International Atomic Energy Agency

INDC(NDS)-70/G+P

INDC

INTERNATIONAL NUCLEAR DATA COMMITTEE

PROGRESS

IN

FISSION PRODUCT NUCLEAR DATA

Information about activities
in the field of measurements and compilations/evaluations
of fission product nuclear data (FPND)

edited

by

G. Lammer
Nuclear Data Section
International Atomic Energy Agency
Vienna, Austria

No. 1 November 1975

IAEA NUCLEAR DATA SECTION, KÄRNTNER RING 11, A-1010 VIENNA

Reproduced by the IAEA in Austria
November 1975
75-9280

INDC(NDS)-70/G+P

PROGRESS

IN

FISSION PRODUCT NUCLEAR DATA

Information about activities
in the field of measurements and compilations/evaluations
of fission product nuclear data (FPND)

edited

by

G. Lammer
Nuclear Data Section
International Atomic Energy Agency
Vienna, Austria

No. 1 November 1975

TABLE OF CONTENTS

* The contributions with (*) had to be included in the last minute and could therefore not get adequate page-numbers.

FOREWORD

This is the first issue of a report series on Fission Product Nuclear Data (FPND), which will be published every six months by the Nuclear Data Section (NDS) of the International Atomic Energy Agency (IAEA). Its purpose is to inform scientists working on FPND, or using such data, about all activities in this field which are planned, ongoing, or have recently been completed.

This report consists of reproductions of essentially unaltered original contributions which the authors have sent to IAEA/NDS. Therefore, the IAEA cannot be held responsible for the information contained nor for any consequences resulting from the use of this information.

The types of activities being included in this report are measurements, compilations and evaluations of:

Fission product yields;
Neutron cross-section data of fission products;
Data related to β-,γ-decay of fission products;
Delayed neutron data; and
Fission product decay-heat.

The present issue includes contributions which were received by NDS before 1 November 1975.

The cooperation of all those who have helped to start the FPND-report series, is gratefully acknowledged.

<u>How to submit contributions</u>:

The next issue will be published on 15 May 1975. All scientists who are presently working – or have recently completed work – in the field of FPND and who want to contribute to the 2nd issue of this series, are kindly asked to send contributions to me between now and the end of April 1976, so that they reach NDS <u>before 30 April 1976</u>.

Those scientists or groups who have already contributed to the present issue and who want to leave their contribution(s) unchanged or who wish to suggest only slight changes, should write an appropriate note to me before the above deadline.

<u>Format of the contributions</u>:

Generally, the size of one contribution should preferably not exceed one page. Of course, the number of contributions per working group or laboratory is not restricted. Similar experiments (or calculations, evaluations, etc.) performed by one person or group should preferably be combined to one contribution, if this is possible without loss of clarity.

The headings suggested for the 3 types of contributions are, for

Measurements:	Compilations:	Evaluations:
Laboratory and address	Laboratory and address:	Laboratory and address:
Names:	Names:	Names:
Facilities:		
	<u>Compilation</u>:	<u>Evaluation</u>:
<u>Experiment</u>:	purpose:	purpose:
Method:	major sources of information:	method:
Accuracy:	deadline of literature coverage:	major sources of information:
Completion date:	cooperation:	deadline of literature coverage:
Discrepancies to other reported data	other relevant details:	status:
Publications:	computer file:	cooperation:
	completion date:	other relevant details:
	Publications:	computer file of compiled data:
		computer file of evaluated data:
		discrepancies encountered:
		completion date
		Publications:

For the sake of consistency it is requested that the suggested headings be used, except when they are not appropriate, and their order of sequence be kept.

Comments or suggestions concerning the format, content and layout of this report series are most welcome and should be directed to me in time before the next issue.

I would like to thank the contributors for their cooperation.

G. Lammer
editor

Subject-index, measurements *

1) Fission yields

Fissionable isotope	Pages: thermal reactor neutrons	Pages: fast reactor neutrons	Pages: $E_n \cong 14$ MeV neutrons
^{232}Th			35
^{231}Pa		7	
^{233}U	8,23,31	7,33	15
^{234}U		7	
^{235}U	8,12,16,23,31	7,12,31,33	
^{236}U		7	
^{238}U	16	7,33	15,31
^{237}Np		7,33	
^{239}Pu	8,18,23,31	31,33	
^{240}Pu		33,35	35
^{241}Pu	8	33	
^{242}Pu		33	
^{241}Am		33	
^{243}Am		33	
^{249}Cf	31		

2) Neutron cross-sections

Isotopes	pages	(type of c.s., energy)
$^{86-88}Sr$	38	((n,γ),fast)
^{89}Y	38	((n,γ),fast)
^{90}Zr	38	((n,γ),fast)
^{91}Zr	4	(reson. params., resonance + fast);
	38	((n,γ), fast)

- cont'd -

* Contributions from U.K. are not indexed.

-cont'd -

Isotopes	pages	(type of c.s., energy)
$^{92,94}Zr$	38	$((n,\gamma)$, fast)
^{96}Zr	4	(reson. params., resonacne + fast)
^{93}Nb	2; 38	(reson. params., resonance); $((n,\gamma)$, fast)
$^{92,94-98,100}Mo$	38	(n,γ), fast)
^{99}Tc	11	(transmission, resonance)
$^{99-102,104}Ru$	11	(transmission, resonance)
^{103}Rh	38	$((n,\gamma)$, fast)
$^{104-106,108,110}Pd$	38	$((n,\gamma)$, fast)
^{109}Ag	6	$((n,\gamma)$, fast)
$^{106,108}Cd$	11; 38	(transmission, resonance); $((n,\gamma)$, fast)
$^{110-112}Cd$	11	$((n,\gamma)$, fast)
$^{113,114}Cd$	11; 38	(transmission, resonance); $((n,\gamma)$, fast)
^{116}Cd	38	$((n,\gamma)$, fast)
$^{122-126,128,130}Te$	38	$((n,\gamma)$, fast)
^{123}I	1	(reson.params., resonance)
^{129}I	11	(transmission, resonance)
$^{133/135/137}Cs$	11	(transmission, resonance) measured together
$^{134-136,138}Ba$	38	$((n,\gamma)$, fast)
^{139}La	38	$((n,\gamma)$, fast)
^{140}Ce	38	$((n,\gamma)$, fast)
^{141}Pr	38	$((n,\gamma)$, fast)
$^{142-146,148}Nd$	38	$((n,\gamma)$, fast)
^{149}Pm	31	$((n,\gamma)$, thermal)
^{156}Gd	22	(reson. params., resonance)
^{159}Tb	38	$((n,\gamma)$, fast)
^{165}Ho	38	$((n,\gamma)$, fast)
^{169}Tm	38	$((n,\gamma)$, fast)
FP-Mixtures	11	(transmission, resonance)

3., Decay data

Isotopes	Pages $T_{1/2}$	β-data	γ-data	Isotopes	Pages $T_{1/2}$	β-data	γ-data
^{79}Ga	30	29		^{119}In			29
$^{80-83}Ga$	30			^{120}In		29	
83 a)	9		9	$^{121,123,125}In$		29	29
^{85}As	30			^{124}In		29	
85 a)	9		9	$^{127-132}In$	30		
^{86}Br		29		$^{127,129,130-132}Sm$		29	
86 a)	9		9	$^{133,134}Sm$	30		
^{87}Br	30	29	29	$^{130,133}Sb$		29	
87 a)	9		9	^{134}Sb	30	29	
$^{88-92}Br$	30			$^{135,136}Sb$	30		
88 a)	9		9	^{135}Te		29	
^{93}Kr	30			^{136}Te	30		
^{88}Rb		29		^{131}I			13
^{90}Rb		29		$^{125,136}I$		29	
$^{92-94}Rb$	30,32			^{137}I	30	29	29
^{95}Rb	30,32		29	^{138}I	30	29	
$^{96,97}Rb$	30,32			$^{139-141}I$	30		
^{98}Rb	30			^{139}Xe		29	
^{93}Sr		29		^{134}Cs			13
^{95}Sr			29	$^{138-140}Cs$		29	
^{96}Y			29	^{141}Cs	30		
^{95}Zr			13	$^{142,143}Cs$	30,32		
96–102 a)	9		9	$^{144,145}Cs$	30,32		
^{103}Ru			13	^{146}Cs	30,32		
^{106}Rb			13	^{140}Ba			13
^{110m}Ag			13	$^{144,145}Ba$			29
$^{113,115}Ag$			29	^{140}La			13
^{116}Ag		29		^{143}La	27		27
^{117}Ag		29	29	$^{144,145}La$	27		27,29
$^{119,121}Ag$			29	^{146}La	27		27
$^{122,123}Ag$	30			$^{144}Ce-^{144}Pr$			13
$^{117,121}Cd$			29	$^{145-150}Ce$	27		27
^{119}Cd		29	29	^{145}Pr			41
^{128}Cd	30			$^{147-150}Pr$	27		27
				145–150 a)	9		9

a) only mass chains are given in this contribution.

4., Delayed neutron data[a]

Precursors	Pages: Identification	P_n-value	neutron-energy-spectrum
^{79}(Zn,Ga)	30		19
^{80,81}Ga	30		19
^{82,83}Ga	30		
$^{87-91}$Br			19
90[b]		10	
91[b]		10	
^{93}Rb		32[c]	
93-95[b]		10	
^{96,97}Rb		32[c]	
99[b]		10	
^{122,123}Ag	30		
^{127,128}In	30		
^{129,130}In	30		19
^{131,132}In	30		
^{134}Sn	30		19
134[b]		10	
^{135}Sb			19
^{136}Sb	30		
^{136}Te			
^{137,140}I			19
137-139[b]		10	
141(I,Cs)			19
^{142}(Xe,Cs)			19
^{142}Cs		32[c]	
^{143,144}Cs		32[c]	19
^{145,146}Cs		32[c]	

Half-life groups } yields for thermal neutron fission of ^{237}Np, ^{238}Pu, ^{240}Pu, ^{241}Pu , ^{241}Am, p.21

a) Half-lives of d.n. precursors are included in "decay data" (item 3.,)
b) Only mass-chains are given in this contribution
c) d.n. counting for half-life determination

5., Decay heat

Fissioned isotope	Pages, thermal fission: β-heat	γ-heat	total-heat
^{233}U			6
^{235}U	25,26,40	25,26,40	6
^{239}Pu	25,26,40	25,26,40	6

Subject-index, compilations/evaluations*

c ... compilation
e ... evaluation

1. Fission yields

Fissionable isotope or element	neutron-energy	c, e	page
^{235}U	fast spectrum, 14 MeV	e	46
Th, U, Pu	thermal, fast spectrum, 14 MeV	c	55
Many[a)]	thermal, fast spectrum, 14 MeV	e	47
Many[a)]	not specified	c	43
		c+e	50

a) isotopes are not specified by authors

2. Neutron cross-sections

Isotopes	Pages: thermal neutrons (n,γ)	thermal neutrons others	resonance neutrons (n,γ)	resonance neutrons others	fast neutrons (n,γ)	fast neutrons others
$^{95,\ 97,\ 98,\ 100}Mo$, ^{99}Tc, $^{101-104}Ru$, ^{103}Rh, $^{105,107}Pd$, ^{109}Ag, $^{133,135}Cs$, ^{141}Pr, $^{143,145}Nd$, ^{147}Pm, $^{149,151}Sm$, ^{153}Eu	49(c+e)	(total, elastic, inelastic, (n,2n), (n,γ), (n,α)) 49(c+e)	49(c+e)	49(c+e) (see thermal neutrons)	44(e), 49(c+e)	44(e) (inelastic), 49(c+e) (see thermal neutrons)
Many[a)]	43(c)		43(c)			
Many[b)]	50(c+e), 51(c),(e)		?		?	

a) isotopes are not specified by authors

b) isotopes and energy are not specified by authors

3. Decay data

	pages (c/e)
β-data	43(c), 45(c), 57(c)
γ-data	43(c), 45(c), 53(e), 57(c)
T 1/2	43(c), 45(c), 57(c)
not specified	50(c+e), 53(c)

4. Delayed neutron data

	pages (c/e)
P_n-value	45(c)
not specified	53(c)

5. Decay heat

	pages
β-heat	50(e)
β-,γ-heat	54(e)

* Contributions from U.K. LASL/HANFORD are not indexed.

I. MEASUREMENT ACTIVITIES

Laboratory and address: CBNM, Euratom, Geel, Belgium

Names: G. Rohr and R. Shelley

Facilities: Neutron time-of-flight spectrometer at the 70 MeV Linac (pulse width 23 nsec; flight path length 60 m).

Experiment: Resonance parameters of ^{123}I

1) Capture cross section measurements.

   Energy range: 20 eV - 5 keV.
   Experiments completed, analysis will be started soon.

2) Selfindication ratio measurements.

   See capture.

3) Total cross section measurements.

   Energy range: 10 eV - 5 keV
   Experiments completed, analysis will be started soon.

Method:

1) Capture cross section measurements.

   Detector: C_6F_6 detectors using Maier-Leibnitz method.
   Sample material: PbI_2
   Sample thickness: $5.453 \cdot 10^{-3}$ at/barn
   Neutron flux measurement: C_6F_6 detectors with a boron slab.
   Normalization: Ag using black resonance technique.

2) Selfindication ratio measurement.

   Detector: C_6F_6 detectors
   Sample material: PbI_2
   Sample thicknesses: $7.438 \cdot 10^{-3}$ at/barn and $1.236 \cdot 10^{-3}$ at/barn.

3) Total cross section measurements.

   Transmission measurements using C_6F_6 detectors with a boron slab.
   Sample material: PbI_2.
   Sample thicknesses: $2.485 \cdot 10^{-3}$, $7.438 \cdot 10^{-3}$ and $1.236 \cdot 10^{-3}$ at/barn.

Accuracy: Expected on final resonance parameters. $g\Gamma_n$, Γ_γ between 7% and 20% depending on the energy range and on the strength of the resonances.

Expected completion date: End of 1976.

Laboratory and address: CBNM, Euratom, Geel, Belgium
SCK/CEN, Mol, Belgium
RUCA, University Antwerp, Belgium

Names: J. Winter, A. Brusegan, L. Mewissen, F. Poortmans, G. Rohr, T. van der Veen and G. Vanpraet

Facilities: Neutron time-of-flight spectrometers at the 70 MeV Linac (Pulse width: 23 nsec).

