AEAT/R/PSEG/0411
INDC(UK)-057/LN

Report

Report

UK Nuclear Science Forum

Progress Report: Data Studies During 2000

A report produced for the IMC

Milestone M2
Contract: IMC/NP/GNSR/5022E

Edited by A L Nichols

The running of the UK Nuclear Science Forum is financed by the Industry Management Committee (IMC) comprising Nuclear Electric Limited, Scottish

June 2001

AEA TECHNOLOGY
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AEA Technology,
Future Technologies for Nuclear Technology

Title	UK Nuclear Science Forum Progress Report: Data Studies During 2000
Customer	BNFL Magnox Generation (on behalf of IMC)
Customer reference	IMC/NP/GNSR/5022E
File reference	AEAT/PSSD/2400
Report location	PSSD/2400
Report status	Issue 1, Final

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Reviewed by	C J Dean		15/6/2001
Approved by	N R Smith		18/6/01

Executive Summary

The UK Nuclear Science Forum (UKNSF) now meets once per year to discuss issues of direct relevance to forum members, and to review nuclear data for application in the UK nuclear industry. Links are also maintained throughout the year, mainly through e-mail and the normal postal system. Work of immediate interest includes the measurement and evaluation of decay data (eg., half-lives and gamma-ray emission probabilities), fission yields and thermal neutron cross sections; all known UK studies in 2000 are summarised in this document. Specific applications and international links of relevance in the field of nuclear data are also described.

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Tables

1. INTRODUCTION

The UK Nuclear Science Forum (UKNSF) is provides a suitable environment for technical discussions of the measurement and evaluation of nuclear data (e.g., neutron cross sections, decay data and fission yields). Membership ranges across approximately 20 UK-based organisations. The Forum also has the support of the UK Department of Trade and Industry and the nuclear-based Industry Management Committee (IMC), and acts as the communications network for all matters relating to the NEA Data Bank/Nuclear Science Committee and the IAEA-Nuclear Data Section.

One meeting of the UKNSF were held in 2000 on 1 June (Chairman, A L Nichols (AEA Technology, Future Technologies, Harwell) and Secretary, R J Perry (AEA Technology, Consulting, Winfrith)). UKNSF members have also assisted the NEA-Nuclear Science Committee and the IAEA-Nuclear Data Section during the year to formulate new programmes and define data-file priorities.

2. MEASUREMENTS

2.1 **Radioactivity Metrology and Radionuclide Decay Data** (contact: S A Woods (Radioactivity Metrology Group, Centre for Ionising Radiation Metrology, National Physical Laboratory, Teddington))

Work has continued on the primary and secondary standardisation of radionuclides identified important to the UK measurement community, in parallel with studies of selected decay scheme parameters. NPL also provides recommended radionuclide decay data upon demand.

(a) Standardisations of ^{60}Co, ^{89}Sr and ^{152}Eu have been completed.

(b) Standardisations of ^{238}Pu and ^{241}Am are ongoing. An international collaboration continues, under the auspices of BIPM, to investigate the problems with the standardisation of ^{204}Tl.

(c) The method of Digital Coincidence Counting is being extended to facilitate the use of this technique with atmospheric proportional counters.

(d) Measurement of the alpha emission probabilities for ^{235}U has begun (EUROMET Project 591).

(e) The new Triple-to-Double Coincidence Ratio Liquid Scintillation counting system has been validated against existing standardisation methods for ^{3}H.

(f) Evaluations of the decay schemes of ^{56}Co, ^{85}Kr, ^{94}Nb, ^{103}Ru and ^{106}Ru/^{106}Rh are underway as part of an IAEA-CRP to provide internationally-recommended radionuclide decay data.

Financial support is provided by the National Measurement System Policy Unit for the UK Department of Trade and Industry.

2.2 Plutonium Mass Measurements

(L Bourva and S Croft (Harwell Instruments Ltd), and D R Weaver (University of Birmingham))

2000 saw the conclusion of a three-year research project undertaken by the University of Birmingham (Birmingham, UK), Harwell Instruments Ltd (Harwell, UK), The Institute for Transuranic Element (ITU, Karlsruhe, Germany) and the EURATOM Safeguards Directorate (Luxembourg). The project resulted in the development of advanced techniques applicable to several aspects of passive neutron coincidence counting (PNCC). This measurement technique is widely used for the plutonium determination controls at European On-Site Laboratories (OSL) in Sellafield (UK) and La-Hague (France).

