Oak Ridge National Laboratory

# SCALE Newsletter

Number 27 January 2003

**Special points of interest:**

- SCALE 5 target release in late 2003
- SCALE ORNL workshops in April/May
- KENO V.a Primer available as free download

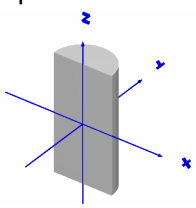
**Inside this Issue:**



## KENO V.a Primer

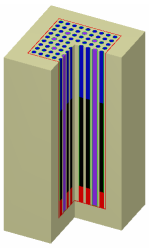
It's hot off the press! The *KENO V.a Primer: A Primer for Criticality Calculations with SCALE /KENO V.a Using CSPAN for Input*, published by ORNL, is designed to help a new user understand and use the CSAS/KENO V.a Monte Carlo code sequence for nuclear criticality safety analyses. There is no assumption of familiarity with Monte Carlo codes in general or with SCALE or KENO V.a in particular. The primer is designed to teach by example, with each example illustrating two or three features of CSAS/KENO V.a that are useful in criticality safety analyses.

The primer is based on SCALE 4.4a and the **C**riticality **S**afety **P**rocessor for **An**alysis (CSPAN) input processor for Windows personal computers (PCs). A second edition of the primer that uses the new SCALE **G**raphically **E**nhanced **E**diting **Wiz**ard (GeeWiz), currently under development at ORNL, is planned for publication in late 2003. Each example, in this first edition of the primer, uses CSPAN to provide the framework for data input.



Starting with a *Quickstart* section, the primer gives an overview of the basic requirements for SCALE/KENO V.a input and allows the user to quickly run a simple criticality problem with SCALE/KENO V.a. Each subsequent section provides a list of basic objectives at the beginning that identifies the goal of the section and the individual SCALE/KENO V.a features which are then covered in detail in the example problems in that section. The document contains over 100 figures, most of them in color, illustrating the CSPAN input screens, the KENO V.a geometry, and the KENO V.a example models.

Upon completion of the primer, a new user should be comfortable using CSPAN to set up criticality problems in SCALE/KENOV.a. The primer provides a starting point for the criticality safety analyst or nuclear engineering student using SCALE/KENO V.a. Complete descriptions are provided in the SCALE/KENO V.a manual. The KENO V.a primer is available to download from the SCALE website at www.ornl.gov/scale/pubs/tm2002_155.pdf.



## SCALE 5

Many users have been asking when SCALE 5 will be available, and many others are wanting to know what's new in SCALE 5. At the ANS Winter Meeting in November, SCALE Project Leader Steve Bowman presented "An Overview of What's New in SCALE 5." For those who were not able to attend that meeting, we have posted a copy of the presentation on the SCALE website at www.ornl.gov/scale/pubs/ans2002-scale5.ppt.

The release date of SCALE 5 is still uncertain due to continued funding uncertainties for this fiscal year. The current target is late 2003.

## SCALE Workshop in Paris, France
### (OECD/NEA Data Bank: June 23-27, 2003)

Attention, European SCALE users! A SCALE Workshop is scheduled 23-27 June, 2003, in Paris, France. The workshop topic will be determined based on feedback from registrants. Six possible topics are being considered:

| New SCALE 5 Topics | Standard SCALE Courses |
|---|---|
| STARBUCS Burnup Credit Sequence (Using ORIGEN-ARP and KENO) | KENO Va. Criticality Safety (+ ORIGEN-ARP) |
| ORIGEN-ARP and TRITON/NEWT 2-D Depletion/Decay and Source Terms | KENO-VI Criticality Safety (+ ORIGEN-ARP) |
| TSUNAMI Sensitivity/Uncertainty Sequences for Criticality Safety (1-D and 3-D Using XSDRN and KENO) | SCALE Source Terms and Shielding |

**NOTE:** The STARBUCS course is designed for experienced KENO V.a or KENO-VI users only.
The TSUNAMI course is designed for experienced KENO V.a users only.
All other courses are open to new and experienced users.

You can get more information and register at http://www.nea.fr/html/dbprog/scalecourses2003.htm.

## SCALE 5 Seminar at M&C 2003 Topical Meeting
### (Gatlinburg, Tennessee: April 10, 2003)

A half-day seminar highlighting significant new capabilities in SCALE 5, plus current developments that will appear in later SCALE releases, is planned as part of the American Nuclear Society M&C 2003 Topical Meeting in Gatlinburg, Tennessee.

*Gatlinburg, Tennessee*

The seminar will feature presentations on new computational capabilities to be released in SCALE 5:

- TSUNAMI (formerly SEN3) 3-D sensitivity/uncertainty sequence (using KENO V.a),
- TRITON/NEWT 2-D flexible mesh discrete ordinates for criticality safety and depletion analyses,
- New resonance cross-section processing capabilities using continuous energy cross sections, and
- New 2-D interactive plotting of KENO and XSDRNPM results with Javapeno.