Experiment: Resonance parameters for ^{93}Nb between 30 eV - 7 keV

1) Capture γ-ray experiments

   Energy range: 30 eV - 3 keV
   Analysis completed.

2) Capture cross section measurements

   Energy range: 30 eV - 8 keV
   Experiments completed; analysis in progress.

3) Selfindication ratio

   See capture.

4) Total cross-section measurements

   Energy range: 30 eV - 7.2 keV
   Experiments completed, analysis in progress.

5) Scattering cross-section measurements

   Energy range: 100 eV - 4 keV
   Experiments completed; analysis will be started soon.

Method:

1) Capture γ-ray spectra measurements.

   Low level population method to determine J and, or l values for resonances.
   Detector: GeLi gamma ray spectrometer.
   Flightpath length: 15 m.
   Sample thickness: $2.235 \cdot 10^{-2}$ at/barn.

2) Capture cross section measurements.

   Detector: C_6F_6-detectors using Maier-Leibnitz method.
   Flightpath length: 60 m
   Sample thickness: $5.463 \cdot 10^{-3}$ at/barn.
   Neutron flux measurement: C_6F_6 detectors with a boron slab.
   Normalization: Ag using black resonance technique.

- cont'd -

- cont'd -

3) Selfindication ratio measurements.

   Detector: C_6F_6 detector
   Flightpath length: 60 m
   Sample thickness: $2.235 \cdot 10^{-2}$ at/barn.

4) Total cross section measurements.

   Detector: ^{3}He gaseous scintillators.
   Flightpath length: 60 m
   Cooled samples at liquid nitrogen temperature.
   Sample thicknesses: $4.232 \cdot 10^{-3}$ at/barn
   $1.268 \cdot 10^{-2}$ at/barn
   $2.533 \cdot 10^{-2}$ at/barn

5) Scattering cross section measurements.

   Detector: ^{3}He gaseous scintillators
   Flightpath: 30 m
   Normalization: relative to the scattering cross section of Pb.

Accuracy: Expected on final resonance parameters $g\Gamma_n$, Γ_γ between 5% and 20% depending on the energy range and on the strength of the resonances.
s-wave strength function: 10%
Mean capture width: 7%.

Expected completion date: end of 1976.

Laboratory and address:	CBNM, Euratom, Geel, Belgium CNEN, Bologna, Italy
Names:	A. Brusegan, C. Coceva, F. Corvi, P. Giacobbe, G. Rohr, T. van der Veen and G. Vanpraet
Facilities:	Neutron time-of-flight spectrometers at the 70 MeV Linac (pulse width: 23 nsec).
Experiment:	Resonance parameters for ^{91}Zr and ^{96}Zr. separated isotopes: 89% enriched ^{91}Zr and 57% ^{96}Zr. 1) Capture γ-ray measurements. Energy range: 150 eV - 3200 eV. Experiments completed, analysis in progress. 2) Capture measurement. Energy range: 150 eV - 20 keV Experiments completed, analysis in progress. 3) Selfindication ratio measurements. See capture. 4) Total cross section measurements. Energy range: ^{91}Zr: 930 eV - 14.8 keV ^{96}Zr: 150 eV - 130 keV. Experiments completed, analysis in progress.
Method:	1) High and low energy γ-ray spectra measurements. Detector: GeLi gamma ray spectrometer. Flightpath: 13 m Sample thickness: $14.4 \cdot 10^{-3}$ at/barn. 2) Capture cross section measurements. Detector: C_6F_6 detectors using Maier-Leibnitz method. Flightpath: 60 m Sample material: ZrO_2 Sample thicknesses: ^{91}Zr $8.184 \cdot 10^{-3}$ at/barn ^{96}Zr $4.780 \cdot 10^{-3}$ at/barn. Neutron flux: boron slab with C_6F_6 detectors. Normalization: Ag using black resonance technique.

- cont'd -

- cont'd -

Method:

3) Selfindication ratio measurements.

Detectors: C_6F_6 detectors.
Flightpath: 60 m.
Sample material: nat. Zr (metal).
Sample thickness: $6.206 \cdot 10^{-3}$ at/barn.

4) Total cross section measurements.

Detectors: NaI(Tl) crystals with a boron slab.
Flightpath: 100 m.
Sample material: ZrO_2 enriched to 57% ^{96}Zr and 89% ^{91}Zr.

Sample thicknesses:	^{91}Zr	$0.8 \cdot 10^{-3}$ at/barn
		$2.4 \cdot 10^{-3}$ at/barn
		$6.4 \cdot 10^{-3}$ at/barn
		$14.4 \cdot 10^{-3}$ at/barn
	^{96}Zr	$0.8 \cdot 10^{-3}$ at/barn
		$3.5 \cdot 10^{-3}$ at/barn
		$4.3 \cdot 10^{-3}$ at/barn

Accuracy:

Expected on final resonance parameters

^{91}Zr $g\Gamma_n$, Γ_γ between 7% and 20%

^{96}Zr $g\Gamma_n$, Γ_γ between 10% and 20%

depending on the energy range and the strength of the resonances.

Expected completion date: end of 1976.

Laboratory and address: DRE/SEMNR - CEN/CADARACHE B.P. No. 1
13115 - SAINT PAUL LEZ DURANCE - FRANCE

A. Names: Cl. LE RIGOLEUR - J.P. MARQUETTE

Facilities: VAN DE GRAAFF pulsed - 5 MeV.

Experiments: Planned - Capture cross section of Ag 109

Method: Absolute method using the Meier-Leibnitz Technique

Energy range: 20 keV - 550 keV

Completion date: July 1976

Laboratory and address: DRE/SEN - CEN/CADARACHE B.P. No. 1
13115 - SAINT PAUL LEZ DURANCE - FRANCE

B. Name: M. FICHE

Experiment: ongoing
decay heat measurements per thermal fission of
233 U, 235 U amd 239 Pu between 100 and 10^5 seconds after shutdown.

Method: calorimetry

Accuracy: 5 %

75-8562
Translated from French

Laboratory and address:	Department of Fundamental Research Laboratory of Nuclear Physical Chemistry Grenoble Nuclear Studies Centre BP 85 Centre de Tri GRENOBLE CEDEX, France
Names:	J. BLACHOT, A. FERRIEU, G. LHOSPICE and A. MOUSSA.
Facilities:	Study of the fission of uranium isotopes (233, 234, 235, 236, 238) and neptunium-237 irradiated in a fission spectrum. (Caramel mock-up inserted in core of the Mélusine reactor at the Grenoble Nuclear Studies Centre).
Experiment:	Comparative study of the final mass distributions of the five uranium isotopes irradiated in the fission spectrum.
Method:	The cumulative yields are measured by Ge/Li gamma spectrometry. The method is relative to the 537.3 keV ray of barium-140 (see publication (1)).
Accuracy:	The mean accuracy of our measurements is 3 to 5%. Publication of the results is anticipated for the beginning of 1976. We expect subsequently to do the same study with fission by 3 MeV neutrons and to measure cumulative yields of ^{231}Pa in a fission spectrum.
Publications:	(1) Mass distribution in ^{238}U fission by 14 MeV neutrons, J. Inorg. Nucl. Chem. 36 (1974) 495-501. (2) Cumulative fission yields of ^{252}Cf, Journal of Radioanalytical Chem. 26 (1975) 107-125.

Laboratory and address :

Département de Recherche Fondamentale
Laboratoire de Chimie Physique Nucléaire
Centre d'Etudes Nucléaires de Grenoble
BP.85 Centre de Tri - 38041 GRENOBLE CEDEX - France.

Names :

R. BRISSOT, J. CRANÇON, Ch. RISTORI, J.P. BOCQUET et A. MOUSSA.

Facilities :

On li[illegible]pic separation of fission products (Ariel facility) connected with swimming pool reactor.

Experiment :

Independent and cumulative yields of rare gas isotopes have been measured in ^{233}U and ^{235}U thermal fission (from A = 87 to A = 93 for Krypton and 137 to 142 for Xenon).

From our measurements, cumulative yields for Bromine and Iodine isotopes can be obtained and independent yields can be deduced.

Method :

Cumulative yields are measured by $4\pi\beta$ counting (see publication 2)

Accuracy :

The average relative uncertainly of our measurements is typically 4%.

We plan to measure the same quantities for ^{239}Pu and ^{241}Pu thermal fission.

Publications :

1/- Distributions isotopiques des gaz rares dans la fission par neutrons thermiques de ^{235}U et ^{233}U. To be published in Nuclear Physics A. (1975).

2/- One line measurements of rare gas fission yields in 14 MeV neutron fission. Nuclear Physics A 189 (1972) p. 556-576.

Laboratory and address : -Département de Recherche Fondamentale
Laboratoire de Chimie Physique Nucléaire
Centre d'Etudes Nucléaires de Grenoble
BP.85 Centre de Tri - 38041 GRENOBLE CEDEX - France -

*Names** : J. BLACHOT, E. MONNAND, F. SCHUSSLER (CENG/DRF)
G. BAILLEUL, J.P. BOCQUET, B. PFEIFFER (ILL).

* This work is a collaboration between this laboratory and :
- Institut Laue-Langevin -BP 156 - 38042 (Grenoble) (M. ASGHAR, J.P. GAUTHERON).
- Institut fur Neutronenphysik Julich (RFA).

Facilities : Recoil focussing parabola type mass separator for unslowed fission products LOHENGRIN installed at the GRENOBLE high flux reactor.

Experiment : E_γ, I_γ, T 1/2 have been measured for the mass chains 96, 97, 98, 99, 100, 101, 102, 145, 146, 147, 148, 149, 150 and also 135, 136, 137, 83, 85, 86, 87, 88. Some decay schemes have been derived.

Method : The fission products are either handled with the use of a tape transport system or with a air jet device. The γ energy spectra are measured with a geLi detector and recorded in a 4096 channels memory of a Telefunken (TR 86) on line computer.

Publications :

G. SADLER et al. , Decay ^{96}Y - to be published in Nucl. Phys.
G. BAILLEUL et al - Z. Physik, A 273 (1975) 2B3.

Laboratory and address : Département de Recherche Fondamentale
Laboratoire de Chimie Physique Nucléaire
Centre d'Etudes Nucléaires de Grenoble
BP.85 Centre de Tri - 38041 GRENOBLE CEDEX - France.

Names[※] : Ch. RISTORI and J. CRANÇON

※ This work is a collaboration between this laboratory and :
- Institut Laue-Langevin - BP.156 - 38042 GRENOBLE)
  (M. ASGHAR, J.P. GAUTHERON).
- Kelvin Laboratory, University of Glasgow, Scotland.
  (G.I. CRAWFORD).

Facilities : Recoil focussing parabola type mass separator for unslowed fission products LOHENGRIN installed at the GRENOBLE high flux reactor.

Experiment : P_n values measurements of the $^{235}U(n_{th},f)$ produced precursors in the mass chains 90, 91, 93, 94, 95, 99, 134, 137, 138 and 139.

Method : A neutron detector and a $4\pi\beta$ detector were used simultaneously to measure the neutron and β activities (the ratio of the neutron activity of a nuclide to the β activity of its precursor defines the P_n value) collected on a continuous moving tape system.

Accuracy : The accuracy of each measure is depending on the level mass activity. Typically the uncertainty is 15%.
We plan to measure other P_n values up to the lower level sensitivity of this present detection system :

$P_n \times Y_q(m) > 0{,}4\,10^{-6}$ n/f (see the publication).

Discrepancies to other reported data :

^{90}Br

^{137}Te

Publications :

- The P_n values of the $^{235}U(n_{th}, f)$ produced precursors. Nuclear Physics A 247 (1975) p.359-376.
- J.P. GAUTHERON, thesis, Université Scientifique et Médicale de Grenoble - Décembre 1974.

Laboratory and address:

Institut für Reine und Angewandte Kernphysik der Universität Kiel (IKK),
D-2054 Geesthacht, Reaktorstation

Names:

K. Freitag, U. Harz, P. Podewils, H. G. Priesmeyer

Facility:

Fast Chopper Neutron Time-of-Flight Spectrometer, 42 m flight path in front of beam hole of 5 MW - FRG-1 reactor. 15 ns/m nominal resolution, with special equipment for transmission measurements on highly radioactive samples.

Experiments:

Neutron resonance investigations by transmission measurements between 1eV and 1.5keV on separated stable or radioactive isotopes of special interest to reactor physics (especially fission products), gross fission products.
Possibility of extending energy range to thermal region with crystal spectrometer, which can be made available.

Completed: Cs 133/135/137 fission product mixture
Ru 99, 100, 101, 102, 104
Cd 113

Ongoing: Cd 114, gross fission products
Isotope content determinations in irradiated fuel.

Planned: Cd 106/108, fission gas samples, Tc 99, I 129, gross fission products.

Method:

sample-in-beam, sample-out-of-beam transmission measurement; black resonance or boron filter background determination technique; 42 m flight path; 15 μs/m resolution; 11 li-6 glass-scintillation detectors; max. rotor speed 15000 upm; min. burst width 0,64 μs; min. time channel width 100 ns.

Accuracy: for resonance parameters: about 5% or better, depending on statistical accuracy desired.

Recent publications:

1.) GKSS 75/E/17
2.) ATKE 25 (1975) 109-113
3.) Nuclear Cross Sections and Technology Paper HB 6, Conference, Washington D.C. March 1975

Laboratory and address:	Physikalisch-Technische Bundesanstalt D - 33 Braunschweig, Bundesallee 100
Names:	K. Debertin
Facilities:	^{252}Cf-source; thermal reactor FMRB; calibrated Ge(Li)-spectrometer.
Experiment:	Determination of ^{235}U-fission yields in the fast neutron spectrum of a ^{252}Cf-source and in a thermal neutron spectrum. Only yield ratios (fast/thermal) are determined. The evaluation of the measurements is in progress.
Method:	The ^{252}Cf-source is mounted 15 m above ground in the open air. ^{235}U-samples, enriched to 93 % ^{235}U, are irradiated in a 1 cm distance. Fission product activities are determined by measuring the γ-ray spectrum with a calibrated Ge(Li)-spectrometer. Six irradiations of different duration (2 h to 10 d) were carried out.
Accuracy:	$\pm$ 1 % to $\pm$ 2 % (1σ uncertainty) for fast to thermal yield ratios
Completion date:	1976
Publication:	Preliminary results will be published in PTB-Jahresbericht 1975 (appears in April 1976).

