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COG - Special Features of Interest to Criticality Safety Practitioners

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Abstract

COG is a modern, general-purpose, high fidelity, multi-particle transport code developed at the Lawrence Livermore National Laboratory specifically for use in deep penetration (shielding) and criticality safety calculations. This paper describes some features in COG of special interest to criticality safety practitioners.

Why use COG?

It's free! COG10[2] is available to the public (and free to criticality safety practitioners) from the Radiation Safety Information Computational Center (RSICC) and (free to all) from the OECD NEA Data Bank.

It's DOE O 414.1C compliant! Software Quality Assurance documentation is maintained for COG in the LLNL safety software registry[3].

It's benchmarked! The COG website[4] contains benchmark reports that meet the requirements of ANSI/ANS-8.1-1998; R2007, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, and ANSI/ANS-8.24-2007, *Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations*. The corresponding benchmark COG input files will also be available on the website.

It has some user-friendly features and killer apps! These are briefly described below. Full details are available in the *COG User's Manual* which may be downloaded from the website.

Data Blocks and **BASIC**

COG input data is organized into Data Blocks with easily recognizable names such as GEOMETRY, SURFACES, DETECTOR, etc. Inside each Data Block, the user specifies input data is given in a format-free "namelist". This feature is fairly transparent and consequently

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[1] heinrichs1@llnl.gov
[2] UCRL-CONF-224715, *COG – Publicly Available Now to Criticality Safety Practioners*, Richard M. Buck, Dermott E. Cullen, David P. Heinrichs, Edward M. Lent, Dale E. Nielsen, Jr., Kenneth E. Sale.
[3] http://isqa.llnl.gov/cog
[4] http://cog.llnl.gov

easier for a new user to understand than the older "card type" input used by many other popular codes.

The BASIC block allows the user to change the default unit of distance from centimeters (cm) to millimeters (mm) or inches, etc. This feature is particularly useful when COG model units match those of engineering drawings that define a physical configuration of interest. Similarly, the units of time and energy can be changed from their default units of second and MeV to other customary units such as shake and eV.

ASSIGN-MC, **PICTURE**, **SWEEP** and **VOLUME**

The ASSIGN-MC feature allows the user to assign colors of their choice to any sector when specifying a picture. This feature is useful in comparing COG pictures to design drawings to ensure that materials are assigned to the correct locations in the geometry.

PICTURE allows the user to specify cross-sectional pictures of materials, sectors, or regions, as well as perspective pictures.

VOLUME allows the user to specify that COG calculate the volume of sectors, materials, or regions within a specified box. This calculation is performed statistically so there is no restriction on the complexity of the geometry within the box and RESOLUTION is a parameter that may be increased for higher precision.

SWEEP is a feature for the user to specify that COG sweep a line through two endpoints and list the distance of each boundary surface intercept for each sector. This feature is useful in discovering complex geometry errors with small volumes that may not be visible in a picture.

ASSIGN-D, **ASSIGN-ML**, **MIX**, **NLIB** and **SABLIB**

ASSIGN-D can be used to increase or decrease the material density of a sector. ASSIGN-ML can be used to assign materials to a list of sectors.

Material compositions are specified by isotope, element or compound using one of four methods in the MIX data block: (1) total density and constituent weight fractions; (2) total density and constituent atom fractions; (3) constituent concentrations; or (4) constituent atoms per barn-cm. Note that the user may specify material compositions by their constituent elements or compounds even if the underlying nuclear data is given by isotope. In this case, COG calculations the elemental and compound total cross-sections from internal libraries containing the natural abundances of the isotopes and compound formulae.

Data can be mixed and matched from several cross-section libraries or thermal scattering law libraries using the NLIB and SABLIB feature within the MIX data block. Multiple scattering laws may be specified for a material (e.g., a mixture of D_2O and H_2O). This feature is not available in some codes.

REVOLUTION and **PRISM**

COG allows the user to specify complex contours as point-defined curves of various types. This feature greatly minimizes the number of sector definitions with the complexity residing the in the bounding surfaces. Two of the most useful of these are REVOLUTION and PRISM.

REVOLUTION allows the user to specify a surface of straight-line segments defined by points rotated about an axis. Points may be specified in cylindrical (x,ρ) or polar (r,θ) coordinates. A COG model of the ES2100 shipping container was developed, which extensively utilized this feature to model the many parts with rotational symmetry. A COG picture of the ES2100 model is provided as Figure 1.

PRISM allows the user to specify a general right prism along the x-axis by specifying the coordinates of the (y,z) coordinates of the vertices (or corners). Figure 2 illustrates use of this feature in COG to describe the outermost surfaces of a nuclear reactor fuel plate of involute curvature. The involute is common to the design of the HFIR at the Oak Ridge National Laboratory (Oak Ridge, Tennessee), the FRM-II at the Technical University of Munich (Garching, Germany), and the RHF at the Institute Laue-Langevin (Grenoble, France).

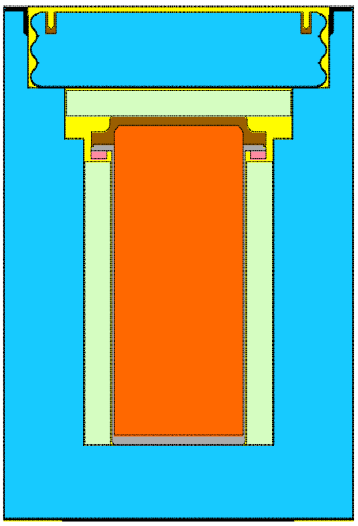

Figure 1

Figure 2

UNIT and **TR**

A subset of the geometry can be defined as a UNIT and may be used repeatedly in any location or orientation using the TR (translate and/or rotate) feature. TR may also be used to translate and/or rotate individual surfaces.

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