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SINBAD

SHIELDING INTEGRAL BENCHMARK ARCHIVE AND DATABASE

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ABSTRACT

SINBAD is a new electronic database¹ developed to store a variety of radiation shielding benchmark data so that users can easily retrieve and incorporate the data into their calculations. SINBAD is an excellent data source for users who require the quality assurance necessary in developing cross-section libraries² or radiation transport codes. The future needs of the scientific community are best served by the electronic database format of SINBAD and its user-friendly interface, combined with its data accuracy and integrity.

I. INTRODUCTION

For several decades, radiation shielding has been studied in fission, fusion, accelerator, and radioactive nuclide systems, worldwide, and involving investments of hundreds of millions of dollars. The experimental benchmarks resulting from these studies have been instrumental in the design of power reactors and nuclear research facilities. The information supplied by the experimental benchmarks exists in many forms at various locations. Some benchmarks may not contain a single reference with complete information and must be assembled from other documents or through verbal communication with sources such as the experimentalists responsible for the benchmark work. *As experimental benchmark facilities close and experimentalists leave the field, the need to preserve experimental benchmark results now becomes increasingly important.* Consequently, experimental benchmarks need to be collected and stored in a complete and accurate fashion.^{3,4}

II. BENCHMARK INFORMATION

The guidelines developed by the Benchmark Problems Group of the American Nuclear Society Standards Committee (ANS-6) on formats for benchmark problem description have been followed by

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SINBAD.⁵ SINBAD data include benchmark information on (1) the experimental facility and the source; (2) the benchmark geometry and composition; and (3) the detection system, measured data; and an error analysis. A full reference section is included with the data. Relevant graphical information, such as experimental geometry or spectral data, is included. All information that is compiled for inclusion with SINBAD has been verified for accuracy and reviewed by two scientists.

III. SELECTION OF BENCHMARKS

A feasibility study has been successfully completed, using a sample of fission and fusion benchmarks with associated computations installed in SINBAD. Currently, an extended list of high-priority benchmarks will be incorporated into SINBAD. The benchmarks to be installed in SINBAD will be selected from those previously sanctioned by an accredited group or organization and/or have been widely used, such as those from the Nuclear Energy Agency Nuclear Science Committee (NEANSC), the Cross-Section Evaluation Working Group (CSEWG), and the IAEA Consultants' Meetings on Fusion Benchmarks.⁶ Several more relevant benchmarks will be added as they become available. The list of selected benchmarks follows:
Note: * indicates benchmark is currently in SINBAD or is in the process of being added.

NEANSC:

- *1) Winfrith Iron Benchmark Experiment (ASPIS)
- *2) Ispra Iron Benchmark Experiment (EURACOS)
- *3) Wuerenlingen Iron Benchmark Experiment (PROTEUS)
- 4) Osaka Iron Benchmark Experiment (OKTAVIAN)
- 5) Karlsruhe Iron Sphere Benchmark Experiment
- *6) Winfrith Water/Iron Benchmark Experiment (ASPIS)
- *7) Winfrith Water Benchmark Experiment (ASPIS)
- *8) Ispra Sodium Benchmark Experiment (EURACOS)
- 9) Cadarache Sodium Benchmark Experiment (HARMONIE)
- *10) Winfrith Graphite Benchmark Experiment (ASPIS)

CSEWG:

- 11) SDT1 Iron Broomstick Benchmark Experiment (TSF-ORNL)
- 12) SDT2 Oxygen Broomstick Benchmark Experiment (TSF-ORNL)

13) SDT3 Nitrogen Broomstick Benchmark Experiment (TSF-ORNL)

14) SDT4 Sodium Broomstick Benchmark Experiment (TSF-ORNL)

*15) SDT11 Iron and Stainless Steel Experimental Benchmark (TSF-ORNL)

*16) SB5 Fusion Benchmarks for Attenuation in Iron, Borated Polyethylene, and Lithiated Paraffin (ORNL)

*17) SB6 Fusion Reactor Duct Streaming Experiment (ORNL)

OTHER BENCHMARKS:

18) University of Illinois Iron Sphere Benchmark

*19) PCA-PV 'Blind Test' and Replica Benchmarks

20) Winfrith NESDIP2 and NESDIP3 Radial Shield and Cavity Experiments.

