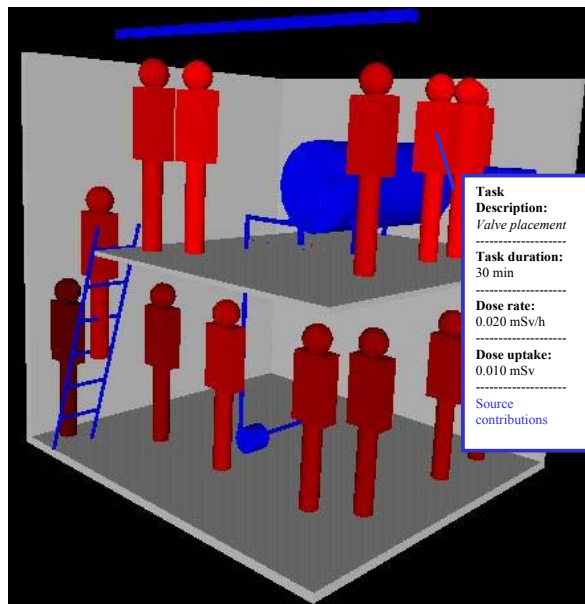


Fig. 7. VRML-HTML output from VISIPLAN

Conclusion

The planning and the dose prognoses for a work in a radiative environment involves the handling of data concerning geometry, materials, source distribution and work organisation. In order to streamline this information we developed the PC-based VISIPLAN ALARA planning tool. The use of a graphical interface for the dose rate representation and for the work definition allows a straightforward approach towards an effective ALARA work planning. Trajectories can be visualised and different work scenarios can be investigated, evaluated and documented in a short period of time. The program has been applied with success for different application such as dose prognoses for routine work and dose prognoses for decommissioning activities.

The further development of the program involving the VRML-HTML reporting module will considerably enhance the reporting capabilities of the VISIPLAN tool.

References

- [1] Massaut, V., Deboodt, P., Vermeersch, F., Lefévre, A. Klein, M., "Optimisation and decommissioning: Challenge and limits", 1st European ALARA Network Workshop, ALARA & Decommissioning, 1-3 December 1997, INSTN Saclay France, Paper No 1
- [2] G.Eggermont, N.Buls, A.Hermanne, W.Van Suetendael and F.Vermeersch, "Optimisation opportunities in the decommissioning of accelerators", 1st European ALARA Network Workshop, ALARA & Decommissioning, 1-3 December 1997, INSTN Saclay France, Paper No 14.