International Atomic Energy Agency

INDC(NDS)-86/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)

collected

by

G. Lammer

Nuclear Data Section
International Atomic Energy Agency

Vienna, Austria

No. 3 May 1977

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FOREWORD

This is the third issue of a report series on Fission Product Nuclear Data (FPND) which is published by the Nuclear Data Section (NDS) of the International Atomic Energy Agency (IAEA). The purpose of this series 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 first two issues have been published in November 1975 as INDC(NDS)-70/G+P and in May 1976 as INDC(NDS)-75/G+P respectively. The present issue includes contributions which were received by NDS between 1 June 1976 and 15 May 1977.

The next issue of this report seires is envisaged to be published in May 1978.

How to submit contributions:

The next issue is expected to be published in May 1978. All scientists who are presently working - or have recently completed work - in the field of FPND and who want to contribute to the 3rd issue of this series, are kindly asked to send contributions to me between now and the end of April 1978, so that they reach NDS before 30 April 1978.

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.

Format of the contributions:

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

Subject-index[a)]

1. Measurements

1.1. Fission Yields

Fissionable isotope	pages: Thermal reactor neutrons	fast reactor neutrons	$E_n \cong 14$ MeV	E_n pointwise
^{232}Th	76	76	67	
^{233}U	(8),32,38,65,66, 75,76	58,65,66,76	65,66,76,24	
^{235}U	(8),11,14,15,17, 26,32,38,60,75, 76,64,65,66	(40),41,(48), 58,64,65,66,11 76	64,65,66,76.24	
^{238}U	64,65,66,76	11,(40),41,(48), 58,64,65,66,76	24,64,65,66,76	42,50,spont.:62
U-isotopes: T3-yields	44	44		
^{236}Np	71			
^{237}Np		58		
^{239}Pu	(8),16,32,38,60, 64,65,66,75,76	(40),41,(48), 58,64,65,66,76	64,65,66,76,24	43
^{240}Pu	64	(48),58,64,69	68	64
^{241}Pu	(8),28	(48),58		
^{242}Pu		58		
Pu-isotopes: T3-yields	44	44		
^{241}Am		(58)	70	
^{242m}Am	66	66	66	
^{243}Am		58		
^{245}Cm	27			
^{249}Cf	13,38			

a) as compared to INDC(NDS)-75:

____ , underlined page-numbers refer to new contributions,

( ) , page-numbers in brackets refer to unchanged contributions, others refer to revised contributions.

1.2. Neutron cross-sections

Isotopes	pages	type of c.s., neutron-energy
Kr^{85}	10	transmission, E = 1eV-1.5keV
Rb^{87}	77	(n,γ) integ, E = fast
Sr^{86-88}	72	(n,γ), E = 2.6-500keV
Y^{89}	72	" " "
	77	(n,γ) integ, E = fast
Zr^{90}	(72)	(n,γ), E = 2.6-500keV
Zr^{91}	6	(n,γ), Res-int,total,E = 150eV-3keV
	31	res.pars, E ≤ 15keV
	72	(n,γ), E = 2.6-500keV
$Zr^{92,94}$	72	" " "
Zr^{96}	6	(n,γ),Res-int,total,E = 150eV-3keV
	31	res.pars, E ≤ 15keV
Nb^{93}	4	(n,γ),Res-int,scatt,total,E = 30eV-7keV
	(72),77	(n,γ), E = 2.6-500keV ; integ, E=fast
$Mo^{92,94,96,97}$	72	" " "
Mo^{98}	72	" " "
	77	(n,γ) integ, E = fast
Mo^{100}	72	(n,γ), E = 2.6-500keV
	77	(n,γ) integ, E = fast
Tc^{99}	77	" " "
	10	transmission, E = 1eV-1.5keV
$Ru^{100,101}$	72	(n,γ), E = 2.6-500keV
$Ru^{102,104}$	72	" " "
	77	(n,γ) integ, E = fast
Rh^{103}	77	" " "
	(72)	(n,γ), E = 2.6-500keV
$Pd^{104-106}$	(72)	" " "
$Pd^{108,110}$	72	" " "
	77	(n,γ) integ, E = fast
$Ag^{107,109}$	77	" " "
$Cd^{106,108,110-114,116}$	(72)	(n,γ), E = 2.6-500keV
In^{115}	77	(n,γ) integ, E = fast
$Sb^{121,123}$	77	" " "
$Te^{122-126,128,130}$	(72)	(n,γ),E = 2.6-500keV
I^{127}	3	(n,γ),res-int,total, E = 20eV-5keV
	77	(n,γ) integ, E = fast

Isotopes	pages	type of c.s., neutron-energy
I^{129}	77	(n,γ) integ, E = fast
$Xe^{132,134}$	77	" " "
Xe^{135}	53	absorption, reactor-neutrons
Cs^{133}	77	(n,γ) integ, E = fast
$Cs^{133+135+137}$	10	transmission, E = 1eV-1.5keV
$Ba^{134-138}$	72	(n,γ), E = 2.6-500keV
La^{139}	72	" " "
	77	(n,γ) integ, E = fast
Ce^{140}	77	" " "
	(72)	(n,γ), E = 2.6-500keV
Ce^{142}	77	(n,γ) integ, E = fast
Pr^{141}	77	" " "
	(72)	(n,γ), E = 2.6-500keV
$Nd^{142-145}$	72	" " "
$Nd^{146,148}$	72	" " "
	77	(n,γ) integ, E = fast
Nd^{150}	77	" " "
Pm^{147}	77	" " "
Pm^{149}	53	absorption, reactor neutrons
Sm^{152}	77	(n,γ) integ, E = fast
Eu^{151}	77	" " "
$Eu^{151+\ldots+155}$	(10)	transmission, E = 1eV-1.5keV
Eu^{153}	77	(n,γ) integ, E = fast
Gd^{156}	31	res.pars, E ≦ 3keV
$Gd^{158,160}$	77	(n,γ) integ, E = fast
Tb^{159}	72	(n,γ), E = 2.6-500keV
Ho^{165}	(72)	" " "
Tm^{169}	72,77	" " " ; integ, E=fast
Unseparated fissions products	53	absorption, reactor neutrons

1.3. Decay data

Isotopes or Mass Chains	Pages $T_{1/2}$	Pages γ-data	Pages β-data, Q-values
A = 75-96		36	36
Zn^{75-78}			36
Ga^{76-79}			36
$Ge^{79,80}$			36
$As^{80,81,83}$			36
Se^{85-88}	19		
$Br^{85,86}$			36
Br^{87-89}	36	36	36
A =90-106	9	9	
Y^{96-100}	20	20	
$Zr^{101-104}$	18	18	
$Nb^{101-106}$	18	18	
$Mo^{103-108}$	18	18	
Ru^{103}	12	12	
Ru^{106}	12		
A = 116-146		36	36
$In^{120-129}$	36	36	36
$Sn^{127-133}$			36
Sb^{125}		12	
$Sb^{128,130-132,134}$			36
Te^{132}	12	12,63	
Te^{134}			36
Te^{135}		19	36
$Te^{136,137}$		19	
I^{131}	12	12	
I^{134}		63	
$I^{137-139}$	36	36	36
Xe^{133m}		(49)	
Co^{134}	12		
Ba^{139}		63	
Ba^{140}	12	12	
La^{140}	12	12	
La^{141}		63	

	$T_{1/2}$	γ-data	β-data, Q-values
$La^{143-148}$	34	34	
$Ce^{145-150}$	34	34	
$Pr^{145,146}$		63	
$Pr^{147-150}$	34	34	

1.4. Delayed neutron data [a]

Precursors	Pages: Pn-value	Pages: neutron-energy spectrum	Precursors	Pages: Pn-value	Pages: neutron-energy spectrum
A = 79-83	36		Sn^{134}		29
Zn^{79}		29	Sb^{135}	21	23,29
$Ga^{80,81}$		29	Te^{136}		23,29
As^{85}	21	23	$I^{137,138}$		23,29
A = 85	36		$I^{139,140}$		29
A = 87-96	36		Xe^{142}+Cs^{142}		29
$Br^{87,88}$		23,29	Cs		56
Br^{89-91}		29	Cs^{141}		23,29
Rb		56	Cs^{142}		23
Rb^{93}	21	23,29	$Cs^{143,144}$		23,29
Rb^{94-97}	21	23	$Cs^{145,146}$		23
Rb^{98}	21				
A = 123-146	36				
In		56	$U^{235,238}$ Pu^{239} fast fission	6 groups + total yield: 45	
$In^{129,130}$		29			

a) Half-lives of d.n. precursors are included in "decay data" (item 1.3.)

