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UK Chemical Nuclear Data Committee Progress Report:

Data Studies During 1991

Edited by

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AEA REACTOR SERVICES

AEA TECHNOLOGY

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UK CHEMICAL NUCLEAR DATA COMMITTEE: PROGRESS REPORT DATA STUDIES DURING 1991

Edited by

A L NICHOLS

SUMMARY

Studies of the basic nuclear data for commercial and industrial application are monitored by the UK Chemical Nuclear Data Committee (UKCNDC). Such data are defined on the basis of chemical methods of analysis, and include half-lives, decay parameters and fission yields. Work undertaken within this area is described in this document for information. Funding problems continue to affect both the experimental and evaluation programmes, and it is proving increasingly difficult to maintain the necessary UK expertise despite the fundamental importance of these studies to reactor physics and nuclear power production.

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1. INTRODUCTION

The UK Chemical Nuclear Data Committee provides a forum within the UK to monitor the measurement and evaluation of radionuclide decay data and fission product yields for reactor applications. The requirements and priorities for nuclear data measurements and evaluations are regularly reviewed within the UKCNDC (see UKCNDC Request List published in March 1990 (AEEW-M 2613)). Two meetings of the UKCNDC were held in 1991 in July and December (Chairman, A L Nichols (WTC) and Secretary, W J Symons (WTC)). The UK Data Library Sub-Committee (DLSC) also met twice over the same time period (Chairman, M F James (WTC) and Secretary, R W Mills (BNFL, on attachment to WTC)). Members of the DLSC are responsible to the UKCNDC for the maintenance of the following computerised libraries:

(a) fission product yields,
(b) fission product decay data,
(c) activation product decay data,
(d) heavy element and actinide decay data.

Much of the progress during the year has involved the evaluation of fission yields and activation product decay data based on partial funding from Nuclear Electric, BNFL and AEA Reactor Services. All of this evaluation effort is linked to the international Joint Evaluation File (JEF).

2. MEASUREMENTS

2.1 Measurement and Evaluation of Decay Data

(P Christmas, D Smith, M J Woods, J L Makepeace, J P Sephton, D H Woods, S A Woods, G R Worthington, J C J Dean, S M Jerome, S E M Lucas, M T Curry (National Physical Laboratory, Teddington) and R D Daniels (University of Manchester)).

Specific measurements have been completed or are underway:

(a) Measurement of the half-life of ^{90}Sr continues.

(b) Measurements of half-lives are in progress for radionuclides for which more accurate data are required, viz. ^{3}H, ^{54}Mn, ^{57}Co, ^{65}Zn and ^{75}Se.

(c) Measurements are underway to relate activity, ion-chamber current and air-kerma rate of ^{192}Ir brachytherapy sources.

(d) NPL evaluated half-life values have been published as part of the IAEA-CRP on X-Ray and γ-Ray Standards for Detector Calibration (IAEA-TECDOC-619, Vienna, 1991).

(e) The SERC-supported collaboration with the University of Manchester has continued in conjunction with Argonne National Laboratory, USA. Measurements of the α-, γ- and internal-conversion electron spectra for the decay of ^{245}Cm have been completed. A further SERC CASE studentship has been awarded.

(f) A high resolution α-particle spectrometer has been commissioned. Performance checks and calibration are underway.

(g) Measurements of tritium-in-nitrogen by internal gas counting are continuing; an international intercomparison of tritium-in-nitrogen is nearing completion.

(h) A primary standard of ^{222}Rn, verified by intercomparison with the standard held at NIST, is now available. An international comparison is planned for 1992.

Various papers have been published or accepted for publication during 1991 associated with radioactivity measurements undertaken at NPL (1-10).

2.2 Measurements of Gamma-Ray Emission Probabilities

(M Hammed and T D MacMahon (Centre for Analytical Research in the Environment, Imperial College, Ascot)).

Relative gamma-ray emission probabilities have been measured for the complex decays of ^{101}Mo and ^{101}Tc. Results have been compared with previous data in the literature, and an evaluated set of relative gamma-ray emission probabilities has been determined. By carrying out a decay scheme balance, using available conversion-electron data, absolute gamma-ray emission probabilities and beta branching ratios have been deduced.