The following topics were investigated during 2000:

(a) A new theoretical evaluation was undertaken of the first three factorial moments of the spontaneous and neutron-induced fission neutron multiplicity distributions of plutonium and uranium isotopes. Correction factors were derived by combining these parameters according to the PNCC equations. This work showed that the traditional approach for determining the correction factors based on simplified assumptions gave essentially equivalent results for plutonium oxide materials. However, this is no longer the case for mixed oxide (MOX) material.

(b) Data collected from the measurements of pure ^{238}Pu, ^{240}Pu and ^{242}Pu samples in a N95 neutron multiplicity counter (Harwell Instruments Ltd) were used to derived absolute values of the ^{240}Pu effective mass of ^{238}Pu and ^{242}Pu for both double and triple coincidence. These parameters play a crucial role in the validity of the instrument calibration because they account for the three spontaneously fissile isotopes of plutonium. This work showed that the newly evaluated values are significantly different from previous evaluations; the recommended values are

$$\gamma_{238} = 2.784 \pm 0.042, \text{ and}$$
$$\gamma_{242} = 1.633 \pm 0.020.$$

(c) Research on the effect of albedo neutrons on the neutron leakage self-multiplication of samples has resulted in the development of a new algorithm for the determination of this parameter. A second version of the MEPL code was written to account for this effect. The resulting software has been benchmarked to MCNP calculations, and has been shown to be capable of deriving in a matter of seconds the neutron self-multiplication values of samples that are similar to those adopted at the OSL facilities.

The work performed from 1997 to 2000 has resulted in better characterisation of the OSL-counter response. Through the development of new analytical tools

for the PNCC data, a potentially more accurate analysis scheme has been proposed for the determination of plutonium content by coupled neutron-gamma measurements. The resulting method is based on interpreting the neutron coincidence count rates using a "known multiplication" approach. This development, along with the production of new calculation tools for PNCC analyses, has a role in ensuring the better safeguarding of nuclear materials at Sellafield and La-Hague.

2.3 Nuclear Materials Assay

(S Holloway (AWE), P M Keates and D R Weaver (University of Birmingham))

Quality assurance objectives associated with the non-destructive assay and sentencing of radioactive wastes containing fissile material require a detailed understanding and assessment of the total measurement uncertainty. The assay techniques employed to measure such wastes, which primarily detect and analyse both passive and induced neutron and gamma-ray signatures, can be modelled with a variety of simulation computational tools (e.g. Monte-Carlo based). AWE is sponsoring a programme of work to utilise and develop such tools to aid in understanding the performance of a variety of neutron and gamma-ray based waste assay systems through a rigorous assessment of the total measurement uncertainty. Such waste assay systems are an integral part of the overall AWE waste management strategy.

This work will also directly benefit another AWE programme, initiated by the 1998 UK Strategic Defence Review, which seeks to examine the verification role of radiometric non-destructive assay technologies in establishing the effectiveness of any future nuclear weapon arms control agreements. Work commenced in October 2000 and initial scoping calculations have been undertaken.

2.4 Surveying Licensed Nuclear Sites for Land Contaminated by Radioactivity

(A R Meehan and M E Phillips (BNFL-Magnox, Berkeley), and D R Weaver (University of Birmingham))

An extensive programme of site investigations has been undertaken to determine the nature, level and extent of land contamination by radioactivity. The work has been completed, and the PhD thesis was successfully defended in 2000. This research project was supported by British Nuclear Fuels plc.

3. DATA LIBRARIES: EVALUATIONS

3.1 Data Library Developments

The status of the UK Decay Data and Fission Yield Libraries is summarised in Table 1. Progress has been maintained in the evaluation of specific decay data (primarily actinides, and activation and fission products). These studies have been undertaken to assist in the development of the Joint Evaluated Fission and Fusion Files (JEFF).

Table 1: UKNSF Decay Data and Fission Yield Libraries - Status Table, December 2000.

