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SINEX: SCALE Shielding Analysis GUI for X-Windows

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Abstract

SINEX (SCALE INterface Environment for X-windows) is an X-Windows graphical user interface (GUI), that is being developed for performing SCALE radiation shielding analyses. SINEX enables the user to generate input for the SAS4/MORSE and QADS/QAD-CGGP shielding analysis sequences in SCALE (Ref. 1). The code features will facilitate the use of both analytical sequences with a minimum of additional user input. Included in SINEX is the capability to check the geometry model by generating two-dimensional (2-D) color plots of the geometry model using a new version of the SCALE module, PICTURE. The most sophisticated feature, however, is the 2-D visualization display that provides a graphical representation on screen as the user builds a geometry model. This capability to interactively build a model will significantly increase user productivity and reduce user errors. SINEX will perform extensive error checking and will allow users to execute SCALE directly from the GUI. The interface will also provide direct on-line access to the SCALE manual.

1. INTRODUCTION

SCALE (Standardized Computer Analyses for Licensing Evaluation) is a widely used computational code system that has been developed and maintained by Oak Ridge National Laboratory. The purpose of SCALE has been to provide a comprehensive collection of easy-to-use calculational tools for performing accurate analyses of nuclear facilities and package designs. Included in the current release of SCALE are several one-dimensional (1-D) and three-dimensional (3-D) automated radiation shielding analysis sequences. The SAS1 sequence is designed to perform general 1-D shielding analyses. It uses the 1-D discrete ordinates code XSDRNPM to calculate radiation transport through a slab, sphere, or cylindrical shield model. The SAS3 sequence in SCALE uses the 3-D Monte Carlo shielding code MORSE-SGC. However, in a Monte Carlo shielding analysis of a deep-penetration problem such as a spent fuel cask, variance reduction techniques must be employed in order to calculate good results in reasonable run times. The SAS4 sequence performs a 1-D adjoint calculation with XSDRNPM to generate the biasing parameters for MORSE-SGC. SAS4 automatically passes the biasing parameters to MORSE-SGC and executes the code. A generic cask model has also been developed for SAS4 to enable a simplified cask geometry input option. QADS is a control module that performs 3-D point-kernel estimation of gamma transport through practically any type of shielding materials using a simplified input scheme that follows the general input philosophy of the other SCALE shielding sequences. QADS reads the input in a typical SCALE format and executes the QAD-CGGP 3-D point kernel code automatically. The SCALE shielding sequences SAS1, SAS4, and QADS can read the neutron and/or gamma source spectra directly from the user input file or from an ORIGEN-S output file.

As part of ORNL's continuing efforts to make SCALE easier to use, a Motif X-Windows graphical user interface (GUI) named SINEX (SCALE INterface Environment for X-windows), is being developed for performing SCALE radiation shielding analyses. SINEX enables the user to generate input for the SAS4/MORSE and QADS/QAD-CGGP shielding analysis sequences. SCALE Standard Composition input will be interchangeable between SAS4 and QADS. The GUI will convert the QADS 3-D geometry input to the appropriate format for SAS4

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automatically. The reverse conversion from SAS4 to QADS is possible if the SAS4 geometry input does not use arrays. These features will facilitate the use of both analytical sequences with a minimum of additional user input. Included in SINEX is the capability to check the geometry model by generating two-dimensional (2-D) color plots of the geometry model using a new version of the SCALE module, PICTURE. The most sophisticated feature, however, is the 2-D visualization display that provides a graphical representation on screen as the user builds a geometry model. This capability to interactively build a model will significantly increase user productivity and reduce user errors. SINEX will perform extensive error checking and will allow users to execute SCALE directly from the GUI. The interface will also provide direct on-line access to the SCALE manual.

2. DESCRIPTION OF THE INTERFACE

SINEX has the capability to read, setup, and write SCALE input files for SAS4 and QADS and to write input files for the PICTURE plotting program. In addition, these SCALE modules can be executed from within SINEX.

