



MERCURAD[®]

3D Simulation Software for Dose Rate Calculation

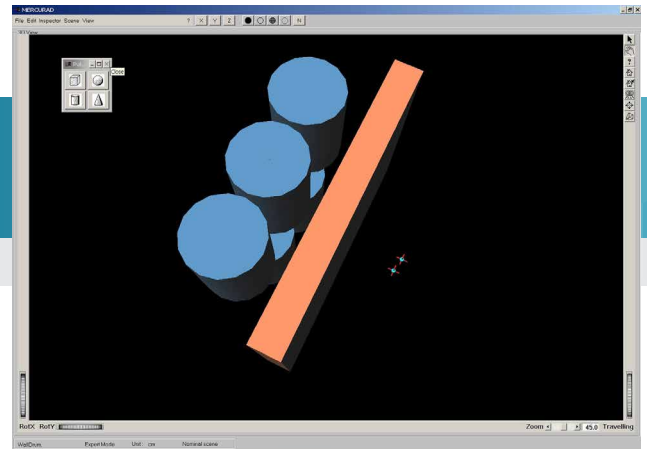


Figure 1. Top view of a waste barrel stack behind a wall

KEY FEATURES

- 3D dynamic simulation of structures (sources, shielding, collimators, etc.)
- Various 3D interactive displays modes (full, transparent, wiring, etc.)
- Multiple sources can be defined. Each source is also an attenuator for other sources
- Doses calculated for multiple points at the same time
- Multi-layer shield construction can be used
- Automatic attenuation build-up calculations - no user guesswork involved
- Core computation method is the powerful MERCURE V6
- Faster than Monte Carlo codes
- Multiple layers build-up calculation (new CEA method based on neural networks)
- Allows "what if" calculations using maximum and minimum values of key parameters
- User friendly user interface under Windows NT, Windows 2000, or Windows XP

DESCRIPTION

The MERCURAD software, with its powerful user interface that can display 3D scenes, offers a practical solution to meet the complex dose calculation requirements of health physics specialists, shielding calculation engineers, and staff involved with nuclear facility maintenance and nuclear installation dismantling projects.

The new MERCURAD software is built using the computation engines of the well known and tested MERCURE calculation code⁽¹⁾. It makes extensive use of a new graphical user interface, thus allowing very complex items to be easily defined and presented.

SIMPLE USE, WITH TOOL BARS

The main functions of MERCURAD software are immediately available using tool bars located at the upper part of the screen.

USER FRIENDLY INTERFACE

Geometrical, chemical and nuclear properties are entered through templates and computer aided sequences to build the view to be measured. In these sequences the operator enters the dimensions of 3D-shapes, their chemical compositions, their densities, the types of radioactive sources, and the locations of the sources.

Reoccurring objects in the scene (e.g., the drum in Figure 4) can also be saved independently as a compound volume and reused within the same scene or saved to be used in future scenes. An operator can create his own views at any time or operate from previously stored acquisition data using stored composite volumes, and typical chemical compositions (concrete, stainless steel, alloys, etc.)

(1) MERCURAD is CEA and COGEMA licensed software.

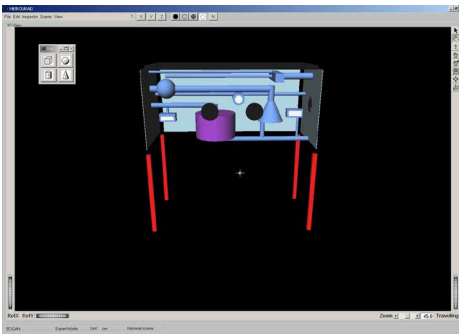


Figure 2. Front view of the inside of a glove box

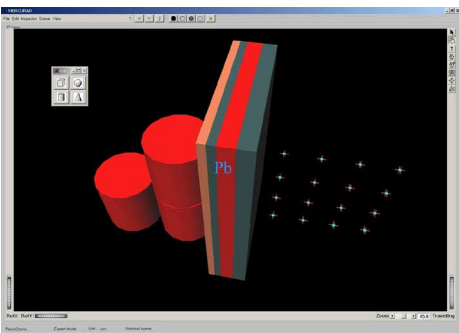


Figure 3. Top-side view of three highly active resin waste drums with multiple shields and multiple calculation points