Data	Present status	File development
Fission product decay data	UKFPDD-2 evaluations (ENDF-5 format) were submitted for JEF-1.1 and partially included. Some of these evaluations have been converted to ENDF-6 format and carried through to JEF-2.2.	None, but see UKPADD-6.1 library, below.
Activation product decay data	UKPADD-6.1 library (ENDF-6 format) remains the officially released version, containing comprehensive decay-scheme data for 457 activation products and specific fission products.	Decay data for further radionuclides (mainly activation products) are being evaluated, as agreed within the EAF Fusion programme (see Section 3.1.1).
Heavy element and actinide decay data	UKHEDD-2.2 evaluations (ENDF/B-VI format) have been submitted to the NEA Data Bank; includes re-evaluated decay data for Pa-234g, Pa-234m and Th-234.	Decay data for specific actinides and their decay products are in the process of being re-evaluated (see Section 3.1.2).
Fission yields	UKFY-2 was submitted and accepted for JEF in 1990. After minor modifications (to achieve consistency with JEF-2.2 decay data and to allow for missing decay data), a final version of UKFY-2 was incorporated into JEF-2.2. A new evaluation was produced in 1994 (UKFY-3), maintaining consistency and allowing for missing decay data, although further improvements are proposed.	An update is envisaged now that JEFF-3 decay data are available (ensuring consistency with JEFF-3 decay data, and including fewer approximations for missing decay data). This improved fission yield file will be submitted for inclusion in JEFF-3.

3.1.1 Activation and Fission Product Decay Data

(A L Nichols (AEA Technology, Harwell))

The decay data files of 50 radionuclides within the EAF library were identified by Robin Forrest in 1995 as being problematic or incomplete when used for fusion reactor applications (1, 2). Some of the data files do not contain any gamma-ray emissions, while others exhibit inconsistencies between the mean gamma energies and component radiations listed in the files. These problematic radionuclides were extended to over 80 nuclides, with the addition of related metastable states and daughter nuclides. The decay data for many of these radionuclides have been evaluated over the previous 5 years as part of an improvement project funded through UKAEA Fusion by the UK Department of Trade and Industry, and Euratom (3). Part of the work programme in 2000 involved the evaluation of decay data for a further 8 of these nuclides (Table 2).

Table 2: Radionuclides Evaluated from 1995 Listing

Nuclide	Half-life
77-Ir-187	10.5 h
(77-Ir-191m)	4.9 s
77-Ir-191n	5.5 s
77-Ir-197	5.8 min (?)
77-Ir-197m	8.9 min (?)
(78-Pt-197)	18.3 h
(78-Pt-197m)	94.4 min
(79-Au-197m)**	7.8 s

Radionuclides in parentheses have not been specifically requested, but have been evaluated because they are either related metastable states or short-lived daughter nuclides.

**Evaluation of decay data for 79-Au-197m resulted in re-evaluation of decay data for 80-Hg-197 amd 80-Hg-197m.

A more extensive exercise was initiated in 1999/2000 to assess the contents of the decay-data files for an additional 180 radionuclides within EAF-99 (4). The aim was to produce a comprehensive list of nuclides that require more detailed evaluations of their discrete decay data. These more recent studies revealed evidence for discrepant (and even erroneous) decay-data files within EAF (eg., Pr-143 and 144). Many of the differences are a consequence of omissions in JEF-2.2, and three forms of recommendation were given: no further action; undertake a new evaluation; adopt existing decay data from other sources (4). This exercise stressed the need for a rigorous (and automatic/computer-based) test procedure to determine the consistency and completeness of all decay-data files in EAF and JEF-2.2, and so improve the quality of future libraries such as JEFF-3. A limited number of radionuclides from this exercise were also included in the decay-data evaluation programme for 2000/01 (Table 3).

Table 3: Radionuclides Evaluated from 1999/2000 Listing

Nuclide	Half-life
26-Fe-63	6.1 s
50-Sn-110	4.0 h
56-Ba-126	100 min
67-Ho-164	29 min
(67-Ho-164m)	37 min
68-Er-172	49 h
80-Hg-190	20 min
81-Tl-193	22.6 min
(81-Tl-193m)	2.1 min

Radionuclides in parentheses have not been specifically requested, but have been evaluated because they are related metastable states.