1.5. Decay heat

Fissioned Isotope	Pages: thermal β-heat	thermal γ-heat	thermal total	fast β-heat
Th^{232}			51	
U^{233}			51	
U^{235}	33,74	33,74	51	39
Pu^{239}	74	74	51	39

2. Compilations, evaluations [a]

(c .... compilation
e .... evaluation)

2.1. Fission yields

Fissionable element	neutron energy	pages
^{235}U	fast spectrum, 14 MeV	89 (c)
Th,U,Np,Pu,Cf	thermal, fast spectrum, 14 MeV	102 (c)
All	thermal	106 (c + e)
All	thermal to 15 MeV	(97) (c), 98 (e), 104 (e)

2.2. Neutron cross sections

type of c.s.	pages		
	c	e	group c.s.
elastic	93	92,93,96	92,96,104
inelastic	93	87,92,93,96	92,96,104
(n,γ)	93	87,92,93,96	92,96,104
(n,2n)		92,96	92,96,104
(n,p)		92	92,104
(n,α)		92	92,104
total	93	92,93,96	92,96,104

a) as compared to INDC(NDS)-75

———, under-lined page-numbers refer to new contributions,

( ) , page-numbers in brackets refer to unchanged contributions, others refer to revised contributions.

2.3. Decay data

data type	Pages c	Pages e
half-life	99, 103, 104	99
decay-scheme	95	100
Q-value	99, 103, 104	99
radiation spectra (energies+intens.)	99, 103, 104	95, 99, 104
β-strength		88

2.4. Delayed neutron data

	Page
spectra of 6 groups from Th^{232}, $U^{233,235,238}$, $Pn^{239,241}$	101 (e)

2.5. Decay heat

	Pages
β, γ-heat	95, 104

I. MEASUREMENT ACTIVITIES

C.E.C., Belgium

Laboratory and address: CBNM, Euratom, Geel, Belgium

Names: G. Rohr and R. Shelley

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

Experiment: Resonance parameters of ^{127}I

1) Capture cross section measurements.

   Energy range: 20 eV - 5 keV.
   Experiments completed, analysis completed in energy range 20-2020 eV

2) Selfindication ratio measurements.

   See capture.

3) Total cross section measurements.

   Energy range: 10 eV - 5 keV
   Experiments completed, analysis completed in energy range 20 - 900 eV

Method:

1) Capture cross section measurements.

   Detector: C_6F_6 detectors using Maier-Leibnitz method.
   Sample material: PbI_2
   Sample thickness: $2.485 \cdot 10^{-3}$ 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 $1.236 \cdot 10^{-2}$ 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 $1.236 \cdot 10^{-2}$ at/barn.

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

Expected completion date: Measurement completed. Results have been submitted for publication.

C.E.C., Belgium

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, R. Shelley, T. van der Veen and G. Vanpraet
Facilities:	Neutron time-of-flight spectrometers at the 60 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 Analysis completed. 3) Selfindication ratio Analysis up to 1 keV completed. 4) Total cross-section measurements Energy range: 30 eV - 7.2 keV Analysis completed. 5) Scattering cross-section measurements Energy range: 100 eV - 4 keV Analysis in progress.
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 Mayer-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.

contd.

contd.

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 1977.

C.E.C., Belgium

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 60 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.
   Analysis completed, spin and parity assigned for 13 resonances.

2) Capture measurement.

   Energy range: 150 eV - 20 keV.
   Analysis completed up to 3 keV.

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: 60m
   Sample material: ZrO_2
   Sample thicknesses: ^{91}Zr $7.310 \cdot 10^{-3}$ 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.

3) Selfindication ratio measurements.

   Detectors: C_6F_6 detectors.
   Flightpath: 60 m.
   Sample material: nat. Zr (metal).
   Sample thickness: ^{91}Zr $6.222 \cdot 10^{-3}$ at/barn.

contd.

C.E.C., Belgium

Method: 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: ^{91}Zr: end of 1977
^{96}Zr: end of 1978

FRANCE

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

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

Facilities : On line isotopic separation of fission products (Ariel facility) conncected with swimming pool reactor.

Experiment : Independent and cumulative yields of rare gas isotopes have been measured in thermal fission of ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu (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 uncertainty of our measurements is typically 4 %.

Publications :

1/ Distributions isotopiques des gaz rares dans la fission par neutrons thermiques de ^{235}U et ^{233}U.
Nuclear Physics A 255 (1975) p. 461-471.

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

3/ Distributions isotopiques des gaz rares dans la fission par neutrons thermiques de ^{239}Pu et ^{241}Pu.
To be published.

Laboratory and address:

GSF, Forschungsreaktor Neuherberg
Ingolstädter Landstraße 1
D-8042 Neuherberg bei München

Names: H.-J. Kreiner and P. Schlechte

Facilities: Pulsed TRIGA reactor Mark III,
Ultrafast Conveyor Tube System (URS)

Experiment: Growth-and-decay curves, E_γ, $T_{1/2}$ of shortlived light fission products (0.05 s < $T_{1/2}$ < 15 s) of ^{235}U, ^{239}Pu (and ^{247}Cm) with 90 < A < 106.

Method: The thin actinide-target is irradiated by the reactor puls (HW: 11 ms), the FP's were partly separated by mass absorption in thin foils and the catcher with the light FP is shot in measuring position within a transport time of 50 ms. The γ-energy spectra are measured with a GeLi-detector and recorded in multispectrum mode by a ND 812 multichannel analyser in time steps of 0.2 and 2 s.

Discrepancies to other reported data: The primary formation of ^{100}Zr, ^{101}Nb and ^{103}Nb was measured to be rather low, for these masses (and ^{235}U) $Z_p \geq Z_{UCD}$.
$T_{1/2}$: ^{99}Y, ^{103}Nb, ^{98}Y, ^{99}Zr

Publication: H.-J. Kreiner, Nucl. Instr. Meth. 141 (1977) 119

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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; 11 Li-6 glass-scintillation detectors; max. rotor speed 15 000 upm; min. burst width 0.64 μs; min. time channel width 100 ns.

Experiments:

Neutron resonance investigations by transmission measurements between 1 eV and 1.5 keV 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.

Ongoing: Tc 99 transmission with different sample thickness to clear up discrepancies in Γ_γ of first resonance;
low energy transmission of gross fission product mixture;
Cs 133/135/137 FP mixture for isotope identification of 42.8 eV and 880 eV resonances;
Pu 240 precision measurement for resonance parameter determination of 1.056 eV resonance.

Planned: EuO isotope mixture from fast reactor control rod (transmission & resonance identification);
Kr transmission (stable isotopes), in order to prepare Kr 85 measurement.

Method:

Sample-in-beam, sample-out-of-beam transmission measurement;
black resonance or boron filter background determination technique.

Accuracy:

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

Recent publications:
K. Freitag, U. Harz, H.G. Priesmeyer:
ICINN Conf., Lowell/Mass. 1976
K. Freitag: Diplomarbeit, Kiel 1977
U. Harz, H.G. Priesmeyer:
Frühjahrstagung DPG - Kernphysik - Konstanz 1977

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Laboratory and address:	Physikalisch-Technische Bundesanstalt D - 33 Braunschweig, Bundesallee 100
Name:	K. Debertin
Facilities:	^{252}Cf-source; thermal reactor FMRB; calibrated Ge(Li)-spectrometer
Experiment:	Determination of ^{235}U- and ^{238}U-fission yields in the fast neutron spectrum of a ^{252}Cf-source and, for ^{235}U, in a thermal neutron spectrum. Measurements are completed, evaluation is in progress.
Method:	The ^{252}Cf-source is mounted 15 m above ground in the open air. Uranium-samples, are irradiated in a 1 cm distance. Fission product activities are determined by measuring the γ-ray spectrum with a calibrated Ge(Li)-spectrometer.
Accuracy:	$\pm$ 1 % to $\pm$ 2 % (1σ uncertainty) for ^{235}U fast to thermal yield ratios, $\pm$ 2 % to $\pm$ 5 % for ^{238}U relative yields
Completion date:	^{235}U: completed ^{238}U: 1977
Publication:	Contribution to Review Paper 10 of the Second Advisory Group Meeting on Fission Product Nuclear Data, organized by IAEA, Petten, 5 - 9 September 1977 (preprints available)

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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 ^{103}Ru, ^{125}Sb, ^{131}I, $^{132}Te/^{132}I$, ^{134}Cs, $^{140}Ba/^{140}La$;

Determination of half-lives for ^{103}Ru, ^{106}Ru, ^{131}I, ^{132}Te, ^{140}Ba and ^{140}La

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 was calibrated in the energy range of interest to an accuracy of $\pm$ 1 % or less (1σ).

