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# THE JEFF PROJECT AND THE JEFF-3 NUCLEAR DATA LIBRARY.

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## ABSTRACT

The OECD-NEA Joint Evaluated File Project, JEF, is co-operating with the European Fusion File Project, EFF, to produce a new neutron cross-section data library suitable for both fission reactor and fusion reactor technology applications. The new Joint Evaluated Fission and Fusion Project, JEFF unites the two projects, JEF and EFF, in the work of producing the new library, JEFF-3. In addition to the general purpose file the new library will include improved special purpose files, in particular new fission yield and decay data files. Also the European Activation File, EAF-97, will form part of JEFF-3 .

## 1. Introduction.

In the past the JEF and EFF projects have worked closely together but with different timescales for producing their data libraries. The latest JEF Project general purpose file[1], JEF-2.2, was frozen in January 1992 whereas the EFF Project continued to adopt improved evaluations, the latest EFF Project library[2], EFF-2.4, being produced in 1994.

These libraries are now complete and have been extensively validated. They are now being adopted by different organisations in Western European countries for neutronics studies.

The differences between the evaluations in the two libraries are primarily for the structural materials, Cr, Fe, Ni, etc. and materials of particular interest for fusion applications, Li, Be, Mo, Pb etc. These differences have resulted in duplication of the work of processing and validating the data libraries. In particular, we can refer to the extensive benchmark testing of the data for Fe which has been made for the evaluations in both libraries. These benchmark studies and new differential measurements for Fe, together with calculational investigations of the importance of representing the resonance structure above 800 keV, have resulted in the production of an improved evaluation for Fe. The extensive benchmark testing programmes have shown the need for improvements to a number of evaluations. Several new evaluations have now been produced (and there are also newer evaluations available in other libraries). The JEF and EFF Projects have decided to cooperate to produce a single new library, JEFF-3. The new Joint Evaluated Fission and Fusion Project, JEFF, unites the two projects in this work.

A significant feature of the JEF-2.2 and EFF-2.4 libraries is their extensive validation. Because of this there is the aim of making changes only when they are well justified, so as to try to minimise the new validation work required. Nevertheless, improved evaluations

are proposed for many key materials (Fe, U-235, Pu-239 etc.) and this will affect the predicted values of most neutronic parameters.

Formal QA procedures have now been established by the NEA Data Bank to ensure a high level of quality assurance in the assembly of the new file. In addition, the use of standard checking codes to test the evaluations prior to inclusion in the file will help to eliminate certain types of error.

**2. JEF-2.2 and EFF-2.4**

The JEF-2.2 general purpose file contains evaluations for 313 materials as compared with 80 in EFF-2.4. It includes data for 42 actinide isotopes and a large number of fission products, as well as for some important activation products. The set of materials in the EFF library is thus a subset of the JEF library, but the evaluations are in many important cases improvements over those in JEF-2.2. There are newer EFF evaluations for the following: Li-7, Be-9, Al, Si-28, V, isotopes of Cr, Fe, Ni and Mo, Pb-nat. All of these include photon production data.

For about 25 other materials newer evaluations than those in JEF-2.2 have been incorporated in EFF-2.4 from other libraries. The JEFF-3 library will include all of these newer evaluations.

It is the structural materials which are of common interest to the two projects. In addition to the extensive benchmarking of the data for these, the JEF Project has carried out cross-section adjustment studies for thermal and fast reactors and benchmark calculations for actinide transmutation experiments and criticality configurations. Analyses of thermal and fast reactor fission product experiments are continuing. The performance of the JEF-2 based applications libraries is broadly satisfactory but an improved performance can be obtained by modifying some cross-sections, as has been done, for example, in the adjusted fast reactor cross-section set produced at Cadarache. Some of this improvement would be obtained by adopting updated basic evaluations.

**3. Selection of data for JEFF-3.**

New evaluations have recently been completed, or are currently being produced, for Li-7, Be-9, Al, V, Cr-52 and Fe-56, together with revisions to the resonance regions of other isotopes of Fe and Ni. A new evaluation of the U-235 resonance region is being carried out in cooperation with ORNL. In addition to these there are new resonance region evaluations for Pu-240 and other actinide isotopes. It is planned to include these in JEFF-3.

It is also planned to include the following enhancements:

(a) A more complete representation of energy production data, including gamma energy yields. EFF-2.4 is already complete in this respect for the materials of primary concern for fusion reactor technology.

(b) Reevaluations of those items of data shown to require modification by the benchmark studies. These include, for example, sodium inelastic scattering and oxygen (n,α).

(c) Inclusion of the results of differential cross-section measurements recently analysed (or reanalysed), such as inelastic scattering in Na and U-238.

To serve as a basis for the selection of new evaluations an intercomparison has been made between the evaluations in the different libraries, BROND, CENDL, EFF, ENDF/B, ENDL, JEF and JENDL. Many of the evaluations in JEF-2.2 were adopted from earlier versions of the ENDF/B, ENDL and JENDL libraries. In these cases the plan is to move to the newest evaluation. In some cases the choice is complicated because of modifications made to these evaluations in the JEF-2.2 versions, such as the addition of reaction data and, in some cases the adjustment of cross-sections to take into account integral measurements. Possible sources for data missing from JEF, such as photon production data, have also been noted.

The JEF library includes the special purpose files: thermal scattering data; fission product yield data for 21 fissioning systems; radioactive decay data for 2345 nuclides, and photon interaction data. A new fission yield library has been produced[3]. The general evaluation methodology has remained the same but much new data has been included and an improved analysis made. The file has been used (together with a recent evaluation of Pn values) to calculate delayed neutron yields by summation and an improved accuracy is being found. Revised decay data are being produced[4] for a set of 39 important fission products and data included for 37 fission products missing from JEF-2.2. Decay data for 74 activation products in EAF are also being evaluated. The decay data evaluation work is planned for completion in 1998.