Laboratory and address:	Physikalisch-Technische Bundesanstalt, D - 33 Braunschweig, Bundesallee 100
Names:	K. Debertin, U. Schötzig, K. F. Walz and H. M. Weiß
Facilities:	1) $4\pi\beta$-γ-coincidence systems (normal and high pressure proportional-counters, NaI(Tl)-crystals); 2) calibrated Ge(Li)- and Ge-spectrometers
Experiment:	Determination of absolute γ-ray emission probabilities for

^{95}Zr, ^{106}Rh, ^{144}Ce - ^{144}Pr	published
^{140}Ba/^{140}La	completed
^{103}Ru, ^{134}Cs, ^{131}I	ongoing
$^{110}Ag^{m}$	planned

Method:	The decay rates are determined by facilities 1) using the extrapolation method; γ-ray emission rates are determined by facilities 2), the efficiency of which has been calibrated in the energy range of interest to an accuracy of $\pm$ 1 % or less (1σ). For this purpose PTB standard sources of about 15 radionuclides were used. Details are described in Annals of Nuclear Energy 2, 37 (1975) and PTB-Mitteilungen 83, 307 (1973).
Accuracy:	$\pm$ 1 % to $\pm$ 2 % (1σ uncertainty)
Completion date:	End of 1976

- cont'd -

- cont'd -

Discrepancies to other reported data:

1. ^{144}Pr: For the emission probability of the 696 keV γ-radiation a value of 0,01342 ± 0,00014 was obtained which is about 10 % lower than the "recommended" value.
2. ^{140}Ba: For the emission probability of the 537 keV γ-radiation a value of 0,244 ± 0,003 was obtained which is about 20 % higher than the value given in the Nuclear Data Sheets (1974)

Publications:

"Gamma-Ray Emission Probabilities of the Fission Products ^{144}Ce - ^{144}Pr, ^{106}Rh, ^{95}Zr" in Annals of Nuclear Energy 2, 37 (1975)

"Messung von Gammastrahlen-Emissionswahrscheinlichkeiten der Nuklide ^{103}Ru, ^{140}Ba, ^{140}La und ^{152}Eu" in PTB-Jahresbericht 1974, p. 222 (Copies available on request).

Laboratory and address: Institute of Experimental Physics, Kossuth Lajos University. H-4026 Debrecen, Bem tér 18/a, Hungary.

Names: dr. Sándor Daróczy, dr. Sándor Nagy, Péter Raics.

Facilities: Neutron generators, 0.5 mg ^{252}Cf source.
GeLi detector of 40 cm³ with Atomki /Hungary/ electronics, 4000 channel DIDAC analyser and Multi 20 - Plurimat system.
$4\pi\beta$ -counter /for counting of the activity of flux measuring foils/.

Experiment: Fission yield measurements at 14 MeV.
Completed: mass distribution of ^{238}U/n,f/ reaction.
Ongoing: ^{235}U/n,f/, for products with half life greater than 1 day, only.
Planned /for 1976-77/: ^{233}U/n,f/ or ^{237}Np/n,f/.

Method: Measurement of direct gamma spectra of a thick target with an absolutely calibrated GeLi spectrometer and determination of partial fission cross sections /cumulative yields/ relative to the ^{27}Al/n,alpha/ or ^{63}Cu /n,2n/ reaction cross section.

Accuracy: Generally 2 - 5 % random and about 3 % systematic error reached.

Expected completion date: ^{235}U/n,f/: 1976; ^{233}U/n,f/ or ^{237}Np/n,f/: 1977.

Discrepancies to other reported data: Pronounced symmetry to A_o=117.3 was found in the mass distribution of the ^{238}U/n,f/ reaction; there are no indications for fine structure.

Publications: Results to be published in the Proceedings of the Symposium on Fast Neutron Interactions and on the Problems of High Current Neutron Generators /Suppl. Atomki Közl., Debrecen/ and perhaps in J.nucl.inorg.Chem.

Laboratory and Address	: Radiochemistry Division Bhabha Atomic Research Centre Trombay, Bombay 400 085.
Names	: Rao V.K., Bhargava V.K., Marathe S.G. Sahakundu S.M. and Iyer R.H.
Facilities	: Low background beta counters, NaI(Tl) and high resolution Ge(Li) detectors, beta proportional counters and multi-channel analyser
Experiment	: Measurement of the fission yields of low yield products in the neutron induced highly asymmetric fission ($A < 70$ and $A > 160$) of uranium.
Method	: Stringent radiochemical separation techniques followed by low level beta counting. Fission yields of ^{66}Ni, ^{67}Cu, ^{72}Zn, ^{77}As, ^{161}Tb, ^{172}Er ^{175}Yb, ^{177}Lu and upper limits for the yields of ^{183}Ta and ^{199}Au were determined relative to ^{99}Mo in the reactor neutron induced fission of enriched ^{235}U, natural uranium and depleted ^{238}U($^{235}U = 0.217$). Yields of some typical high yield products such as ^{89}Sr, ^{111}Ag and ^{140}Ba were also measured in these experiments. Measurements of yields of other lighter and heavier products e.g. ^{167}Ho and ^{173}Tm are in progress.
Accuracy	: $\pm$ 30% to 40% for low yield products and $\pm$ 5% to 10% for high yield products (estimated)
Completion data	: Partly completed. Similar more extensive studies are continuing
Descripancies to other reported data	: The upper limits for the yields of ^{66}Ni ^{67}Cu in the fission enriched ^{235}U reported by us are lower than the literature values (Ref. 1-3) and this may be due to the highly purified target material and improved counting techniques used in the present work.
Remarks	: This study has lead to the first ever experimental hint at the existence of a possible influence of the 28 proton shell in low energy fission and this is reflected in the form of small shoulders in the low yield wings of the mass yield curve (Ref. 4-6).

- cont'd -

- cont'd -

Publications

1. : Rao V.K., Bhargava V.K., Marathe S.G., Sahakundu S.M. and Iyer R.H.
search for low yield products in the neutron induced highly asymmetric fission of uranium
Phys. Rev. C 9 (1974) 1506

2. Marathe S.G., Sahakundu S.M., Bhargava V.K. Rao V.K. and Iyer R.H.
Possible influence of the 28 proton shell on fission mass distribution

Proceeding of the nuclear Physics and Solid State Physics Symposium, Bangalore, India Vol 16B, Dec. 27-31 (1973), 21

3. Rao V.K., Bhargava V.K., Marathe S.G., Sahakundu S.M., and Iyer R.H.

Studies on highly asymmetric fission Part 1: Fission of uranium with reactor neutrons

Proceedings of the nuelear Physics and Solid State Physics Symposium, Bombay. Vol. 14B, Feb. 1-4 (1972), 53.

References

1. Flynn K.F. and Glendenin L.E. Argonne National Laboratory Report No. ANL-7749 (1970)

2. Roy J.C., Can J. Physics 39 (1961)

3. Munze R and Haldic, O, Kernenergie, 6, (1963), 225.

4-6 Same as 1-3 listed under publications.

Laboratory and Address	:	Radiochemistry Division Bhabha Atomic Research Centre Trombay, Bombay 400 085.
Names	:	Ramaniah M.V., and Jain H.C.
Facilities	:	High resolution γ-spectrometry and Radiochemical techniques.
Experiment	:	Determination of fission yields in thermal neutron fission of ^{239}Pu.
Method	:	Fission yields in the thermal neutron fission of plutonium-239 were determined using high resolution γ-spectrometry and radiochemical technique.
Accuracy	:	About 5%
Completion date	:	Data on 29 nuclides completed in 1971, some more investigations are being done.
Publications	:	Ph.D thesis submitted to Bombay University India (1971), "Radiochemical Studies of the Heavy Elements Fission and Solution Chemistry". INS Atomindex, 3, RN-023110, INS-mf-274 (1972)
Remarks	:	1. Fission yields for ^{99}Mo, ^{103}Ru and ^{131}I have major differences when compared with literature values. 2. These data give more or less the same light and heavy mass peaks while theliterature data gave a some what lower light peak compared to the heavy peak. 3. Remarks about ^{99}Mo yield in the paper IAEA-SM-170/13 (1973) have to be confirmed by experimental evidence. ^{99}Mo yield calculated using comparison method in the same series of experiments give a value of $6.87 \pm 0.19\%$ and this does not involve any fission cross-section, in the calculations. (See Radiochemica Acta 19, 9093 (1973) for details)

THE ENERGY DISTRIBUTION OF DELAYED NEUTRONS EMITTED FROM MASS-SEPARATED FISSION PRODUCTS

G. RUDSTAM — The Swedish Research Councils' Laboratory
Studsvik, Nyköping, Sweden

S. SHALEV — Department of Nuclear Engineering
Technion - Israel Institute of Technology
Haifa, Israel

Facilities

The OSIRIS on-line isotope separator has been used to extract selected delayed neutron precursors from thermally-fissioned ^{235}U. Delayed neutron energy spectra have been measured with a very high resolution ^{3}He neutron spectrometer, developed and marketed by the Technion Research and Development Foundation.

Experiment

The energy distribution of delayed neutrons has been determined over the energy range 100 - 1600 keV for the following precursors:

^{79}Zn, $^{80-81}Ga$, $^{87-91}Br$, ^{93}Rb, $^{129-130}In$, ^{134}Sn, ^{135}Sb,

^{136}Te, $^{137-140}I$, $^{141}(I + Cs)$, $^{142}(Xe + Cs)$, $^{143-144}Cs$.

Many of the spectra exhibit discrete structure and well-spaced peaks, which are attributed to neutron emission from individual nuclear levels populated by β-decay from the precursor. Work is progressing on additional precursors.

Method

A small quantity of ^{235}U is located in the ion source of the OSIRIS isotope separator, and exposed to a beam of thermal neutrons from a 1 MW reactor. Fission products are extracted, formed into an ion beam and separated into isobaric beams by electromagnetic deflection. One selected

- cont'd -

- cont'd -

beam passes through a collimation system to impinge on an aluminized mylar tape in close proximity to the neutron spectrometer. The tape is continuously advanced to remove long-lived decay products. No detectable contamination exists from adjacent mass beams. In most cases the neutron-emitting isobar is positively identified by decay-time considerations, although for the mass numbers 141 and 142 at least two isobars contribute to the measured neutron spectrum.

The energy resolution of the spectrometer was determined experimentally, and shown to be in the range 16 - 35 keV for neutrons with energy up to 1 MeV. Corrections were applied for the finite resolution of the spectrometer, the energy-dependent detection efficiency and the background neutron energy distribution.

Publications

(1) LF-54, LF-55, LF-56, LF-57, LF-60, LF-61, LF-64
The Swedish Research Councils' Laboratory, Studsvik.

(2) Nuclear Instruments and Methods 120 (1974) 333-344.

(3) Nuclear Physics A230 (1974) 153-172.

(4) Nuclear Physics A235 (1974) 397-409.

LABORATORY AND ADDRESS: Cesnef Politecnico di Milano
Via Ponzio 34/3 Milano Italy

NAMES: A.Cesana,V.Sanjust,M.Terrani

FACILITIES: Small research reactor (50 kW water boiler)
Pneumatic systems for sample transfer
"Long counters" for neutron detection and usual instrumentation for gamma counting (Ge-Li detectors coupled to 8196 multichannel analyzer)

EXPERIMENT: Type - Determination of delayed neutron (D.N.) group yelds of Np-237,Pu-238,Pu-240,Pu-241 and Am-241

Energy range - Pile neutrons

Status - Ongoing

METHOD : The D.N. yeld of a given group is given by

$$Y_n^{(x)} = \frac{C^{(x)} \cdot I^{(s)} \cdot Y^{(x)}}{C^{(s)} \cdot I^{(x)} \cdot Y^{(s)}} \; Y_n^{(s)}$$

where Y_n is the D.N. yeld of the given group, C the D.N. group counting rate, I the activity of a chosen fission product whose cumulative yeld is Y ; (x) and (s) refer to the fissile isotope under investigation and to a standard respectively. The fission product activities (e.g; Ba-140) are determined by gamma counting; U-235 is used as standard.
Fissile samples are contained in small Zirconium capsules (prepared at Oak-Ridge)

ACCURACY : Between 5 and 15 % ; the major uncertainty coming from the uncertainties on the Y_n and Y values

PUBLICATION : Foreseen for the second half of 1976

Laboratory and address: CNEN, Centro di Calcolo, Via Mazzini 2, 40138 Bologna (Italy)

Names: C. Coceva, P. Giacobbe, M. Magnani, M. Mauri, M. Stefanon.

Facilities: Electron Linac of CBNM Euratom, Geel (Belgium).

Experiment:

1) Precise determination of average spacing of s-wave neutron resonances in ^{156}Gd. Measurements completed; data analysis planned for 1976.

2) Low-energy capture γ-ray spectra from single resonances in ^{99}Ru and ^{101}Ru for spectroscopy of low-lying states of ^{100}Ru and ^{102}Ru. Measurements completed; data analysis planned to start late 1976.

Expected completion date:

1) 1976

2) 1977

Measurements of fission-yields

Laboratory and address: Institute of Atomic Energy, Kyoto University, Uji, Kyoto 611, Japan

Names: Tomota Nishi, Ichiro Fujiwara and Nobutsugu Imanishi

Facilities: 5 MW research reactor [Research Reactor Institute, Kyoto University]

Experiment: Cumulative and independent fission-yields of some fission products have been measured in the thermal-neutron induced fission of ^{233}U, ^{235}U and ^{239}Pu.

Cumulative yields: ^{128}Sn, ^{130}Sn, ^{131}Sn and ^{133}Sb

Independent yields: $^{128}Sb^{m,g}$, $^{130}Sb^{m,g}$, ^{131}Sb, $^{132}Sb^{m,g}$, $^{131}Te^{m,g}$ and $^{133}Te^{m,g}$

Method: The fission yields were measured by radiochemical methods.

Irradiation: A dilute nitrate solution containing ^{233}U, ^{235}U or ^{239}Pu was irradiated in the reactor for 30 sec.

Chemical separation: tin: extraction by isopropyl ether; antimony: distillation of SbH_3 from a 6 M HCl solution in contact with metallic zinc-powder; tellurium: reduction of Te(VI) to the metallic form.