The Main Menu provides six choices:

- ◆ MIP Data
- ◆ SAS4 Data
- ◆ QADS Data
- ◆ PICTURE
- ◆ Display GIF

2.1 MIP DATA

The MIP Data button opens the MIP Menu, which contains the input menus for the SCALE Material Information Processor (MIP) that is common to all the SCALE shielding analysis sequences. MIP reads descriptive composition names such as "H2O" or "UO2" known as basic standard compositions. The SCALE Standard Composition Library currently contains over 600 composition names with default densities and and isotopic compositions, which may be overridden by the user. The user may also construct other compositions through the input of arbitrary materials that are specified by weight percent (wt %) or chemical formula of elements and/or isotopes. MIP automatically calculates the number densities for each isotope and provides problem-dependent resonance self-shielded cross sections. The input options available on the MIP Menu (Figure 1) include:

- MIP Data
- Standard Compositions
- Arbitrary Materials
- Solutions
- Review Mixtures
- Unit Cell Data
- MORE DATA

The MIP Data menu includes such basic information as the shielding sequence, PARM=, title card, cross section library, and unit cell calculation type. When the user selects a cross section library, SINEX accesses the library and compiles a list of all the valid basic standard compositions that are available in that library. If the user changes cross section libraries after compositions have been entered, SINEX checks if the compositions previously entered are valid for the new cross section library. If a composition is no longer valid, a warning message is printed and that composition name is erased. All the other data for that composition is kept, but the user must select a new composition name from the list of valid choices.

The Standard Compositions window (Figure 2) allows the user to define mixtures by selecting valid basic standard compositions from a multiple choice menu. SINEX automatically increments the mixture number for each new mixture. The user may override this mixture number with another if the user wants to make two compositions with the same mixture number or to skip a mixture number (e.g., to use it for an arbitrary material). The user may review mixtures that have already been made. This option displays a list of mixture numbers and composition names. If the user wants to create a new composition that is very similar to one the user have previously entered,

