SG-8 Critical Benchmark Rating System v1.0

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Draft. Document has not been reviewed and approved for public release.

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ABSTRACT

Over twenty-five years of benchmarking activity, the expectations and review rigor required for ICSBEP has evolved, the benchmarks are being used for unanticipated scenarios, tools and computational power exist to solve more complex problems, and new practitioners are entering the field. The OECD/NEA WPNCS Subgroup 8 (SG-8) has developed a critical benchmark rating system to collect, preserve, and disseminate expert knowledge and judgement regarding the suitability of ICSBEP evaluations to common uses such as modern code validation, nuclear data evaluation, and nuclear data adjustment.

# INTRODUCTION

With the increasing rigor of the ICSBEP review process, there exists a disparity between earlier and modern benchmarks in terms of uncertainty quantification and more realistic modelling of the configurations. For example, earlier benchmarks may quote unrealistic uncertainties that are then used to set safety limits or assess nuclear data evaluations. Additionally, there are benchmarks that have clear consistency problems, internally across cases or compared to other, similar benchmarks. As part of Subgroup 8 (SG-8), an activity was undertaken to outline a methodology for collecting and disseminating feedback on evaluations from qualified experts to better serve users of the ICSBEP benchmarks**.**

ICSBEP benchmarks are used throughout the nuclear engineering community in such areas as code and/or data validation, nuclear data evaluation, nuclear data adjustment, and bias estimation. As a result of SG-8, it was agreed upon by the authors to focus on the following for an additional rating system.

1. Transfer knowledge from individual criticality safety experts to the rest of the community.
   1. not anonymous
   2. not by institution
2. Conveys benchmark usefulness in a straightforward way.
   1. accessible to novices
   2. can be integrated with other processes
3. Focus on how **confident** we are that a benchmarkis useful to **validate codes and data.**

There may be additional revisions in the future, for example, to potentially allow ratings from automated processes, such as AI or ML-generated reviews. These will need to be managed carefully as the original goal of the subgroup was to preserve human expert knowledge.

# V1.0 RATING SYSTEM DESCRIPTION

Ratings are collected in an Excel spreadsheet shown in Figure 1. The assessor’s name is entered once near the top. The spreadsheet is periodically re-populated with every existing ICSBEP benchmark so that the assessor can simply filter and enter data for their specific cases using the remaining fields.

* **Add Cases**: enter a comma-separated list, range, or ‘ALL’ for the cases for which the rating applies.
* **Rating**: the numeric rating 1-4.
* **Issue Keys** (optional): specific issues summarized with a key.
* **Improvements Recommended** (optional)
* **Additional Notes** (optional)

Note that all cases are present in the spreadsheet and one can enter a general rating for a range or ‘ALL’ for any case and then a specific rating for a specific case and the processing will take care of the difference. For version 1.0, three issue keys have been declared. They are not mutually exclusive and a single case could have all three issues. If there is an issue with the benchmark model, such as an inconsistency, incorrect value, or even unjustifiably complex, can be indicated with an ‘M’. A revision that corrects ‘M’ issues may be a low cost way to improve benchmark. A benchmark that shows a large bias that leads to loss of utility for validation can be denoted with a ‘B’. Finally, a benchmark where uncertainty is either significantly under or over-estimated or has missing components can be denoted with a ’U’.

Table

Description automatically generated with medium confidence

Figure : Screenshot of v1.0 of the collection form.

# EXAMPLES

The following table (Table 1) shows examples of feedback entries. Note that the detailed improvements recommended and additional notes are of particular utility for the goal of knowledge preservation.