21) YAYOI Iron and Sodium Fast Reactor Shielding Benchmarks (University of Tokyo)

22) Thermal Reactor Duct Streaming (IRI/University of Budapest)

IAEA FUSION BENCHMARKS:⁶

23-38) OKTAVIAN facility neutron and gamma-ray measurements on chromium, manganese, iron, tungsten, nickel, molybdenum, lithium, beryllium, lead, beryllium/lithium, lithium fluoride, and lithium fluoride/lead

39-42) IPPE facility, at Obninsk, neutron leakage measurements on iron, beryllium, lead, and lead/lithium

*43-52) FNS facility neutron and gamma-ray spectra measurements on iron, carbon, oxygen, tungsten, SS316, SS316L, beryllium, lead, and lithium dioxide

53,54) TUD facility neutron and gamma-ray leakage measurements on iron and lead

*55) FNG facility gamma dose measurements on SS316

*56-59) ORNL facility neutron and gamma-ray spectra measurements on iron, SS304, tungsten, and borated-polyethylene (same as 16 and 17 above)

60) KfK facility neutron spectrum measurements on beryllium

61) INEL facility total neutron leakage measurements on beryllium

62,63) SWINPC facility, at Chengdu, total neutron leakage measurements on beryllium and lead

64-66) BARC facility total neutron leakage measurements on beryllium, beryllium oxide, and lead

67,68) LLNL facility neutron spectra measurements on lithium-6 and lithium-7

Those experiments involving combinations of different materials and/or sources or configurations will be broken down, subdividing the experiment into unique additions to SINBAD. Therefore, the above numbering of the experiments to be included into SINBAD is not representative of the final number of separate entries.

IV. COMPUTATIONS

The secondary function of SINBAD is the incorporation of accompanying analyses of the benchmarks to help reduce redundant computational work in the future and to supply a user complete information, such as (1) description of the computational procedure, (2) references to codes, (3) approximations and simplifications in modeling, (4) code input deck, (5) computational results, etc., as described in reference 6. Given the possible number of calculations performed for any one of the above benchmarks, and the effort required to install the results, only published calculations will be added as time and space allow.

V. DATABASE DESIGN

SINBAD stores the benchmark information in relational databases that have index keys on unique identification numbers called Shielding Benchmark Experiment codes (SBE) assigned to each benchmark. The index key serves as a means of finding information quickly within a database and as a relationship with other databases housing different parts of the benchmark data.

An abstract outlining each benchmark has been constructed to allow the user to easily peruse important benchmark characteristics before making a selection. The abstract contains ten specific areas of information: (1) Name of Experiment, (2) Purpose and Phenomena Tested, (3) Description of the Source and Experimental Configuration, (4) Measurement System and Uncertainties, (5) Description of Results and Analysis, (6) Special Features, (7) Author/Organizer/Compiler, (8) Availability, (9) References, and (10) Data and Format. Each benchmark has additional categorical information, such as source type, source particle(s), measured particle(s), materials and thicknesses, date of experiment, and data type that further aids in a user selection. Currently, SINBAD uses three databases to store benchmark characteristics, search parameters, and search results.

The experimental benchmark data, which includes the source, geometry, material(s), detector(s), and measurement(s), are stored in separate files that contain formatted text with associated graphs, figures, and equations. The experimental benchmark file is retrieved into SINBAD upon user selection, along with associated computation(s) that are also stored in separate files.

VI. DATABASE ACCESS AND RETRIEVAL

The retrieval process in SINBAD may progress by one of two methods. If the user knows a benchmark

in which he is interested, information on the benchmark may be obtained by a perusal of the alphabetized list of benchmark experiment names. Before one selects the bulk of a benchmark's information, one may preview the benchmark via the process information and the experimental abstract, mentioned above. Once a benchmark has been selected, the experimental and calculational data are retrieved directly or may be accessed later by reference to the benchmark's SBE code (See Figure 1).