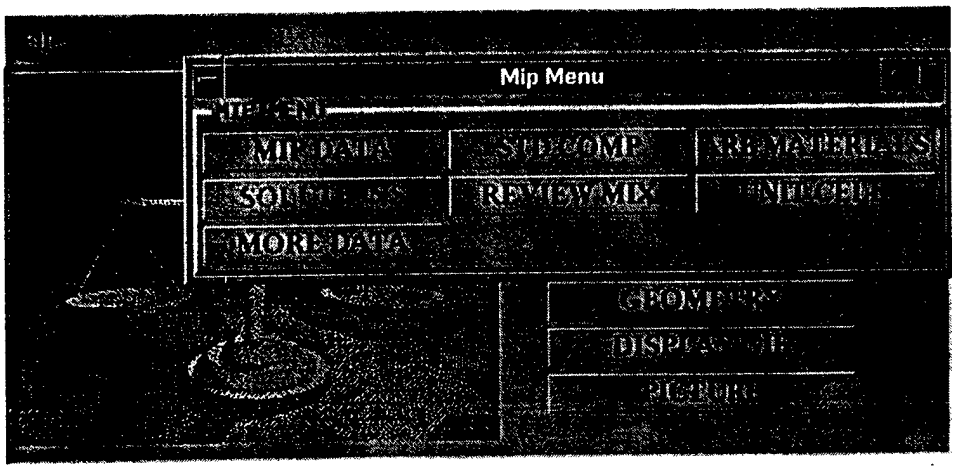

Fig. 1. MIP Menu

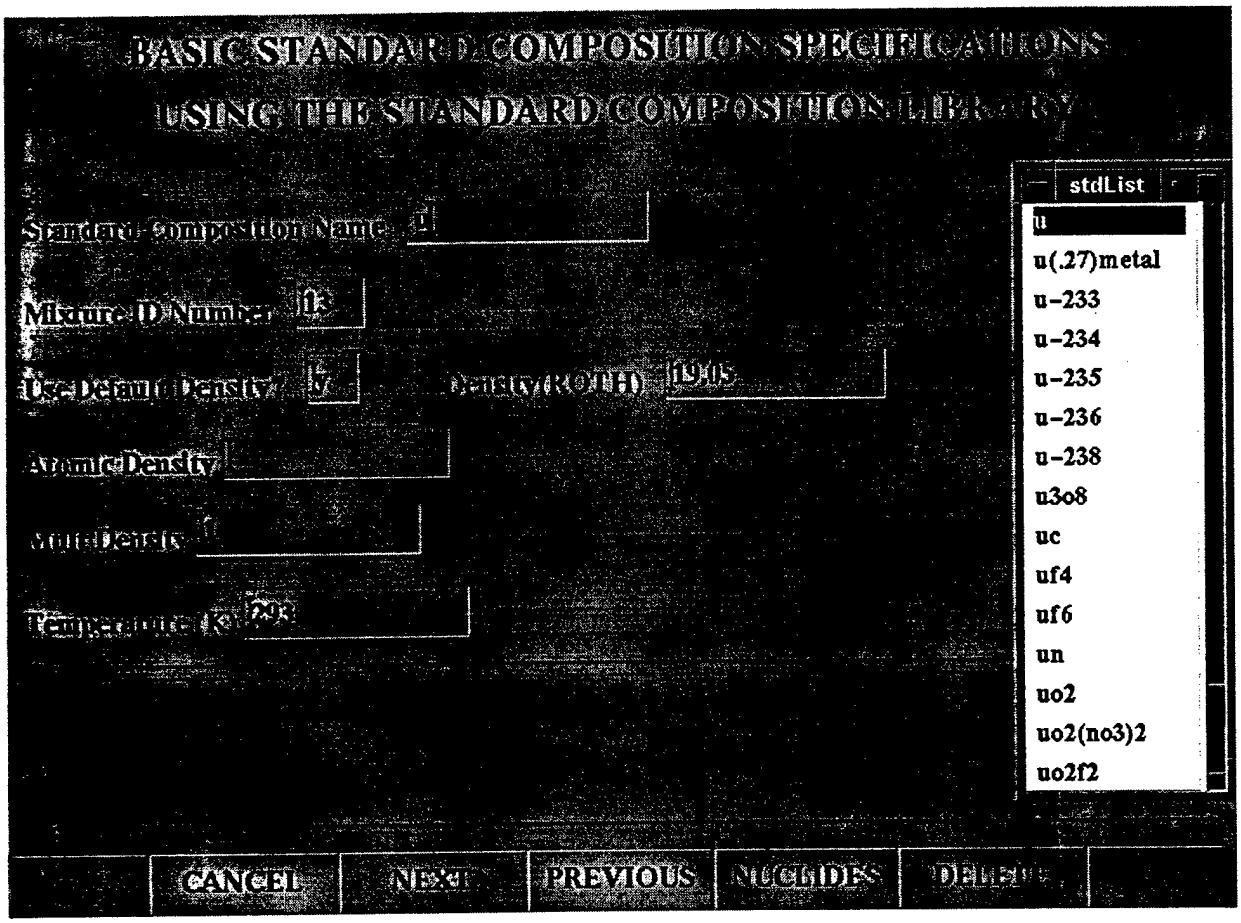

Fig. 2. Standard Composition Input Screen

the user may page back to the old one and enter a new mixture number, and SINEX recognizes that the user is creating a new composition rather than modifying an old one. Once a composition has been created in SINEX, the user can change the composition name to replace it with a different composition using the same mixture number or the user can delete it. A second input screen is available only for multiple isotope nuclides (e.g, UO2, BORON, B4C, etc.). It contains the isotopic distribution by wt %. The SCALE default distribution, which is the natural distribution for all nuclides except plutonium, is initially displayed. The distribution must sum to 100%.

The Arbitrary Materials window allows the user to define arbitrary material mixtures by selecting valid nuclides from a multiple choice menu. The nuclide distribution is by atoms per molecule or by wt %. If the isotope is a multiple isotope nuclide, SINEX presents the user with additional fields at the bottom of the screen for isotopic distribution of the nuclide (Figure 3).

The Solutions menu contains three fissile solutions available in SCALE. The window is very similar to the Standard Compositions window. The second screen is not optional, because all the solutions contain multiple isotopes.