It is planned to develop an Intermediate Energy File, the emphasis being on data for studies of accelerator driven reactor systems.

Associated with the EFF Project is the European Activation File, EAF, and the calculational scheme, EASY. The latest version of the file, EAF-97, is a development of EAF-4.1 including an additional 200 selected reactions and newer data sources.

**4. Validation.**

The JEF-2.2 library has had the benefit of 5 years of benchmark validation work, and the work is still not complete and fully reviewed. In particular, the fission product validation studies are still in progress. In the course of this validation work the need for revisions to some cross-sections has been identified and also some sources of inconsistency in the data specification in the files have been found. The changes involved in moving to a new library must not be such as to require all of this work to be repeated.

The JEF benchmark studies have validated the data for the following materials:
(1) The major fission reactor materials, H, B, O, Na, Fe, Zr, U-235, U-238, Pu-239, -240, 241.
Most of the thermal and fast reactor, and criticality validation studies give information only about these materials. The criticality systems are also sensitive to data for N, F and Gd.

(2) The principal fission products. The studies relate to about 10 fission products in thermal reactor spectra and 30 in fast reactor spectra.
(3) The capture and fission cross-sections of some minor actinide isotopes in thermal and fast reactor spectra. About 10 additional actinide isotopes are involved.

Thus we see that the validation studies relate to only a small subset of the 313 materials in JEF-2.2. The studies have shown the need to revise the data for about half of the principal materials: O, Na, Fe, U-235, Pu-239. There are other reasons why one is considering revising the data for U-238, Pu-240, Pu-241, these being the availability of new differential inelastic scattering data for U-238 and resonance region evaluations for Pu-240 and -241.

A first estimate of the performance of JEFF-3, relative to JEF-2.2, will be obtained using the sensitivities which have formed the basis for the cross-section adjustment studies, supplemented by direct calculations for a small subset of the benchmarks.

**5. Quality Assurance procedures for the assembly of the Data File.**

The NEA Data Bank has introduced standard Quality Assurance procedures for the assembly of the JEFF-3 data file. The requirements for a such a system have been specified in the ISO 9000 family of international standards which mandates that the organisation define appropriate quality standards, document its processes and prove that it consistently adheres to both. Adoption of a quality assurance system is not a short-term limited effort, but is something that has to be continuously updated and maintained in order to stay in conformity with the ISO 9000 standard. Even though this will imply an additional workload, the benefits are considered to merit the extra effort, giving, for example, time savings through standardised handling of the JEFF data and better quality of the data through rigorous verification procedures.

The present QA plans can be divided into three categories: short term, medium term and long term plans:

- The short term goal consists of developing and implementing a QA plan for the compilation and maintenance of the JEFF-3 general purpose file, including the necessary tools to perform this work.
- The medium term goal will be to extend the JEFF QA plan to cover also the special purpose files of JEFF-3, such as the radioactive decay data and fission yield files, and to write the remaining documents.
- It is proposed to define longer term plans at a later stage, following a critical evaluation of the experience gained in the first two stages.

A comprehensive set of documentation is required in a Quality Management System, including a Quality Manual, Control Procedures, and Work Instructions. The Quality Manual is a formal declaration by the organisation of how it assures quality, and form a set of managerial policy statements on quality matters. The Control Procedures define in detail the methods and controls adopted throughout the organisation and frequently cover interfaces between different functions. The Work Instructions define how to perform specific tasks and processes.

The Work Instructions correspond approximately to the existing JEFF Quality Plan. A draft Quality Plan was written in 1995. Following extensive review the Data Bank was authorised in 1996 to start the compilation of the JEFF-3.0 library, according to the procedures defined in the Quality Plan.

The Data Bank has, in this context, developed a new data base system for the JEFF-3 library. It consists of a UNIX based ORACLE data base, with associated application programs for the storage, maintenance and retrieval of the data. The data base has been installed on one of the new in-house workstations and is in the final stage of testing.

It is now proposed to write the remaining Control Procedures and then to extend the existing JEFF Quality Plan to cover also the JEFF-3 special purpose files. Systematic procedures have to be employed in order to update and maintain this large and complex volume of data.

**6. Timescales for the development of JEFF-3.**

The plan is to start validation work on the general purpose file in 1998. It will first concentrate on shielding benchmarks, for fusion, fast reactor and thermal reactor applications, these being sensitive to the data for Fe, Cr, Ni, Na and $H_2O$. The second step (starting in 1999) will focus on fission systems (fast and thermal) and will involve the analysis of several hundred critical benchmarks. The release of JEFF-3 for industrial testing is planned for 2001.

The new fission yield evaluation is complete. However, because the set of isotopes included must correspond to those in the decay data file, and work is continuing on this, release of the yield file will probably be in 1998.

**7. Concluding remarks.**

The JEF-2.2 and EFF-2.4 libraries have undergone extensive validation studies. On the basis of these, together with new differential cross-section measurements and some reanalyses of the differential data indicated as needed by the validation studies, a new library of evaluated nuclear data, JEFF-3, is being produced. The EFF and JEF projects are cooperating in this work. The aim is to release the file for industrial testing in the year 2001, following a period of validation studies.

The problems that occurred in the past which it is hoped to avoid by using the new QA system are predominantly minor format errors in the file. However, through the use of the checking codes FIZCON and PSYCHE, and via pointwise processing and plotting of the data it is hoped to detect and correct physical errors in the files, such as unphysical discontinuities between different energy regions in an evaluation, and problems such as the partials not summing to the total.

**8. References.**

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