Earlier studies reported in previous progress reports have been published during 1991 (11, 12, 13).

2.3 Nuclear Data Measurements

(A J Fudge, M F Banham, J Tibbles, R A P Wiltshire and J W McMillan (Harwell Laboratory))

Efforts have continued to improve the measurement facilities, which include a full range of alpha-particle and gamma-ray counters and spectrometers, and the codes for analysis of the spectral data. Accreditation of the laboratory under the National Physical Laboratory NAMAS scheme has continued for alpha-particle measurements, and several gamma-ray spectrometry systems are subject to strict quality control procedures.

Work has continued in the following areas:

(a) Calibration of ^{93m}Nb

A solution of ^{93m}Nb has been prepared from pure niobium metal irradiated for a long period of time in the Dounreay Fast Reactor (DFR). The calibration of this solution has been carried out simultaneously at Harwell, NPL and PTB Braunschweig, FRG. Aliquots of this solution are now available for use (14).

(b) Source preparation for nuclear data measurements

The production of sources has continued for a range of actinide and transactinide nuclides for use in other laboratories.

(c) Measurements of low-energy beta and electron capture nuclides

As part of a contract concerned with the characterisation of radioactive waste, methods have been developed for the separation and measurement of ^{41}Ca, ^{55}Fe, ^{63}Ni, ^{3}H and ^{14}C in irradiated concrete. Each element concerned is separated from the matrix to a sufficient purity to enable the radioactive isotope to be measured, without interference from other radioactive species, by liquid scintillation counting (15).

3. UKCNDC DATA LIBRARY SUB-COMMITTEE

Membership during 1991:

M F James	WTC (Chairman)
R W Mills	WTC/BNFL/University of Birmingham (Secretary)
A Ainsworth	Amersham International
A Harris	Nuclear Electric, Berkeley
T D MacMahon	Imperial College at Ascot
D Smith	National Physical Laboratory
G Sutton	MAFF, Lowestoft
A Whittaker	BNFL
D R Weaver	University of Birmingham
C H Zimmerman	BNFL

3.1 Data Library Development

The current status of the UKCNDC Data Libraries is summarised in Table 1. Significant progress has been made in the evaluation of fission yield and decay data. Efforts have also been made during the year to incorporate these data into the UK and JEF files. ENDF/B-VI format has been identified as the most appropriate form for the data files in the 1990s, and the COGEND data-processing code has been modified to generate this format for the radionuclide decay data.

(a) Fission Product Decay Data (A L Nichols WTC))

No progress has been made in producing an updated version of the UKCNDC fission product decay data files.

(c) Activation Product Decay Data (A L Nichols (WTC))

Considerable progress has been made in evaluating the decay data for a wide range of activation products and generating the data files. The contents of this library are based on a

TABLE 1

UKCNDC DATA LIBRARIES: STATUS TABLE - DECEMBER 1991

Data	Present Studies	File Development
1 Fission Product Decay Data	Part of JEF-1 Decay Data Files, which include UK evaluations (ENDF/B-V format). UKFPDD-2 library superseded, but largely included in JEF-2.	P_n values for delayed neutron precursors from Swedish evaluation. Delayed neutron precursor spectrum from Kratz et al and Rudstam et al.
2 Activation Product Decay Data	UKPADD-1 forms part of JEF-2 Decay Data Files, which include UK evaluations (ENDF/B-V format).	175 nuclides have been evaluated for UKPADD-2 in ENDF/B-VI format. All evaluations will eventually be submitted to JEF.
3 Heavy Element and Actinide Decay Data	JEF-2 Decay Data Files include UKHEDD-2 evaluations (ENDF/B-VI format).	The heavy element and actinide decay data library has been re-issued as UKHEDD-2, following the re-evaluation of the majority of decay parameters within the files.
4 Fission Yields	JEF-1 fission yields based on UKIFY-1 evaluation. UKIFY-2 (Mills and James) now complete and incorporated into JEF-2: 39 sets of evaluated independent yields for 21 fissile nuclides adjusted to satisfy conservation of nucleons and charge	Major reports on evaluations leading to UKIFY-2 have been prepared and issued by James, Weaver and Mills. Weaver and James have recommended integral yields, group data and spectra for delayed neutrons.