The input window displayed by the Unit Cell Data option is only available if the MULTIREGION unit cell type is selected in the MIP Data window. This option is not active for INFHOMMEDIUM, which is the typical choice for most shielding applications.

The MORE DATA option displays a window of optional parameters. Most of the fields are XSDRNPM options.

2.2 SAS4 DATA

The SAS4 data are divided into four parts: Parameters, Adjoint Data, Source and Geometry. The Parameters window includes all MORSE problem parameters such as number of batches, source particles per batch, and maximum run time. The Adjoint Data includes all input required for the XSDRNPM 1-D adjoint case. The Source input window includes all input data for the neutron/gamma radiation source.

The Geometry window facilitates the input of the MARS geometry. It contains push buttons across the top of the screen labeled "Geometric Objects" for all geometric body types available (see Figure 4): arbitrary polyhedron (ARB), box (BOX), ellipsoid (ELL), right circular cylinder (RCC), right elliptical cylinder (REC), right parallelepiped (RPP), truncated cone (TRC), and wedge (WED). Pressing one of these object button displays an input form for that object type. In Figure 4 the input form for a right elliptical cylinder is shown. The geometry data is input by zones. Geometric bodies or objects are joined to form a zone by the use of Boolean logic parameters. Each zone is assigned a name, number, and color. The "Zone Tools" for constructing each zone are displayed on the right hand side of the screen. The user begins the construction of a zone by pressing the "Start" button. The bodies in that zone are then specified one at a time, each being joined to the previous body by an "and," "not," or "or" operator. An "Undo" button allows the user to correct any errors. Once the zone is finished, the user presses the "Stop" button. The zone geometry can be displayed at any time in X-Y, X-Z, and Y-Z views by pressing the "Draw Geom" button (Figure 5). The zones are then combined into universes to define the global problem geometry.

2.3 QADS DATA

The QADS Data is still being designed. It is similar to the SAS4 Data, but simpler. QADS does not have the capability to model arrays in its geometry package, and it does not include an adjoint calculation. Thus, the input data will be divided into three portions: Parameters, Source, and Geometry. The Geometry window for QADS will be identical to that for SAS4, except that it will not include arrays.

2.4 PICTURE

The PICTURE window presents an input screen for running the PICTURE module to generate color plots in GIF files that display two-dimensional (2-D) slices through the 3-D MORSE or QAD-CGGP geometry. The user can select from X-Y, X-Z, and Y-Z plots. The user specifies the coordinates of the plots so that they can view in detail any portion of the geometry or slices through the entire model. PICTURE is executed in a separate window by pressing the "Run PICTURE" button.