Accuracy: $\pm$ 1 % to $\pm$ 2 % (1σ uncertainty) for emission probabilities and less than $\pm$ 0,1 % for half-lives

Completion date: 1977

Publication: Contribution to Review Paper 12 of the Second Advisory Group Meeting on Fission Product Nuclear Data, organized by IAEA, Petten, 5 - 9 September 1977 (Preprints available)

Laboratory: Institut für Kernchemie
Universität Mainz
Postfach 1980
D-6500 Mainz, Germany

Names: H. Meixler, K. Wolfsberg (LASL), H.O. Denschlag

Facilities: TRIGA Mark II Reactor

Experiment: Fractional cumulative fission yields of Kr-89, -91, -92 and Xe-139 to -142 for $^{249}Cf(n_{th,f})$ and Kr-91, -92 and Xe-139 for $^{250}Cf(sp,f)$ have been determined.

Method: Radiochemical: Fission fragments from a thin layer of the fission material are stopped in Mg-stearate. Fission rare gases are diffusing through the stearate layer into an evacuated chamber. Fractional yields are calculated from the ratio of long lived descendants in the stearate and on the walls of chamber.

Accuracy: $\sim$ 10 % (relative to value)

Completion date: Completed

Publications: Jahresberichte 1975 and 1976,
Institut für Kernchemie
Universität Mainz

Laboratory:	Institut für Kernchemie Universität Mainz D-6500 Mainz, Germany and Institut Laue Langevin 38 Grenoble, France
Names:	H.O. Denschlag, Z. Alfassi (U. Beershava, Israel), J. Blachot (CENG, Grenoble), H. Braun, W. Faubel, T. Izak-Biran (SOREQ, Israel), H. Meixler, G. Paffrath, H. Schrader, G. Siegert, T. Tamai (KURRI, Japan) K. Wolfsberg (LASL, USA).
Facilities:	LOHENGRIN Mass-separator for unslowed fission products at ILL, Grenoble.
Experiment:	The charge distribution in the heavy-mass-peak fission products from $^{235}U(n_{th,f})$ is being measured at various well defined kinetic energies (excitation energies) of the fission fragments.
Method:	Fission fragments separated according to mass (Resolution $\frac{M}{\Delta M} = 400$) and kinetic energy (resolution ~ 2 MeV) are intercepted on a moving transport tape, transported continuously or discontinuously in front of a Ge(Li) γ-ray dectector, and counted via the γ-rays emitted in their β-decay.
Accuracy:	Varying.
Completion:	1979
Publication:	Progress reports are appearing since 1975 in Jahresberichte, Institut für Kernchemie, Universität Mainz and Annex to the Annual Reports, Institut Laue Langevin, Grenoble.

Laboratory: Institut für Kernchemie
Universität Mainz
Postfach 3980
D-6500 Mainz, Germany

Names: M. Weis, H.O. Denschlag

Facilities: TRIGA Mark II Reactor

Experiment: The fractional independent or fractional cumulative (FC) yields of the following nuclides were determined in the fission of ^{235}U by thermal neutrons:
Y-99 (FC), Zr-99, Nb-99m, Nb-99g, Zr-101 (FC), Nb-101, Mo-101, Zr-102 (FC), Nb-102m, Nb-102g, Nb-104 (FC), Nb-105 (FC). Measurements on Nb-96, Nb-97 (m+g) and Nb-98 (m+g) are in progress.

Method: Fast radiochemical separation of Nb or Zr after pulsed irradiation.

Accuracy: Generally ± 5 % (relative to value).

Completion date: 1978

Publications: Jahresberichte 1975 and 1976,
Institut für Kernchemie
Universität Mainz

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Laboratory: Institut für Kernchemie
Universität Mainz
Postfach 3980
D-6500 Mainz, Germany

Names: G. Paffrath, H.O. Denschlag

Facilities: TRIGA Mark II Reactor

Experiment: Independent (IN), cumulative (CU) and fractional independent (FI) or fractional cumulative (FC) yields of the following nuclides were determined in $^{239}Pu(n_{th,f})$: Sn-131 (CU), Sn-132 (FC), Sb-132m (FI), Sb-132g (FI), Te-132 (FI), Sb-133 (CU), Sb-134 (CU) and in $^{249}Cf(n_{th,f})$: Sn-132 (CU), Sb-132m (IN), Sb-132g (IN), Sb-133 (CU), Sb-134 (CU).

Method: Fast radiochemical separation by hydride volatilization of Sb, Sn and/or Te fission products and direct γ-ray spectroscopic measurement and/or indirect measurements via daughter nuclides.

Accuracy: Error margins varying between ± 3 % and ± 60 % of the resulting value.

Completion date: Completed

Publications: G. Paffrath, Dissertation Mainz 1976

Laboratory:	Institut für Kernchemie Universität Mainz Postfach 3980 D-6500 Mainz, Germany
Names:	G. Fischbach, H.O. Denschlag
Facilities:	TRIGA Mark II Reactor
Experiment:	The fractional cumulative yields of the following isotopes were measured in $^{235}U(n_{th,f})$: Ba-144, La-145, La-146, Ce-146, Ce-148 and Ce-149
Method:	Fast radiochemical separations and direct γ-ray spectroscopic measurement and/or indirect measurements via daughter nuclides.
Accuracy:	Varying
Completion date:	1977
Publications:	Jahresberichte 1975 and 1976, Institut für Kernchemie Universität Mainz

Laboratory and address: Institut für Kernchemie
Universität Mainz, Postfach 3980
D-6500 Mainz

Names[x]: N. Kaffrell, G. Tittel, N. Trautmann

[x]This work is a collaboration between this laboratory and:
- H. Ahrens, GSI, D-6100 Darmstadt
- Institut Laue-Langevin
F-38042 Grenoble.

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

Experiment: E_γ, $T_{1/2}$ and partial decay schemes have been determined for the nuclides $^{101-104}Zr$, $^{101-106}Nb$ and $^{103-108}Mo$.

Method: The fission products have been handled with an air jet device combined with a tape transport system. The γ-ray singles and γ-γ coincidence spectra have been measured simultaneously with different Ge(Li) detectors.

Laboratory and address:	Institut für Kernchemie Universität Mainz Postfach 3980 D-6500 Mainz, Germany
Names:	M. Zendel, E. Stender, N. Trautmann and G. Herrmann
Facilities:	TRIGA Mark II reactor
Experiment:	Development of on-line separation procedures. Studies on short-lived isotopes of tellurium and selenium- Recently studied are the decays of $^{135-137}Te$ and $^{85-88}Se$.
Method:	Combination of a gas jet recoil transport system with a separation method in the gaseous phase. γ-singles and γ-γ-coincidence measurements in the energy range 0.1-4 MeV.
Expected completion date:	1977/1978

GERMANY, FED. REP.

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Laboratory and address:	Institut für Kernchemie Universität Mainz Postfach 3980 D-6500 Mainz, Germany
Names:	G. Klein, N. Kaffrell, E. Stender, N. Trautmann and G. Herrmann
Facilities:	TRIGA Mark II reactor
Experiment:	Determination of $T_{1/2}$ and E_γ for the nuclides $^{96-100}Y$; some partial decay schemes.
Method:	Fast chemical separation procedure. γ-singles and γ-γ-coincidence measurements on chemically separated samples.
Expected completion date:	1977
Publications:	G. Klein, N. Kaffrell, N. Trautmann and G. Herrmann, Inorg. Nucl. Chem. Letters 11, 511 (1975)

Laboratory and address: Institut für Kernchemie
Universität Mainz
Postfach 3980
D-6500 Mainz, Germany

Names*: H. Ohm, W. Rudolph, K.-L. Kratz (Kernchemie Mainz), K.D. Wünsch, R. Decker, H. Wollnik (Univ. Giessen/ ILL Grenoble)
C. Ristori, J. Crançon (CEN Grenoble)
M. Asghar (ILL Grenoble)

*This work is a collaboration between Kernchemie Mainz and:
- Institut Laue-Langevin-BP 156 - 3842 Grenoble
- II. Physikal. Institut der Univ. Giessen - D-6300 Giessen
- Laboratoire de Chimie Physique Nucléaire - DRF - CENG-38041 Grenoble

Facilities: Mass separator for unslowed fission products LOHENGRIN and alkaline isotope separator OSTIS installed at the Grenoble high-flux reactor.