Table 4: Consistency of Evaluated Decay Data, 2000/01 Work Programme

Radionuclide	Evaluated Half-life	Consistency (% Deviation)
26-Fe-63	6.1(6) s	0.0119
50-Sn-110	4.1(1) h	0.0064
56-Ba-126	to be evaluated	
67-Ho-164	28.6(6) min	0.0101
(67-Ho-164m)	37.6(5) min	0.0498
68-Er-172	to be evaluated	
77-Ir-187	10.5(3) h	-0.0621
(77-Ir-191m)	4.90(2) s	-0.7742
77-Ir-191n	5.5(7) s	0.0097
77-Ir-197	5.8(5) min	-0.2184
77-Ir-197m	8.9(3) min	0.0004
(78-Pt-197)	19.8915(19) h	0.1082
(78-Pt-197m)	95.3(2) min	0.1698
(79-Au-197m)	7.74(7) s	-0.0267
80-Hg-190	to be evaluated	
(80-Hg-197)	64.6(6) h	0.1223
(80-Hg-197m)	23.9(5) h	0.0878
81-Tl-193	to be evaluated	
(81-Tl-193m)	to be evaluated	

Radionuclides in parentheses have not been specifically requested, but have been evaluated because they are either related ground/metastable states or short-lived daughter nuclides.

Uncertainties in the half-life data are listed in the format 12.34(18), which represents 12.34 ± 0.18; these uncertainties are expressed at the 1σ confidence level.

The discrete decay data for a number of fusion-based radionuclides have been evaluated during 2000: ^{63}Fe, ^{110}Sn, ^{164}Ho, ^{164m}Ho, ^{187}Ir, ^{191m}Ir, ^{191n}Ir, ^{197}Ir, ^{197m}Ir, ^{197}Pt, ^{197m}Pt, ^{197m}Au, ^{197}Hg and ^{197m}Hg. As listed in Table 4, the recommended decay data exhibit good to excellent consistency, when Q-values and branching fraction data are compared with the discrete emission data (ie. gamma rays, x-rays, Auger and conversion electrons, and EC and beta-particle transitions). These decay-data files have been assembled in ENDF-6 format for insertion into the Joint Evaluated Fission and Fusion library (JEFF-3) – OECD, Nuclear Energy Agency. This work continues with respect to the remaining nuclides to be evaluated.

These studies have been funded by UK Atomic Energy Authority (Fusion Division).

3.1.2 Heavy Element and Actinide Decay Data

(A L Nichols (AEA Technology, Harwell))

The decay data for an agreed set of actinides and their heavy-element decay products are in the process of being evaluated (Table 5). This list of 34 nuclides arose from a knowledge and assessment of decay-data measurements published over recent years (from the mid-1980s onwards). Full decay-scheme evaluations have been completed and others are underway.

These studies have been funded by British Nuclear Fuels plc.

Table 5: Actinide Decay Data Evaluations

Nuclide
Radium Ra-226 and daughters, (Rn-222, Po-218, At-218, Pb-214, Bi-214, Po-214, Tl-210, Pb-210, Bi-210, Po-210, Tl-206 and Hg-206)
Thorium Th-228 and daughters (Ra-224, Rn-220, Po-216, Pb-212, Bi-212g, Bi-212m, Po-212 and Tl-208)
Uranium U-235, U-236, U-238
Neptunium Np-237
Plutonium Pu-236, Pu-239, Pu-241
Americium Am-241, Am-242g, Am-242m
Curium Cm-242, Cm-244

3.2 International Decay Data Evaluation Project

(T D MacMahon (Department of Nuclear Science and Technology, HMS Sultan, Gosport))

Participation continues with collaborators at AEA Technology (UK), Idaho Falls, Brookhaven National Laboratory and Lawrence Berkeley Laboratory (USA), LPRI(France), PTB (Germany), CIEMAT (Spain) and Khlopin Radium Institute (Russia) to provide evaluated decay scheme data for the following:

(a) ENDSF,
(b) NUCLÉIDE and Table of Radionuclides by LRPI/PTB,
(c) IAEA decay database.

