SINBAD PROJECT AND OUTCOMES OF WPEC SUBGROUP 47 ON SHIELDING BENCHMARK USE

I. KODELI[1], O. CABELLOS[2], L. LEAL[3]

[1]UKAEA, Culham Centre for Fusion Energy, Abingdon, OX14 3DB, UK
[2]Polytechnic University of Madrid(UPM), Madrid, Spain
[3]Institut de Radioprotection et de Sûreté Nucléaire, PSN-RES/SNC, Fontenay-aux-Roses, 92260, France

Email contact of corresponding author: ivan.kodeli@ukaea.uk

The Shielding Integral Benchmark Archive and Database (SINBAD) [1] project started about 30 years ago as a collaboration between the OECD/NEA Data Bank and RSICC, following the discussions in the late 1980's within the NEACRP specialists' meetings on shielding benchmark calculations and the proposal at the Radiation Shielding conference in Bournemouth, UK [2]. The main goal of the project was to preserve the information on the performed radiation shielding benchmarks and make them available in a standardised form to the international community. The database is intended for different users, including nuclear data evaluators, computer code developers, experiment designers and university students. SINBAD is available from RSICC and from the NEA Data Bank [5]. The database was extensively used in the scope of numerous national and international projects, such as PWR Pressure vessel surveillance, fusion programme (ITER reactor studies), different OECD Working Party on Evaluation Cooperation (WPEC) Subgroups, nuclear data validation, IAEA nuclear data projects (FENDL, IRDFF), etc. Lately, the database is used for the validation of FENDL-3.2a and JEFF-4T nuclear data.

The SINBAD initial interest was, in particular, focused in collecting and preserving the information on integral benchmark data for fast reactor programme, however the project soon extended to fusion and accelerator relevant experiments. The delimitation between the SINBAD fission and fusion benchmarks is mainly based on the radiation source used (14-MeV D-T neutrons and fission source for fusion and fission, respectively) and measured quantities (e.g. tritium breeding ration for fusion). In practice, the "fission" benchmarks can however still be valuable for the validation of nuclear data for fusion applications and vice versa. Examples include the iron benchmarks where combined use of fission and fusion benchmarks contributes to a more complete validation of iron cross section over the wide energy range, fission benchmarks including thick (~1m) penetrations in iron/stainless steel with large sensitivity to iron nuclear data, and 14 MeV benchmarks providing valuable data in the high-energy (in-)elastic scattering including anisotropy. Accelerator benchmarks have the potential to extend the validation to higher energy range. However, the need to improve the quality of the available accelerator benchmarks was often evoked, e.g. at the WPEC SG47 meetings.

The activity in the SINBAD evaluation and development was considerably reduced in the last decade and more due to funding support. Working Party on International Nuclear Data Evaluation Co-operation Subgroup 47 (WPEC SG47) entitled "Use of Shielding Integral Benchmark Archive and Database for Nuclear Data Validation" [3] was organised at the OECD/NEA from 2019 to 2021 with the objectives to promote more systematic and wider use of shielding benchmark experiments in nuclear data and transport code validation and development, and to obtain feedback from the users on the SINBAD database. The recommendations of the SG47 will help to better orient and focus further SINBAD improvement and developments based on the experience, needs and expectations of nuclear data community. The “renaissance” of the project would furthermore contribute to the diversification of the nuclear data validation practice by including more extensively different types of integral measurements, such as shielding benchmarks, and result in production of more general-purpose cross-section evaluations.

Several proposals for new or updated benchmark evaluation were presented and discussed at the WPEC SG47 meetings (about 6 meetings), such as:

- FNG-Cu evaluation done within F4E in 2018, under review since.
- KFK 1977 gamma fields in iron spheres with ^{228}Th and ^{252}Cf source (Stanislav Simakov).
- LLNL: 75 pulsed-sphere neutron-leakage spectra for 20 different materials (Soon Kim).
- CIAE neutron leakage spectra from Fe, (SiC, graphite, Bi) with D-T neutrons; TOF measurements at different angles (Yanyan Ding).
- REZ Fe sphere and slab benchmarks.
- Oxygen broomstick benchmark: review and updates of SINBAD evaluation by Stanislav Simakov.
- FNS and OKTAVIAN benchmarks (Cu, Ti, Li_2O, etc.): availability issues discussed.
- TIARA benchmark.
- BALSAC/MASURCA (A. Hajji, G. Rimpault, L. Buiron (CEA Cadarache).
- JANUS experimental Fast reactor programme (1984-87, AEA Reactor Services Winfrith & CEA Cadarache):CA (1988): internal storage for fast reactors (A. Hajji).
- PETALE program in CROCUS on stainless steel nuclear data (Vincent Lamirand, EPFL).

Adding new features in the database with was also discussed, for example providing the information on the geometry, (radiation source) and materials in CAD format will allow an easier and less error prone computational model preparation for different transport codes. Moreover, providing the nuclear data sensitivity profiles more systematically would facilitate and better guide the use of data. Inputs for various transport codes and other benchmark data from participants have been shared via NEA GitLab which could hopefully in future evolve and form a bases for critically checked and validated set for computer code analysis tools. Evaluation of the FNG-Copper (by I. Kodeli, M. Angelone), KFK Fe spheres g-leakage and ORNL O broomstick (both by S. Simakov) are available from the NEA Gitlab, as well as many other information, such as computer code inputs and reports contributed by IJS, NRG and UPM on ASPIS Fe88, TIARA, OKTAVIAN, FNS and LLNL benchmarks. INEST Hefei contributed SuperMC computer code inputs for a series of fusion benchmarks to be included in SINBAD. Inputs for the SERPENT code were also prepared at CCFE, KIT, JSI and CEA Cadarache for FNG and ASPIS-Fe88 benchmarks.