Experiment: Partial neutron emission probabilities to excited states and total P_n-values have been measured via γ-ray spectroscopy for the following precursors: ^{85}As, $^{93-98}Rb$, ^{135}Sb.
Work is progressing on additional precursors.

Method: According to the definition of the total neutron emission probability, the partial probabilities to certain levels in the neutron final nucleus can be defined as: $P_n^i = Y_n^i(A)/Y_f(A)$ where $Y_f(A)$ is the fission yield of the neutron precursor and $Y_n^i(A)$ is the absolute yield of neutrons feeding the $i^{\underline{th}}$ level in the final nucleus. $Y_n^i(A)$ was determined by comparison of γ-ray intensities in

the decay of excited states in the final nucleus observed in the mass chain containing the neutron emitter (mass A) with those observed in the chain containing the β^--decay parent (mass A-1).
In a similar way, the total P_n - feeding of excited states plus the ground state - can be determined via the intensity ratio of identical γ-lines in a daughter nucleus of the neutron final nucleus.
Another possibility to determine P_n^i and P_n results from the normalization of the intensities of γ-lines from the $\beta^- n\gamma$-decay to the known absolute intensities of γ-rays of long-lived daughter products.

Publications:

H. Franz et al., Angew. Chem. 83 (1971) 902.
H. Gunther et al., Nucl. Phys. A242 (1975) 56.
K.-L. Kratz et al., CERN-Report 76-13 (1976) 304.
K.-L. Kratz et al., Phys. Lett. 65B (1976) 231.
K.-L. Kratz et al., Proc. Int. Workshop, Hirschegg, Austria, AED-Conf. 77-017-001 to 77-017-043 (1977) 208.

Laboratory and address: Institut für Kernchemie
Universität Mainz
Postfach 3980
D-6500 Mainz, Germany

Names:* H. Ohm, W. Rudolph, M. Zendel, K. Sümmerer,
K.-L. Kratz (Kernchemie Mainz), F.M. Nuh,
S.G. Prussin (Univ. of Calif., Berkeley)
K.D. Wünsch, G. Jung (Univ. Giessen/ILL Grenoble)
C. Ristori, J. Crançon (CEN Grenoble)

*This work is a collaboration between
Kernchemie Mainz and:
- Department of Nuclear Energineering - Univ. of California, Berkeley, Calif. 94720
- Institut Laue-Langevin - BP 156 - 38042 Grenoble.
- II. Physikal. Institut der Univ. Giessen - D-6300 Giessen.
- Laboratoire de Chimie Physique Nucléaire - DRF - CENG - 38041 Grenoble.

Facilities: Triga Mark II reactor (Kernchemie Mainz). OSTIS on-line separator installed at the Grenoble high-flux reactor.

Experiment: The energy spectra of delayed neutrons have been measured in the energy range 10-3500 keV with high resolution for the following precursors: ^{35}As, $^{87,88}Br$, $^{93-97}Rb$, ^{135}Sb, ^{136}Te, $^{137,138}I$, $^{141-146}Cs$.

In the case of ^{95}Rb decay the delayed neutron spectrum was measured in coincidence with γ-rays depopulating excited states in the neutron final nucleus ^{94}Sr.

Neutron-gamma coincidence work is progressing.

Laboratory and address: Institute of Experimental Physics, Kossuth Lajos University, H-4026 Debrecen, Bem tér 18/A P.O.Box 105, 4001 Debrecen, Hungary.

Names: S.Daróczy, S.Nagy, P.Raics.

Facilities: Neutron generator with analysed deuteron beam / 0.5 mA/ and wobble tritium target, 0.3 mg ^{252}Cf source.
GeLi detector of 40 cm^3 with ATOMKI /Hungary/ electronics, 4000 channel DIDAC analyser and Multi 20-Plurimat N minicomputer-analyser system /France/.
$4\pi\beta$-counter, fission chambers.

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 10 hours only.
Planned: /for 1978-79/ ^{233}U/n,f/ or ^{239}Pu/n,f/.

Method: Measurement of direct gamma spectra of a thick sample with an absolutely calibrated GeLi spectrometer and determination of partial fission cross sections /cumulative yields/. The neutron flux is measured by the ^{27}Al/n,alpha/, ^{63}Cu/n,2n/ and ^{238}U/n,f/ reactions.

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

Expected completion date: ^{235}U/n,f/:1977, ^{233}U/n,f/ or ^{239}Pu/n,f/: 1979-80.

Discrepancies to other reported data: Pronounced left-right 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. The measured yields in the valley region are about 20 % higher than that of compilated by Meek and Rider /in 1974/.

Remarks: 47 cumulative yields for 37 mass chains in ^{238}U/n,f/ have been measured using 65 gamma lines. The lowest measured partial fission cross section is 3 mb and the highest one is 70 mb. The shortest half-life investigated is about 3 minutes and the longest one is 30 years. The sum of the mass yields amounts the two-thirds of the total fission cross section.

Publications: Results have been presented at the Symposium on Fast Neutron Interactions and on Problems of High Current Neutron Generators /27-30 August 1975, Debrecen Hungary/, ATOMKI Közl., 18,/2/ 1976, p.317.

INDIA

Laboratory and Address	:	Radiochemistry Division, Bhabha Atomic Research Centre, Trombay, Bombay 400085.
Names	:	Ramaswami A., Sampat Kumar R., Chaudhuri N.K., Srivastava B.K., Natarajan V., and Iyer R.H.
Facilities	:	High Resolution Ge(Li) detector, multichannel analyser, solid state track detector, and Optical microscope.
Experiment	:	Measurement of absolute fission yields in the neutron induced fission of actinide isotopes.
Method	:	Absolute fission yields in the thermal neutron fission of ^{235}U were determined using high resolution gamma spectrometry. The total number of fissions in the sample was determined by track etch technique using Mica as the track detector.
Accuracy	:	1 to 5% for the asymmetric fission products.
Completion data	:	Twelve asymmetric fission product yields are completed. Similar more extensive studies on other fissile isotopes are in progress.
Remarks	:	In this technique errors arising out of inaccuracies in the estimation of fission cross section due to variation of neutron energy spectrum, flux determination and in the estimation of the fissile atoms are eliminated.
Publications	:	To be published.
References	:	Iyer R.H., Sampat Kumar R., and Chaudhuri N.K., Nucl. Inst. Methods 115, 23 (1974).
		Scrokina A.V., Skovorodkin N.V., Soviet Atomic Energy 31, 99(1971).
		Larsen R.P., Dudly N.D., Heinrich R.R., Oldham R.D., Armani R.J., Popek R.J., Gold R., Nucl. Sci. Engg. 54, 263 (1974).

Laboratory and Address	:	Radiochemistry Division, Bhabha Atomic Research Centre, Trombay, Bombay 400085.
Names	:	Ramaswami A., Dange S.P., SatyaPrakash and Ramaniah M.V.
Facilities	:	High Resolution Ge(Li) detector, multichannel analyser, beta proportional counters and low background counters.
Experiment	:	Determination of fission yields in thermal neutron fission ^{245}cm.
Method	:	Fission yields in the thermal neutron fission of curium-245 were determined using high resolution gamma spectrometry and radiochemical techniques. Yields were determined compared to ^{235}U fission yields by using comparison technique.
Accuracy	:	About 5%.
Completion date	:	Already completed.
Publications	:	Ramaswami A., Dange S.P., Kannabiran R., Satya Prakash and Ramaniah M.V. Presented in Nuclear Physics and solid state Physics Symposium" December1975 held in Calcutta, India.
References	:	1. Harbour R.M. and MacMurdo K.W., J. Inorg. Nucl. Chem. 34, 2109 (1972).
		2. VonGuten H.R., Flynn K.F. and Glendenin L.E. Physics. Rev., 161, 1192(1967).

INDIA

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Laboratory	Radiochemistry Division Bhabha Atomic Research Centre Trombay, Bombay 400 085, India
Names	C.K. Mathews, S.A. Chitambar, H.C. Jain
Facilities	Reactors, Mass Spectrometry Laboratory
Experiment	Yields of stable and long-lived isotopes in the fission ^{241}Pu
Method	Mass spectrometry
Accuracy	1-2%
Expected completion date	Mid 1978

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ISRAEL (+ SWEDEN)

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

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

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

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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.

(5) Nuclear Physics A275 (1977) 76-92.

