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**KENO3D Visualization Tool for KENO V.a and KENO-VI**

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# **KENO3D Visualization Tool for KENO V.a and KENO-VI**

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**Abstract.** Criticality safety analyses often require detailed modeling of complex geometries. Effective visualization tools can enhance checking the accuracy of these models. This report describes the KENO3D visualization tool developed at the Oak Ridge National Laboratory (ORNL) to provide interactive visualization of KENO V.a and KENO-VI criticality safety models. The development of KENO3D is part of the current efforts to enhance the SCALE (Standardized Computer Analyses for Licensing Evaluations) computer software system.

## **1 INTRODUCTION**

The SCALE computer software system<sup>1</sup> developed at ORNL is widely used and accepted around the world for criticality safety analyses. SCALE includes the well-known KENO V.a and KENO-VI three-dimensional (3-D) Monte Carlo criticality safety computer codes. Criticality safety analyses often require detailed modeling of complex geometries. Effective visualization tools can enhance checking the accuracy of these models. To address this need, ORNL has recently developed a powerful state-of-the-art visualization tool called KENO3D. The purpose of this paper is to describe the capabilities of KENO3D.

## **2 KENO3D OVERVIEW**

KENO3D enables KENO V.a and KENO-VI users to interactively display their 3-D geometry models. The interactive options include:

- \$ Shaded or wireframe images
- \$ Standard views, such as top view, side view, front view, and isometric (3-D) view
- \$ Rotating the model
- \$ Zooming in on selected locations
- \$ Selecting parts of the model to display
- \$ Editing colors and displaying legends
- \$ Displaying properties of any unit in the model

- \$ Creating cutaway views
- \$ Removing units from the model
- \$ Printing image or saving image to common graphics formats

KENO3D reads CSAS, KENO V.a, and KENO-VI input files. It attempts to verify that the KENO geometry input is "legal" (i.e., it conforms to the code input guidelines). KENO3D prints a warning message for illegal geometry input, and if possible, it displays the illegal KENO geometry to facilitate debugging of the input. Problems with more than 300,000 KENO V.a bodies have been successfully tested and displayed. (In general, a body in KENO3D is equivalent to a geometry region in KENO.)

KENO3D has the look and feel of a typical PC Windows application. Toolbar buttons are included for all major menu options. A setup dialog allows the user to specify toolbars that should be displayed. KENO3D has a fully integrated help system to aid both beginning and advanced users.

KENO3D has several unique options that provide users with increased flexibility in visualizing portions of a model in greater detail or for visualizing parts of larger models that may be too big to provide a useful image when viewed in their entirety. Some of these options are described below.

- \$ The "Load Slice" option allows the user to define a 3-D slice to display prior to loading the model. The slice can be specified by defining the corners of a bounding box or by identifying a portion of an array in the model.
- \$ A variety of cutting tools allows the user to remove sections from the model to view the internal structure. A "Remove Section" option allows the user to remove a block or pie shaped section from the model. Another cut-tool is the interactive block eraser. The user drags the eraser to the desired location by holding down the left mouse button, and then double clicks the left mouse button to remove the part of the model under the eraser. A sample KENO3D model visualization using the cutting tools is shown in Figure 1.
- \$ Using the "Rebuild in Window" option, the user can draw a window around a portion of the model in the view. KENO3D will then reload the model, displaying only the portion that is in the window. This option is useful when displaying smaller parts of a complicated model.
- \$ The user may use nesting level control to reduce the amount of detail in the model by setting the nesting level for arrays and holes to a small value such as zero or 1, depending on the model. With a nesting level of zero, no holes or arrays are filled. If the nesting level is 1, only the first level of arrays and holes are filled, etc. A recommended strategy is to load the model with a

nesting level of zero, make cuts, adjust the view to desired zoom level and orientation, change the nesting level, and then reload the model. Though for a large model the execution time can be significant, the majority of interactive steps occur in the first few seconds. With care, the reloaded model requires little or no interactive changes.

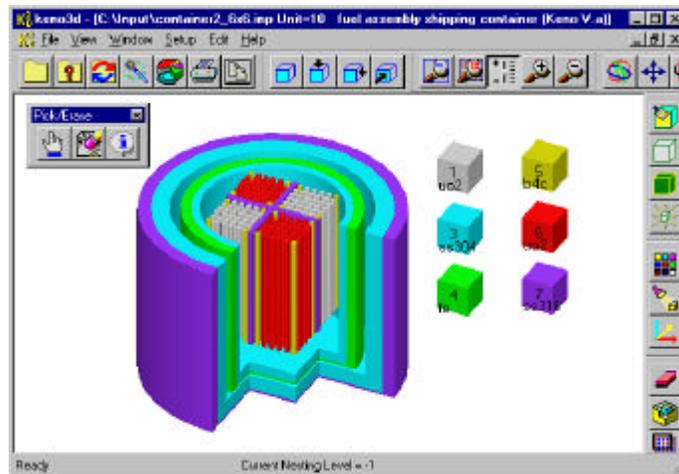


Fig. 1. KENO3D sample LWR shipping container

### 3 Small Model Example

Using KENO3D to visualize models with less than 400 bodies is relatively easy to do with the default settings. The example demonstrated comes from the KENO V.a user manual and is included in the KENO3D distribution package as "keno12.inp." To run this problem with KENO3D:

1. Start KENO3D.
2. Click the "File" menu.
3. Click "Open."
4. Move to the Examples subfolder that contains the KENO V.a examples and select the file (keno12.inp).
5. Click the "Open" push button.
6. Use the "Erase Mixture" option to remove mixture zero (void).
7. Click on "Remove Section" followed by "OK" to get the resulting image shown in Figure 2.