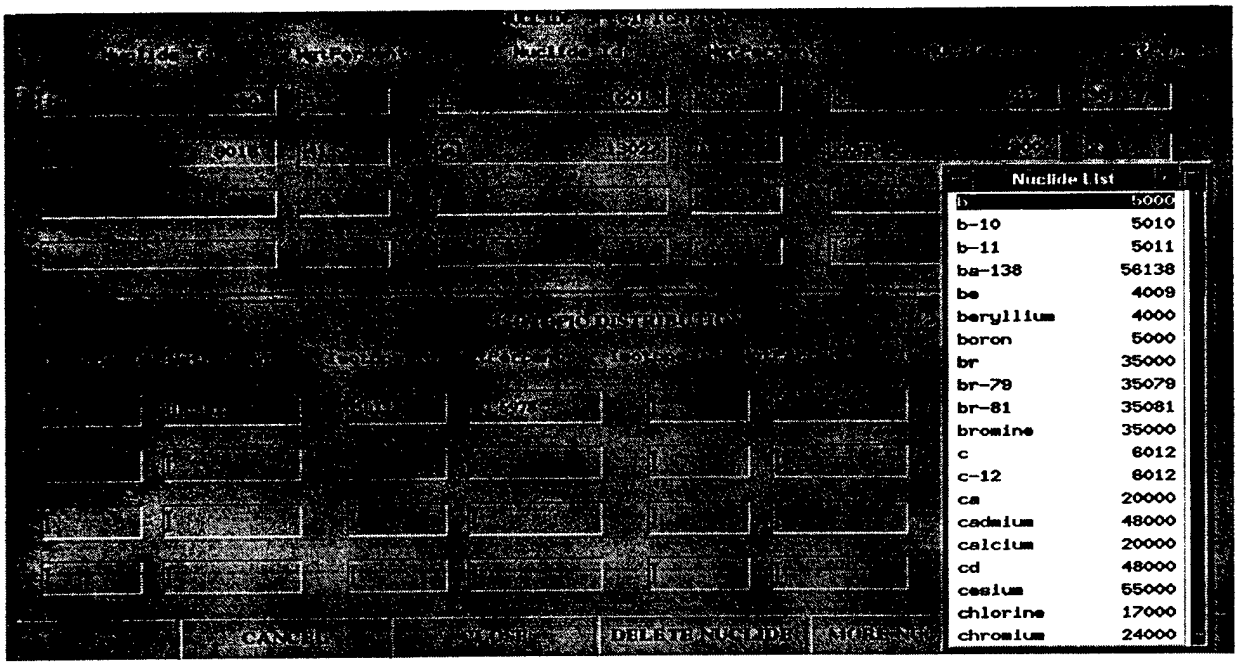

Fig. 3. Arbitrary Materials Input Screen

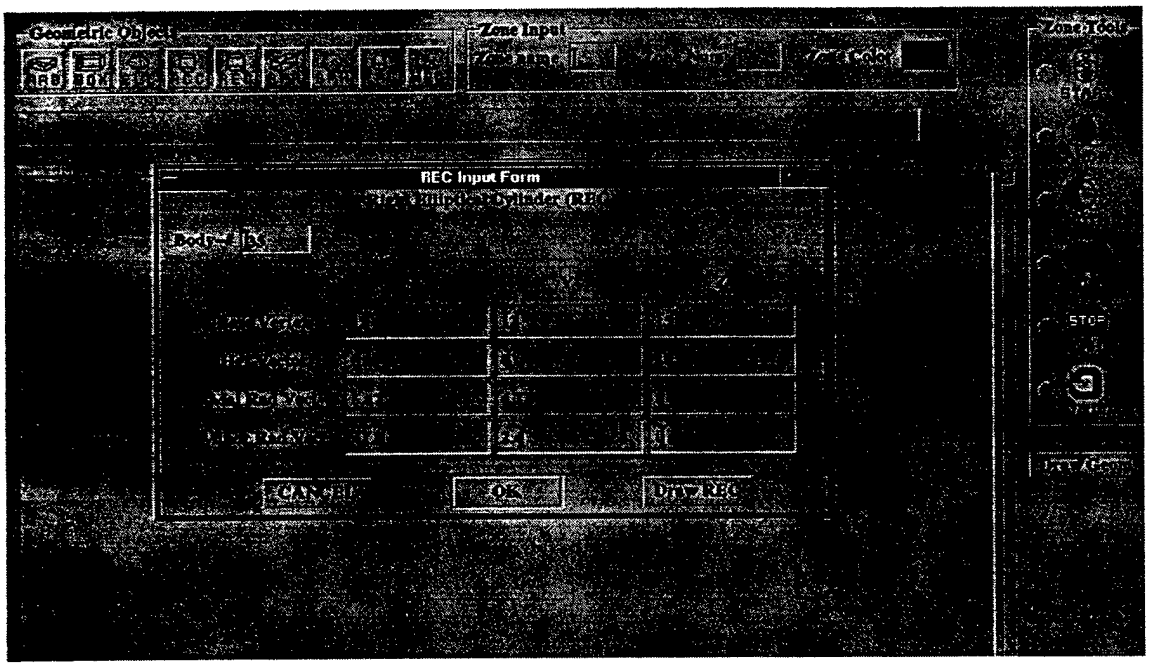

Fig. 4. Geometry Input Screen

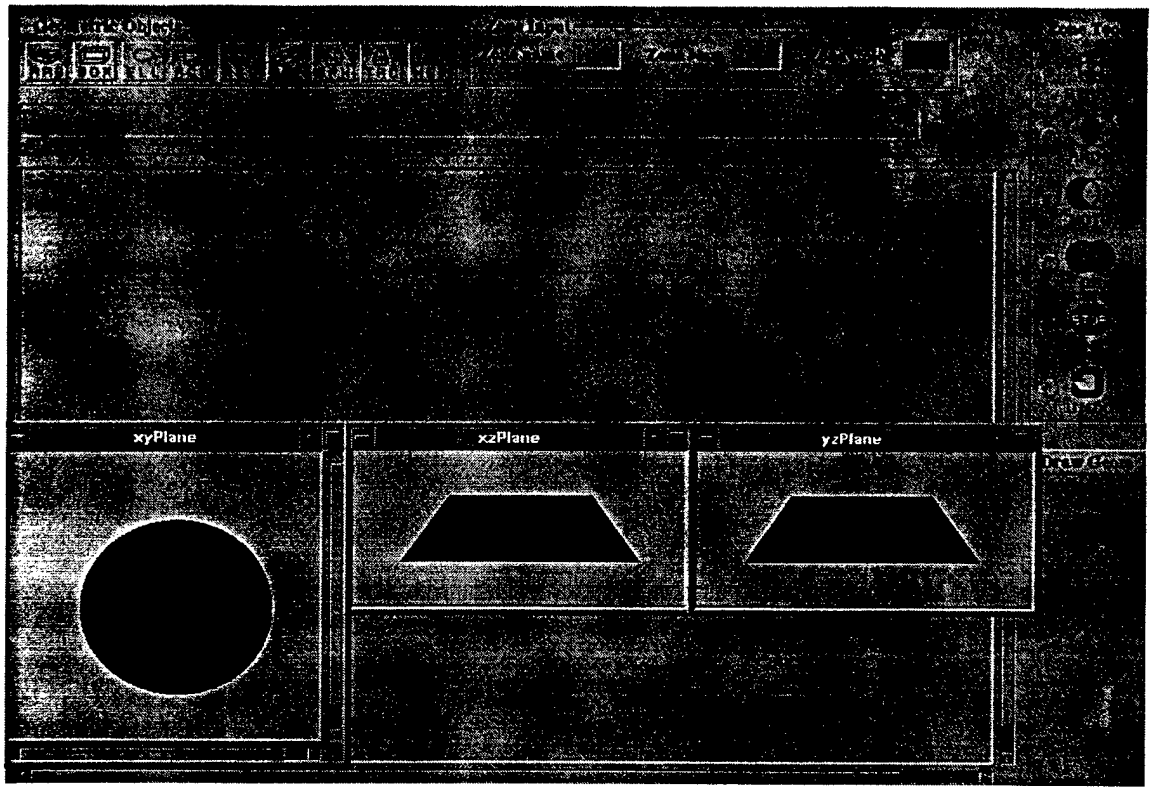

Fig. 5. Geometry Input with 2-D Views

2.5 DISPLAY GIF

The Display GIF window allows the user to select any GIF file created by PICTURE and display it using the freeware X-windows program XV. Figure 6 shows two PICTURE plots being displayed on the screen.

3. FUTURE PLANS

SINEX is scheduled for release from the Radiation Safety Information Computational Center (RSICC) in late 1998. Future development plans call for the additional capability to perform SAS1 1-D shielding analyses with SINEX. A button will also be added to the main menu to access the entire SCALE Manual online via Adobe Acrobat Reader with Search. The electronic manual includes the following features: a table of contents that can be used to access any section of the manual; thumbnails of each page; and an index that gives the user the capability to search all sections of the manual for a word or phrase. This powerful search feature enables the user to easily find needed information anywhere in the more than 4,500 pages of the manual. Access to the manual within SINEX will give the user a complete set of resources for performing shielding analyses with SCALE.

REFERENCE

1. *SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation*, NUREG/CR-0200, Rev. 5 (ORNL/NUREG/CSD-2/R5), Vols. I-III (March 1997). Available from Radiation Safety Information Computational Center, Oak Ridge National Laboratory, as CCC-545.