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

1. Names: C. Coceva, A. Mauri, M. Stefanon

Facilities: Neutron time-of-flight at the electron Linac of CBNM Euratom, Geel, Belgium.

Experiment: Measurement of S-wave neutron resonances of ^{156}Gd up to 3 keV. Aim of the experiment is to study the applicability of Mehta-Dyson statistics to practical cases, to obtain reliable confidence limits for the level spacing and estimate the s-wave and p-wave neutron strengtn functions. The measurement is completed; the data analysis is completed up to 2 keV.

Method: Montecarlo simulation of samples of experimental sequences, i.e. affected by missed and spurious levels, and comparison with the measurement for ^{156}Gd.

Expected completion date: 1977.

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2. Names: C. Coceva, P. Giacobbe, M. Magnani, A. Mauri

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

Experiment: Time-of-flight neutron transmission experiment with ^{91}Zr and ^{96}Zr enriched targets. Energy range 0-15 keV. Experiment completed.
Determination of ^{91}Zr resonance parameters, Γ_n below 5 keV, Γ_γ below 3 keV, J and π when possible, accomplished. Further refinements to take into account crystalline effects in progress.

Method: ZrO targets from 0.9×10^{-3} to 1.6×10^{-2} at/barn, 89.3% ^{91}Zr-enriched.
ZrO targets from 0.9×10^{-3} to 6×10^{-3} at/barn, 57.4% ^{96}Zr-enriched.

Expected completion date: 1977.

JAPAN

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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 in the thermal-neutron induced fission of ^{233}U, ^{235}U and ^{239}Pu.

Method: Radiochemical for fission yields; Instrumental with GeLi detectors

Accuracy: Errors range from 7 % to 20 % with different combinations of the fission products and the fissile isotopes.

[Expected] completion date:) see Table I
Publication:)

Table I

Nuclides		Completion date	Publication
$^{128,130,132}Sn$, ^{133}Sb $^{128,130,132}Sb^{m,g}$, ^{131}Sb, $^{131,133}Te^{m,g}$	[Cum.] [Ind.]	Sep. 1975	N.Imanishi, I.Fujiwara and T.Nishi,"Independent isomer yields of Sb and Te isotopes in thermal-neutron fission of ^{233}U, ^{235}U and ^{239}Pu", Nucl. Phys. A263,141(1976)
^{135}I $^{131,133}I$, $^{132,134,136}I^{m,g}$	[Cum.] [Ind.]	Dec. 1976	
$^{90}Rb^{m,g}$, $^{138}Cs^{m,g}$	[Ind.]	End of 1977	

SWEDEN

Laboratory and address:	Neutron Physics Laboratory AB Atomenergi Fack S-611 01 NYKÖPING Sweden	33
Names:	P-I. Johansson and G. Nilsson	
Facilities:	6 MeV VdG accelerator PDP-15 Computer 24 k memory (on line) NaI(Tl) and Ge(Li) spectrometers, β-spectrometer 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 radiometric study of small uranium specimens at cooling times longer than 3 seconds after irradiation with thermal neutrons. The residual power of gamma radiation from thermal fission of ^{235}U has been obtained with an accuracy of ±7 % in the time interval 10 sec to 25 min after fission. Measurements are in progress for studying also the residual power due to β-emission.	
Method:	A facility for thermal neutron irradiation of fissile specimens using a VdG accelerator has been built. Specimens are transported between the neutron source and a spectrometer by means of a pneumatic system. The absolute number of fissions in the sample is determined by two independent methods: a) by utilizing an absolutely calibrated fission chamber with an active volume of about the same size as the samples, b) by counting the number of gamma quanta emitted from fission products with known yields and decay properties. The gamma radiation was measured with a 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 measured pulse height spectra to energy spectra.	
Accuracy:	Better accuracy than ± 10 % is expected for the total energy released as β or γ-radiation from the fission products at any time between a few seconds and 30 minutes after fission.	
Completion date:	Measurements on gamma-radiation were completed in December 1976 and the study on beta emission will be finished at the end of 1977.	

SWEDEN

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Laboratories:

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

Department of Nuclear Chemistry
University of Oslo
Oslo 3
Norway

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

Names:

The SISAK Collaboration:

G. Skarnemark and K. Brodén (Göteborg)

T. Björnstad (Oslo)

N. Kaffrell, E. Stender and N. Trautmann (Mainz)

Facilities:

Two SISAK systems for studies of radionuclides with half-lives >0.5 s.

Experiments:

$T_{1/2}$-determinations, γ-singles, γ-γ coincidence and γ-γ angular correlation measurements in the energy range 0 - 4 MeV, at present on $^{143\text{-}148}La$, $^{145\text{-}150}Ce$ and $^{147\text{-}150}Pr$.

Method:

Fast chemical on-line 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

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) T. Björnstad, E. Kvåle, G. Skarnemark, P.O. Aronsson, N. Kaffrell, N. Trautmann and E. Stender, J. inorg. nucl. Chem. In print.

8) G. Skarnemark, E. Stender, N. Trautmann, P.O. Aronsson, T. Björnstad, N. Kaffrell, E. Kvåle and M. Skarestad, Radiochim. Acta 23 (1976) 98

9) G. Skarnemark, P.O. Aronsson, T. Björnstad, E. Kvåle, N. Kaffrell, E. Stender and N. Trautmann, J. inorg. nucl. Chem. In print

10) T. Björnstad, E. Kvåle, G. Skarnemark and P.O. Aronsson, Submitted to J. inorg. nucl. Chem.

11) G. Skarnemark, A Study of Some Neutron-rich Isotopes of Lanthanum, Cerium and Praseodymium by means of the Fast Chemical On-line Separation Technique SISAK. Thesis, Chalmers University of Technology, Göteborg 1977.

SWEDEN

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

Facility: The OSIRIS on-line isotope separator has been used to extract selected nuclei from thermally fissioned ^{235}U.

1. Names: K Aleklett, E Lund and G Rudstam

   Experiment: Total beta decay energies and atomic masses have been deduced for the following nuclides:

   $^{75-78}Zn$, $^{76-79}Ga$, $^{79,80}Ge$, $^{80,81,83}As$, $^{85-87}Br$, $^{120-129}In$, $^{127-132}Sn$, $^{128,130-132,134}Sb$ and $^{134,135}Te$.

   Method: Beta particles were recorded in coincidence with gamma rays that depopulated known levels in the daughter nuclei. The end-points of the beta-spectra were determined, and by adding the level energy the total beta-decay energies were obtained. The beta-particles were recorded in a Si(Li)-detector while the gamma-rays were recorded in a Ge(Li)- or two NaI(Tl)-detectors.

   Publications: (1) LF-73, LF-74, LF-75, LF-76, The Swedish Research Councils' Laboratory Reports.
   (2) Ph. Thesis, K Aleklett
   (3) Ph. Thesis, E Lund

2. Names: K Aleklett and G Rudstam

   Experiment: Determination of the average energy of the beta particles that are emitted in the decay of individual fission products in the mass regions A=75-96 and 116-146.

   Method: One selected mass beam from the isotope separator passes through a collimation system to impinge on an aluminized mylar tape. By a proper timing of a multispectrum experiment it is possible to assing beta spectra to individual isobars. The average energy of these spectra is then determined. The beta-spectra is recorded with a Si(Li)-detector system.

   Completion date: Expected at the end of 1977.

3. Names: K Aleklett, O Glomset, E Lund and G Rudstam

   Experiment: P_n-values measurements of the $^{235}U(n_{th},f)$ produced precursors in the mass chains 79-83,85,87-96, 123, 123-146.

   Method: Neutron and beta activities are measured simultaneously in MCA mode. The neutron counter consists of 29 ^3He detectors while the beta particles are detected with a 2 mm plastic detector.

   Completion date: 1978

4. Names: K Aleklett, P-I Johansson, G Nilsson and G Rudstam

   Experiment: Determination of the average energy released as gamma radiation per decay of individual fission products in the mass regions A = 75-96 and 116-146.

   Method: For each nuclide the distribution of gamma-rays are measured with a NaI-detector. Normalization is achieved by means of beta-counting.

Completion date: 1978

5. Names: B Fogelberg, P Hoff and H Tovedal

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

At present the decays of the following nuclei are under study: $^{87,88,89}_{Br}$, $^{122,124,126,128}_{In}$, $^{137,138,139}_{I}$.

Completion date: 1978

Discrepancies to other reported data: The neutron binding energy of ^{137}Xe reported by us[1] is markedly higher than the lower[2] of the two previously reported[2,3] values.