3.3 Fission Product Yield Evaluations

(R W Mills (BNFL plc, Sellafield))

International collaboration has continued with colleagues in the USA, China, France, Germany, Japan, Netherlands and Russia through the forum of an IAEA-CRP on Fission Product Yield Data required for Transmutation of Minor Actinide Nuclear Waste. This year collaboration has concentrated on the collection of experimental data and the preliminary analysis of high energy (>10 MeV) neutron- and proton-induced fission yield data.

The document describing the previous IAEA-CRP on the Evaluation of Fission Product Yields has been issued (5). This publication includes a CD-ROM containing extensive data tables, and a computer program in which observed systematics are adopted to calculate fission-product yields for the low-energy induced fission of actinides.

Work on the fission product yield evaluation for JEFF-3 has continued with a review of reported problems in JEF-2.2 and the draft UKFY-3 evaluations. One aim in 2001 will be to address these concerns in the production of a revised evaluation for JEFF-3.

4. APPLICATIONS DEVELOPMENT

4.1 Reactor Physics, Shielding and Criticality Applications

(N R Smith, C J Dean and R J Perry (AEA Technology, Winfrith))

The ANSWERS help-desk has observed a substantial increase in the use of JEF-2.2 based neutron cross-section libraries for the application codes MONK, MCBEND and WIMS. Furthermore, the additional availability of ENDF/B-VI and JENDL-3.2 based libraries has enabled a useful range of cross-checks and inter-comparisons to be performed at minimal effort with the Monte Carlo codes MONK and MCBEND.

Specific JEFF-3 data have been evaluated as part of an MSc project by Oliver Zaudtke (University of Birmingham, based at Winfrith). The latest ^{235}U evaluation was processed as part of a verification exercise to cross-check results reported elsewhere, and some pin-cell comparisons were made between different ^{235}U data evaluations. Results from these analyses were extrapolated to experimental configurations: for near-optimum moderated low-enriched uranium oxide lattice experiments, the JEFF-3 library produces results with MONK that are further from (and lower than) measured values than those with JEF-2.2 based data (over 0.5% difference in k-effective between JEFF-3 and experiment). This observation is similar to findings from other countries, where reports have been made of JEFF-3 calculated values of k-effective between 0.5 and 1% lower than experiments for similar cases. However, for grossly under-moderated high-enriched systems, the sizeable over-prediction observed with JEF-2.2 (3% in k-effective) is greatly reduced by the new library. Further international data evaluation studies are in progress, with some reviewers suggesting that the focus of attention should shift to ^{238}U – some experts believe that developing the ^{235}U evaluation in isolation will limit progress.

A major overhaul has taken place of the nuclear data library production route for WIMS, with the new route standardising on the more modern 'datagram' format of the library rather than the older WIMSE format. This work has included an update to the version of NJOY used in the route, together with the adoption of the standard international version of the WIMSR module. The primary objective was to modernise and streamline the route in order that future library enhancements can be undertaken more cost-effectively.

Development and verification of a WIMS-based reference calculation route for both AGR and Magnox reactors has been undertaken (IMC project). This work will now move on to the development of a production/design calculation route.

Activity has continued to develop the MONK validation database (joint AEA Technology/BNFL programme). Several experiments have been studied, including the coverage of a range of criticality application requirements. Significant use is made of the handbook produced by the International Criticality Safety Benchmark Evaluation Project (ICSBEP). The most interesting studies have involved two sets of Russian experiments performed in 1999, with support from the USA. Uranium and plutonium lattices were contained within a SiO_2 moderator, aimed at simulating the physics conditions of a waste repository. A range of moderation levels was studied and the sets of experiments provide good tests of the relevant data within the intermediate energy range (not well covered by other experiments). The uranium cases will be particularly valuable additions to the set of experiments to consider, as the $^{235}U/^{238}U$ data continue to evolve.

Further UK contributions to ICSBEP have included the addition to the handbook of the critical configurations from the DIMPLE 'AGR Skip' series of experiments (joint AEA Technology/IMC project). Involvement with the new reactor physics benchmark group (IRPhE) has begun by studying DIMPLE

reactor core measurements and initiating the process of preserving ZEBRA experimental data (IMC project).

The development of the new collision-processing package for MONK and MCBEND (BINGO module) has made great strides during the year. This AEA Technology/BNFL collaborative activity has seen the finalisation of the data production route and major progress on the collision-modelling component. Preliminary MONK-with-BINGO calculations are expected in mid-2001.

