Argonne NATIONAL LABORATORY

Nuclear Engineering

Nuclear Criticality Safety

The Nuclear Engineering Division (NE) of Argonne National Laboratory is experienced in performing criticality safety and shielding evaluations for nuclear facilities with complex configurations and operations involving wide ranges of geometries, materials, and neutron spectra. The NE nuclear criticality safety (NCS) capabilities are based on a staff with decades of cumulative experience in both the experimental and analytical aspects of the subject, and who have available to them state-of-the-art software and nuclear data libraries. Division NCS activities are complemented by ongoing R&D programs in software and analytical methods development, nuclear data library validation and benchmark experiment evaluation.

Experience

We have extensive experience in performing criticality safety evaluations to support the design and operations of a variety of Argonne facilities and operations: the Alpha- Gamma Hot Cell Facility (AGHCF), Chemical Engineering Division (CMT) separation technology development, Nuclear Operations Division (NOD) waste management and storage activities and other laboratory-scale operations. NCS section staff were also the primary developers of criticality safety evaluations for the Fuel Conditioning Facility (FCF), the Hot Fuels Examination Facility (HFEF), the Zero Power Physics Reactor (ZPPR) materials storage vault and other facilities that are now part of the Idaho National Laboratory (INL). NE staff also prepares the criticality-related sections of authorization basis safety documents for many of the Argonne facilities and provides ongoing criticality safety support for nuclear facility operations at Argonne.

NE personnel have broad involvement in national and international criticality safety programs and are familiar with relevant DOE, NRC, and DOT regulations concerning criticality safety. Division staff are members of:

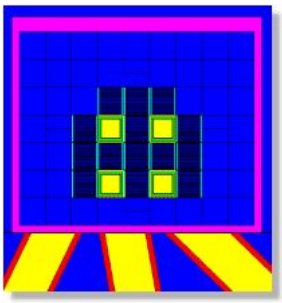
- the NEA/NSC International Criticality Safety Benchmark Experiment Project (ICSBEP),
- the NEA/NSC Working Party on Nuclear Criticality Safety (WPNCS),
- the NEA/NSC Working Party on International Evaluation Cooperation (WPEC),
- the DOE Criticality Safety Support Group (CSSG), and
- American Nuclear Society criticality safety consensus standards writing groups.

NE personnel participate in the programs and planning of the DOE Nuclear Criticality Safety Program (NCSP), the DOE Criticality Safety Support Group (CSSG), the NCSP Nuclear Data Advisory Group (NDAG) and the NCSP Critical-subcritical Experiments Design Team (CsubEdT). The NCSP is a comprehensive, crosscutting program that integrates the need to maintain the US criticality safety infrastructure with effective support for criticality safety programs throughout the DOE complex. Tasks within the NCSP include maintenance of a critical experiments program, development of advanced analysis methods, creation of a benchmark experiment library, development of NCS training materials and collection and dissemination of criticality safety data, including historical experiment records.

Analysis Tools

NE staff employ state-of-the-art analysis tools to support NCS work, including:

- **MCNP-V**, a Monte Carlo code for simulation of neutral particle transport developed by LANL. It includes a large variety of variance reduction features especially useful for shielding and detector flux applications. It uses continuous-energy cross sections produced by NJOY and allows general 3D geometry based on surfaces.
- **VIM**, a Monte Carlo code for simulation of neutral particle transport developed by Argonne. Used primarily for reactor and criticality safety applications, VIM employs continuous-energy cross section data and a general 3D geometry based on solid shapes. Its nuclear data have been extensively tested in comparisons with experiments and other neutronics codes.



- **SCALE 5**, a package developed at ORNL that includes the multi-group Monte Carlo codes KENO V.a and KENO VI. Both codes are used for criticality safety analysis of non-reactor nuclear facilities transport packages, spent fuel treatment, waste storage and disposal.
- **MONK 8B**, an ultra-fine multi-group Monte Carlo code developed in Great Britain and licensed by the NRC. The standard cross-section libraries are based on JEF 2.2 and ENDF/B-VI data. MONK has an extensive library of common shapes that give it a general 3D geometry capability.

Criticality Safety Activities

Current criticality safety activities within the NE Division include:

- Ongoing support for nuclear facility operations at Argonne. Activities include criticality safety evaluations, development of training programs, and providing criticality safety representatives for the NOD Division, the CMT Division and the Materials Control and Accountability Group.
- Review of Safety Analysis Reports for Packaging (SARPs). The criticality-safety material in the SARP is reviewed, and confirmatory analysis is performed as required.
- ICSBEP - Generation of criticality safety benchmarks focusing on methods and data validation needs, such as the Uranium/Iron Benchmark Assembly (ZPR-9 Assembly 34).
- Preservation of ZPR 3, 6, & 9 and ZPPR critical experimental data, including log books and loading records.

Current Research and Development Activities

The Nuclear Engineering Division maintains an active R&D program in areas of importance to criticality safety, including the following:

- Participation in several elements of the DOE Nuclear Criticality Safety Program. Argonne contributes to the analytical methods, nuclear data, web-based training module development, preservation of nuclear criticality data, the ICSBEP and the criticality safety web site tasks of the NCSP.
- Development of the stratified source sampling method to improve the reliability of Monte Carlo criticality safety analysis of loosely coupled systems, e.g., stored arrays of weapons pits or spent reactor fuel. The traditional Monte Carlo source iteration algorithm can appear to converge to the wrong eigenvector and a non-conservative eigenvalue when coupling is sufficiently weak.
- Upgrading of cross section preparation methods to exploit recently improved data evaluations. This work includes development of a more accurate Doppler broadening method, improved thinning criteria for redundant energy points, and investigations into more accurate schemes for interpolation in energy and temperature.
- Verification and validation of a variety of cross sections. Comparison of point-wise cross sections from Reich-Moore resonance parameters with corresponding multipole calculations ensures the rigor of the resolved resonance treatment. Benchmarking between ENDF/B-VII.0, JEF-2.2 and experiments is used to validate the two libraries. Participation in Argonne and international benchmark programs with VIM improves the confidence in other codes and libraries.

For additional information, please visit
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