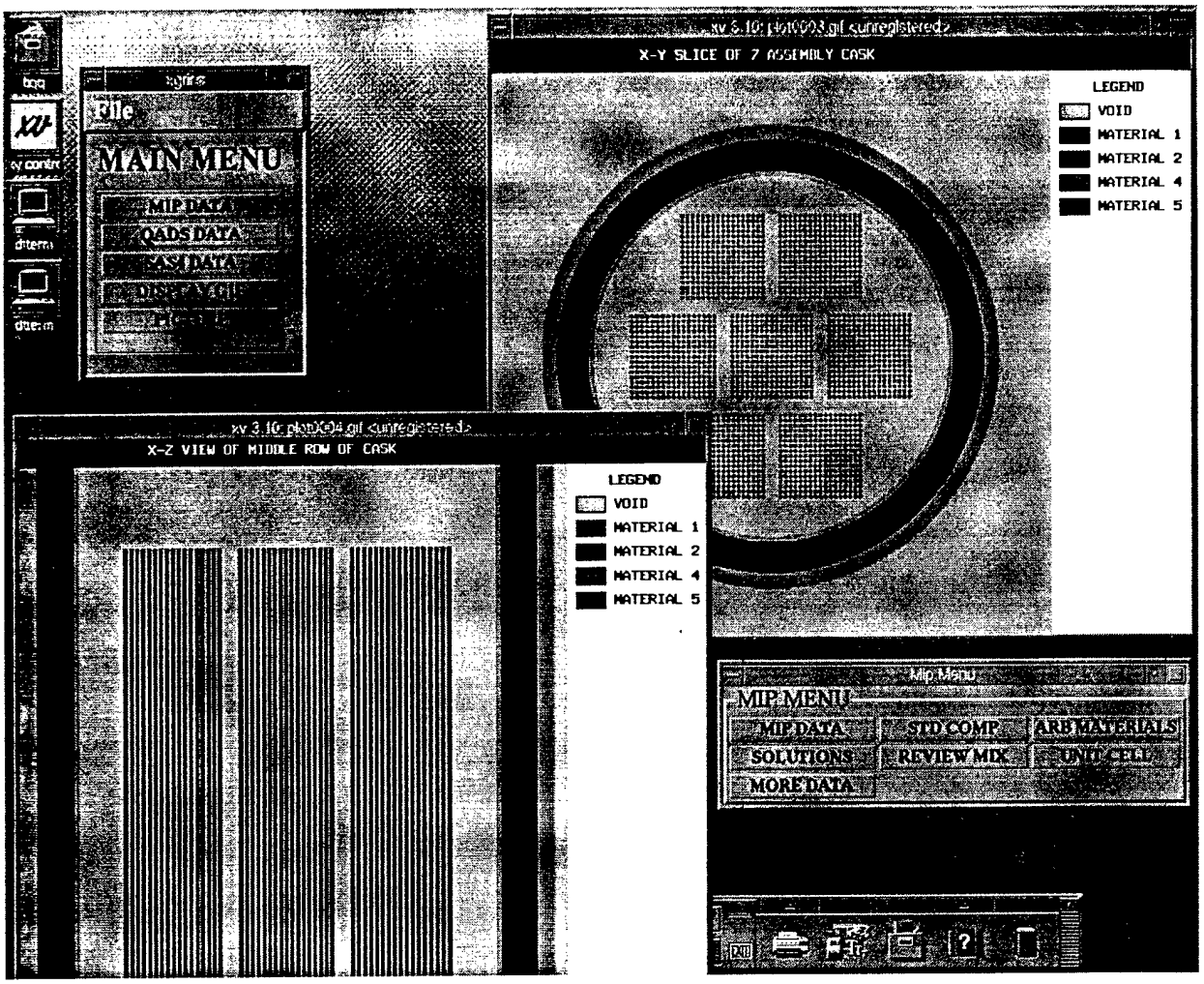

Fig. 6. PICTURE 2-D Color Plots of Shipping Cask

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