γ-ray measurements: γ-rays emitted from the samples were measured with a Ge(Li) detector.

Fission monitor: The activity of ^{92}Sr was used as a fission monitor.

Determination of the independent yields: For the determination of the independent fission yields the measured activities were corrected for the contribution of those ones built up from the

- cont'd -

- cont'd -

precursors during the irradiation and before the time of chemical separation.

Accuracy: Errors range from 7 % to 20 % with different combinations of the fission products and the fissile isotopes. The errors include uncertainties of half lives, absolute abundances of γ-rays, counting efficiencies and fission yields of the fission monitor and the precursors, in addition to the statistical errors in the activity measurements.

Completion date: September 1975

Publication: to be published

Laboratory and address: Neutron Physics Laboratory
AB Atomenergi
Studsvik, Fack
S-611 01 NYKÖPING
SWEDEN

Names: P.I. Johansson and J. Lorenzen

Facilities: 6 MeV VdG accelerator
PDP-15 Computer 24 k memory (on line)
NaI(Tl) and Ge(Li) spectrometers
CDC-CYBER 73 Computer (off line)

Experiment: The objective of the experiment is to improve on the accuracy of currently available fission product decay heat data by means of the radiometric study of small irradiated uranium and plutonium specimens at cooling times longer than about 3 seconds after the end of irradiation.

The residual power of gamma radiation from the thermal fission of U-235 has already been studied over the time interval 10 sec to 35 min after fission. Measurements are planned to obtain the residual power due to β emission from U-235 and the β- and γ-radiation from thermal fission of Pu-239.

Method: A spectrometer and a facility for thermal neutron irradiation of fissile specimens of uranium or plutonium using a 6 MeV VdG accelerator has been built. The dimensions of the specimens have been selected taking into account the available flux and the minimizing of gamma ray self-absorption. The specimens are transported between the neutron source and the detector by means of a pneumatic system.

The absolute number of fissions in the sample is determined by three independent methods: a) by utilizing an absolute calibrated fission chamber with an active volume of the same size as the samples, b) by counting the gamma rays emitted from fission products with well known yields and decay properties, c) by comparison of the gamma ray yield of uranium samples irradiated by the accelerator and in the R2 reactor. The neutron spectrum in the chosen reactor position is well thermalized and can be determined with high accuracy.

For decay heat determination the gamma radiation from the fission products is measured with a well-shielded and collimated NaI(Tl) crystal of diameter and length 12.5 cm. A 4096 channel analyzer is used for recording the spectra. Sample transportation, irradiation and counting times are handled by a PDP-15 computer. Spectra are automatically stored on magnetic tape for off-line data analysis, i.e. the transformation from complex pulse height spectra to energy spectra.

Accuracy: Better than 10 % accuracy is expected on the total energy released as β or γ from the fission products at any time between a few seconds and 30 minutes after fission.

Laboratory:	AB ATOMENERGI, STUDSVIK, SWEDEN
Name:	Dr R Persson
Facility:	R2-0 pool reactor
Experiment: (planned)	Integral measurement of decay heat from thermal neutron fission of U-235. Later: probably similar measurements for Pu-239
Method:	Calorimetry The design of a calorimeter with a relatively short time constant is under way. The heat from β decay and γ decay will be separated.
Accuracy:	The accuracy is expected to be better than 10 % for a time interval from about 20 sec to 1000 sec.
Time schedule:	Start of preliminary measurements in late spring 1976. Expected completion date, summer 1977.

Laboratory: Department of Nuclear Chemistry
Chalmers University of Technology
Fack
S-402 20 Göteborg 5
SWEDEN

Names: The SISAK Collaboration:

P.O. Aronsson and G. Skarnemark

Department of Nuclear Chemistry
Chalmers University of Technology
Fack
S-402 20 Göteborg 5
Sweden

T. Björnstad and E. Kvåle

Department of Nuclear Chemistry
University of Oslo
Oslo 3
Norway

N. Kaffrell, E. Stender and N. Trautmann

Institut für Kernchemie
Johannes Gutenberg Universität
Postfach 3980
D-6500 Mainz
Germany

Facilities: One SISAK system for the study of radionuclides in the half-life range 3s - 15 min.

Experiments: $T_{1/2}$-determinations, γ-singles and γ-γ coincidence measurements in the energy range 0 - 4 MeV, at present on $^{143-146}La$, $^{145-150}Ce$ and $^{147-150}Pr$.

Method: Fast on-line chemical separations. The measurements are carried out on flow cells or ion exchange columns. Ge(Li)-detectors are used.

Discrepancies
to other data: There are very few data available in this region.

Publications:

1) P.O. Aronsson, E. Ehn and J. Rydberg, Phys. Rev. Lett. 25 (1970) 550

2) P.O. Aronsson, G. Skarnemark and M. Skarestad, J. inorg. nucl. Chem. 36 (1974) 1689

3) P.O. Aronsson, B.E. Johansson, J. Rydberg, G. Skarnemark, J. Alstad, B. Bergersen, E. Kvåle and M. Skarestad, J. inorg. nucl. Chem. 36 (1974) 2397

4) P.O. Aronsson, G. Skarnemark and M. Skarestad, Inorg. nucl. chem. Lett. 10 (1974) 499

5) P.O. Aronsson, G. Skarnemark, E. Kvåle and M. Skarestad, Inorg. nucl. chem. Lett. 10 (1974) 753

- cont'd -

- cont'd -

6) N. Trautmann, P.O. Aronsson, T. Björnstad, N. Kaffrell, E. Kvåle, M. Skarestad, G. Skarnemark and E. Stender, Inorg. nucl. chem. Lett. 11 (1975) 729

7) E. Stender, N. Trautmann, P.O. Aronsson, T. Björnstad, N. Kaffrell E. Kvåle and G. Skarnemark, to be published in J. inorg. nucl.Chem.

8) G. Skarnemark, E. Stender, N. Trautmann, P.O. Aronsson, T. Björnstad, N. Kaffrell and E. Kvåle, to be published in Z. Physik

9) G. Skarnemark, E. Stender, N. Trautmann, P.O. Aronsson, T. Björnstad, N. Kaffrell, E. Kvåle and M. Skarestad, to be published in Z. Physik

Laboratory and address: The Swedish Research Councils' Laboratory, Studsvik, Fack, S-611 01 Nyköping, Sweden

Facilities: The OSIRIS on-line mass-separator for thermalized fission products.

A. Names: B Fogelberg, H Tovedal

Experiment: Nuclear spectroscopic studies of the β-decays of fission product nuclei.

Recently studied are the decays of ^{87}Br, ^{95}Rb, ^{95}Sr, ^{96}Y, ^{113,115,117,119,121}Ag, ^{117,119,121}Cd, ^{119,121,123,125}In, ^{137}I, ^{144,145}Cs, ^{144,145}Ba, ^{144,145}La

Publications: H Tovedal and B Fogelberg, High-energy γ-rays in ^{87}Kr following the decay of ^{87}Br, Nucl. Phys. (in press).

B Fogelberg, L-E de Geer, K Fransson and M af Ugglas, Transition probabilities and low-energy levels in heavy odd-mass isotopes of tin, to be published in Z. Phys.

B. Name: Eva Lund

Experiment: Determination of total beta decay energies. Q-values determined for: ^{79}Ga, ^{86,87}Br, ^{88,90}Rb, ^{93}Sr, ^{116,117}Ag, ^{119}Cd, $^{120,121,123-125}$In, $^{127,129,130-132}$Sn, ^{130,133,134}Sb, ^{135}Te, $^{135-138}$I, $^{138-140}$Cs, ^{139}Xe.

Method: Spectrometer consisting of Si(Li) detectors for beta counting and Na(I) detectors for gamma counting in a coincidence arrangement.

Publications: "Spectrometer for measuring total beta decay energies." E Lund and G Rudstam (report, in manuscript)

"Q-values of some nuclides on the neutron rich side of stability." G Rudstam, E Lund, L Westgaard, and B Grapengiesser, CERN Yellow Report 70-30, 1 (1970) p.341.

"Total beta decay energies of neutron-rich fission products". E Lund and G Rudstam (will appear in the proceedings of the V th International Conference on Atomic Masses and Fundamental Constants, Paris, June 1975)

- cont'd -

- cont'd -

C. Name: Eva Lund

Experiment: Identification and half-life determinations of delayed neutron precursors, using a ^{3}He counter with a total efficiency of 13 %.
Measured activities: $^{79-83}Ga$, ^{85}As, $^{87-92}Br$, ^{93}Kr, $^{92-98}Rb$, $^{122,123}Ag$, $^{127-132}In$, ^{128}Cd, $^{133,134}Sn$. $^{134-136}Sb$, ^{136}Te, $^{137-141}I$, $^{141-146}Cs$.
Precursors identified for the first time: $^{79}(Zn,Ga)$, $^{80-83}Ga$, $^{122,123}Ag$, $^{127-132}In$, ^{134}Sn, ^{136}Sb.

D. Names: G Rudstam, S Shalev, E Lund

Delayed neutron spectrometry

Neutron spectra for the precursors ^{88}Br, ^{90}Br, ^{138}I, ^{140}I, $^{142}(Xe+Cs)$, ^{144}Cs: data available as in the Swedish Research Councils' Report LF-64 (1975).
For a more detailed description, see p. 19.

Publications:

Reports: "Delayed neutron activities produced in fission. Part I, Mass range 79-98" by G Rudstam and E Lund, The Swedish Research Councils' Laboratory Report LF-60, 1974 (to be published in Phys. Rev.)

"Delayed neutron activities produced in fission. Part II, Mass range 122-146" by E Lund and G Rudstam, The Swedish Research Councils' Laboratory Report LF-61, 1975 (submitted to Phys. Rev.)

Laboratory and address:	Eidg. Institut für Reaktorforschung CH-5303 Würenlingen Switzerland
Names:	H.R. von Gunten, A. Grütter
Facilities:	- Swimming-pool type reactor (SAPHIR) - Heavy-water reactor (DIORIT) - Zero-energy reactor (PROTEUS) with GCFR-neutron-spectrum - 14 MeV neutron-generator
Experiments:	Fission yields: - Thermal, - GCFR-spectrum, - 14 MeV $\}$ completed
Method:	- Radiochemical for independent yields - Instrumental with GeLi-detectors, mostly relative to ^{235}U thermal
Accuracy:	Independent yields of ^{150}Pm: 10 - 35 % GCFR-spectrum 2 - 10 % for ^{235}U R-values for ^{239}Pu 1.5 - 18 % 14 MeV 5 - 20 %
Measurements completed:	Spring 1975
Publications:	- Mass yields in 14 MeV neutron-induced fission of ^{238}U, J. inorg. nucl. chem. in press. - Mass yields in the fission of ^{235}U and ^{239}Pu in the neutron spectrum of a GCFR, Nucl. Sci. Eng. in press. - Independent yields of ^{150}Pm in the thermal neutron-induced fission of ^{233}U, ^{235}U, ^{239}Pu and ^{249}Cf and cross section for the ^{149}Pm(n,γ)^{150}Pm reaction. J. inorg. nucl. chem. in press.

31/1

Laboratory: AEE Winfrith

UKAEA
Atomic Energy Establishment
Winfrith
Dorchester, Dorset DT2 8DH

Names: M. F. Murphy, W. H. Taylor

Facilities: Zero-power fast reactor Zebra

Experiment: Measurement of gross beta-decay power from products of Pu239 and U235 fission in a fast reactor. Irradiation period 10^5 seconds, detection (continuing) for at least 10^7 seconds after shut-down. Experiment near completion.

Method: Thin deposits of Pu239 and U235 irradiated with catcher foils at centre of Zebra core with neutron energy spectrum close to that of fast power reactor. Fissions monitored by absolute (alpha-calibrated) counters. Catcher foils transferred rapidly to scintillation detector, current output from photo-multiplier being measure of beta power. Calibrated using standard Sr-90-Y-90 source. Various subsidiary experiments to obtain corrections and check for systematic errors.

Accuracy: Target accuracy is $\pm$ 7% (standard error) on absolute beta power as function of time from 30 sec. to 10^7 seconds after irradiation.

Expected completion date: mid-1976.

UKAEA
AERE Harwell
Oxfordshire OX11 ORA

Laboratory: AERE Harwell

Names: E.A.C. Crouch, I.C. McKean

Facilities: D.F.R.

Experiment: Absolute yields of ^{95}Nb/Zr, ^{106}Ru, ^{137}Cs, ^{144}Ce, Nd isotopes, and perhaps other isotopes, from the fission of ^{235}U and ^{239}Pu in DFR.

Method: Samples of ^{235}U as enriched uranium dioxide, ^{238}U as depleted uranium dioxide and ^{239}Pu as plutonium dioxide were irradiated at various positions in DFR.

Four samples of ^{235}U have been dissolved,chemically separated and analysed using a mass spectrometer and the isotope dilution technique. The analysis is complete and the results are being calculated.

It is expected that ^{238}U and ^{239}Pu samples will be dissolved, separated and analysed during the next year.

Accuracy: Expected $\pm$ 2% (1σ)

Completion date: Expected end of 1976

Laboratory: AERE Harwell

UKAEA,
AERE, Harwell,
Oxfordshire OX11 ORA

Names: J. G. Cuninghame, H. H. Willis

Facilities: 3 MeV van de Graaff "IBIS"

Experiment: Absolute fission yields of ^{99}Mo and 5 other nuclides in ^{239}Pu fission using monoenergetic neutrons. 6-8 energies from ~ 130 keV to ~ 2 MeV are being used; all irradiations now complete except at one energy.

Method: Flux measured by track detectors. Yields measured by thick source β-counting on very low count-rate samples.

Accuracy: Expected ~ 4% relative, ~ 5-10% absolute

Expected completion date: 1976

UKAEA,
AERE, Harwell,
Oxfordshire OX11 ORA

Laboratory: AERE Harwell

Names: J. G. Cuninghame, Mrs. J.A.B. Goodall, H. H. Willis

Facilities: Zero energy fast reactor "ZEBRA"

Experiment: Fission yields as a function of neutron spectrum - from core centre to blanket. Eight irradiations, each of 3 samples, carried out, 5 with ^{235}U as target, 3 with ^{239}Pu. Between 10 and 30 yields being measured per sample.
In progress.

