Development of an ICSBEP Benchmark Evaluation

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Idaho National Laboratory

AEN NEA

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

OECD

Topics

- Purpose of the International Criticality Safety Benchmark Evaluation Project (ICSBEP)
- Development of an ICSBEP Benchmark
- Publication in the ICSBEP Handbook (Quality Assurance)
- ICSBEP Handbook

Purpose of the ICSBEP

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- Compile benchmark-experiment data into a **standardized** format that allows analysts to **easily** use the data to validate calculational techniques and cross section data.
- Evaluate the data and quantify overall uncertainties through various types of sensitivity analyses
- Eliminate a large portion of the tedious and redundant research and processing of experiment data
- Streamline the necessary step of validating computer codes and nuclear data with experimental data
- Preserve valuable experimental data that will be of use for decades

DEVELOPMENT

of an

ICSBEP

BENCHMARK

Basic Structure of All Benchmarks

- Describe the Experiments
- Evaluate the Experiments
- Provide Concise Benchmark-Model Specifications
- Provide Sample Results

- References
- Appendix – Code Input
- Appendix – Other

Describe the Experiments

- Geometry
- Materials
- Temperature
- Other Relevant Information

ICSBEP CONTENT & FORMAT

1.0 DETAILED DESCRIPTION

1.1 Overview of Experiment

- Summary of the experiment, its original purpose, the parameters that vary in a series of configurations
- Name of the facility, when the experiments were performed, the organization that performed the experiments, and perhaps the names of the experimenters if available
- The conclusions of the Evaluation of Experimental Data (Section, Section 2) should be briefly stated

ICSBEP CONTENT & FORMAT (Cont.)

1. 2 Description of Experimental Configuration

- Detailed description of the physical arrangement and dimensions of the experiment
- Uncertainties assigned by the experimenter
- Method of making the specific measurements
- Some measurement types such as subcritical measurements may require more detailed information about the source and detectors than is typically required for critical assemblies

ICSBEP CONTENT & FORMAT (Cont.)

1.3 Description of Material Data

- Detailed description of **all** materials used in the experiment as well as significant materials in the surroundings
- Uncertainties assigned by the experimenter
- Specify source of composition data (physical or chemical analyses or from material handbooks when only the type of material was specified)
- Details of the methods of analysis and uncertainties
- Dates of the experiment, of the chemical analysis, and of isotopic analysis or purification (When isotopic buildup and decay are important)

ICSBEP CONTENT & FORMAT (Cont.)

1.4 Temperature Information

- The Temperature at which the experiments were preformed is given and discussed.

ICSBEP CONTENT & FORMAT (Cont.)

1.5 Supplemental Experimental Measurements

- Additional experimental data that are not necessarily relevant to the derivation of the benchmark model
- Subcritical measurements include a description of the measurement technology and a discussion on the interpretation of the measurements as well as the measured data

Evaluate the Experiments

- How good are the data?
- What are the uncertainties?

ICSBEP CONTENT & FORMAT (Cont.)

2.0 EVALUATION OF EXPERIMENTAL DATA

- Evaluation of the experimental data and conclusions
- Missing data or weaknesses and inconsistencies in published data
- Effects of uncertainties (if uncertainties are not provided, they must be estimated)
- Summary table
- Unacceptable data are not included in Sections 3 & 4
- Unacceptable data may still be used in validation efforts if the uncertainty is properly taken into account
- Random versus Systematic Uncertainty

Provide Concise Benchmark-Model Specifications

ICSBEP CONTENT & FORMAT (Cont.)

3.0 BENCHMARK SPECIFICATIONS

- Benchmark specifications provide the data necessary to construct calculational models – Should be concise and complete
- Retain as much detail as necessary to preserve all important aspects of the actual experiment
- Simplifications include description of the transformation from the measured values to the benchmark-model values, the transformation, and the uncertainties associated with the transformation

ICSBEP CONTENT & FORMAT (Cont.)

3.1 Description of Model

- General description of main physical features of the benchmark model(s)
- Simplifications and approximations made to geometric configurations or material compositions are described and justified
- Resulting biases and additional uncertainties in k_{eff} are quantified
- Justification for omitting any constituents of the materials

ICSBEP CONTENT & FORMAT (Cont.)

3. 2 Dimensions

- Include all dimensions and information needed to completely describe the geometry of the benchmark model(s)
- Sketches, including dimensions and labels, of the benchmark model(s) should be used liberally
- Reviewer should be able to derive all dimensions in Section 3 from the information included in Sections 1 and 2.

ICSBEP CONTENT & FORMAT (Cont.)

3. 3 Material Data

- Atom densities for all materials specified for the model(s) are concisely listed
- Provide unique or complicated formulas for deriving atom densities
- Reviewer should be able to derive all material specifications in Section 3 from the information included in Sections 1 and 2.

ICSBEP CONTENT & FORMAT (Cont.)

3. 4 Temperature Data

- Temperature data for the model(s)

ICSBEP CONTENT & FORMAT (Cont.)