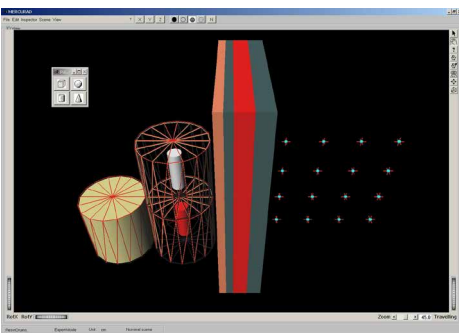


Figure 4. Illustration of the transparent mode and use of the drum as a compound volume

COMPOSITION OF MATERIALS

During the entry of sources and shields, the material must be specified. A predefined list of materials is already available in the software for quick selection. The user can also build and store a complete new material by calling the composition editor.

Any material can be defined based on its chemical formula.

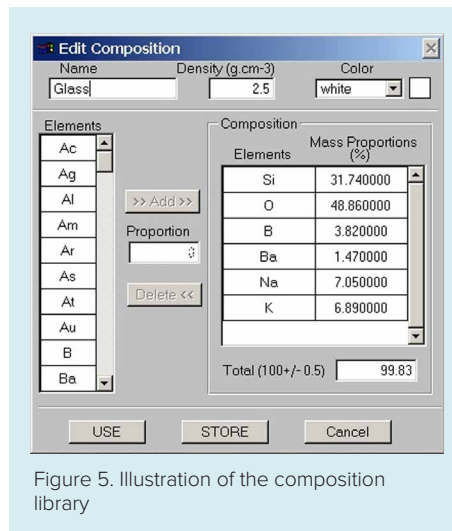


Figure 5. Illustration of the composition library

CALCULATION OF BUILD-UP FACTORS

The latest version of the MERCURE V6, used as a computing engine for dose rate, integrates a powerful function for build-up factor calculation.

The software enables the build-up factor calculation for composed shields by using new algorithms developed by the CEA and ensuring more accurate calculations. Extensive testing has shown that the automatic mode (avoiding any user guesswork) to be highly accurate, even in thick and complex multi-layer shields, up to 50 mfp.

The new algorithm developed using neural networks to accurately calculate the build-up factor of multiple shields quickly. The method allows the user to have no practical limit on the amount of shields in the scene, and still having high accuracy results and short calculation time.

ENERGY GROUPS

MERCURAD software computes the dose rate values either from the radioisotopes specified by the user or from the list of gamma-rays and associated photon intensities. The dose rate calculation can also be made from energy groups.

The determination of the energy groups is automatically performed if the calculation is made from the isotopic list. The software can now manage up to 195 energy groups between 15 keV and 10 MeV.

DEFINITION OF CALCULATION POINTS

One of the strong points of the MERCURAD software consists of its ability to manage, in the automatic calculation mode, a large number of dose calculation points: 100 points is achievable for instance. It makes it possible to cover an entire scene with an unprecedented accuracy and speed.

CALCULATION START

The calculations are performed automatically and sequentially; a separate window is displayed during the calculation process, allowing the user to see the progress of the series of steps in the calculation. This gives the operator the opportunity to see, for example, the convergence factor.

PRINTING OF THE CALCULATION REPORT

MERCURAD software manages the creation of a complete calculation report including the main scene characteristics like source volumes, radioisotopes and associated activities, position of the different calculation points, dose rate values in $\mu\text{Sv/h}$ in $H^*(10)$ ICRP74, $\mu\text{Sv/h}$, $\mu\text{Gy/h}$, mrad/h , mR/h , flux MeV/s , direct fluence ($\text{gammas/cm}^2/\text{s}$), and a 3D presentation of the scene as shown on the screen, before printing the report.

WHAT IF...

MERCURAD software allows the user to define some minimum and maximum dimensions to certain objects in the scene. This allows the user to see the effect of a minimum or maximum configuration of certain dimension in the scene and to observe the effect on the dose calculation. The software has the ability to calculate three dose values for each scene, Nominal, Minimum and Maximum.

For example, the effect of a wall thickness of Nominal X cm, but with a tolerance of X cm – Y cm (Minimum configuration) and a (different) tolerance of X cm + Z cm (Maximum configuration).

COMPLEMENTARY EQUIPMENT FOR *IN SITU* MEASUREMENTS

Mirion offers a full range of complementary products to assist the user in finding radioactive sources and/or qualitatively and quantitatively identifying the radioisotopes (what it is and how much). Those complementary products can help the MERCURAD user to have a more accurate simulation of the complete scene.