Publications:

1. B Fogelberg and W Mampe, Determination of the neutron binding energy of the delayed neutron emitter ^{137}Xe, Z Phys A281, 89 (1977).

2. E Monnand and B Fogelberg, Beta- and gamma-ray studies of ^{144}Cs, ^{144}Ba and ^{144}La, CERN-76-13 (1976) 503.

References:

1. same as 1 under Publications

2. P A Moore, P J Riley, C M Jones, M D Mancuse, J L Foster Jr., Phys Rev 175 (1968) 1516.

3. E J Schneid, B Rosner, Phys Rev 148 (1966) 1241.

SWITZERLAND

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Laboratory and address:	Eidg. Institut für Reaktorforschung, CH-5303 Würenlingen Institut für anorganische, analytische und physikalische Chemie, Universität Bern, CH-3012 Bern, Switzerland
Names:	H.R. von Gunten, H. Gäggeler and T. Kaiser
Facilities:	- Swimming-pool type reactor (SAPHIR) - Heavy-water reactor (DIORIT)
Experiments:	- Independent yields of ^{96}Nb and ^{98g}Nb in the thermal neutron-induced fission of ^{233}U, ^{235}U and ^{239}Pu. - Yields of ^{91}Sr, ^{111}Ag, ^{112}Ag, ^{113}Ag, ^{115}Cd, ^{117}Cd and ^{117m}Cd in the 0.3 eV neutron resonance in the fission of ^{239}Pu. - Cumulative yields of rare earth elements in the thermal neutron-induced fission of ^{249}Cf. - Independent and fractional cumulative yields of isotopes of Nb, I and Cs in the thermal neutron-induced fission of ^{249}Cf.
Method:	- Radiochemical and instrumental (GeLi). - Irradiations for measurements in the 0.3 eV neutron resonance in Gd and Cd neutron filters.
Accuracy:	5 - 10 %
Measurements completed:	End of 1976
Publications:	Cumulative Yields of Rare Earth Elements in the Thermal Neutron-Induced Fission of ^{249}Cf, J. Inorg. Nucl. Chem., in press.

UNITED KINGDOM

(Editor: I.C. McKean, Secretary UK Chemical Nuclear Data Committee) 39

Laboratory and Address:	AEE Winfrith	UKAEA Atomic Energy Establishment Winfrith Dorchester, Dorset DT2 8DH
Names:	M.F. Murphy, W.H. Taylor	
Experiment	Measurement of gross beta-decay power from products of ^{239}Pu and ^{235}U fission in a fast reactor. Irradiation period 10^5 seconds, detection continued up to 3.10^7 seconds after shutdown. Experiment completed.	
Method:	Thin deposits of ^{239}Pu and ^{235}U 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. Results of various subsidiary experiments have confirmed the validity of the experimental method and determined the necessary corrections.	
Accuracy:	Target accuracy is $\pm$ 7% (standard error) on absolute beta power as function of time from 30 seconds to 1 year after irradiation.	
Expected Completion Date:	The final report is presently being written.	

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Laboratory and Address:	AERE Harwell	UKAEA, AERE, Harwell, Oxfordshire OX11 ORA
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, ^{238}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:	Delayed due to lack of effort.	

Laboratory and Address:	AERE Harwell	UKAEA AERE, Harwell, Oxfordshire OX11 ORA
Names:	J.G. Cuninghame, Mrs J.A. Goodall, I.C. McKean, A.L. Nichols, H.H. Willis	
Facilities:	P.F.R.	
Experiment:	To measure the effect of change of reactor neutron spectrum on fission yields	
Method:	Samples of ^{235}U, ^{238}U and ^{239}Pu will be irradiated at four different positions in PFR during a low power run. Radio-chemical analysis of the samples will be by β counting. A method of γ-spectrum analysis using a PDP11 computer is being developed. The flux will be measured by fission chambers.	
Accuracy:	Expected $\pm$ 10%	
Completion date:	Expected mid-1978	

UNITED KINGDOM

Laboratory and Address:	AERE Harwell	UKAEA AERE, Harwell, Oxfordshire OX11 ORA
Names:	J.G. Cuninghame, H.H. Willis	
Facilities:	IBIS (Intense Bunched Ion Source)	
Experiment:	To determine absolute fission yields in the fission of ^{238}U by mono-energetic neutrons of energies in the range 900-1700 KeV. In progress.	
Method:	Radio-chemical analysis of the targets with β-counting of the selected fission products. Flux measured by solid state track detectors.	
Accuracy:	± 5%	
Completion date:	Expected mid-1978	

Laboratory and Address:	AERE, Harwell	UKAEA AERE, Harwell, Oxfordshire, OX11 ORA
Name:	J.G. Cuninghame, H.H. Willis	
Facilities:	IBIS (Intense Bunched Ion Source)	
Experiment:	To measure absolute fission yields in the fission of ^{239}Pu by mono-energetic neutrons of energies in the range 900-1700 Kev.	
Method:	Radio-chemical analysis of the targets with β-counting of selected fission products.	
Accuracy:	± 5-10% absolute	
Completion date:	Completed	
Publications:	JINC 39, (1977) P.383	

UNITED KINGDOM

Laboratory: and Address:	AERE Harwell	UKAEA AERE, Harwell Oxfordshire, OX11 ORA
Names:	I.C. McKean and E.A.C. Crouch	
Experiment:	^{3}H yield in thermal and fast fission spectra for U and Pu isotopes	
Facilities:	DIDO and 'ZEBRA' Reactors	
Method:	Samples of the fissile nuclides of about 1 mg dissolved in about 0.2 ml dil. Nitric acid irradiated by "Rabbit" in'Dido' and by manual loading in 'Zebra'. The ^{3}H produced is converted to $^{3}H_2O$ and counted by liquid scintillation at the N.P. Division Low background Laboratory.	
Accuracy:	$\pm$ 10%	
Completion date:	End of 1977	

Laboratory and Address: AWRE Aldermaston

MOD(PE)
AWRE Aldermaston.
Reading RG7 4PR

Names: C.B. Besant*, P.J. Challen+, M.H. McTaggart+.
P. Tavoularidis* and J.G. Williams*

*Imperial College, University of London

+MOD(PE) AWRE Aldermaston, Berkshire

Facilities: Pulsed reactor VIPER

Experiment: Absolute Yields and Group Constants of Delayed Neutrons in the Fast Fission of ^{235}U, ^{238}U and ^{239}Pu

Method: Absolute yields and group constants of the delayed neutrons from the fast fission of ^{235}U, ^{238}U and ^{239}Pu have been measured. The method was based on irradiating a sample in the fast pulsed reactor VIPER and transferring it pneumatically to the neutron detector, outside the biological shield of the reactor. The neutron efficiency of the detector was measured by a number of calibrated neutron sources and account was taken of its energy response function.

The fissions in the sample were measured by an activation technique. The 1596 Kev gamma activity, emitted by ^{140}La, of the sample was measured using a high resolution detector. The necessary conversion factor of activity into the number of fissions was determined by a calibration experiment where a thin deposit of known mass was irradiated within a fission chamber, along with a thick foil which was subsequently gamma counted.

The delayed neutron decay curve was approximated by six groups, using the least squares technique.

Results:

The absolute delayed neutron yields were found to be

^{235}U 0.0164 $\pm$ 0.0006 (n/F)
^{238}U 0.0432 $\pm$ 0.0017 (n/F)
^{239}Pu 0.00598 $\pm$ 0.0022 (n/F)

The reactivity (dollars) -period relationship, using the present group constants, is in agreement with the currently used values to within 3% for any isotope and practically used period.

The measured and corrected values are compared with recently evaluated data from Tuttle and with Keepin's values below:

ISOTOPE	^{235}U	^{238}U	^{239}Pu
Present Experiments	0.0164 ± 0.0006 (3.6)	0.0432 ± 0.0017 (4.0)	0.00598 ± 0.00022 (3.7)
Keepin	0.0165 ± 0.0007 (4.2)	0.0412 ± 0.0025 (6.1)	0.0063 ± 0.00045 (7.1)
Plateau Values Corrected for Spetrum of Measurement Facility			
Present Experiments	0.0164 ± 0.0006 (3.6)	0.0439 ± 0.0017 (4.0)	0.00598 ± 0.00022 (3.7)
Keepin	0.0167 ± 0.0007 (4.2)	0.0421 ± 0.0025 (5.9)	0.00636 ± 0.00045 (7.1)
Tuttle	0.01714 ± 0.00022 (1.3)	00.04510 ± 0.00061 (1.4)	0.00664 ± 0.00013 (1.9)

figure in brackets is % error

Publication:

A full account of this work is in process of publication in Journal of British Nuclear Energy Society. (Expected to be published early 1977).