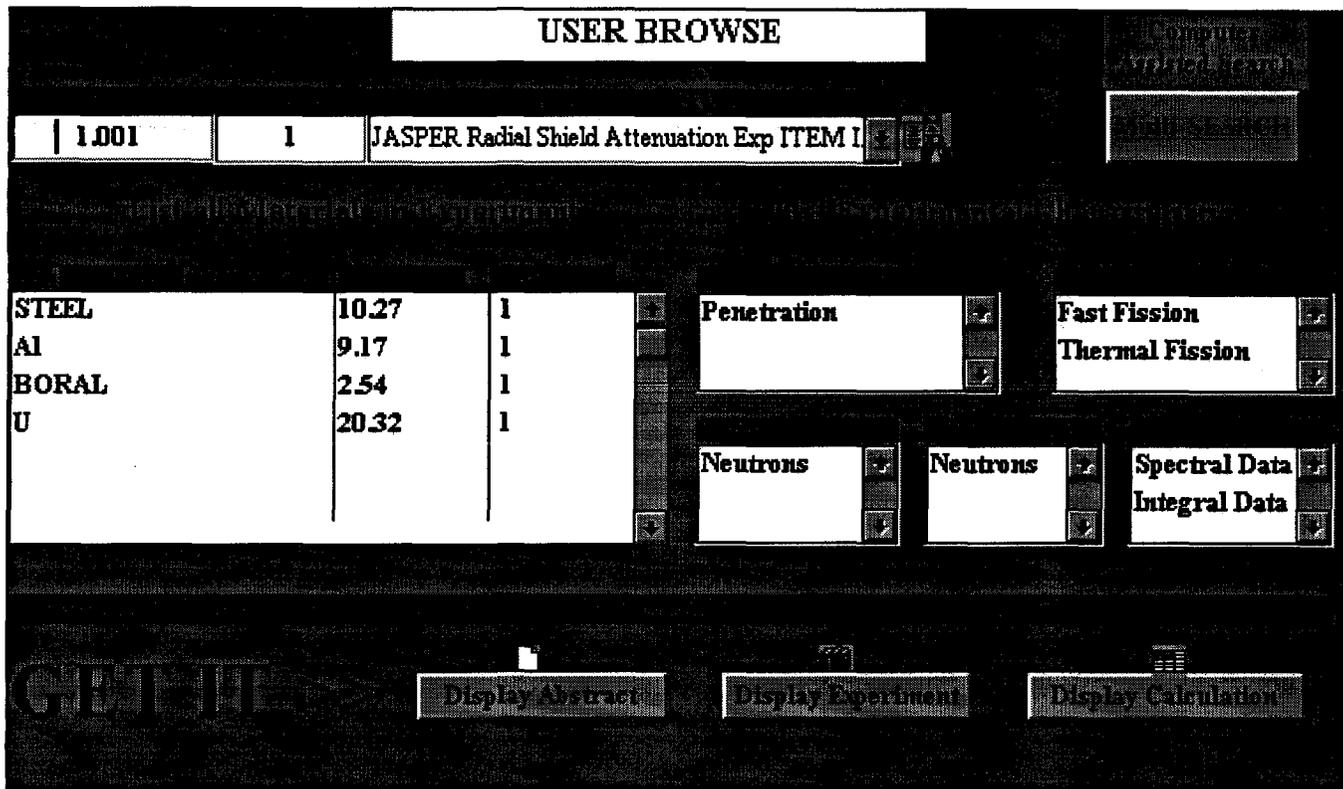


Figure 1. Sample SINBAD Browse Screen

If the user is not familiar with the available benchmark experiments, then SINBAD has an interactive, multiple-search capability, whereby the user may select the benchmark from a list of candidates generated by user supplied experimental characteristics. For example, a user may specify an interest in penetration of experiments involving a source of fission neutrons passing through a 50-cm-thick steel plate. Only the benchmarks' satisfying these requirements will be retrieved, creating a subset of benchmarks which will improve the user's chances of finding the best benchmark to satisfy his needs (See Figure 2).

Benchmark information may be viewed, printed, or saved to an ASCII file for a user to manipulate further into computer readable formats. Currently under investigation is a standard format for source and measured data files to reduce the user's need for file manipulation when the data are used with personal plotting or computation codes. Hypertext, Bookmarks, and Sticky Notes may be added at the user's discretion to further aid in finding and interpreting the benchmark information.

VII. SOFTWARE REQUIREMENTS

The SINBAD database was written in Visual FoxPro 3.0 (Microsoft) for a Windows 3.1 (Microsoft) PC