Spectral data from the decay data files may be accessed via the retrieval system described by Tobias (RD/B/5170N81, 1981).

subset of the listing in reference 16. Decay data have been evaluated for 175 radionuclides, and these data sets have been generated in ENDF/B-VI format (Table 2). Some of the measured data for specific radionuclides proved insufficient to produce a consistent decay scheme, and additional parameters had to be derived (eg beta-branching fractions and theoretical internal conversion coefficients):

47-Sc, 54-Mn, 59-Fe, 58-Co, 58m-Co, 60-Co, 60m-Co, 59-Ni, 65-Ni, 63-Zn, 89-Sr, 89m-Y, 89-Zr, 89m-Zr, 110-Ag, 110m-Ag, 111m-Cd, 113-Cd, 113m-Cd, 111-In, 111m-In, 113m-In, 113-Sn, 113m-Sn, 123-Sn, 123m-Sn, 125-Sn, 125m-Sn, 122-Sb, 122m-Sb, 125m-Te, 125-Xe, 125m-Xe, 127-Xe, 127m-Xe, 135-Cs, 135m-Cs, 136-Cs, 135m-Cs, 145-Pm, 145-Sm, 155-Eu, 157-Tb, 157-Dy, 159-Dy, 174-Hf, 179-Ta, 180-Ta, 180m-Ta, 182-Ta, 182m-Ta, 182n-Ta, 181-W, 185-W, 185m-W, 187-W, 203-Hg, 204-T1, 207-Bi, 204-Pb and 204m-Pb.

A L Nichols attended the International Conference on Nuclear Data for Science and Technology (13-17 May 1991, Jülich, FRG) at the request of the IAEA Nuclear Data Section to present a paper on the Coordinated Research Programme for X-ray and Gamma-ray Standards for Detector Calibration (17). All of the nuclides evaluated will be included in the Activation Product Decay Data Library being prepared for BNFL and AEA Reactor Services. The conference represented an extremely useful forum for various meetings and discussions outside the auditorium. JEF-2 was discussed on this basis, and an agreement was reached on the best way forward to produce user-friendly data listings from the ENDF/B-VI files (see Section 3.1(d), below).

(c) Heavy Element and Actinide Decay Data (A L Nichols (WTC))

A re-evaluation has been made of the decay data for 126 heavy elements and actinides of direct application in nuclear fuel cycle calculation. Computer-based files have been generated in ENDF/B-VI format (18). These evaluated data include half-lives, average decay energies, branching ratios, alpha, beta and gamma-ray energies and emission probabilities, internal conversion coefficients, spontaneous fission decay data and all associated uncertainties.

(d) Interrogation and Extraction of Decay Data (A Hill and D R Weaver (University of Birmingham))

A computer program has been developed using a vacation studentship which facilitates the extraction and display of decay data from the JEF-2 file. It is designed for use on IBM PC-compatible computers and, via an interaction display of the chart of the nuclides, the user can list the required decay parameters. The emphasis at present is on gamma-ray and alpha-particle data, although provision has been made for the extension to other decay data. The program has been supplied to a number of interested users for testing, and it

TABLE 2

ACTIVATION PRODUCTS FOR UKPADD-2

Status: E, evaluated
NE, to be evaluated

File No.	Radionuclide	Status	File No.	Radionuclide	Status
7000	3-H	E	7023	26-Na	E
7001	6-He	E	7024	27-Mg	E
7002	8-He	E	7025	28-Mg	E
7003	8-Li	NE	7026	26-Al	E
7004	9-Li	NE	7027	26m-Al	E
7005	7-Be	E	7028	28-Al	E
7006	8-Be	NE	7029	29-Al	E
7007	10-Be	E	7030	30-Al	E
7008	11-Be	E	7031	31-Si	E
7009	12-B	E	7032	32-Si	E
7010	13-B	E	7033	32-P	E
7011	14-C	E	7034	33-P	E
7012	15-C	E	7035	34-P	E
7013	13-N	E	7036	35-S	E
7014	16-N	E	7037	37-S	E
7015	19-O	E	7038	34-Cl	E
7016	18-F	E	7039	34m-Cl	E
7017	20-F	E	7040	36-Cl	E
7018	23-Ne	E	7041	38-Cl	E
7019	22-Na	E	7042	38m-Cl	E
7020	24-Na	E	7043	37-Ar	E
7021	24m-Na	E	7044	39-Ar	E
7022	25-Na	E	7045	41-Ar	E

