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NEUTRON METROLOGY FILE NMF-90

**An integrated database for performing
neutron spectrum adjustment calculations**

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Abstract: The Neutron Metrology File NMF-90 is an integrated database for performing neutron spectrum adjustment (unfolding) calculations. It contains 4 different adjustment codes, the dosimetry reaction cross-section library IRDF-90/NMF-G with covariance files, 6 input data sets for reactor benchmark neutron fields and a number of utility codes for processing and plotting the input and output data. The package consists of 9 PC HD diskettes and manuals for the codes. It is distributed by the Nuclear Data Section of the IAEA on request free of charge. About 10 MB of disk space is needed to install and run a typical reactor neutron dosimetry unfolding problem.

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1. Introduction

The Neutron Metrology File NMF-90 is a package containing the data input sets for six reactor benchmark neutron fields, the cross-section library of dosimetry cross-sections in 640-group format, unfolding codes and utility codes for preparing inputs for the unfolding procedure in the required formats.

The package is designed to determine neutron spectra at reactor in-core and out-of-core locations from a combination of neutron physics calculations and foil activation measurements. The primary goal is to determine radiation damage parameters characterizing radiation damage inflicted on a given material due to neutron irradiation of components of power and research nuclear reactors. Differential neutron spectroscopy methods are impractical for neutronic measurements in most nuclear reactors, and the foil activation method has to be used instead. The measured activation reaction rates, activation cross-sections and their covariances together with an apriory guess spectrum are used to determine the neutron spectra at given locations through a procedure called adjustment or unfolding with special computer programs.

This package is the result of an international cooperation efforts coordinated by the Nuclear Data Section of the IAEA through more than a decade. The international exercise, known as REAL (Reaction Rates Estimates Evaluated by Adjustment Analysis in Leading Laboratories) was carried out in three runs REAL-80, REAL-84 and REAL-88 with the aim to check the quality of the input data, to improve the cross-section library and its covariance information and to check the consistency of results obtained with different adjustment codes [1,2,3].

2. The input data sets

The package contains 6 input data sets to be used as sample problems for unfolding procedures. Data for the following benchmark neutron fields are given:

1. ANO - Pressure-vessel cavity of the Arkansas Power and Light Reactor (Arkansas Nuclear One).
2. PSI - Oak Ridge Research Reactor Poolside Facility in the metallurgical irradiation experiment. Simulated surveillance capsule position.
3. PS2 - Oak Ridge Research Reactor Poolside Facility in the metallurgical irradiation experiment. Simulated pressure vessel capsule position.
4. RTN - Fusion simulation spectrum measured at the RTNS-11, a 14 MeV neutron source at Lawrence Livermore Laboratory. The spectrum is a simulation of first wall spectrum in a fusion reactor.
5. Fission neutron spectrum of 235-U.
6. CFR - Neutron spectrum in the centre of coupled fast reactivity measurement facility (CFRMF).

The criteria for selection of these benchmarks were the high accuracy to which the spectrum is known, the presence of experimental activation measurements and the thoroughness of the error analysis.

3. Contents of the input data sets

Each input data set contains the following information:

- a. Measured reaction rates for activation foils in the benchmark neutron field.
- b. Uncertainty information in the form of covariance matrices for the measured reaction rates.
- c. Apriori neutron spectrum in the form of group fluence rate values.
- d. Uncertainty information for the apriori fluence rate values.
- e. Weighting neutron spectrum in the form of fluence rate values per unit energy to be used in reducing the cross-section library IRDF-90/NMF-90 to the group structure desired by the user.

4. Neutron Dosimetry Cross-Section Data Library IRDF-90

The cross-section and uncertainty information is taken from the IRDF-90 v. 2 library. Some of the cross-sections in this library present covariance information in the form of MF=32 and MF=33 files of the ENDF/B-6 format. For the convenience of the user this information was transformed to file MF=33 format and considerably reduced in size by E. Szondi. It is given in the package under the name IRDF-90/NMF-G. The file contains data for 58 dosimetry reaction cross-sections and 4 damage cross-sections. To use these data as an input to the unfolding codes the user has to select the needed reactions and reformat the data to the proper format. The input formats are different for different unfolding codes, therefore this package contains utility programs which transform the initial data to the format needed for a given procedure.