Method: Flux measured by fission chambers and by track detectors, yields measured by absolute γ-counting.

Accuracy: Expected 3-5% relative, 5-10% absolute

Expected completion date: 1976

Publications "The measurement by γ-counting of complete mass-yield curves for fission of U-235 in several different fast reactor neutron spectra",
Baghdad Conference 7-11 April 1975

31/5

Laboratory: DERE

UKAEA,
DERE, Thurso,
Caithness, Scotland KW14 7TZ

Names: W. Davies,
V. M. Sinclair

Facilities: DFR

Experiment: The measurement of the absolute yield of ^{90}Sr, ^{137}Cs. ^{144}Ce, ^{143,145,146,148,150}Nd and perhaps other fission products from the fission of ^{235}U, ^{239}Pu and ^{240}Pu. Irradiations completed.
It is expected that the capsules will be dissolved and analysed by mid-1976

Method: Eleven sealed stainless steel capsules were irradiated over a period of 3 years, ending in February 1974.
Prior to irradiation,
3 capsules contained ^{235}U as highly enriched uranium dioxide,
3 capsules contained ^{239}Pu as low ^{240}Pu content plutonium dioxide,
3 capsules contained ^{240}Pu as a dried aqueous solution of plutonium with an isotopic analysis of 98% ^{240}Pu, and
2 capsules contained no added fissile material.

The ^{235}U and ^{239}Pu capsules have been irradiated to about 10% burn-up of the fissile material, and the ^{240}Pu capsules to about 2.5% burn-up.

It is expected that the capsules will be dissolved and analysed by mid-1976.

A set of capsules, identical to the irradiated set, except for irradiation in the reactor, will be dissolved and analysed alongside the irradiated set, with the objective of improving the reliability of the analyses.
The aim is to correlate loss of fissile material during irradiation with the amounts of fission products formed, for each capsule, to enable absolute measurements of fission yields to be obtained.

Accuracy $\pm$ 2% for ^{235}U and ^{239}Pu fission yields,
$\pm$ 6% for ^{240} Pu fission yields. (Total uncertainties as one-sigma confidence limits).

Expected completion date: December 1976

Laboratory: DERE

UKAEA, DERE,
Thurso, Caithness, Scotland
KW14 7TZ

Names: W. Davies, V. M. Sinclair

Facilities: P.F.R.

Experiment: The measurement of the absolute yields of ^{90}Sr, ^{137}Cs, ^{144}Ce, $^{143,145,146,148,150}Nd$ and perhaps other fission products, from the fission of ^{235}U, ^{238}U, ^{239}Pu, ^{240}Pu and ^{241}Pu.

In progress.

Method: Twelve sealed stainless steel capsules are to be irradiated.

Of these,

3 capsules contain ^{235}U as highly enriched uranium dioxide,

3 capsules contain ^{239}Pu as low ^{240} Pu content plutonium dioxide,

2 capsules contain ^{238}U as depleted uranium dioxide with an isotopic analysis of 99.7% ^{238}U,

1 capsule contains ^{240}Pu as a dried aqueous solution of plutonium with an isotopic analysis of 99% ^{240}Pu,

1 capsule contains ^{241}Pu as a dried aqueous solution of plutonium with an isotopic analysis of 93% ^{241}Pu, and

2 capsules contain no added fissile material.

The ^{235}U and ^{239}Pu capsules contain stainless-steel powder mixed with the fissile material dioxide for heat transfer reasons.

It is expected that the ^{235}U and ^{239}Pu capsules will receive irradiation corresponding to about 16% burn-up of the fissile material, the ^{238}U capsule to about 0.7% burn-up, the ^{240}Pu capsule to about 4% burn-up and the ^{241}Pu capsule to about 23% burn-up.

A set of capsules identical to the irradiated set except for irradiation in the reactor will be dissolved and analysed alongside the irradiated set, the objective being to improve the reliability of the analyses.

The aim is to correlate loss of fissile material during irradiation with the amounts of fission products formed, for each capsule, (except ^{238}U) to enable absolute measurements of fission yields to be obtained.

Accuracy

$\pm$ 2% for ^{235}U and ^{239}Pu fission yields

$\pm$ 6% for ^{238}U, ^{240}Pu and ^{241}Pu fission yields

Expected completion date: mid-1977

Laboratory and address:

Battelle, Pacific Northwest Laboratories,
Battelle Blvd., P.O. Box 999, Richland, Wa 99352, USA

Names: N.E. Ballou, P.L. Reeder, J.F. Wright and L.J. Alquist

Facilities: Solar-spectrometer for on-line analysis of radionuclides. This is an on-line mass spectrometer which incorporates a 235-U target in a surface ionization source located in the thermal column of a 1 MW Triga reactor at Washington State University, Pullman, Wa.

Experiment: Half-lives of 92-97 Rb and 142-145 Cs have been measured by beta counting isotopically separated sources. Half-lives of 93,96,97 Rb and 142-146 Cs have been measured by delayed-neutron counting. Half-lives of other isotopes of Rb, Cs, Br and I fission products will be measured using the same techniques whenever possible.

Method: Separated isotopes were collected on the first dynode of an electron multiplier detector. Beta half-lives were measured by following the time dependence of pulses from the elctron multiplier after the ion beam was switched off. Delayed neutron half-lives were measured using a 35% efficient neutron counter surrounding the electron multiplier. Decay curves were analyzed by CLSQ, a least-squares decay-curve fitting program. Daughter and grandaughter components were included in the fitting routine whenever necessary.

Accuracy: The statistical accuracy of CLSQ-fitted half-lives was about 1-2% in most cases. However, larger discrepancies were observed between the Beta and del. neutron half-lives. Half-lives from delayed-neutron counting are generally preferred because of the simplicity of the decay curve analysis.

Data: The half-lives in sec. (uncertainty) measured by delayed-neutron counting are as follows: 93 Rb:5.82(.04); 96 Rb:0.197(.002); 97 Rb:0.167(.002); 142 Cs:1.69(11); 143 Cs:1.79(.02); 144 Cs:0.99(.02); 145 Cs:0.578(.008); 146 Cs:0.28(.05). The half-lives measured by beta counting have been published (see below).

Publication: P.L. Reeder and J.F. Wright, Phys.Rev. C 12, 716 (1975), "half-lives of 92-97 Rb and 142-145 Cs".

FPND NEWSLETTER CONTRIBUTION

Laboratory: Idaho National Engineering Laboratory

Address: Allied Chemical Corporation
550 Second Street
Idaho Falls, Idaho, 83401
United States

Name: William J. Maeck

Experiment: Fast Reactor Fission Yields and Determination of Burnup for Fast Reactor Fuels

A program is in progress to measure the major fraction of the mass yield curve for the fast fission of ^{233}U, ^{235}U, ^{238}U, ^{237}Np, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, and ^{243}Am. All irradiations have been completed and yield measurements completed for ^{233}U, ^{235}U, ^{238}U, ^{239}Pu, and ^{241}Pu. Currently, measurements are in progress for ^{240}Pu and ^{242}Pu.

Method: The principal measurement technique is isotope dilution mass spectrometry for the isotopes of Kr, Rb, Sr, Zr, Mo, Ru, Xe, Cs, Ba, La, Ce, Nd, and Sm. The number of fissions is established by the summation of the total atoms in the heavy mass peak.

Accuracy: In general, the errors associated with the ^{233}U, ^{235}U, and ^{239}Pu yields are $\sim$1.5%. For ^{238}U the uncertainty in the reported yields are $\sim$3%.

Future Work: It is expected that the measurements for the fast fission yields of ^{240}Pu and ^{242}Pu will be completed by June 1976. It is anticipated that the fast yield measurements for ^{237}Np, ^{241}Am, and ^{243}Am will be completed by June 1977.

Special Comments: The yields reported in this program are for irradiations carried out in a neutron spectrum which is believed to be typical of a Liquid Metal Fast Breeder Reactor. An extensive effort was made to define the spectrum for these irradiations.

Because fast yields vary with neutron energy, all reported fast yield data must be associated with a known reactor spectrum.

- cont'd -

- cont'd -

Publications: Maeck, W. J., Editor, "Fast Reactor Fission Yields for ^{233}U, ^{235}U, ^{238}U, ^{239}Pu and Recommendations for the Determination of Burnup on FBR Mixed-Oxide Fuels: An Interim Project Report", U.S. ERDA Rept. ICP-1050-I, January 1975.

Available from National Technical Information Service, U.S. Dept. of Commerce, 5285 Port Royal Road, Springfield, Virginia, 22161, USA.

The following is an abstract of this report.

Fast fission yield data are presented for over 40 stable and long-lived nuclides for ^{233}U, ^{235}U, and ^{238}U irradiated in EBR-II. Also reported are preliminary fast fission yield data for ^{239}Pu. Capture-to-fission ratio measurements are reported for ^{233}U, ^{235}U, ^{238}U, ^{237}Np, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{242}Pu irradiated in the same assembly. The neutron environment for the irradiation is described. Monitors and their fast fission yield values are recommended for the determination of burnup on uranium-plutonium mixed-oxide FBR fuels.

CONTRIBUTION I

LABORATORY	Lawrence Livermore Laboratory University of California P. O. Box 808 Livermore, California 94550
NAMES	D. R. Nethaway A. L. Prindle N. L. Smith
FACILITY	Livermore ICT Facility (14-MeV neutron source)
EXPERIMENT	Measure fission yields (both total chain yields and independent yields) for fission of Th-232 with 14.8-MeV neutrons
METHOD	The Th-232 target foil is covered with U-238 foils so that the fission yields can be measured relative to the fission of U-238. Measurements are made both by doing chemical separations and by direct counting with Ge(Li) detectors. The accuracy of the measurements is about ± 5%.
COMPLETION DATE	The experimental measurements have been completed. The final results should be available as a UCRL report in the spring of 1976, and later as an article in The Physical Review.
DISCREPANCIES TO OTHER REPORTED DATA	The independent yields of Nb-96 and Cs-136 previously reported by S. A. Rao (Phys. Rev. C 5, 171 (1972)) were found to be in serious error.

LABORATORY	Lawrence Livermore Laboratory University of California P. O. Box 808 Livermore, California 94550
NAMES	D. R. Nethaway A. L. Prindle W. A. Myers W. C. Fuqua
FACILITY	Livermore ICT Facility (14-MeV neutron source)
EXPERIMENT	Measure fission yields (both total chain yields and independent yields) for fission of Pu-240 with 14.8-MeV neutrons.
METHOD	The Pu-240 target material is covered with U-238 foils so that the fission yields can be measured relative to the fission of U-238. Measurements are made both by doing chemical separations and by direct counting with Ge(Li) detectors. The accuracy of the measurements is about ± 5%.
COMPLETION DATE	The experimental measurements are almost completed. The results should be published in 1976.

CONTRIBUTION III

LABORATORY	Lawrence Livermore Laboratory University of California P. O. Box 808 Livermore, California 94550
NAMES	D. R. Nethaway A. L. Prindle W. A. Myers M. Kantelo
FACILITY	Undecided
EXPERIMENT	Measure fission yields for fission of Pu-240 with fission-spectrum neutrons.
COMPLETION DATE	We plan to start the measurements early in 1976.

Laboratory: Oak Ridge National Laboratory, Bldg. 6010, P.O. Box X, Oak Ridge, Tenn., 37830

Names: R.L. Macklin, J. Halperin

Facilities: Oak Ridge Electron Linear Accelerator (ORELA)
Flight Path 7

Experiment: Fast Neutron (n,γ) Cross Sections $E_n = 2.6 - \sim 500$ keV
Target-isotopes: see Table I

Method: Total Prompt Photon Energy Detectors, Neutron Time-of-Flight.
Nucl.Instr. & Meth. 91, 565-571 (1971), Phys.Rev. C11, 1270-1279 (1975).

Accuracy: 2-5% in cross section, $\lesssim$ 0.2% resolution (FWHM)

[Expected] completion date: } see Table I

Publications: }

Table I

Isotopes	Completion date	Publications
$^{86,87,88}Sr$	indefinite	Data taken, some analysis at U. Antwerp by G. Vanpraet, ^{88}Sr analysis at Lucas Heights and Oak Ridge by J.W. Boldeman, B.J. Allen, R.R. Winters
^{89}Y	1976	Data taken, analysis at Lucas Heights, Australia, J. Boldeman starting resonance analysis (9/75) of the data.
$^{90,91,92,94}Zr$	1976	Data taken, analysis at Lucas Heights, Australia. J.W. Boldeman, A.R. Musgrove, B.J. Allen, R.L. Macklin, "Valence Component in the Neutron Capture Cross Section of ^{90}Zr", submitted to Nuclear Physics
^{93}Nb	Jan 1976	R.L. Macklin, Neutron Capture Cross Section of Niobium from 2.6 to 700 keV, accepted Nuclear Sci. & Eng. issue of January 1976.
$^{92,94,95,96,97,98,100}Mo$	1976	O.A. Wasson et al, Neutron Resonance Parameters of ^{92}Mo, Phys. Revw. C7, 1532-1541(1973). J. Boldeman, B.J. Allen, data being analyzed (1975) near N=50 especially. H. Weigmann, resonance parameter analysis for $^{100}Mo(n,\gamma)$ in progress (9/75)
^{103}Rh	indefinite	Data taken, analyst needed.
$^{104,105,106,108,110}Pd$	indefinite	Data taking completed 1974, ^{105}Pd preliminary analysis (Rlm) distributed to requestors. Analyst needed.

continued

Table I, cont'd

Isotopes	Completion date	Publications
$^{106,108,110,111,112,113,114,116}Cd$	indefinite	Data taken, analyst needed. O.A. Wasson and B.J. Allen, "P-Wave Resonances in $^{111}Cd(n,\gamma)$", Phys.Rev. C7, 780-787 (1973).
$^{122,123,124,125,126,128,130}Te$	1977	R.R. Winters (Denison Univ., ORNL Consultant) analyzing the data.
$^{134,135,136,138}Ba$	1976	Data taken, analysis in progress at Lucas Heights, Australia. A.R. Musgrove, B.J. Allen, J.W. Boldeman, R.L. Macklin, "keV Neutron Resonance Capture in ^{138}Ba", submitted to Nuclear Physics. A.R. Musgrove, B.J. Allen, R.L. Macklin, "keV Neutron Resonance Capture in ^{135}Ba", AAEC/E327 (12/74) (INDC(AUL)-23/L)
^{139}La	indefinite	Data taken, analyst needed.
^{140}Ce	indefinite	Sample procured, data taking scheduled for 10/75.
^{141}Pr	indefinite	Data taken, analyst needed.
$^{142,143,144,145,146,148}Nd$		Data taken, analysis at Lucas Heights, Australia, by A.R. Musgrove and B.J. Allen.
^{159}Tb	indefinite	Data taken, analyst needed.
^{165}Ho	1976	R.L. Macklin, "The $^{165}Ho(n,\gamma)$ Standard Cross Section from 3 to 450 keV", submitted to Nucl.Sci. & Eng., 1975.
^{169}Tm	indefinite	Data taken, analyst needed.