- Finding sources of radioactive material – The CARTOGAM™ unit is a Mirion product that is designed as an industrial gamma imaging system (left on the picture). The CARTOGAM unit gives the user the ability to see gamma and video images. The result is that the user can easily identify the position of the gamma emitting radioactive sources.
- Qualitative and quantitative identification of radioactive material – The ISOCS™ system is a Mirion product that is designed to accurately determine the composition of a gamma emitting source and to accurately determine as well the activity of the radioactive source (right on the picture). ISOCS calibration is based on a high resolution semiconductor detector.



Figure 6. At the left the CAROGAM unit finds sources, at the right the ISOCS software qualitatively and quantitatively measures radioactive isotopes

ILLUSTRATION OF THE 3D USER INTERFACE

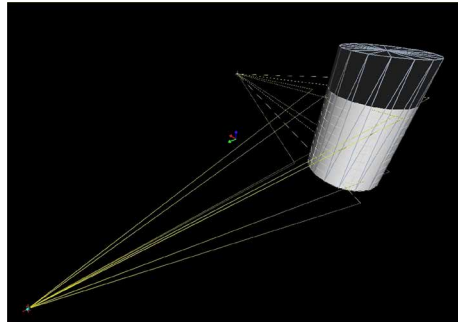


Figure 7. Single waste barrel with active content in the bottom part, mesh drawing mode, with gamma flux visualization

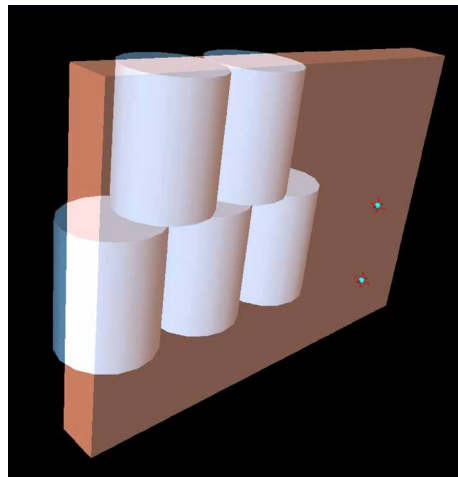


Figure 8. Waste barrel stack behind a wall, in semi-transparent mode

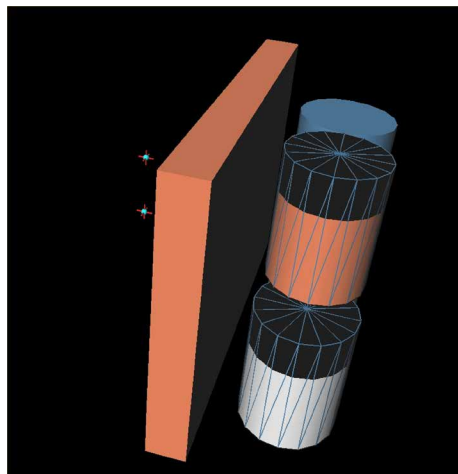


Figure 9. Waste barrel stack behind a wall, in opaque mode, after scene rotation

SPECIFICATIONS

COMPUTING METHODS

Gamma-ray transport:

- Straight line attenuation mode, with integration of point kernels in 3D geometry

Build-up algorithms:

- New CEA method; new multi-layer formula developed using neural networks, up to 50 mfp

Numerical integration of sources:

- By using Monte Carlo method

Calculated values:

- Dose equivalent rate: $\mu\text{Sv/h}$ in $H^*(10)$ ICRP74
- Effective (anterior posterior) dose rate: $\mu\text{Sv/h}$
- KERMA rate in air: $\mu\text{Gy/h}$ or mrad/h
- Exposure: mR/h
- Energy flux rate: flux in MeV/s
- Uncollided flux: $\text{gammas/cm}^2/\text{s}$

Involved interactions:

- Photoelectric absorption
- Incoherent interactions
- Coherent interactions
- Pair Production
- Bremsstrahlung
- Fluorescence

Quantitative values:

- Energy range from 15 keV to 10 MeV
- Maximum group number: 195

Display:

- Volume drawings: Opaque, Semi-transparent, Mesh, Thread, Normal
- Image view: Normal view, perspective
- 3D rotate: On X and Y axis, with virtual rotation knobs
- Special effects: Zoom (direct, reverse)
- Travelling, with virtual rotation knobs