Plus, the seminar will also feature presentations on current developments planned for future release:

- Continuous energy version of the KENO V.a criticality safety code, and
- 3-D automated variance reduction for Monte Carlo radiation shielding analysis.

## SCALE Training Courses at ORNL
### (April 28 - May 2 and May 5 - 9, 2003)

The SCALE staff at Oak Ridge National Laboratory (ORNL) are offering two training courses this Spring. The courses emphasize hands-on experience solving practical problems on PCs. There will be workgroups of two persons each. Courses are open to new and experienced SCALE users.

The registration fee is $2,000 for one course or $3,500 for both courses (early registration discount for one course is $200 and for both courses is $300). **Foreign nationals must register at least 2 months in advance for security clearance**. RSICC offers attendees a copy of the SCALE software and manual on CD for a discounted fee of $1000 and the KENO3D 3-D visualization tool on CD for $1100 (single license).

Registrations are accepted on a first-come basis. Registration forms submitted directly from the Web are preferred. Registration via FAX or e-mail is also acceptable. The registration fee may be paid by check, travelers checks, bank transfer, or credit card (Visa or MasterCard only). The upcoming SCALE course agendas are included on page 3 of this issue.

## SCALE KENO-VI Criticality Safety Course Agenda (April 28 - May 2, 2003) ORNL

**Monday**
Overview of SCALE System
Introduction to CSAS6
Standard Composition Library
Material Information Processor
Resonance Self-Shielding
Unit Cell/More Data
CSPAN VI Demo
Problem Session 1

**Tuesday**
Geometry Data
Plot Data
Introduction to KENO-VI Output
Problem Session 2

**Wednesday**
Parameter Data
Array Data
Content Data - Media/Hole/Array
KENO3D Tutorial
Problem Session 3

**Thursday**
KENO-VI Output - How To Read It
Mixing Table Data
Start Data
Bias Data
Boundary Data
Problem Session 4

**Friday**
Monte Carlo Uncertainties
Code and Data Validation Issues
Conclusion / Questions and Answers

**The course will conclude with lunch on Friday.**

## SCALE Source Terms & Shielding Course Agenda (May 5-9, 2003) ORNL

**Monday**
Overview of SCALE System
Introduction to SCALE Shielding Sequences
ORIGEN-ARP
Plotting ORIGEN Results with OPUS/PlotOPUS
OrigenArp/PlotOPUS Demonstration
ORIGEN-ARP Problem Definitions
ORIGEN-ARP Problem Session
How to Create ORIGEN-ARP Libraries

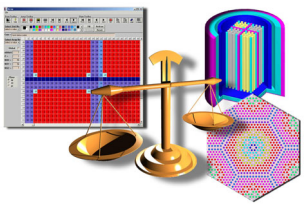
**Tuesday**
Material Information Processor
SAS2 Depletion/Decay/Source Terms Analysis Sequence
SAS2 Problem Definitions
SAS2 Problem Session

**Wednesday**
SAS1 1-D Shielding Sequence
SAS1X 1-D Combined Criticality/Shielding Sequence
SAS1 Problem Session

**Thursday**
SAS4 3-D Monte Carlo Shielding Analysis Sequence
SAS4 Variance Reduction Techniques
SAS4 MARS Geometry Option
SAS4 Validation/Limitations
ESPN DEMO
SAS4 Problem Definitions
SAS4 Problem Session

**Friday**
QADS 3-D Point Kernel Shielding Analysis Sequence
QADS Problem Definitions
QADS Problem Session
Shielding Course Wrap-up

**The course will conclude with lunch on Friday.**



# SAS4 Guidance for Streaming Calculations

The methodology used for automated bias generation in SAS4 is very effective for cylindrical cask systems; however, it has a number of limitations arising from the use of one-dimensional (1-D) adjoint fluxes in the creation of automated biases. One such limitation is the estimation of particle streaming through voids. The increasing popularity of storage casks with large air vents has increased the need for a particle streaming capability in the SCALE system methodology. ORNL has developed a technique for obtaining credible streaming dose results with the current version of SAS4 and applied it to the calculation of vent streaming in a typical storage cask configuration.

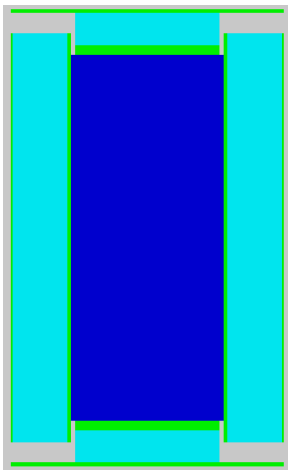
The technique consists of a two-step procedure to increase the number of particles tracked through the void region:

1. start a larger number of particles near the void location, and
2. change the 1-D adjoint configuration to a source + void geometry appropriate for particles that penetrate the void streaming path.