3.5 Experimental and Benchmark-Model k_{eff} and/or Subcritical Parameters

- Experimental Values
- Benchmark Values (adjusted to account for bias)
- Uncertainty in the Benchmark Value

Provide Sample Results

ICSBEP CONTENT & FORMAT (Cont.)

4.0 RESULTS OF SAMPLE CALCULATIONS

- Calculated results obtained with the benchmark-model specification data given in Section 3
- Sample calculations only
- Discrepancies between Benchmark values (Section 3.5) and calculated values (Section 4.0) are noted

ICSBEP CONTENT & FORMAT (Cont.)

5.0 REFERENCES

- All formally published documents referenced in the evaluation that contain relevant information about the experiments
- References to handbooks, logbooks, code manuals, textbooks, personal communications with experts, etc. are given in footnotes

ICSBEP CONTENT & FORMAT (Cont.)

APPENDIX A Typical Input Listings

Brief comments about options chosen for calculations are included in an introductory paragraph. Any small differences from the benchmark-model specifications in Section 3 are noted. This paragraph states the version of the code (e.g., KENO-IV, KENO-V.a, MONK6B, etc.) that was used for the calculations and additional information including:

- **S_N Codes**
- Quadrature order (i.e., N)
- Scattering order for cross sections (P1, P2, P3, etc.; corrected or not corrected for higher-order effects)
- Convergence criteria for eigenvalue and flux
- Representative mesh size (cm)
-
- **Monte Carlo Codes**
- Number of active generations
- Number of skipped generations
- Number of histories per generation or total number of histories

Unique and/or important features regarding the input may also be discussed just prior to the input listings. Listing titles refer to the case number and number of the table in Section 4.0 that gives the calculated result.

Why Such a Rigorous Format?

- Handbook or Reference Book
  - For the benefit of the user
  - Orderly layout to assist the user
  - Information is always in the same location
  - Information has been rigorously verified
- Separation of Geometry, Materials, Temperature
  - Neutronics computer code input
  - Allows systematic & detailed review / verification
- Not a Compilation of Technical Reports

Quality Assurance

Quality Assurance

Each experiment evaluation included in the Handbook undergoes a thorough internal review by the evaluator's organization. Internal reviewers are expected to verify:

1. The accuracy of the descriptive information given in the evaluation by comparison with original documentation (published and unpublished).
2. That the benchmark specification can be derived from the descriptive information given in the evaluation
3. The completeness of the benchmark specification
4. The results and conclusions
5. Adherence to format.

Quality Assurance (continued)

In addition, each evaluation undergoes an independent peer review by another Technical Review Group member at a different facility. Starting with the evaluator's submittal in the appropriate format, independent peer reviewers are expected to verify:

1. That the benchmark specification can be derived from the descriptive information given in the evaluation
2. The completeness of the benchmark specification
3. The results and conclusions
4. Adherence to format.

Quality Assurance (continued)

A third review by the Technical Review Group verifies that the benchmark specifications and the conclusions were adequately supported.

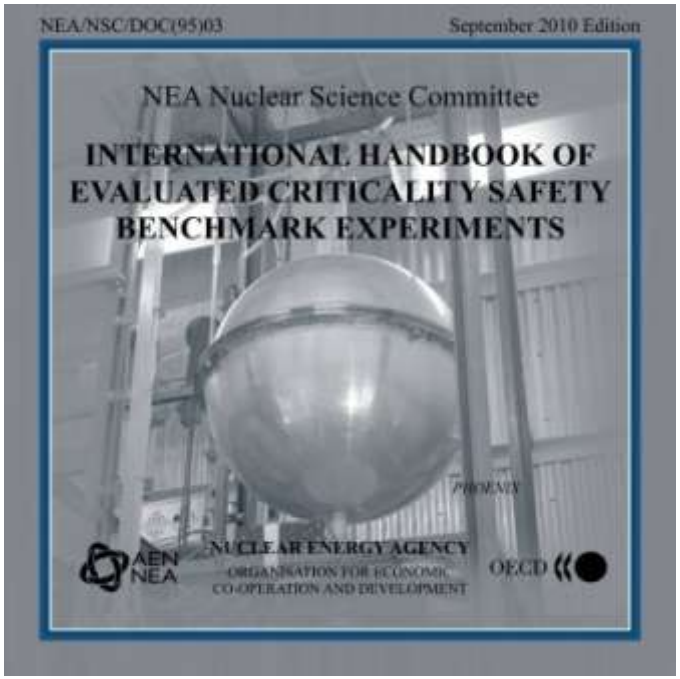
ICSBEP

Handbook

International Handbook of Evaluated Criticality Safety Benchmark Experiments

September 2010 Edition

- 20 Contributing Countries
- Spans over 55,000 Pages
- Evaluation of 516 Experimental Series
- 4,405 Critical or Subcritical Configurations
- 24 Criticality-Alarm/Shielding Benchmark Configurations – numerous dose points each
- 155 fission rate and transmission measurements and reaction rate ratios for 45 different materials



- http://icsbep.inl.gov

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- Available in September 2011
- Contact email: icsbep@inl.gov