5. Adjustment (unfolding) codes and utilities

5.1 *STAYNL program*

The neutron spectrum adjustment program STAYNL [4] developed by the Institute of Nuclear Techniques of the Technical University of Budapest and the Netherlands Energy Research Foundation solves the neutron spectrum adjustment problem by the generalized least squares method in a linear space. It performs also the neutron spectrum normalization before adjustment and takes into account the cross-covariance terms. The package contains the source module of STAYNL and also execution modules compiled with LAHEY F77L3 EM/32, Microsoft FORTRAN v. 5 and RMFORT 2.42 compilers for use on different PC DOS systems.

Before using the STAYNL code the user has to run the utility code X333 for generating cross-section and covariance files in the users' energy grid structure [5]. The output of X333 code is produced in the input format of STAYNL. Another utility code XSSPPP uses the output files from the STAYNL run to prepare the cross-section and neutron spectrum data for plotting by the ENDF/B preprocessing code package by D.E. Cullen, available from the IAEA-NDS-39.

The program COVPLOT written in FORTRAN90 language plots the covariance matrices in 2 or 3 dimensions both black and white and in color from the input and output files.

5.2 *MSANDB, MSITER and MIEKEB adjustment program [6,7,8]*

MSANDB program uses the algorithm of the original SAND-II code by W. McElroy [6] but the uncertainties of the reaction rates can be taken into account. It may be preferable to users with experience in SAND-II calculations.

MSITER is another modification of the original STAY'SL algorithm by F.G. Perey [7]. It also calculates the normalization factor of the neutron spectrum.

MIEKEB is an original adjustment Monte Carlo code written by M. Matzke [8]. It is advisable to use this code in cases with a lack of preliminary information on the neutron spectrum.

Several utility codes are given for users to prepare the input for these codes and to plot the results of the adjustment runs.

- MCROBI transforms the ENDF formatted data to SAND-II type group structure.
- XSC32M90 transforms covariance data originally given in MF=32 and MF=33 formats.
- UNC33M recalculates cross-section covariance matrices in MF=33 format to the user structure.
- MSPECT creates a neutron fluence file in the user defined structure.
- UMSDAT transforms the input data sets (see item 2) to the format needed for these adjustment codes. PLOT and PLOF are plotting utility codes for spectrum files and cross-section data. Covariance information cannot be plotted with these routines.

6. The package also contains 2 demo diskettes

After installation the demo shows to the user all consecutive steps in the procedure needed for input data preparation, running adjustment programs and plotting the results of the calculations on the screen. It is recommended to run the demo diskettes first to see all the details of the calculations. The demo shows also the results of the calculations with the LSL-M2 code by F.W. Stallman. The code itself is not distributed in this package but can be obtained from RSIC, Oak Ridge, USA.

References

- [1] W.L. Zijp, E.M. Zsolnay, H.J. Nolthenius, E.J. Szondi, G.C.H.M. Verhag, D.E. Cullen, C. Ertek, "Final report on the REAL-80 Exercise", report ECN-128; INDC(NED)-7; BME-TR-RES-6/82. Netherlands Energy Research Foundation, Petten, February 1983.
- [2] W.L. Zijp, E.M. Zsolnay, H.J. Nolthenius, E.J. Szondi, "Final report to the REAL-84 Exercise", report ECN-212; BME-TR-RES-18/88; IAEA(NDS)-212. Netherlands Energy Research Foundation, Petten, November 1988.
- [3] H.J. Nolthenius, "Information for the REAL-88 Exercise", report ECN-88-023, Netherlands Energy Research Foundation, Petten, January 1988.
- [4] E.J. Szondi, H.J. Nolthenius, "Users' guide to the code STAYNL", to be published as ECN-I-93-054.
- [5] E.J. Szondi, H.J. Nolthenius, "Users' guide to the code X333", to be published as ECN-I-93-05
- [6] W.N. McElroy et al., "A computer automated iteration method for neutron flux spectra determination", report AFWL-TR-67-41, New Mexico 1967.
- [7] F.G. Perey, "Least-squares dosimetry unfolding: The program STAY'SL". report ORNL/TM-6062, ENDF-254, Oak Ridge National Laboratory 1977.
- [8] README text in program package by M. Matzke, "MIEKE: A package of programs for neutron spectrum unfolding based on few channel measurements", Physikalisch-Technische Bundesanstalt, Braunschweig, version March 1991.