Laboratory and address: Oak Ridge National Laboratory
P. O. Box X, Building 6010
Oak Ridge, Tennessee 37830

Names: J. K. Dickens and R. W. Peelle

Facilities: Total Beta and Gamma Energy Release for Thermal-Neutron Fission of ^{235}U and ^{239}Pu for Cooling Times of 3 to 2000 secs.

Method: Microgram samples of ^{235}U(and later ^{239}Pu) will be irradiated for short periods with thermal neutrons, and returned pneumatically to a counting area. Beta- and gamma-ray energy spectra of moderate resolution will be obtained using scintillation detectors (NE110 for beta rays and NaI for gamma rays) for selected time intervals within the time range of interest. The spectra will be reduced to differential production cross sections $d\sigma/dE$ and will be integrated to obtain total energy release rates for beta and gamma rays (separately). These data will be summed to obtain the total energy release.

Accuracy: 3% to 4% (1σ) for ^{235}U, 5% for ^{239}Pu

(Expected) Completion Date: August 1976 for ^{235}U, September 1977 for ^{239}Pu

Discrepancies to Other Reported Data: None as yet.

Publications: J. K. Dickens, R. W. Peelle, and F. C. Maienschein "Experiment for Accurate Measurements of Fission Product Energy Release for Short Times After Thermal-Neutron Fission of ^{235}U and ^{239}Pu," Oak Ridge National Laboratory Report No. ORNL-TM-4676 (May, 1975).

Laboratory and address: Texas A&M University, College Station, Texas 77843
Names: J. C. Hill*
Facilities: Reactor

Experiment: Decay of ^{145}Pr

Method: Fission Product

Accuracy:
[Expected] completion date: Published
Discrepancies to other reported data

Publications: D. L. Hillis, C. R. Bingham, D. A. McClure, N. S. Kendrick, Jr., J. C. Hill, S. Raman, J. B. Ball, and J. A. Harvey, Nuclear Spectroscopy of ^{145}Nd, Physical Review 12, 260 (1975).

*Present Address: Ames Laboratory - USERDA
and Department of Physics
Iowa State University
Ames, Iowa 50010

II. COMPILATIONS AND EVALUATIONS

Laboratory and address: DRE/SERMA/LEP - CEN.SACLAY
B.P. no. 2 91190 GIF SUR YVETTE - FRANCE

Name: Cl. DEVILLERS - DETOUREIL

Compilation: ongoing

Purpose: improvement of Fission Products Data File

Cooperation: A.E.R.E. HARWELL

DRE/SEN - Laboratoire de Chimie Physique Nucleaire (DRF) - GRENOBLE

Other relevant details: The file includes β-, γ-energy spectra, half life, branching ratio, fission yield, energy of the reactions, capture cross section for thermal neutrons extended to the resonance energy range by a Westcott type formalism.

Completion date: The file exists, its revision is underway.

Computer files: ongoing on ENDFB IV format

Laboratory and address: DRE/SEMNR - CEN.CADARACHE B.P. No. 1
13115 - SAINT PAUL LEZ DURANCE - FRANCE

Names: MM. E. FORT - A.P. SCHMITT

Evaluations:

Purpose: Evaluation of capture and inelastic cross sections for the fast neutron reactor programme.

Method: Determination of the parameters as $\overline{D_{obs}}$, Γ_γ, Γ_n, a from the published experimental data

Criticism of the existing experimental cross section measurements

Calculation of the cross sections using statistical and optical models depending upon the energy range and for the later different types of potential.

Comparison of the calculated and experimental cross sections obtained; improvement of local or total systematics for evaluation of cross sections of nuclei for which no experimental results exist.

Major sources of information:

Neutron physics literature, BNL 325, Nuclear Data Sheets ENDFB Files, CINDA, NEWDADA, etc....

Status: ongoing for 22 fission products 95 Mo, 97 Mo, 98 Mo, 100 Mo, 99 Tc, 101 Ru, 102 Ru, 103 Ru, 104 Ru, 103 Rh, 105 Pd, 107 Pd, 133 Cs, 135 Cs, 141 Pr, 143 Nd, 145 Nd, 147 Pm 149 Sm, 151 Sm, 153 Eu, 109 Ag, planned for 40 other Fission Products.

Cooperation: with the C.N.E.N./BOLOGNA

Completion date: Autumn 1975 for the 22 first; July 1976 for the 40 others.

Publications: Details of the techniques used will be published before end of 1975.

Laboratory and address :	Département de Recherche Fondamentale Laboratoire de Chimie Physique Nucléaire Centre d'Etudes Nucléaires de Grenoble BP.85 Centre de Tri - 38041 GRENOBLE CEDEX - France.
Names :	Jean BLACHOT.
Compilation :	Decay data (T 1/2, Eγ, Iγ, Eβ, Qβ, Pn) of fission products.
Purpose :	Library for the C.E.A.

Major sources of information : Nuclear Data Sheet and all journals.

Deadline of literature coverage : September 1975.

Cooperation :	C. DEVILLERS (Saclay), C. FICHE (Cadarache).
Computer file :	2 files : 1/ Fission products 2/ Others isotopes.

Magnetic tape can be obtained from CCDN (ENDF/B3) and from Jean BLACHOT.

Publications :	C. DEVILLERS et al. - IAEA - SM - 170/63 (1975). J. BLACHOT et al. - Note CEA à paraître (1975).

Laboratory and address: Health Physics Division,
Bhabha Atomic Research Centre,
Bombay 400 085, India.

Names : D.N.Sharma, M.R.Iyer and A.K.Ganguly.

A. THEORETICAL COMPILATION

(1) Type of data : Fission product independent yields for higher energy fission. (Fast and 14.7 MeV neutron fission of ^{235}U)

(2) Purpose : To predict fission product independent yields for higher energy fission using a fission model because experimentally determined data for these yields are very rare.

(3) Major sources of information: The Order-Disorder Model (ODM)[1,2] developed for thermal fission has been extended to higher energy fission case by evolving a scheme for the distribution of the extra excitation energy between the impending fragments. The experimental data on product mass yields and charge distribution parameters compiled by Meek and Rider[3] have been used as the input values for the computational purpose.

(4) Results and discripencies: The experimental[3] and predicted values as independent and cumulative yields of fission products do not agree very well in all cases. But generally speaking agreement seems to be better in higher yield region. In view of the large variations in the recommended values of Meek and Rider[3,4] and the range of experimental uncertainties quoted for experimental values, it can be stated that the present approach predicts the independent and

- cont'd -

- cont'd -

cumulative yields within reasonable limits of error.

(5) Relevant details: The predicted total charge yield distribution shows a small peak in the vicinity of Z = 28. This can be attributed to the proton magic shell effect of Z = 28. Similar conclusion has been drawn after observing experimentally, a shoulder around Z = 28 by Iyer et al[5,6] of this research centre.

(6) Completion date : March 1975.

(7) Publications :

(i) Sharma,D.N., Charge Distribution, Neutron Evaporation and Energy Distribution in Higher Energy Binary Fission, M.Sc. Thesis, Bombay University, Bombay, India (1975).

(ii) Sharma,D.N., Iyer,M.R. and Ganguly,A.K., Charge Distribution, Neutron Evaporation and Energy Distribution in Higher Energy Binary Fission, Paper submitted for publication in Phys. Rev.

B. EVALUATION

(1) Type of data : Experimental data on fission product mass yields and charge distribution parameters.

(2) Purpose and method: The equality of yields of complementary charges is a built-in and necessary condition but not sufficient condition for a fission process. As the evaporation of neutrons from fragments does not shift the charge line of the fragment, the total charge yield distribution remains same for fragment and products. Based upon the above criterian various parameters have been derived to test the consistency of a given set of data on product mass yields and charge distribution parameter.

- cont'd -

- cont'd -

(3) Results : The latest set of data compiled by Meek and Rider[3] has been evaluated. In general it is found that fast and high energy (14.7 MeV) data sets are not consistent but the thermal fission data are comparably more consistent except ^{235}U (Thermal) data which also falls in the category of less consistent one.

(4) Completion date : March, 1975.

(5) Publication :

(i) Sharma,D.N., Charge Distribution, Neutron Evaporation and Energy Distribution in Higher Energy Binary Fission, M.Sc. Thesis, Bombay University, India (1975).

REFERENCES

1. Iyer,M.R., Ganguly,A.K., Nuclear Charge Distribution in Fission Fragments, Phys. Rev. C 3 (1971) 785.

2. Iyer,M.R., Ganguly,A.K., Neutron Evaporation and Energy Distribution in Individual Fission Fragments, Phys. Rev. C 5 (1972) 1410.

3. Meek,M.E., Rider,B.F., Compilation of Fission Products Yields, Rep. NEDO-12154-1 (1974).

4. Meek,M.E., Rider,B.F., Compilation of Fission Products Yields, Rep. NEDO-12154 (1972).

5. Rao,V.K., Bhargava,V.K., Marathe,S.G., Sahakundu,S.M. and Iyer,R.H., Search for low-yield products in the neutron induced highly asymmetric fission of Uranium, Phys. Rev. C 9 (1974) 1506.

6. Marathe,S.G., Sahakundu,S.M., Bhargava,V.K., Rao,V.K. and Iyer,R.H., Possible Influence of the 28 Proton Shell on Fission Mass Distribution Nuclear Physics and Solid State Physics Symposium Indian Institute of Science, Bangalore (Proc. Symp. Bangalore, 1973) Bangalore, India (1973) 21.

Laboratory and address: Laboratorio Dati Nucleari - Centro di Calcolo del CNEN -
Via Mazzini, 2 - 40138 Bologna.

Names: V. Benzi, F. Fabbri, E. Menapace, M. Motta, G.C. Panini, G. Reffo, M. Vaccari.

Evaluation : Complete evaluation and compilation in ENDF/B format, in the energy range 10^{-5} eV - 15 MeV, of the following isotopes: Mo-95,-97,-98, -100; Tc-99 ; Ru-101,-102, -103,-104 ; Rh-103 ; Pd-105,-107 ; Ag-109 ; Cs-133,-135 ; Pr-141 ; Nd-143,-145 ; Pm-147 ; Sm-149,-151 ; Eu-153. Each file contains resolved and mean resonance parameters, relevant cross sections (i.e. total, elastic, inelastic, n-2n, n-γ, n-p and n-α), angular and secondary energy distributions.

purpose : Estimate of fast reactor long term reactivity changes.

method : Calculations by BW-single and-multilevel formalism (resonance region) and by statistical and optical models.

major sources of information : NEUDADA, CINDA.

deadline of literature coverage : June 1975.

status : completed.

cooperation : CEA: Cadarache and Saclay, RCN: Petten.

other relevant details : 25 group cross sections at infinite dilution and 0°K temperature have been generated.

Computer file of compiled data :
Computer file of evaluated data : ENDF/B format.

completion date : October 1975.

Laboratory: Japan Atomic Energy Research Institute, Tokai-mura, Naka-gun, Ibaraki-ken, Japan

Name: K. Tasaka

Evaluation and Compilation: decay data, fission yields and neutron capture cross sections (completed)

purpose : Making data file for calculation of inventory and decay heat of fission products

method : Decay data of unknown short-lived nuclides were estimated by systematics

major source of information :

Decay data ; Our own evaluated and estimated data supplemented by Nuclear Data Sheets and Tables of Isotopes

Yield data ; Meek and Rider, NEDO-12154 (1972)

Neutron capture cross section data ; Cook, AAEC/TM-549 (1969)

dead line of literature coverage : 1972

status : Going to replace Cook's neutron capture cross section data by those of Japanese Nuclear Data Committee

cooperation : none

other relevant details : The file contains 1114 nuclides. Neutron capture cross sections are given for 56 nuclides.

computer file of compiled data : Exist

computer file of evaluated data : Exist

discrepancies encountered : Beta decay heat at short cooling time less than $\sim$ 10 sec was not in good agreement with experimental values

completion date : Feb. 1975

publications :

1. K.Tasaka and N.Sasamoto, "Energy Release from the Decay of Fission Products," JAERI-M 5552 (1974).
2. K. Tasaka and N. Sasamoto, Nucl. Sci. Eng. ,54, 177 (1974).
3. K. Tasaka, "Calculation of the Decay Power of Fission Products considering Neutron Capture Transformation," JAERI-M 5972 (1975).
4. K. Tasaka, "Nuclear Data for Calculation of the Decay Power of Fission Products," JAERI-M 5997 (1975).

Laboratory and Address: Japanese Nuclear Data Committee/F.P. Nuclear Data Working Group (Japan Atomic Energy Research Institute, Tokai-mura, Naka-gun, Ibaraki-ken, Japan)

Names: S. Iijima (Nippon Atomic Industry Group Co.) group leader
S. Igarasi, T. Nakagawa, Y. Kikuchi, Z. Matsumoto(JAERI)
H. Matsunobu (Sumitomo Atomic Industries)
M. Kawai, T. Yoshida, T. Murata (Nippon Atomic Industry Group Co.)
H. Sasaki (Mitsubishi Atomic Industries, Inc.)
H. Nakamura (Fuji Electric Co.)
K. Maki (Hitachi Co.)
T. Watanabe (Kawasaki Heavy Industries)
I. Otake, A. Zukeran (Power Reactor and Nuclear Fuel Development Corporation)
R. Nakasima (Hosei Univ.)