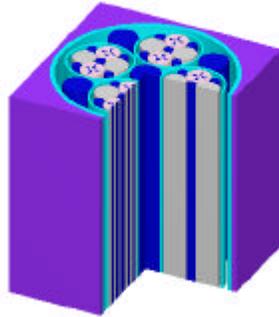


Fig. 2. Simple KENO V.a example

#### 4 Large Model Example

Though it is possible to load models with many thousands of bodies, the resulting image may be of limited usefulness. Often the amount of detail is far greater than the resolution of the screen. Also, due to the number of bodies in the image, the interactive behavior of KENO3D may be very sluggish. Depending on the characteristics of a model, the user may choose a variety of ways to load a view of the model. Loading a very large model may take 20 to 30 minutes of execution time, or more, using the "Open File" button. Getting a slice of the same model, with some mixtures removed, might be achieved in 20 to 30 seconds using "Preload File" followed by "Load Slice." **Warning:** when a model slice intersects a majority of the objects in the model, loading a slice can also be very resource (i.e., memory and time) intensive. To work effectively, the user should try to specify a slice that significantly reduces the number of objects that will ultimately be displayed. Some of the alternatives that may be useful in reducing the number of objects in the KENO3D display when working with larger models are the following:

1. Use "Preload" to read the model input, then load selected units other than the global unit.
2. "Preload" to read the model input, then use "Load Slice" to reduce the number of bodies to be displayed.
3. Reduce the model detail by setting the nesting level for holes and arrays to 1 or zero. With a nesting level of zero, units referenced in holes or arrays in the global unit are represented by a single body. With a nesting level of 1, units referenced in holes or arrays in the global unit are displayed; however, units referenced in holes or arrays in those units are represented by a single body.

The example demonstrated has more than 280,000 bodies when modeled in full detail. The array in the global unit has 314 levels in the Z direction. This example is included in the KENO3D distribution package as "GA4-TruckCask.inp." To achieve the image shown in Figure 3:

1. Load the model input using the "Preload" option.
2. Use "Load Slice" and click on "Bound Array."
3. Set NZ from a minimum of 76 to a maximum of 76 to restrict the image displayed to the array slice at the 76th Z level.
4. Mark mixtures zero (void) and 3(H<sub>2</sub>O) to be hidden from view.
5. Click "OK."
6. Use "Zoom Window" to zoom in on a selected portion of the slice.

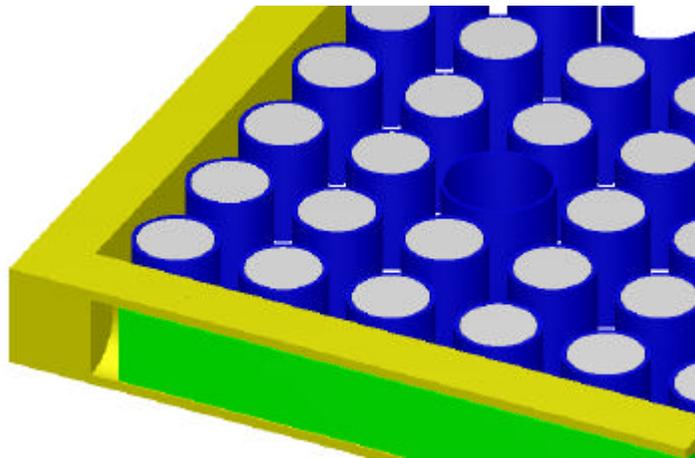


Fig. 3. A zoomed-in slice of a large KENO V.a model with water and void hidden from view

## 5 Summary

The primary objective in the development and ongoing enhancements to KENO3D is to provide an easy-to-use visualization tool that allows criticality safety specialists to interactively display their KENO V.a and KENO-VI geometry models. Version 1.0 of KENO3D for KENO V.a geometry models was released in January 2000. KENO3D Version 2.0 with enhancements to allow modeling of KENO-VI geometry models is to be released in October 2000.

## **Acknowledgment**

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## **References**

*SCALE: A Modular Code System for Performing Standardized Computer Analyses of Licensing Evaluation*, NUREG/CR-0200, Rev. 6 (ORNL/NUREG/CSD-2R6), Vols. I, II, and III, May 2000. Available from Radiation Safety Information Computational Center at Oak Ridge National Laboratory as CCC-545.