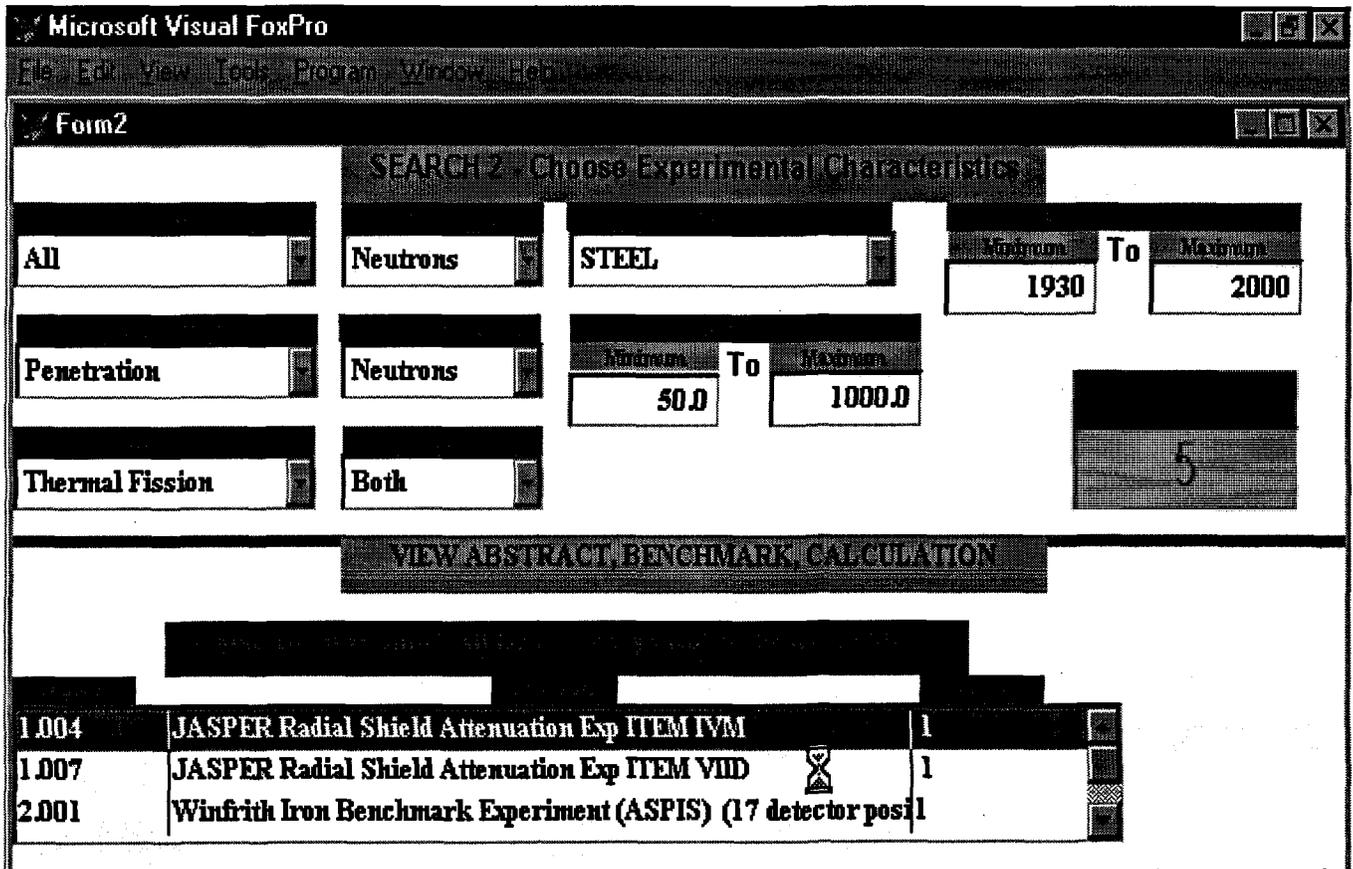


Figure 2. Sample SINBAD Computer Assisted Search Screen

platform. SINBAD incorporates mouse control over selections on a 3-D-like windows display of drop-down lists and text boxes. Graphical data with accompanying text and tables of the experimental benchmark data are stored together within Envoy 1.1 (Novell), a self-opening document viewer compatible with Windows (Microsoft). The contents of the abstract, experiment, and/or associated calculations may be displayed to screen and/or printer from within SINBAD. Both the SINBAD program and the Envoy data files are run-time executable files (*.exe), eliminating the need for users to purchase additional software beyond Windows for the PC. Currently, SINBAD's programming has been completed, and 13 fission and fusion experimental benchmarks have been archived. Current work is proceeding to incorporate other types of benchmarks (accelerator, criticality), as well as the many fission and fusion benchmarks recommended by CSEWG, NEANSC, and the IAEA.

VIII. HARDWARE REQUIREMENTS

A PC or compatible, with a 486 processor, 8 MB of RAM, 40 MB of free hard disk space, and a VGA color monitor are necessary for adequate performance of SINBAD. A printer is recommended, but not necessary. The size and number of benchmarks will be the only limiting factor for PCS since hard disk space is used at the average rate of 1 MB/benchmark.

XI. FUTURE SINBAD UPGRADES

It is envisioned that SINBAD could eventually contain several hundred benchmark experiments, not only for shielding, but for criticality safety experiments and computational benchmarks. The format and software presently used in SINBAD could be converted easily and used on the Internet, allowing greater access by potential users in the future.

X. SUMMARY

The need for an electronic database system for shielding benchmarks to be used on an international level has been demonstrated. The objectives of the database are to:

- (a) preserve the high quality and expensive results from phased-out experiments and lost expertise;
- (b) compile complete and comprehensive benchmarks experiment data and description;
- (c) provide a flexible data storage medium and a versatile, user friendly data access and retrieval process;
- (d) provide an effective tool for quality assurance testing of data and methods;
- (e) facilitate access, acquisition, and use of the benchmark data in the future; and
- (f) provide a mechanism for feedback to data evaluators on the cross-section data inadequacies and improvements.

SINBAD has been structured with the software and hardware capabilities necessary to effectively store, access, and retrieve the data at the user's request and with the flexibility needed to expand to other areas of interest.

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