The use of the VISIPLAN ALARA planning tool in ALARA studies at the SCK•CEN.

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Introduction

ALARA dose assessment for work planning in complex nuclear installations is difficult. The aspects of geometry, source distribution and shield geometry play an important role in the dose prognoses. Also work organisation, type and work duration are non-negligible aspects in ALARA considerations. In order to structure and streamline this information we developed the VISIPLAN 3D-ALARA planning tool. This PC-based tool calculates a detailed dose account for different work scenario's defined by the ALARA analyst, taking into account worker position, work duration and subsequent geometry and source distribution changes.
In the following we give a general description of the VISIPLAN ALARA planning tool together with examples of its present use for ALARA studies in decommissioning and maintenance at the Belgian nuclear research centre SCK•CEN.

VISIPLAN General description

The aim of the VISIPLAN software tool is to provide the ALARA analyst with a tool that allows a fast dose assessment for work planned in a radiative environment. The calculations in the program are based on a 3D model of the work place including geometry, material and source information. All calculations are based on the point-kernel calculation technique using an infinite media buildup correction. The user is provided with a set of tools that allow him to perform a dose assessment and to investigate different work scenario in order to reduce the dose to the workers.

The VISIPLAN methodology is based on four major steps; the model building stage, the general analysis stage, the detailed planning stage and the follow-up stage.

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. Source position, source strength, source geometry and source composition can be entered directly in the model. The source spectrum is selected from an isotope list or can be defined by the user.

General analysis stage

Once the model is defined tools become available for the general analysis stage. They involve 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.

Detailed planning stage

The tools available for the *detailed planning phase* involve a trajectory calculation and a scenario building tool. 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, per task details are given 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 intercomparison of different scenario's then leads to the selection of an optimal work scenario.

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 trough comparison of the predicted and the received dose. Large deviations between both are an indication that risks which where 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 scenario's 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 and 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 [2]. 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 scenario's with the aim to reduce the dose for further work. These 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 workfloor in the hot cell was calculated with the source inference tool. The dismantling of the hot cell walls and the removal of the workfloor with the contamination was simulated. Predicted and measured collective dose agreed within 30%.

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.

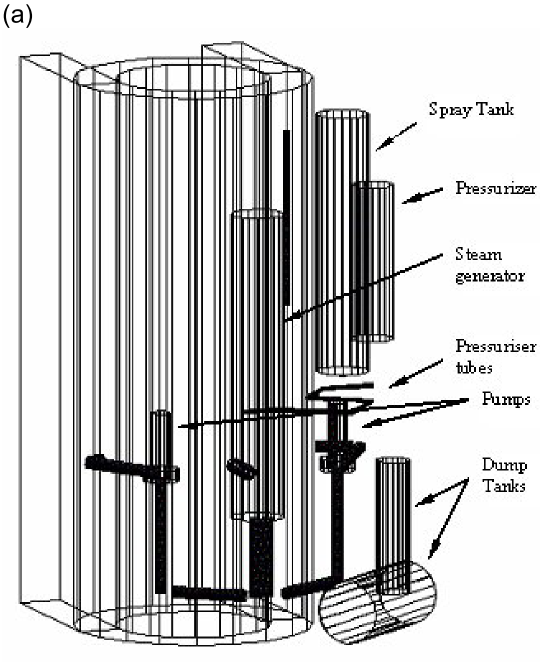
No information was available for the multiple sources present in the target room. The source strengths were estimated, with the source inference technique available in the software, based on a detailed dose mapping of the target room and information on the location of the main sources.

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

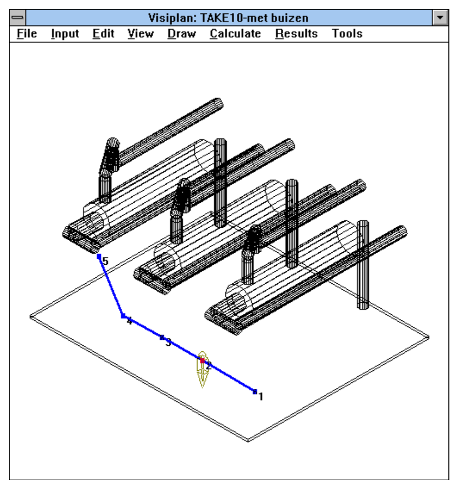
Construction works near BR2 research reactor heat exchangers

An ALARA study which is in progress concerns 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 (see Fig. 1b). During this study we are examining the combined use of VISIPLAN and a gamma scanner for remote hot spot mapping "RadScan 700" from BNFL Instruments. The combined use should provide us with a more detailed model radiological model the heat exchangers. The resultsof this combined use will be published in a later report.

(a)



(b)



c)

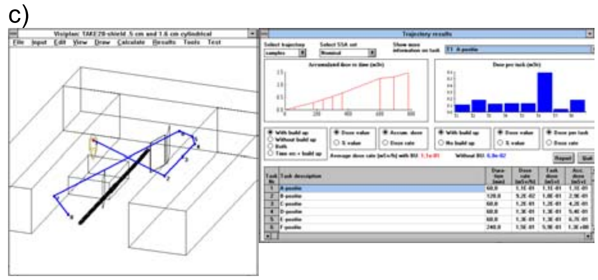


Fig.1.a) VISIPLAN model of the BR3 decommissioning site

b) VISIPLAN model of the BR2 heat exchangers. A trajectory is also plotted on the model.

c) VISIPLAN screen shot for trajectory calculations and results.

In all of these cases the VISIPLAN software contributed to the ALARA decision-process by performing a dose account in a structured way. Not only the planned but also the preparatory tasks such as shield placement or chemical cleaning could be taken into account before deciding on the final work plan.

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.

Further information on the VISIPLAN ALARA planning tool can be obtained from

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