<u>Compilation</u>: Nuclear level scheme by R. Nakasima, Z. Matsumoto and T. Murata. Neutron capture cross sections by H. Matsunobu, M. Kawai and T. Watanabe. (Ongoing.)

purpose: For evaluation of neutron cross sections of F.P.

major sources of information:
Recent literatures and Nuclear Data Sheets (level scheme), and CINDA75 and NEUDADA library (neutron cross section).

deadline of literature coverage: none in particular

cooperation with other groups: none at present

other relevant details: Compilation covers about 90 F.P. nuclides.

computer files: In plan for level scheme data. NESTOR file for cross section data (for use of comparison plotting).

expected completion date: Mid 1976 for about 90 F.P. nuclides.

publications: JAERI-M5752(1974) for level schemes of 28 nuclides.
Paper presented to Bologna conference (1973) by H. Matsunobu.

<u>Evaluation</u>: neutron cross sections (ongoing)

purpose: For entry to JENDL-1 (<u>J</u>apanese <u>E</u>valuated <u>N</u>uclear <u>D</u>ata <u>L</u>ibrary).

method: Calculation with optical model and statistical theory, adjusted by capture data.

major sources of information:
NEUDADA library, BNL-325 3rd edition and the domestic compilation of level scheme data

(continues)

(cont'd)

dead line of literature coverage: 1976

cooperation with other groups: Japanese Nuclear Data Committee/ F.P. Reactor Constants Working Group

status: Evaluation was completed for 27 nuclides on March 1975. For other about 60 nuclides, evaluation started from April 1975.

other relevant details: none

computer file of compiled data: NESTOR

computer file of evaluated data: JENDL

discrepancies encountered: many (see part III of this Newsletter)

expected completion date: mid 1976

publication: JAERI-M5752 (1974), Papers presented to Bologna meeting (1973) and Washington conference (1975). Revision of JAERI-M5752 was completed and is being prepared to submit to Journal of Nucl. Sci. and Technol.

Japanese Nuclear Data Committee/Decay Heat Nuclear Data Working Group

R. Nakasima (Hosei University) group leader
M. Yamada (Waseda University)
T. Tamai (Kyoto University, now at West-Germany)
I. Otake and A. Zukeran (Power Reactor & Nuclear Fuel Development Corp.)
S. Iijima, T. Murata and T. Yoshida (Nippon Atomic Industry Group Co.)
T. Hojuyama (Mitsubishi Atomic Power Industry)
K. Umezawa, K. Tasaka, Z. Matumoto and T. Tamura (JAERI)

1. Compilation: decay data and delayed neutron data (planned)

Purpose: For summation calculation of after heat

Major Sources of Information:

Nuclear Data Sheets, especially Recent Reference List appeared in Nuclear Data Sheets

Deadline of Literature Coverage: None

Cooperation: None

Other Relevant Details: Subgroup member (Hojuyama, Matsumoto, Murata, Tasaka and Iijima) are now studying data storage and retrieval system referring to ORNL nuclear structure file

Computer file: None at present

Expected Completion date: None, but the end of this year for data storage and retrieval system

Publications: None

2. Evaluation: beta decay data (on going)

Purpose: Making more reliable estimation for short-lived nuclides for which experimental data are either not availalbe or less reliable

Method: Application of gross theory of beta decay and various mass formulae

Major Sources of Information:

Several works by M. Yamada and his collaborators, for example Atom. Data and Nucl. Data Tables 12 (1973) 101

Deadline of Literature Coverage: None

Status: A computer porgramm based on gross theory of beta decay, originally developed by Waseda Group, has been revised by Yoshida for the present purpose (GROSS-M,-P) and some 100 nuclides have been tested comparing estimated and experimental results, but quite preliminary

- cont'd -

- cont'd -

Cooperation: Yamada's group at Waseda University

Other Relevant Details: Preliminary test shows that further investigation is necessary for parameters included in GROSS-M and -P.

Computer File of Compiled Data: None

Computer File of Evaluated Data: None

Discrepancies Encountered: Not clear yet

Expected Completion Data: April 1976 for important short-lived fission product nuclides

Publications: "Estimation of Decay Data for Short-Lived Fission Products" (1975), NEACRP A-241
T. Yoshida; to be published

3. Evaluation: released beta and gamma energies from fission products: (planning)

Purpose: Making data file for calculation of after heat

Method: Use of yield and ecay data compiled or estimated by ourselves

Major Sources of Information:

Our own compiled and estimated data supplemented by other evaluated data

Deadline of Literature Coverage: Not set up yet

Status: Decay data; as mentioned above
Yield data; going on

Cooperation: None

Other Relevant Details: Charge yield of fission product nuclides is not so easy to get recommendable value

Computer File of Compiled Data: None at present

Computer File of Evaluated Data: None

Discrepancies Encountered: Not clear yet

Expected Completion Date: Hopefully, early in 1977

Publications: None, but some of the members, for example, Tasaka and Umezawa reported some before our plan was discussed

UKAEA
Atomic Energy Research
Establishment, Harwell,
Oxfordshire, OX11 ORA

Laboratory	AERE Harwell
Name	E.A.C. Crouch
Compilation	Chain, Cumulative and Indpendent fission product yields for all neutron induced fission reactions with neutrons of energy up to 14 MeV, including spontaneous fission. Ongoing compilation.
Purpose	Basic data for fission yield evaluation.
Sources	Journals, Proceedings of Learned Societies, or other open literature.
Deadline	No results prior to 1950 are collected.
Cooperation	We are prepared to exchange files with other groups.
Computer File	Information held in standard forms on Computer Files.
Completions	Continuous compilation.
Publications	AERE R6642 'A library of neutron induced fission product yields maintained and interrogated by computer methods'. 'Part I: The establishment of the library'. E.A.C. Crouch, December 1970. AERE R7207 'A library of neutron induced fission product yields maintained and interrogated by computer methods'. 'Part II: The interrogation of the library'. E.A.C. Crouch, August 1972

Laboratory	AERE Harwell	UKAEA AERE, Harwell, Oxfordshire, OX11 ORA
Name	E.A.C. Crouch	
Evaluation	Evaluation of neutron induced fission product yields for all fissile nuclides at neutron energies up to 14 MeV.	
Purpose	Reactor design and operation	
Method	The individual yields for a given reaction are examined, weighted and the means calculated together with the errors.	
Sources	Compilation described above	
Deadline	No results prior to 1950 are collected.	
Status	Evaluation just started.	
Co-operation	We are prepared to exchange files with other Groups.	
Computer file	Compilation as above.	
Computer file of Evaluated Data	Card file in ENDF/BIV Format.	
Discrepancies	Not yet found.	
Publication	Sometime in 1976	

Laboratory: AERE Harwell

UKAEA
AERE Harwell,
Oxfordshire OX12 ORA,
England.

Working group:

B.S.J. Davies	CEGB, Berkeley
M. F. James	AEE Winfrith
A. L. Nichols	AERE Harwell
D. G. Vallis	Aldermaston

Ongoing and planned activities

1) Compilation and evaluation

Fission Product decay data

purpose : to provide a comprehensive, continually updated data file of radionuclidic half-lives, β and γ energies and intensities.

major sources of information : an initial data base of two separate (pre-1974) γ-libraries are being used, and are to be merged into one data file. They are the FPND of A. Tobias (CEGB RD/B/M2669) and the comprehensive γ-library of G. Erdtmann and W. Soyka (Jülich 1003-AC). The recent literature and NDS are also being surveyed.

deadline of literature coverage : an acceptable data file is expected by late 1976, the first round of the literature evaluation being up to December 1975 and incorporated into the file.

co-operation : the French bibliography (J. Blachot) will be used to aid FP data input.

relevant details : it is hoped that further comparisons of this data with other data files (e.g. US ENDF/BIV file) will be possible. The literature is also continually being assessed, and it is hoped that updating will occur annually from the completion date onwards. The data file will eventually be in ENDF/BIV format. Although the first priority is FP data, the data file will also include decay data of non-FP nuclides.

expected completion date : late 1976, including the first round of literature evaluations.

(cont'd)

2) Decay scheme calculations

purpose : to compare experimental data with decay data calculated from a more basic data set (e.g. spin, parity etc.)

major sources of information : ORNL data file containing the various parameters of decay levels. Internal conversion coefficient data of Trusov, and Hager and Seltzer will be used. The program also uses the calculated $(\bar{E}/E_0)_\beta$ of Widman et al, and the calculated EC/β^+ of Zweifel. The intention is also to use data from the latest Lederer and Hollander Table of Isotopes.

co-operation : Department of Nuclear Technology, Imperial College, London.

relevant details : CASCADE, a computer program written by D. G. Vallis, is being used to compute the decay data of a parent nuclide to its daughter(s). It is hoped that a direct comparison between the computed results and experimental data will highlight discrepancies, and also reveal compilation errors in decay data files. The program will be applied to FP nuclides initially.

publications : The CASCADE program, D.G. Vallis
AWRE Report No. O 45/74

Laboratory and address: General Electric Company, Vallecitos Nuclear Center, P. O. Drawer B, Pleasanton, CA 94566 U.S.A.

Name: B. F. Rider

Compilation: Fission product yields (from thermal, fast, 14 MeV neutron-induced fission in U, Pu, Th nuclides)

purpose: For burnup and fission rate and decay heat calculations. Basis for ENDF/B-IV FP yields.

major sources of information: CINDA, Nuclear Science Abstracts, RECON, correspondence

deadline of literature coverage: ongoing

cooperation: (with other groups, if any) Brookhaven (SIGMA Center), Cross-Section Working Evaluation Group (LSWEG), Evaluation Nuclear Data File (ENDF/B-IV), Fission Product Decay Heat Task Force

other relevent details (if any): approximately 12000 entries from 800 references

Computer file: Tape available as ENDF/B-IV from Brookhaven National Lab., U.S.A.

[expected] completion date: August 1974. ENDF/B-V (next version) planned for 1976 or 1977.

Publications: "Compilation of Fission Product Yields," NEDO-12154-1 available from General Electric Co., P. O. Drawer B, Pleasanton, CA 94566, U.S.A., Attn: B. F. Rider

Laboratory and address: Los Alamos Scientific Laboratory
P.O. Box 1663
Los Alamos, New Mexico 87545

Hanford Engineering Development Laboratory
P.O. Box 1970
Richland, Washington 99352

Names: TR England and RE Schenter

Compilation: "ENDF/B-IV Fission Product Files: Summary of Major Nuclide Data"
LA-6116-MS ENDF-223 9/75

The major fission-product parameters (σ_{th}, RI, $\tau_{1/2}$, $\bar{E}_\beta$, $\bar{E}_\gamma$, $\bar{E}_\alpha$, decay and (n,γ) branching, Q, and AWR] abstracted from ENDF/B-IV files for 824 nuclides are summarized. These data are most often requested by users concerned with reactor design, reactor safety, dose, and other sundry studies. The few known file errors are corrected to date. Tabular data are listed by increasing mass number.

purpose: Two and one-half years ago, a large task force was organized to expand the ENDF/B fission-product data from a 55-nuclide cross-section data set to a comprehensive file which, at present, encompasses data on 824 nuclides; these data include cross sections, decay parameters, and yields. Approximately 30 people from various industrial and government laboratories have cooperated in this task. This ad hoc group of people was divided into several subcommittees working under the Cross Section Evaluation Working Group (CSEWG) Fission-Product Subcommittee Task Force to produce evaluated data for use in decay heat and burnup calculations as part of the general effort to produce an Evaluated Nuclear Data File (ENDF/B).

The motivation for an expanded file began with the need for a reference set of fission-product decay data for calculating decay heating during "loss-of-coolant accidents" (LOCA). However, the task force members recognized the need for expanded fission-product microscopic cross-section data, adequate for thermal and fast reactor analysis; improved fission yields; and detailed fission-product gamma "line" data for a number of applications, including absorption buildup, waste disposal and fuel management, shielding (spectra), fuel integrity (gas content), and the buildup of radiologically hazardous and toxic products.

publications:
1. C. W. Reich, R. G. Helmer, and M. H. Putnam, "Radioactive-nuclide Decay Data for ENDF/B," Aerojet Nuclear Company report ANCR-1157 (ENDF-120) (August 1974).

2. R. E. Schenter and F. Schmittroth, "Radioactive Decay Heat Analysis," Conf. on Nuclear Cross Sections and Tech., Washington, D.C. (March 1975).

publications: (cont'd)

3. R. E. Schenter and T. R. England, "Nuclear Data for Calculations of Radioactivity Effects," Trans. Am. Nucl. Soc. 21, 517 (June 1975).

4. M. G. Stamatelatos and T. R. England, "Fission-Product Gamma Ray and Photoneutron Spectra," Conf. on Nuclear Cross Sections and Tech., Washington, D.C. (March 1975).

Laboratory and address: Hanford Engineering Development Laboratory
P.O. Box 1970
Richland, Washington 99352

Names: RE Schenter, F Schmittroth, and FM Mann

Evaluation:

Capture, inelastic and elastic cross section evaluations for the ENDF/B-V file to be submitted for Phase 1 (differential) and Phase 2 (integral) review and testing by CSEWG (Cross Section Evaluation Working Group).

purpose: The important FP cross sections for fast reactor application are to be updated. These include isotopes of the following elements: Kr, Rb, Sr, Y, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Te, I, Xe, Cs, Ba, La, Ce, Pr, Nd, Pm, Sm.

method: Review of recent experimental integral and differential measurements. Updating methods and input to nuclear model codes NCAP and HAUSER.

major sources of information: RPI and ORNL capture measurements, CFRMF and STEK integral results, CSIRS, and CINDA 75 references.

[expected] completion date: July 1, 1976.

Laboratory: Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tennessee 37830

Names: D.J. Horen et al. (Nuclear Data Project)

Compilation: Mass-chain compilations of structure and decay data. See Table below *.