File No.	Radionuclide	Status	File No.	Radionuclide	Status
7046	42-Ar	E	7071	53-V	NE
7047	38-K	E	7072	54-V	NE
7048	38m-K	E	7073	49-Cr	E
7049	40-K	E	7074	51-Cr	E
7050	42-K	E	7075	55-Cr	E
7051	43-K	E	7076	54-Mn	E
7052	44-K	E	7077	56-Mn	NE
7053	41-Ca	E	7078	53-Fe	NE
7054	45-Ca	E	7079	53m-Fe	NE
7055	47-Ca	NE	7080	55-Fe	NE
7056	49-Ca	E	7081	59-Fe	E
7057	44-Sc	E	7082	55-Co	NE
7058	44m-Sc	E	7083	56-Co	NE
7059	46-Sc	E	7084	57-Co	NE
7060	46m-Sc	E	7085	58-Co	NE
7061	47-Sc	E	7086	58m-Co	NE
7062	48-Sc	E	7087	60-Co	E
7063	49-Sc	E	7088	60m-Co	E
7064	50-Sc	NE	7089	57-Ni	NE
7065	50m-Sc	NE	7090	59-Ni	E
7066	45-Ti	NE	7091	63-Ni	E
7067	51-Ti	NE	7092	65-Ni	E
7068	48-V	E	7093	62-Cu	NE
7069	49-V	E	7094	64-Cu	NE
7070	52-V	NE	7095	66-Cu	NE

File No.	Radionuclide	Status	File No.	Radionuclide	Status
7096	63-Zn	E	7121	95-Nb	E
7097	65-Zn	E	7122	95m-Nb	E
7098	74-As	E	7123	93-Mo	E
7099	75-Se	E	7124	93m-Mo	E
7100	79m-Br	E	7125	99-Mo	E
7101	80-Br	E	7126	99-Tc	E
7102	80m-Br	E	7127	99m-Tc	E
7103	82-Br	E	7128	103-Ru	E
7104	82m-Br	E	7129	102-Rh	E
7105	79-Kr	E	7130	102m-Rh	E
7106	79m-Kr	E	7131	103m-Rh	E
7107	85-Sr	NE	7132	104-Rh	E
7108	85m-Sr	NE	7133	104m-Rh	E
7109	89-Sr	E	7134	107m-Ag	E
7110	88-Y	E	7135	108-Ag	E
7111	89m-Y	E	7136	108m-Ag	E
7112	90-Y	NE	7137	109m-Ag	E
7113	90m-Y	NE	7138	110-Ag	E
7114	89-Zr	E	7139	110m-Ag	E
7115	89m-Zr	E	7140	109-Cd	E
7116	93-Zr	E	7141	111m-Cd	E
7117	95-Zr	E	7142	113-Cd	E
7118	93m-Nb	E	7143	113m-Cd	E
7119	94-Nb	E	7144	111-In	E
7120	94m-Nb	E	7145	111m-In	E

File No.	Radionuclide	Status	File No.	Radionuclide	Status
7146	113m-In	E	7171	125m-Te	E
7147	114-In	NE	7172	125-I	NE
7148	114m-In	NE	7173	126-I	E
7149	115-In	E	7174	125-Xe	E
7150	115m-In	E	7175	125m-Xe	E
7151	116-In	NE	7176	127-Xe	E
7152	116m-In	NE	7177	127m-Xe	E
7153	116n-In	NE	7178	134-Cs	NE
7154	113-Sn	E	7179	135-Cs	E
7155	113m-Sn	E	7180	135m-Cs	E
7156	117m-Sn	E	7181	136-Cs	E
7157	119m-Sn	NE	7182	136m-Cs	E
7158	121-Sn	NE	7183	137-Cs	E
7159	121m-Sn	NE	7184	133-Ba	NE
7160	123-Sn	E	7185	133m-Ba	NE
7161	123m-Sn	E	7186	137m-Ba	E
7162	125-Sn	E	7187	139-Ce	NE
7163	125m-Sn	E	7188	145-Pm	E
7164	126-Sn	E	7189	145-Sm	E
7165	122-Sb	E	7190	146-Sm	E
7166	122m-Sb	E	7191	152-Eu	NE
7167	124-Sb	E	7192	154-Eu	NE
7168	124m-Sb	E	7193	155-Eu	E
7169	124n-Sb	E	7194	157-Tb	E
7170	125-Sb	NE	7195	157-Dy	E