For vent ports near the top or bottom of the cask, the first step above can be accomplished by performing an axial biasing calculation. The default axial calculation does spatial source location biasing such that the particles are preferentially biased towards the top or bottom of the source where the vent ports are typically located. Thus, an axial calculation should be performed, even though the detector locations are on the cask side.

The second step is relatively straight-forward, but critical in the success of the technique. For the axial calculation, the 1-D adjoint model should begin as usual at the axial centerline of a symmetric model. The material in the source region should be homogenized in the 1-D adjoint model, even if an explicit geometry is modeled in the full 3-D calculation. The remaining portions of the cask axial 1-D geometry should be modeled as void (mixture number 0). This technique should effectively bias particles out of the source region, and then allow a statistically significant number of particles to travel through the penetration without further biasing. SAS4 automated biasing based on the shield region creates an incorrect bias for particles that actually do stream through the penetration. Results for such an incorrect biasing either converge to the wrong answer or, at best, very slowly converge.

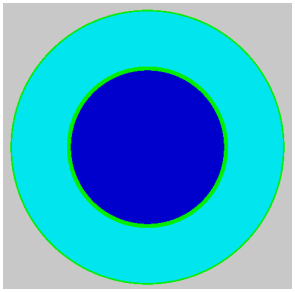
The streaming of particles through the vent ports of storage casks can be easily demonstrated with a fairly simple cask model that is somewhat typical of many modern storage casks.



Axial view of cask.

The plots shown illustrate the simple geometry configurations that were used in this study. The dark blue shading indicates the homogenized source region, with the green areas representing the stainless steel locations. The aqua blue areas correspond to concrete shielding regions. The locations of the vent ports are clearly seen at the top and bottom of the cask geometry (the geometry is symmetric about the axial midplane) and are indicated by a gray shading. The desired location of the dose rate is at the outlet of the vent ports. For simplicity in modeling and analysis, these vent ports are assumed to completely encircle the top and bottom of the cask body.

Verification calculations were performed with SAS4 and MCNP, as shown in the table below. The axial modified biasing scheme in SAS4 compares satisfactorily with the MCNP results. Further investigation of this technique is planned, possibly including a presentation at a future conference.



Radial view of cask.

**Comparison of results for various biasing techniques**

| Method | 1.00E+08 Histories | CPU time (minutes) |
|---|---|---|
| SAS4 axial modified | 3270 ± 2% | 120 |
| MCNP simple bias | 3279 ± 9% | 440 |
| MCNP advanced bias | 3100 ± 3% | 400 |

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## Words to the Wise: The Importance of Good Sampling

A SCALE user recently encountered an anomaly when comparing results from multiple KENO V.a calculations for the same system. The calculated k-eff values for two of the cases were approximately 20% lower than the other cases. The two calculations in question were run with smaller amounts of memory allocated in the "PARM=SIZE=" field that resulted in KENO V.a supergrouping the problem. At first, it was believed that there might be an error in the supergrouping routines in KENO V.a. However, upon closer inspection, it was determined that the lower calculated k-eff values were due to inadequate sampling of the "hot spot" in the system. This spot was an extremely small portion of the system geometry. To ensure adequate sampling of this volume, a start type 6 was needed to start the neutrons in the unit containing the hot spot.

When a KENO V.a problem supergroups, a different random walk is initiated compared to the non-supergrouped case. The poor results for the super-grouped cases were caused by a different random walk that failed to sample the hot spot, thus resulting in a lower calculated k-eff value. In this case, it was readily apparent upon review of the input, that the potential hot spot was so small that it could easily be missed in the Monte Carlo sampling.

At least two lessons can be learned from this situation:

1. Multiple KENO cases with different starting random numbers can reveal erroneous calculated k-eff values (although this is not guaranteed).
2. It is important to use a start type in KENO that ensures sampling of all fissile regions in the system. For more information on start types, please refer to Sect. F11.4.8 of the SCALE Manual.

## PlotOPUS 2.0: Improved ORIGEN Plotting Program

A new version of the PlotOPUS plotting program for Windows is now available on the SCALE Download web page. PlotOPUS is designed to plot calculated results from ORIGEN-ARP, SAS2H, and ORIGEN-S stand-alone cases. The program plots data from OPUS (**O**RIGEN-S **P**ostprocessor **U**tility for **S**CALE):

- most important or user-selected nuclides for a parameter of interest (e.g., radioactivity, decay heat, mass) vs. time
- results from different ORIGEN cases vs. time
- neutron and gamma spectra at selected decay times.

PlotOPUS can be called directly from the OrigenArp for Windows program. It is an interactive program that allows the user to customize the plot via selection of colors, line styles, fonts, settings for axis/legend/grid, and logarithmic or linear plots.

The new version of PlotOPUS provides greatly improved customization features including global linestyle settings, group or individual line colors and line styles, legend options, and a quick one-key toggle between linear and logarithmic X- and Y-axis settings. Other enhancements include improved interactive nuclide or case selection methods, and an unlimited number of nuclides or cases that can be plotted concurrently.