A repository for the data and benchmark evaluations prepared as part of the WPEC SG47 activity should be defined to prevent data loss or dispersion, be it within the present SINBAD, ICSBEP, new SINBAD, GitLab or elsewhere.

The need to clarify the future organisation and format issues was discussed. Although the group took note that a new SINBAD format was chosen by the ICSBEP and IRPhE working groups, alternative organisations of the database were discussed. Separating the evaluation of the experimental measurement data in a more “static” databases from the data describing computational analysis may present some advantages both from the maintenance and data preservation aspects. The latter database (referred as “dynamic”) would include more up-todate computational models, regularly revised input and output data for specific computer codes, C/Es and other information requiring frequent updating.

Task Force was started in January 2022 to carry on the work on further development of SINBAD and will incorporate ~~some~~ recommendations from WG47.

The latest version of SINBAD, distributed by the NEA and RSICC, includes 102 shielding benchmark experiments covering fission reactor shielding (48 benchmarks), fusion blanket neutronics (31), and accelerator shielding (23) applications. Half of these benchmarks went through quality review process to identify the completeness and consistency of the experimental information and to rank the benchmarks accordingly. Most of the fusion (25 out of 31) and fission (17 out of 48) benchmarks were already carefully reviewed. The need to complete this work for the remaining benchmarks was highlighted, in particular, the reference to accelerator benchmarks, where a more careful quality evaluation would be welcome.

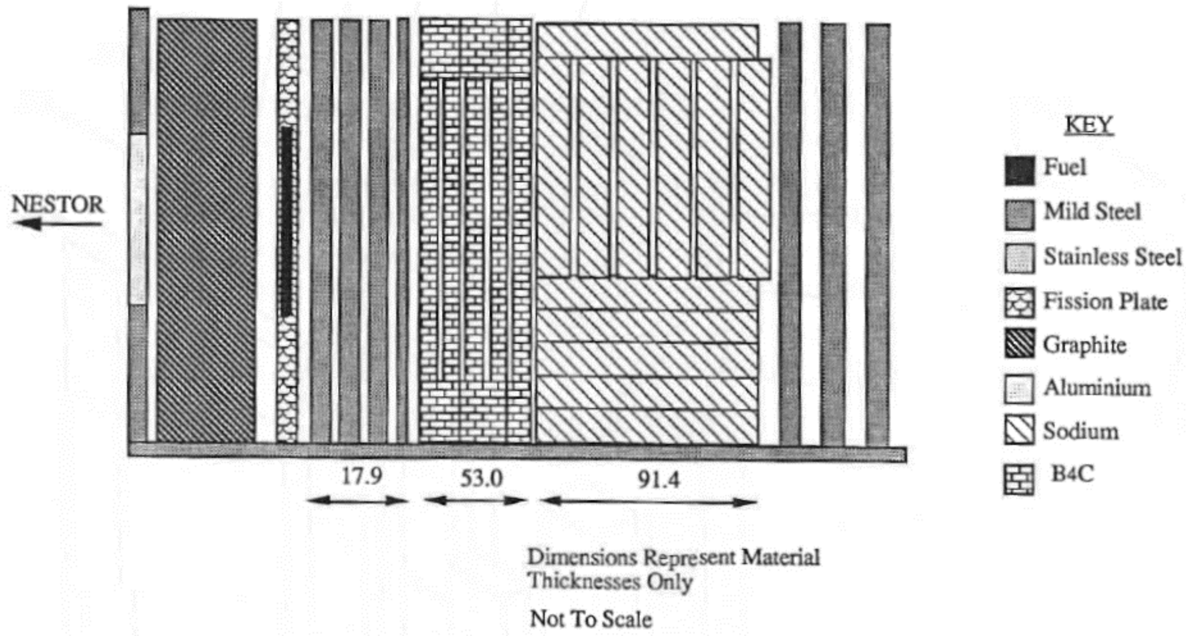

FIG. 1. JANUS Phase 7 experiment consisting of 50 cm B_4C and 120 cm Na

Integral benchmarks are regularly used in the scope of the nuclear data evaluation, either to resolve ambiguities among different differential measurements, or to improve the performance of nuclear data library for the specific applications. However, it is usually subsequently difficult to disentangle the complex dependence between the evaluated nuclear data and integral benchmark experiments. It is strongly recommended that benchmark experiments which were in any way used in the nuclear cross section evaluation process are clearly mentioned and listed. Information should be provided on the method used, be it adjustment, tuning, "guidance" in differential experimental data use etc. This information is fundamental to avoid double counting and excessive weight some benchmark experiments may take if used subsequently be the users for special-purpose library creation.

Examples of the use and some views on future development of the SINBAD benchmark database will be presented.

REFERENCES

[1] KODELI, I., SARTORI, E., SINBAD – Radiation shielding benchmark experiments, Annals of Nuclear Energy 159 (2021) 108254.

[2] MILLER, P., NAGEL, P., SALVATORES, M., SARTORI, E., "Shielding Experimental Benchmark Base at the Nuclear Energy Data Bank", Proc. 7th Int. Conf. on Rad. Shielding, Bournemouth, UK(1988) NEACRP-L-310.

[3] KODELI, I., CABELLOS, O., LEAL, L., Use of shielding integral benchmark archive and database for nuclear data validation, J Web of Conferences 239, 18001 (2020) https://doi.org/10:1051/epjconf/202023918001