Laboratory and Address:	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.	
Completion date:	Changes of emphasis in this program made it unnecessary to proceed with this experiment, and this work on it ceased in March 1977.	

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Laboratory and Address:	DERE	UKAEA, DERE, Thurso, Caithness, Scotland KW14 7TZ
Names:	W Davies, V M Sinclair	
Facilities:	PFR	
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 sontains ^{241}Pu as a dried aquecus 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:	± 2% for ^{235}U and ^{239}Pu fission yields ± 6% for ^{238}U, ^{240}Pu and ^{241}Pu fission yields	
Expected completion date:	Mid-1979	

Laboratory and Address:	National Physical Laboratory	N.P.L. Teddington. Middlesex.
Names:	P. Christmas, P. Cross	
Facilities:	$\pi\sqrt{2}$ Beta-ray spectrometer, isotope separator	
Experiment:	Determination of K and L internal conversion coefficients of ^{133m}Xe	
Method:	Peak-to-Beta-Spectrum (PBS) Preliminary experiments in progress aim to eliminate instrumental distortions of the beta spectrum.	
Accuracy:	Target is $\pm$ 1 per cent	
Completion date:	1977	

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Laboratory and address:	Argonne National Laboratory 9700 South Cass Avenue Argonne, Illinois 60439 USA
Names:	L. E. Glendenin, J. E. Gindler, J. W. Meadows, Jr.
Facilities:	Fast-neutron generator facility (FNGF)
Experiment:	Fission yields as a function of incident neutron energy
Method:	Yields determined (1) radiochemically with either β- or γ-counting and (2) by γ-counting irradiated foils of fissionable material. Neutrons produced by Li-p or D-d reaction. Flux monitored with fission chamber utilizing as the fission source the same material as that being irradiated. Absolute yields determined from flux measurements and/or 200% normalization of mass-yield distribution.
Accuracy:	Yields > 1% determined by γ-counting: 3-5% Yields < 1% determined by γ-counting: 5-20% Yields determined radiochemically with β-counting: 10-20%
Completion date:	Measurements of $^{238}U(n,f)$ for 1.5, 2.0, 3.9, 5.5, 6.9 and 7.7-MeV neutrons completed for ∿ 46 masses (March, 1977). Continuing program for other fissile and fertile materials.
Publications:	"Monoenergetic neutron fission of ^{238}U", K. F. Flynn, S. Nagy, L. E. Glendenin, J. E. Gindler and J. W. Meadows, Amer. Nucl. Soc. Transact. 22, 677 (1975).

IAEA FPND CONTRIBUTION

Laboratory and Address:

Bettis Atomic Power Laboratory
Westinghouse Electric Corporation
West Mifflin, Pennsylvania 15122
United States of America

Names:

S. B. Gunst, D. E. Conway, J. C. Connor*

Facilities:

Materials Testing Reactor, Advanced Test Reactor, and Advanced Reactivity Measurement Facility at the Idaho National Engineering Laboratory

Experiment:

Measured and calculated rates of decay heat in irradiated ^{232}Th, ^{233}U, ^{235}U, and ^{239}Pu.

Method:

Samples of ^{232}Th, ^{233}U, ^{235}U, and ^{239}Pu were irradiated in high neutron fluxes [$> 10^{14}$ n/(cm^2 sec)] and their decay heat was measured as a function of cooling time ranging from 14 to 4500 h after removal from the high flux. To measure the rate of heat emission from the highly radioactive samples, an underwater calorimeter was developed. For the measured exposure histories, decay heat was also calculated (using a procedure called COMBO). The calculations provided the concentrations of 190 fission products, all significant heavy isotopes, and structural nuclides. Account was taken of the energy carried by gamma rays that escaped the calorimeter.

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Nuclear Energy Systems
Pittsburgh, Pennsylvania 15230
United States of America

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Accuracy:

Measurements and calculations of the decay heat captured within the calorimeter agree within two standard deviations of the measurements for all samples and cooling times and, in general, agree within 2%. For the ^{235}U samples, calculations based on the Proposed ANS Standard ANS-5.1 (ANSI N18.6) agree with the measurements within 3% rms deviation.

Completion Date:

1975

Discrepancies to Other Reported Data:

As indicated above, all the measurements and calculations for the four nuclear fuels are in substantial agreement.

Publications:

1. "Measured and Calculated Rates of Decay Heat in Irradiated ^{235}U, ^{233}U, ^{239}Pu, and ^{232}Th," Nuclear Science and Engineering: 56, 241-262 (1975).

2. "Decay Heating Measurements and Calculations for Four Irradiated Reactor Fuels," Transactions of the American Nuclear Society, 19, 406 (October 1974).

3. "Decay Heating Measurements and Calculations for Irradiated ^{235}U, ^{233}U, ^{239}Pu, and ^{232}Th," (LWBR Development Program), WAPD-TM-1183, July 1974.

   Available from National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22151, U. S. A.

IAEA FPND CONTRIBUTION

Laboratory and Address:

Bettis Atomic Power Laboratory
Westinghouse Electric Corporation
West Mifflin, Pennsylvania 15122
United States of America

Names:

S. B. Gunst, J. C. Connor,* D. E. Conway

Facilities

Materials Testing Reactor, Advanced Test Reactor, and Advanced Reactivity Measurement Facility at the Idaho National Engineering Laboratory

Experiment:

Measured and calculated fission-product poisoning in neutron-irradiated uranium-233.

Method:

Samples of ^{233}U and of natural thorium were irradiated in high neutron-flux facilities [$> 10^{14} n/(cm^2\ sec)$], in both soft and hard neutron spectra, and for both short and long exposure times. Included were exposures resulting in depletions of more than 90% of the ^{233}U in the fissile material and burnups of more than 30,000 MWd/MT in the fertile material. Postirradiation mass analyses of the total and the isotopic uranium, of ^{137}Cs, and of the neodymium isotopes were compared with corresponding calculations based on measured exposure histories. Reactivity measurements between irradiation cycles provided experimental results for the fissile content and fission-product poisoning (summed over all fission products) as functions of both irradiation and cooling time.

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Reactivity measurements as a function of cooling time also provided experimental information on transient absorbers in fission-product chains of mass 149 and 135. Information was also presented concerning such matters as fission yields and neutron absorption of neodymium isotopes, the existence of significant transient fission-product poisons other than ^{135}Xe and ^{149}Sm, and the shielding of ^{233}U by ^{232}Th.

Results and Accuracy:

The post-irradiation mass analyses of the total isotopic uranium, of ^{137}Cs, and of the neodymium isotopes generally agreed within a few percent with the corresponding calculations based on measured exposure histories. The primary results obtained from reactivity measurements gave the thermal neutron absorption cross section, summed over all fission products, to 5% accuracy, and the absorption resonance integral of the total fission products to 7% accuracy. The corresponding one-group absorption cross section was accurate to 3%. The calculated thermal cross section for all fission products is on the order of 10% higher than that determined by reactivity measurement, while the calculated epithermal cross section is about 20% lower than measurement. Such behavior is expected because some fission products probably have significant resonances, but were assumed (for want of other information) to vary as 1/v. The measured and calculated one-group effective cross sections generally agree within 3%.

In addition to the primary results, experimental results for transient absorbers in ^{233}U gave a lower limit of 20,000 b for the neutron absorption resonance integral of ^{149}Pm. This is a factor of 15 higher than that obtained by a 1/v extrapolation of the thermal cross section. For transient ^{135}Xe, the measured absorption is 7.5% higher than that calculated using ENDF/B-IV data for the mass 135 chain. Relative to the shielding of ^{233}U by ^{232}Th, the experimental results suggest the need for a change in the energy dependence of the ^{232}Th thermal-neutron cross section.

Completion Date:

1974

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Discrepancies to Other Reported Data:

No other integral measurements are available for the neutron absorption of the total fission products in ^{233}U samples as functions of their irradiation or cooling time. Differences between the measurements and the calculations are discussed in the section on results.

Publications:

1. "Measured and Calculated Fission-Product Poisoning in Neutron-Irradiated Uranium-233," Nuclear Science and Engineering: 58, 387-413 (1975).

2. "Measured and Calculated Heavy-Isotope Concentrations and Fission-Product Poisoning in Irradiated ^{233}U," Transactions of the American Nuclear Society: 18, 330-331 (1974).