The existing MCBEND data and collision model were developed further in 2000, including the enhancement of the temperature capability via extensions to the DICE collision-processing package and library (IMC project).

Detailed investigations into the WIMS resonance modelling continued during 2000 (joint AEA Technology/IMC project), focusing on heterogeneous systems. Such a fundamental evaluation and re-development of this segment of the WIMS code (and data library) constitute the most substantial changes in this area for well over a decade. Formal implementation of the new, improved modelling methods is expected to begin in 2001.

4.2 Nuclear Data Projects at BNFL Research and Technology, Springfields

(C Atterbury (University of Birmingham based at BNFL Springfields), R J Brissenden (BNFL Consultant), S M Connolly (BNFL Springfields), C J Dean (AEAT Winfrith), R W Mills (BNFL Sellafield) and D R Weaver (University of Birmingham))

Work continues on the BINGO collision processor, which is being developed jointly by AEAT and BNFL to replace the existing collision processor used by the MONK and MCBEND Monte Carlo Codes.

Ms Atterbury continued to work on her PhD on nuclear resonances during 2000. Work included a preliminary analysis of recent ^{153}Eu and ^{133}Cs evaluations by Moxon, and a start was made to convert the GENEX cross-section processing code for use with modern data formats. However, staff losses occurred in August 2000, and GENEX development continues using alternative resources.

5. INTERNATIONAL CO-OPERATION

5.1 Development of European Activation File

(R A Forrest (UKAEA Fusion, Culham))

The Euratom/UKAEA Fusion Association has continued the development of the European Activation File (EAF) under the Nuclear Data Task of the EFDA Fusion Technology Programme. EAF covers the neutron-induced cross sections and decay data libraries that are required as input to the inventory code FISPACT.

During 2000, the development of the SAFEPAQ-II application has been completed. SAFEPAQ-II is used to evaluate, select and process the activation cross section data, and has been installed at both JUKO Research (The Netherlands) and CEA Cadarache for use in the production and testing of EAF-2001. An initial version of EAF-2001 has been prepared, and will be tested in 2001 before release as part of EASY-2001.

EAF-2001 contains new data evaluations (^{58}Ni, ^{60}Ni, ^{9}Be) and new model calculations for 35 capture reactions. A great deal of the development work has involved the use of new experimental data (now held in the SAFEPAQ-II relational databases) for branching and renormalising the reactions. Existing integral data can be used by SAFEPAQ-II for adjustment. There are a total of 12,470 reactions available in both point-wise and multi-group format. EAF-2001 also benefits from the ongoing decay-data evaluations carried out by Nichols (see Section 3.1.1 above, and (6)). It should also be noted that SAFEPAQ-II enables consistency between the various EAF files; thus, the nuclide spins in the decay-data library are automatically used as required when constructing the cross section library.

Following production of the documentation, EASY-2001 will be released during the first quarter of 2001 for testing and validation.

5.2 JEFF Programme

(C J Dean (AEA Technology, Winfrith), A L Nichols (AEA Technology, Harwell), D J Edens (BNFL Magnox, Berkeley), R A Forrest (UKAEA, Culham) and R W Mills (BNFL plc, Sellafield))

(a) JEF-2.2 Documentation and Maintenance Policy

A comprehensive report on the JEF-2.2 library has been assembled by J Rowlands, and published as JEF Report 17 and on CD-ROM (electronic version contains hyper-links to references). Although JEF-2.2 and earlier JEF libraries will not be updated, a file of feedback on the contents of JEF-2.2 is maintained on the NEA Web page (including solutions to known problems). Newly developed evaluations will be included only in JEFF-3.

(b) General Purpose Cross Section Library

The JEFF-3T general-purpose (cross-sections for fission and fusion transport studies) starter file has been tested with various versions of NJOY, and proven necessary to use NJOY97.110 and beyond to ensure success. Further benchmarking was reported at the JEFF Working Group meeting in December 2000. An evaluation programme continues, and there will be regular improvements to the starter file; thus, a second issue of the starter file (JEFF-3T2) was prepared in September 2000.