Table : Example feedback entries.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Identifier** | **Case** | **Rev** | **Add Cases** | **Rating** | **Issue Keys** | **Improvements Recommended** | **Additional Notes** |
| HEU-MET-FAST-003 | HEU-MET-FAST-003-001 | 0 | ALL | **4** |  |  | In this series, it seems that experiments involving a tungsten carbide reflector calculate high by more than 1 % for some of them. This overestimation standing outside the 3σ, being not observed for other HMF experiments and being the same whatever the code that is used, it could be due to the nuclear data of tungsten. It has been checked that the trend increases with the reflector thickness, showing that keff is sensitive to the nuclear data of tungsten. |
| LEU-COMP-THERM-078 | LEU-COMP-THERM-078-001 | 0 | ALL | **4** |  |  | The tight grouping of the results indicates low uncertainty and low variability from one case to another. The layout differences are small, so the results may be highly correlated, but even if examined simply as reproducibility measurements they demonstrate high precision. |
| LEU-COMP-THERM-027 | LEU-COMP-THERM-027-001 | 2 | ALL | **3** | B | Some overestimations (outside the 3 σ of the experimental uncertainties) appears for some cases depending on the gap thickness between the lattice of rods and the lead reflector screen and also depending of the lead reflector screen thickness. | It is observed for all codes and is more or less significant depending of the nuclear data. An improvement of the lead nuclear data (angular distributions and cross sections) could lead to an improvement of results. |
| PU-MET-FAST-001 | PU-MET-FAST-001-001 | 4 | ALL | **2** | U | Density of the plutonium parts is not specified, and thus experimental uncertainties are too small. | While the fourth revision to PMF-001 included much new geometry data and significantly revised the original evaluation, since this is a fast, bare plutonium assembly, the density has a very large effect on keff. Given the density is not precisely known, the experimental uncertainties are too small. |
| PU-MET-FAST-008 | PU-MET-FAST-008-001 | 2 | ALL | **2** | U | Uncertainty of 0.0006- way too small, especially considering the model is an idealized sphere. All uncertainties were experimentally determined, and no composition or geometry uncertainties were analyzed. No room return or machine uncertainties included. |  |
| PU-SOL-THERM-033 | PU-SOL-THERM-033-001 | 0 | ALL | **2** | B | This series of experiments exhibits an overall underestimation of keff that can be strong and that is not consistent with other PST series. | Pyrex tubes or Raschig rings are involved in the configurations; however it is not sure that such discrepancies can be explained by the pyrex tubes or Raschig rings all the more that some discrepancies are observed even without these absorbers. Consequently, the composition of the plutonium nitrate solution could be responsible for that tendency and in particular the stoichiometry in nitrate that has been found erroneous for other series. |
| LEU-COMP-THERM-033 | LEU-COMP-THERM-033-001 | 0 | ALL | **2** | B | Calculations using various libraries highlighted relatively higher keff values for the 3%-enriched uranium (Cases 17 to 22 and 47 to 52). Experimental keff uncertainties are of the same order whatever the U235 enrichment. Need to check information about the 3% enriched UF4 powder. | Homogeneous mixtures of divided uranium fluoride (UF4) dispersed in paraffin. The uranium fluoride was dispersed in the paraffin to produce essentially homogeneous mixtures with H/U atomic ratios ranging from 4 to 20. The uranium in the fuel mixtures contained either 2 or 3 wt.% 235U. |
| MIX-SOL-THERM-010 | MIX-SOL-THERM-010-001 | 0 | ALL | **2** | B, U | The uncertainty in Fe and other impurities discussed in Section 2.1.8 is treated as a bias and not an uncertainty. It seems that this should be treated as an uncertainty. | If these biases are treated as uncertainties, calculated and expected results agree better for a number of codes and cross section sets. |
| PU-COMP-MIXED-002 | PU-COMP-MIXED-002-006 | 0 | 6,7,8,9,19,20,21,22 | **1** | U | There are a number of unquantified or under-quantified uncertainties, such as the composition and thickness of contamination control material (tape and plastic wrap) that covered each plutonium oxide-containing polyethylene box in the array. Other uncertainties could arise from the plutonium oxide density, heterogeneity of the oxide and polystyrene moderator, thermal expansion of the boxes, and loss of hydrogen due to radiolysis in the moderator. No temperature data reported, but the reason for the contamination control material was because the boxes got so hot that they melted the glue holding the PE boxes together. | These benchmarks represent the only loose plutonium oxide benchmarks in the handbook and have historically been considered important for criticality safety validation. |
| MIX-COMP-THERM-012 | MIX-COMP-THERM-012-001 | 1 | ALL | **1** | B | There is an inconsistency between cases results. A strong overestimation by more than 3% is observed for some cases whereas a strong underestimation by 3% is observed for others whatever the library. | This discrepancy is not common to other MCT series. The composition of the polystyrene boxes could be at stake. Indeed some parameters were derived from calculations. |

## SECOND-ORDER HEADING

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### Third-Order Heading

#### Fourth-order heading

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