SYSTEM MINIMUM REQUIREMENTS

- Pentium II with 128 MB of memory
- Minimum 60 MB free disk space
- Windows NT SP6, Windows 2000 SR2 or Windows XP PRO
- LPT port

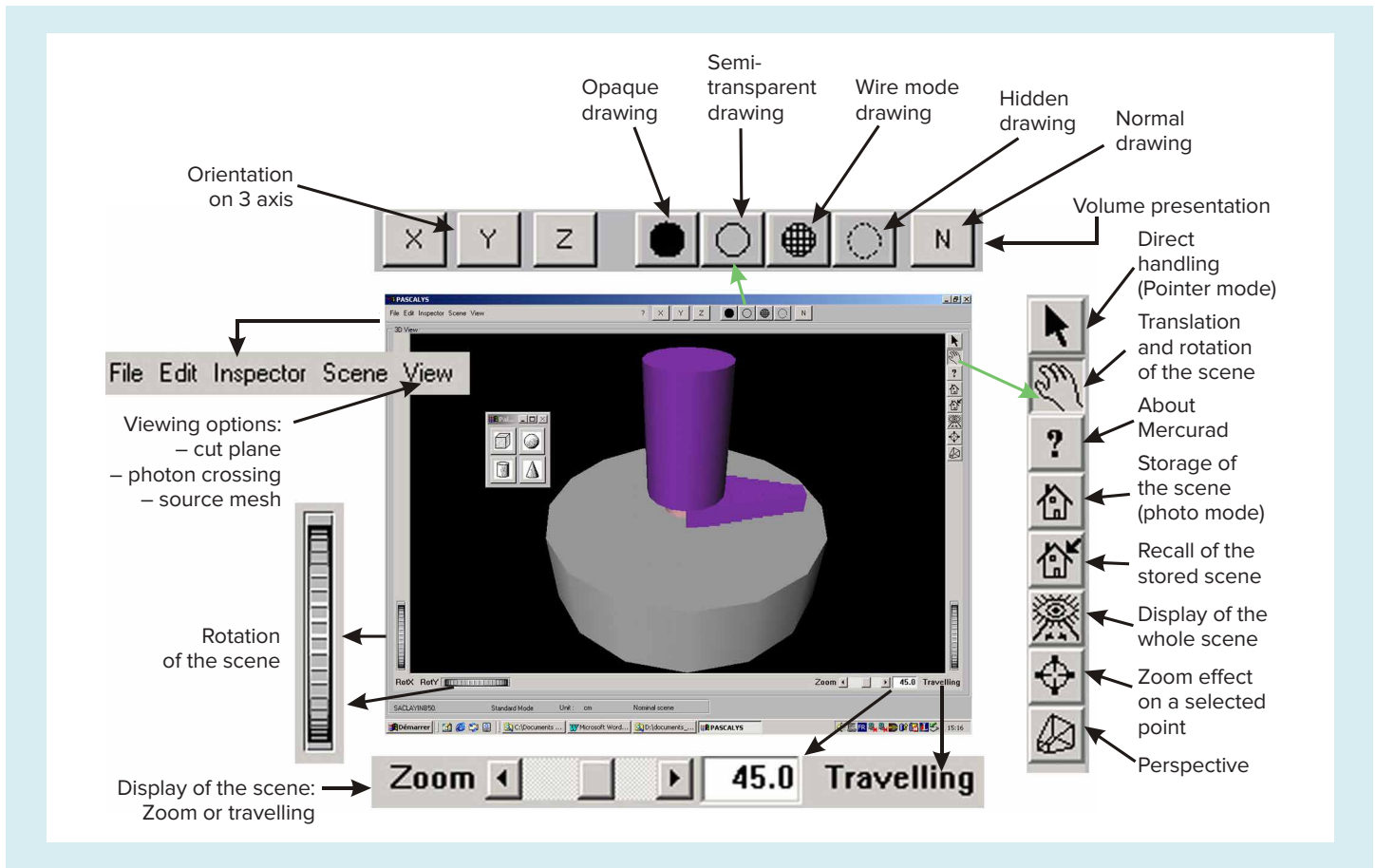


Figure 10. Illustration of the scene manipulation tools in MERCURAD software

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