File No.	Radionuclide	Status	File No.	Radionuclide	Status
7196	159-Dy	E	7216	204m-Pb	E
7197	174-Hf	E	7217	207-Bi	E
7198	175-Hf	NE	7218	228-Th	E
7199	181-Hf	NE	7219	231-Th	E
7200	179-Ta	E	7220	239-Np	E
7201	180-Ta	E	7221	241-Am	E
7202	180m-Ta	E	7222	243-Am	E
7203	182-Ta	E			
7204	182m-Ta	E			
7205	182n-Ta	E			
7206	181-W	E			
7207	185-W	E			
7208	185m-W	E			
7209	187-W	E			
7210	198-Au	E			
7211	197-Hg	NE			
7212	197m-Hg	NE			
7213	203-Hg	E			
7214	204-Tl	E			
7215	204-Pb	E			

is anticipated that a number of improvements based on their comments will be incorporated early in 1992. The work was supported by the NEA Data Bank and it is expected that the final version will be available from that source in due course.

(e) Fission Yields: Evaluations for the European JEF-2 Library (M F James (WTC), R W Mills (BNFL) and D R Weaver (University of Birmingham))

The completed UKFY2 evaluation has been described in a recent publication (19). Work has continued in the following areas: expanding the experimental database (both with new data and with new types of data to help understand more of the fission product production process), adapting the analysis procedure to use more of the data by iteration of the relative and ratio of ratio data, looking at different models (some based upon nuclear theory) and reconsidering the adjustment process.

The UK group continues involvement with the IAEA Collaborative Research Programme on Fission Yield Evaluation and the NEA JEF evaluation programme.

(f) Delayed Neutron Yields (M F James (WTC), R W Mills (BNFL) and D R Weaver (University of Birmingham))

The UKFY2 fission yield library and the preliminary decay data in JEF-2 have been used with the code FISPIN to generate delayed neutron emission rates for a pulse and 'infinite' irradiation (fitted to the Keepin 6 group model), and ν_d. The sensitivity of ν_d to Zp model parameters has also been examined. This has been described at the Jülich International Conference on Nuclear Data for Science and Technology in May 1991. A meeting of the NEA Study Group on Delayed Neutrons was also attended.

3.2 Additional Activities

International Committee for Radionuclide Metrology, 27-31 May 1991, Madrid, Spain.

The aim of ICRM '91 was to maintain the periodic exchange of information between specialists and developing countries working in the field of radionuclide measurements and evaluations. Specific work has been undertaken following the recommendations of A L Nichols and other evaluators in 1987 and 1989 (eg decay data measurements of 56-Co, 125-Sb, 154-Eu, 198-Au, 239-Np, 239-Pu, 241-Am and 243-Am). Difficulties have also been identified with 41-Ca (found in activated concrete waste), 234-Th/234m-Pa (environmental emissions) and 245-Cm (long-lived transactinium nuclide with disagreements between measured sets of gamma-ray data).

4. CONCLUSIONS

As in previous years, progress in the UK measurement and evaluation of nuclear data depends on a low level of effort and dedicated expertise. Suitable personnel to undertake this work are retiring or being redirected towards other studies within AEA Technology, undermining the ability of this organisation to undertake such measurements. While it is hoped that relevant studies can be maintained, it is proving increasingly difficult to achieve such an objective in the UK.

While UK measurement programmes continue under extreme difficulties, the various evaluation efforts have been maintained at a feasible level. Significant achievements in 1991 include the completion of the fission yield files and the heavy element and actinide decay data library. However, even for these areas, support within the UK will be difficult to maintain, underlining the importance of supporting multinational efforts in this field.

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