Nuclear Data Project

CUMULATED INDEX TO A-CHAINS

A	Nuclei	Reference	Date	A	Nuclei	Reference	Date	A	Nuclei	Reference	Date	A	Nuclei	Reference	Date
1	H			67	Zn	NDS 16,417	1975	133	Cs	NDS 11,495	1974	199	Hg	B6-355	1971
2	H			68	Zn	NDS 14,155	1975	134	Xe,Ba	NDS 15,203	1975	200	Hg	B6-387	1971
3	He			69	Ga	ENSDF	•	135	Ba	NDS 14,191	1975	201	Hg	B5-561	1971
4	He	NP A206,1	1973	70	Zn,Ge	B8-1	1972	136	Xe..Ce	NDS 13,191	1974	202	Hg	B5-581	1971
5		NP A227,5	1974	71	Ga	NDS 10,205	1973	137	Ba	NDS 15,335	1975	203	Tl	B5-531	1971
6	Li	NP A227,25	1974	72	Ge	NDS 11,121	1974	138	Ba,Ce	ENSDF	•	204	Hg,Pb	B5-601	1971
7	Li	NP A227,53	1974	73	Ge	NDS 13,305	1974	139	La	NDS 12,139	1974	205	Tl	B6-425	1971
8	Be	NP A227,77	1974	74	Ge,Se	ENSDF	•	140	Ce	NDS 12,343	1974	206	Pb	B7-161	1972
9	Be	NP A227,111	1974	75	As	NDS 16,25	1975	141	Pr	NDS 10,151	1973	207	Pb	B5-207	1971
10	B	NP A227,139	1974	76	Ge,Se	ENSDF	•	142	Ce,Nd	NDS 10,309	1973	208	Pb	B5-243	1971
11	B	NP A248,1	1975	77	Se	NDS 9,229	1973	143	Nd	NDS 13,229	1974	209	Bi	B5-287	1971
12	C	NP A248,1	1975	78	Se,Kr	NDS 15,107	1975	144	Nd,Sm	NDS 16,231	1975	210	Po	B5-631	1971
13	C	NP A152,3	1970	79	Br	NDS 15,257	1975	145	Nd	NDS 12,203	1974	211	Po	B5-319	1971
14	N	NP A152,42	1970	80	Se,Kr	NDS 15,289	1975	146	Nd,Sm	NDS 14,413	1975	212	Po	B8-165	1972
15	N	NP A152,93	1970	81	Br	NDS 15,137	1975	147	Sm	ENSDF	•	213	Po	NDS 10,597	1973
16	O	NP A166,1	1971	82	Se,Kr	NDS 15,315	1975	148	Nd,Sm	ENSDF	•	214	Po	ENSDF	•
17	O	NP A166,61	1971	83	Kr	NDS 15,169	1975	149	Sm	ENSDF	•	215	At	ENSDF	•
18	O	NP A190,1	1972	84	Kr,Sr	B5-109	1971	150	Nd..Gd	ENSDF	•	216	Po,Rn	ENSDF	•
19	F	NP A190,56	1972	85	Rb	B5-131	1971	151	Eu	ENSDF	•	217	Rn	NDS 10,611	1973
20	Ne	NP A190,105	1972	86	Kr,Sr	B5-151	1971	152	Sm,Gd	ENSDF	•	218	Rn	ENSDF	•
21	Ne	NP A214,13	1973	87	Sr	B5-457	1971	153	Eu	NDS 10,429	1973	219	Fr	ENSDF	•
22	Ne	NP A214,31	1973	88	Sr	ENSDF	•	154	Sm..Dy	ENSDF	•	220	Rn,Ra	ENSDF	•
23	Na	NP A214,57	1973	89	Y	NDS 16,445	1975	155	Gd	NDS 15,409	1975	221	Ra	NDS 10,625	1973
24	Mg	NP A214,80	1973	90	Zr	NDS 16,55	1975	156	Gd,Dy	ENSDF	•	222	Ra	ENSDF	•
25	Mg	NP A214,111	1973	91	Zr	B8-477	1972	157	Gd	NDS 9,273	1973	223	Ra	ENSDF	•
26	Mg	NP A214,135	1973	92	Zr,Mo	B7-299	1972	158	Gd,Dy	NDS 12,245	1974	224	Ra,Th	ENSDF	•
27	Al	NP A214,158	1973	93	Nb	B8-527	1972	159	Tb	NDS 9,435	1973	225	Ac	NDS 10,643	1973
28	Si	NP A214,182	1973	94	Zr,Mo	NDS 10,241	1973	160	Gd,Dy	NDS 12,477	1974	226	Ra,Th	ENSDF	•
29	Si	NP A214,212	1973	95	Mo	B8-29	1972	161	Dy	NDS 13,493	1974	227	Th	ENSDF	•
30	Si	NP A214,231	1973	96	Mo,Ru	B8-599	1972	162	Dy,Er	NDS 17,97	1976	228	Th	ENSDF	•
31	P	NP A214,250	1973	97	Mo	NDS 10,1	1973	163	Dy	B8-295	1972	229	Th	B6-209	1971
32	S	NP A214,271	1973	98	Mo,Ru	NDS 11,157	1974	164	Dy,Er	NDS 11,327	1974	230	Th,U	B4-543	1970
33	S	NP A214,293	1973	99	Ru	NDS 12,431	1974	165	Ho	NDS 11,189	1974	231	Pa	B6-225	1971
34	S	NP A214,313	1973	100	Mo,Ru	NDS 11,279	1974	166	Er	NDS 14,471	1975	232	Th,U	B4-561	1970
35	Cl	NP A214,332	1973	101	Ru	NDS 10,47	1973	167	Er	NDS 17,143	1976	233	U	B6-257	1971
36	S,Ar	NP A214,350	1973	102	Ru,Pd	ENSDF	•	168	Er,Yb	NDS 11,285	1974	234	U	B4-561	1970
37	Cl	NP A214,370	1973	103	Rh	NDS 13,337	1974	169	Tm	NDS 10,359	1973	235	U	B6-287	1971
38	Ar	NP A214,388	1973	104	Ru,Pd	ENSDF	•	170	Er,Yb	NDS 15,371	1975	236	U,Pu	B4-623	1970
39	K	NP A214,410	1973	105	Pd	NDS 11,449	1974	171	Yb	NDS 11,549	1974	237	Np	B6-539	1971
40	Ar,Ca	NP A214,428	1973	106	Pd,Cd	NDS 13,397	1974	172	Yb	NDS 15,497	1975	238	U,Pu	B4-635	1970
41	K	NP A214,457	1973	107	Ag	B7-1	1972	173	Yb	NDS 14,297	1975	239	Pu	B6-577	1971
42	Ca	NP A214,483	1973	108	Pd,Cd	B7-33	1972	174	Yb	NDS 10,515	1973	240	Pu	B4-661	1970
43	Ca	NP A214,508	1973	109	Ag	B6-1	1971	175	Lu	ENSDF	•	241	Am	B6-621	1971
44	Ca	NP A214,532	1973	110	Pd,Cd	B5-487	1971	176	Hf	ENSDF	•	242	Pu,Cm	B4-683	1970
45	Sc	B4-237	1970	111	Cd	B6-39	1971	177	Hf	NDS 16,135	1975	243	Am	ENSDF	•
46	Ca,Ti	B4-269	1970	112	Cd,Sn	B7-69	1972	178	Hf	NDS 13,549	1974	244	Pu,Cm	ENSDF	•
47	Ti	B4-313	1970	113	In	B5-181	1971	179	Hf	ENSDF	•	245	Cm	ENSDF	•
48	Ti	B4-351	1970	114	Cd,Sn	NDS 16,107	1975	180	Hf,W	NDS 15,559	1975	246	Cm	ENSDF	•
49	Ti	B4-397	1970	115	Sn	NDS 16,195	1975	181	Ta	NDS 9,319	1973	247	Bk	ENSDF	•
50	Ti,Cr	B3-5,6-1	•	116	Cd,Sn	NDS 14,247	1975	182	W	NDS 14,559	1975	248	Cm,Cf	ENSDF	•
51	V	B3-5,6-37	1970	117	Sn	ENSDF	•	183	W	NDS 16,267	1975	249	Cf	ENSDF	•
52	Cr	B3-5,6-85	1970	118	Sn	NDS 17,1	1976	184	W	ENSDF	•	250	Cf	ENSDF	•
53	Cr	B3-5,6-127	1970	119	Sn	ENSDF	•	185	Re	NDS 12,533	1974	251	Cf	ENSDF	•
54	Cr,Fe	B3-5,6-161	1970	120	Sn,Te	NDS 17,39	1976	186	W,Os	NDS 13,267	1974	252	Cf,Fm	ENSDF	•
55	Mn	B3-3,4-1	•	121	Sb	B6-75	1971	187	Os	NDS 14,347	1975	253	Es	ENSDF	•
56	Fe	B3-3,4-43	1970	122	Sn,Te	B7-419	1972	188	Os	NDS 10,553	1973	254	Cf,Fm	ENSDF	•
57	Fe	B3-3,4-103	1970	123	Sb	B7-363	1972	189	Os	NDS 12,397	1974	255	Fm	ENSDF	•
58	Fe,Ni	B3-3,4-145	•	124	Sn..Xe	NDS 10,91	1973	190	Os,Pt	NDS 9,401	1973	256	Fm	ENSDF	•
59	Co	ENSDF	•	125	Te	B7-465	1972	191	Ir	NDS 9,479	1973	257	Fm	ENSDF	•
60	Ni	NDS 16,317	1975	126	Te,Xe	NDS 9,125	1973	192	Os,Pt	NDS 9,195	1973	258	Fm	ENSDF	•
61	Ni	NDS 16,1	1975	127	I	B8-77	1972	193	Ir	B8-389	1972	259		ENSDF	•
62	Ni	NDS 13,443	1974	128	Te,Xe	NDS 9,157	1973	194	Pt	B7-95	1972	260		ENSDF	•
63	Cu	NDS 14,119	1975	129	Xe	B8-123	1972	195	Pt	B8-431	1972	261		ENSDF	•
64	Ni,Zn	NDS 12,305	1974	130	Te..Ba	NDS 13,133	1974	196	Pt,Hg	B7-395	1972	262		ENSDF	•
65	Cu	NDS 16,351	1975	131	Xe	ENSDF	•	197	Au	B7-129	1972	263		ENSDF	•
66	Zn	NDS 16,383	1975	132	Xe,Ba	ENSDF	•	198	Pt,Hg	B6-319	1971				

EXPLANATION

The cumulated index gives, for each mass value A, the most recent compilation of experimental information on levels of nuclei with that A-value.

NUCLEI The beta-stable member(s) of this A-chain

REFERENCE NP = Nuclear Physics
NDS 9,125 = Nuclear Data Sheets, vol.9, p.125
B4-269 = Nuclear Data Sheets B4, 269
B1-4-85 = Nuclear Data B1-4-85

ENSDF Preliminary summaries of recent results may be obtained as computer printout from the Evaluated Nuclear Structure Data File of the Nuclear Data Project

DATE The year in which the compilation was published

• Indicates that a revision is in progress

*Note from editor: Due to the many items the authors are involved in, they considered it the best to send us this updated version of the cumulated index which is usually included in the Nucl.Data Sheets. Since the compilation is not fission-product oriented, the Table includes also non-FP.

III. DISCREPANCIES

(A brief summary of the discrepancies between experimental data reported in this issue)

A., Discrepancies encountered during experimental work:

a., Fission yields:

15 MeV fission of ^{232}Th: (Nethaway et al, p. 35 of this newsletter)
The independent yields of ^{96}Nb and ^{136}Cs are in serious disagreement to the values reported by S.A. Rao (Phys.Rev. C5, 171 (1972)).

thermal fission of ^{235}U: (V.K. Rao et al, p. 16)
Upper limits for the yields of ^{66}Ni and ^{67}Cu are lower than the values given in literature.

thermal fission of ^{239}Pu: (M.V. Ramaniah and H.C. Jain, p. 18)
Yields of ^{99}Mo, ^{103}Ru and ^{131}I show major differences to literature values. Light and heavy mass peaks are of about equal height, in contrast to the data reported in literature.

b., Gamma-intensities: (Debertin et al, p. 14)

^{144}Pr, 696 keV-line: absolute emission probability obtained is 10% lower than the recommended value.

^{140}Ba, 537 keV-line: absolute emission probability is 20% higher than the value given in Nucl.Data Sheets, 1974.

c., P -values: (Ristore and Crançon, p. 10)

^{90}Br, ^{137}Te: results obtained do not agree with reported data.

B., Discrepancies encountered during compilations/evaluations:

a., (n,γ) cross-sections at 30 keV: (Iijima et al, p. 51)

^{95}Mo: 20%	discrepancies between evaluations of cross-sections for which experimental data are available
^{97}Mo, ^{99}Tc, ^{103}Rh, ^{133}Cs: 30%	
^{102}Ru: 50%	
^{104}Ru, ^{109}Ag, ^{147}Sm: 100%	

(Iijima et al reported also discrepancies between evaluations that are based on theoretical models. Their whole contribution on discrepancies is attached as Appendix (p.57)).

b., Decay-heat: (K. Tasaka, p. 50)

< 10 sec cooling time: calculations based on decay data do not agree with experiments.

APPENDIX

Discrepancies encountered by JNDC/FPND Working Group:

Our recent evaluation of cross sections for 27 nuclides was compared with evaluated data of Cook, Benzi et al., Schmittroth and Schenter, and Lautenbach. Main items of discrepancies encountered are as follows.

(1) (n,gamma) cross sections at neutron energy 30 keV

Discrepancies among the evaluated data sets were very often greater than 30 %. Even for nuclides for which capture data are available, discrepancies were : about 20 % for ^{95}Mo, 30 % for ^{97}Mo, ^{99}Tc, ^{103}Rh, and ^{133}Cs, 50 % for ^{102}Ru, and a factor of 2 for ^{104}Ru, ^{109}Ag and ^{147}Sm.

(2) (n, gamma) cross sections at neutron energy 2 MeV

Comparing our results with those of Benzi et al., large disagreements beyond a factor of 5 were found for ^{143}Nd (factor of 10), ^{149}Sm (factor of 5), and ^{151}Sm (factor of 5). In case of ^{143}Nd, we confirmed that this disagreement has come from the difference in the adopted level scheme data. For ^{151}Sm there seems to be other reason for the discrepancy.

(3) Inelastic scattering cross section

Large disagreements were found for ^{151}Sm as was already noted by Ribon and Krebs (Review paper No. 10, IAEA-169). Our results were somewhat larger than Saclay evaluation in the energy range 10 - 100 keV, but the shape of excitation function was similar. Instead of Moldauer's theory, we have also tried Hauser-Feshbach theory. This choice has given a high inelastic cross section, while compound elastic cross section was diminished.
We are thinking that the choice of calculational method is probably the main reason for large disagreements for this nuclide. We also feel that the exact treatment of mutual competitions among competing reactions is important for this nuclide particularly.

(4) Level scheme

Status for 28 nuclides were given in JAERI-M 5752. There are much to be done in this field.