The JEFF Working Group will form a view on the need for further developments to either ^{235}U or ^{238}U cross-section data, following the low K_{eff} values for low-enriched light water lattices reported by Mattes *et al* at the PHYSOR 2000 conference. More results from CERES benchmarking of

fission products have been reported; the JEFF project will uses CERES and PIE results to benchmark new fission product cross-section evaluations resulting from a collaboration between Korea and the USA (and for adoption in JEFF-3).

There is continued interest in intermediate energy data through the 5th Framework Programme, and files up to 150 MeV are being developed. Plans are being made to include a single evaluation within JEFF-3 for any nuclide by extending the energy range to cover 10^{-5} eV to 150 MeV. Studies of the effective join between experimentally-measured and modelled data at 20 MeV are underway.

(c) JEFF-3 Special Purpose Libraries

The use of EAF-99 and beyond is recommended for activation calculations associated with JEFF-3.

A JEFF-3T decay-data file was provisionally issued in November 2000, together with results from the CHECKR and EFIZCON codes. This file includes decay-data evaluations for 3755 nuclear states, including a set of files for stable nuclides. Data are processed from NUBASE, ENSDF, UKPADD and UKHEDD input. Part of the QA procedure for decay-data files requires analyses of the results from the EFIZCON code by the evaluators. This process has indicated the need for an early re-issue of the file. The files will also need to be enhanced to include important average energy data, when component spectral data are not available or are discrepant. These additions were shown to improve decay-heat predictions when applied to JEF-2.2, but can cause consistency problems. There is a major need to assemble and issue a companion fission yield file.

The contents of other special purpose files are undergoing review:

- thermal scattering data,
- delayed-neutron data,
- particle data (mainly γ source),
- heating (Kerma) and co-variance data – J Rowlands (UK) will be asked to carry out a review,
- dosimetry – NEA to consult with IAEA-NDS.

(d) Decay Data Consistency

New evaluations should be assessed using the code FIZCON (and derivatives), which contains physics checks to determine the consistency between and within data files. Both the OECD and BNFL asked AEA Technology staff to develop and document an enhanced code, EFIZCON. The code and associated report were made available to the OECD and Brookhaven National Laboratory Nuclear Data Centre in the USA (UKNSF(2000)P133 and JEF/DOC-837). These developments have helped clarify the status of the physics checks relative to evaluation techniques.

EFIZCON has been applied to the JEFF-3T decay data library using the original FIZCON default option. Feedback from the USA indicates that the UK methods in COGEND lead to results closer to US calculations that the original FIZCON formulation. This study also indicated the need to consolidate the methods applied to generate data files from NUBASE and ENSDF. Once these files are reissued, EFIZCON will be re-applied, and should lead to a manageable number of comments for analysis.

Differences have been noted in the formulae for calculating beta spectra and resulting energies. M M Bé (CEA Saclay) has issued a table of mean beta energies determined by the SPECBETA code based on work by Behrens. There are noticeable differences between the results of this approach and those adopted in EFIZCON for all except allowed transitions (these discrepancies are under investigation).

Acknowledgement

This report was produced with the support of the IMC, and represents edited contributions from members of the UK Nuclear Science Forum and their co-workers.

References

1. R. A. Forrest and J-Ch. Sublet, *FISPACT 4 User Manual*, UK Atomic Energy Authority Report UKAEA FUS 287, 1995.

2. R. A. Forrest and J-Ch. Sublet, *The European Activation File: EAF-99 Decay Data Library*, UK Atomic Energy Authority Report UKAEA FUS 409, 1998.

3. A. L. Nichols, C. J. Dean, A. P. Neill and R. J. Perry, *UKPADD-6: Evaluated Decay Data Library, March 1999,* AEA Technology Report AEAT-5281, 1999.

4. A. L. Nichols, *Assessment and Evaluation of Decay Data for EAF –1999/2000,* UK Nuclear Science Forum Report UKNSF(99)P130.

5. *Compilation and Evaluation of Fission Yield Nuclear Data: Final Report of a Co-ordinated Research Project 1991-1996*, IAEA-TECDOC-1168, December 2000.

6. A. L. Nichols, *UK Nuclear Science Forum Progress Report: Data Studies During 1999,* AEA Technology Report AEAT/R/PS/0032, INDC(UK)-056/LN.

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