The list of files on diskettes is given in **Appendix 1**.

List of files contained on the diskettes

- | | | | |
|----|---------------------|---|--|
| 1. | Demo disk 1 | DISKID1.DMO
INSRM.BAT
NMFE.ZIP
NMFI.ZIP
NMFJ.ZIP
PKUNZIP.EXE
README.
SUMMARY.TXT | |
| 2. | Demo disk 2 | DISKID2.DMO
INSRM.BAT
NMFE.ZIP | |
| 3. | IRDF-90 | DISKID.IRD
INSTALL.BAT
IRDF90NG.EXE
IRDF90NG.INP
PACKLIST.TXT
SUMMARY.TXT
VALIDATE.COM
VALIDATE.DOC | |
| 4. | MIEKE disk 1 | DISKID1.MIE
FILES.ZIP
INSTALL.BAT
PKUNZIP.EXE
BONNIN.ZIP
BONNOUT.ZIP
FORTRAN.ZIP
INPUT.ZIP
INPUTANO.ZIP | INPUTCFR.ZIP
INPUTPS1.ZIP
INPUTPS2.ZIP
INPUTRTN.ZIP
INPUTU35.ZIP
IRDF1.ZIP
PCOMP.ZIP
REFDATA1.ZIP |

5. **MIEKE disk 2**
- DISKID2.MIE
 - INSTALL.BAT
 - PKUNZIP.EXE
 - IRDFLIB.ZIP
 - PROGRAMS.ZIP
 - PS1OUT.ZIP
 - REFDATA2.ZIP
6. **STAYNL disk 1**
- COVPLOT.EXE
 - DISKID1.BME
 - HOW2PLOT.TXT
 - INSTALL.BAT
 - KEY.ASM
 - KEY.COM
 - MATZA.DAT
 - MT.DAT
 - PACKLIST.TXT
 - SUMMARY.TXT
 - VALIDATE.COM
 - VALIDATE.DOC
 - VALLIST.EXE
 - V.
 - X333SCR.EXE
 - SAMPLE.DAT
 - SAMPLE.LPT
 - SAMPLE.NDF
 - SAMPLE.OUT
 - SAMPLE.PRN
 - SAMPLE.RSP
 - SAMPLE.XSX
- COVPLOT.F90
 - STAYNL.FOR
 - STAYNLS1.FOR
 - STAYNLS2.FOR
 - STAYNLS3.FOR
 - STAYNLS4.FOR
 - STAYPARM.FOR
 - X333MAIN.FOR
 - X333PARM.FOR
 - X333SCR.FOR
 - X333SR1A.FOR
 - X333SR1B.FOR
 - X333SR1C.FOR
 - X333SR2.FOR
 - X333SR3.FOR
 - X333SR4.FOR
 - XSL&OUT.FOR
 - XSL&PARM.FOR
 - XSLXTRCT.FOR
 - XSSPPARM.FOR
 - XSSPPP.FOR
7. **STAYNL disk 2**
- DISKID2.BME
 - INSTALL.BAT
 - STAYNL.EXE
 - X333.EXE
 - XSL&OUT.EXE
 - XSLXTRCT.EXE

8. **STAYNL disk 3** DISKID3.BME
 INSTALL.BAT
 XSSPPP.EXE
 STAYNL.EXE
 V.
 X333.EXE
 X333SCR.EXE
 XSL&OUT.EXE
 XSLXTRCT.EXE
 XSSPPP.EXE

9. **STAYNL disk 4** DISKID4.BME
 INSTALL.BAT
 STAYNL.EXE
 V.
 X333.EXE
 X333SCR.EXE
 XSL&OUT.EXE
 XSLXTRCT.EXE
 XSSPPP.EXE