3. "Measurements and Calculations of Heavy Isotopes in Irradiated Fuels and of ^{233}U Fission-Product Poisoning," (LWBR Development Program), WAPD-TM-1182, Bettis Atomic Power Laboratory (1974).

   Available from National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22151, U.S.A.

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Contribution to "Progress in Fission Product Nuclear Data"

IAEA - April 1977

Laboratory and Address:

Battelle
Pacific Northwest Laboratories
P. O. Box 999
Richland, Washington 99352

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

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, Washington.

Experiment: Neutron and gamma spectroscopy of delayed neutron precursors is currently under investigation.

Method: Mass separated beams of Rb, In, or Cs delayed neutron precursors obtained from the on-line mass spectrometer are deposited on a moving tape collector. Delayed neutron spectra are measured with a ^{3}He ionization chamber and proton recoil detectors (in collaboration with Professor Gene Woodruff, University of Washington). Gamma ray spectra are obtained with a large Ge(Li) detector. Multispectral scaling has been used to identify parent and daughter gammas. Special emphasis has been on the identification of gammas following neutron decay to excited states of the final nucleus.

Accuracy: The absolute efficiency of the Ge(Li) detector has been determined by counting NBS standard sources. Response functions for the ^{3}He ionization chamber have been measured with monoenergetic neutrons from a Van de Graaff accelerator.

Results: This work is still in progress. Previous work on delayed-neutron emission probabilities and the average energies of delayed neutron spectra from separated precursors has been accepted for publication as given below.

Publications:

P. L. Reeder, J. F. Wright, and L. J. Alquist, "Average Neutron Energies from Separated Delayed-Neutron Precursors," BNWL-SA-5890 Rev., Dec. 1976, to be published Phys. Rev. C, June 1977.

P. L. Reeder, J. F. Wright, and L. J. Alquist, "Delayed Neutron Emission Probabilities of Separated Isotopes of Br, Rb, I, and Cs," BNWL-SA-5900 Rev., Dec. 1976, to be published, Phys. Rev. C, June 1977.

U. S. A.

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FPND NEWSLETTER CONTRIBUTION - I

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 to 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, ^{241}Am and ^{243}Am. All irradiations have been completed and the analytical measurements completed for ^{233}U, ^{235}U, ^{238}U, ^{237}Np, ^{240}Pu, ^{241}Pu, and ^{242}Pu. Data reduction and yield calculations have been completed for ^{233}U, ^{235}U, ^{238}U, ^{239}Pu, and ^{241}Pu.

Method: The principal measurement technique is isotope dilution mass spectrometry for the isotopes of Kr, Rb, Sr, Zr, Mo, Ru, Xe, Ce, 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, ^{239}Pu, and ^{241}Pu yields are $\sim$1.5%. For ^{238}U, the uncertainty in the reported yields is $\sim$3%. It is estimated that the uncertainties for the ^{237}Np and ^{242}Pu yields will be about $\sim$2%, and for ^{240}Pu, 3-5%.

Future Work: Data reduction of the experimental results and calculation of the fast fission yields for ^{237}Np should be completed by July 1977, and for ^{240}Pu and ^{242}Pu by about September 1977. Analysis of the dissolved ^{241}Am capsules is in progress.

Measurement of fast reactor fission yields for another set of ^{235}U, ^{239}Pu, and ^{241}Pu capsules irradiated to high burnup in row 4 of EBR-II should start $\sim$ September 1977.

- cont'd -

Special Comments: All yields reported from this work are associated with a known neutron spectrum. The study to correlate fast reactor fission yields with neutron energy is continuing.

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-fo-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.

Maeck, W. J., Editor, "Fast Reactor Fission Yields for ^{239}Pu and ^{241}Pu", U.S. ERDA Rept. ICP-1050-II, in preparation, expected July 1977.

U. S. A.

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FPND NEWSLETTER CONTRIBUTION - II

Laboratory: Idaho National Engineering Laboratory

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

Name: William J. Maeck

Experiment: Thermal Fission Yields for ^{235}U and ^{239}Pu

An existing experiment has been extended to remeasure the major fraction of the mass yield curve for the thermal fission of ^{235}U and ^{239}Pu. The need for this program resulted from serious discrepancies in some measured relative isotopic ratios for certain isotopes in the thermal fission of ^{239}Pu. (See Summary of reported data under Publications).

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 fission will be established by two methods: 1) the summation of the total atoms in the heavy mass peak, and 2) the heavy element difference technique.

Accuracy: The error to be associated with these new results is estimated to be $\sim$1.5%.

Future Work: Analysis of four irradiated capsules of ^{235}U should be completed by about October 1977, and for four capsules of ^{239}Pu by about July 1978.

Data Discrepancies: Maeck, W. J., Emel, W. A., Delmore, J. E., Duce, F. A., Dickerson, L. L., Keller, J. H., Tromp, R. L., "Discrepancies and Comments Regarding ^{235}U and ^{239}Pu Thermal Fission Yields and the Use of ^{148}Nd as a Burnup Monitor", U.S. ERDA Rept., ICP-1092, December 1976.

- cont'd -

U. S. A.

The following is a summary of this report.

Relative thermal fission yields measured on thermally irradiated samples of ^{235}U and ^{239}Pu for Kr, Rb, Cs, Xe, Ba, and Nd show large differences for several isotopes compared to previous measurements made in this laboratory[1] and compared to data in current fission yield compilations[2]. Particularly significant are 14% higher values for ^{138}Ba and 8.5% higher values for the Xe isotopes for ^{239}Pu thermal fission. A major impact is that all of the ^{239}Pu fission yields will have to be adjusted to preserve mass balance. Small differences obtained for the Xe isotopes for ^{235}U cause only a slight effect on the mass yield curve.

Differences also were obtained for the isotopic distribution of Nd, in particular, an increase in ^{148}Nd abundance with increasing neutron flux. This results from a large neutron capture cross section for ^{147}Nd. Previously measured ^{148}Nd fission yields tend, therefore, to be high relative to the nearly instantaneous fission yields measured in this work. Thus, burnup values based on ^{148}Nd and measured on fuels exposed to a low flux could be biased low and for fuels exposed to a high flux biased high.

The primary purpose of this preliminary report is to draw attention to the observed differences and their effect on fission yields, especially for ^{239}Pu, and to caution chemists who are measuring burnup of thermal irradiated fuels by techniques using ^{148}Nd as the burnup monitor.

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1 F. L. Lisman, R. M. Abernathey, W. J. Maeck, J. E. Rein, Nucl. Sci. Eng. 42, 191-214 (1970).

2 IAEA Fission Product Nuclear Data Conference, Bologna, Italy, Nov. (1973), IAEA-169.

U. S. A.

FPND NEWSLETTER CONTRIBUTION - III

Laboratory: Idaho National Engineering Laboratory

Address: Allied Chemical Corporation
550 Second Street
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United States

Name: William J. Maeck

Experiment: Natural Fission Reactor Studies: ^{238}U Spontaneous Fission Yields

In the process of analyzing approximately 25 rich uranium ore samples for fissiogenic ruthenium, a preliminary estimate of the ^{238}U spontaneous fission yields for ^{99}Ru, ^{101}Ru, ^{102}Ru, and ^{104}Ru has been obtained. The measurement technique was mass spectrometry.

After correction for the natural Ru component and the fissiogenic component resulting from ^{235}U induced fission, the best estimate for the isotopic composition of ^{238}U spontaneous fission Ru is:

99	0.2397
101	0.2837
102	0.3124
104	0.1642

Using a value of 6.0% for the ^{238}U spontaneous fission yield of ^{99}Mo, the preliminary ^{238}U spontaneous fission yields for the Ru isotopes are:

^{99}Ru	6.0% (relative to ^{99}Mo)
^{101}Ru	7.09
^{102}Ru	7.81
^{104}Ru	4.11

No rigorous error analysis has been completed to date.

Laboratory and address: Idaho National Engineering Laboratory
EG&G Idaho, Inc.
P. O. Box 1625
Idaho Falls, Idaho 73401 USA

Names: R. J. Gehrke, R. G. Helmer

Facilities: 1) 4π β-γ coincidence counting system
2) Calibrated Ge(Li) spectrometers

Experiment: Determination of absolute γ-ray emission probabilities for:
^{139}Ba, and ^{134}I ongoing
^{146}Pr, ^{145}Pr, ^{132}Te and ^{141}La planned

Method: The decay rates are determined by the 4π β-γ coincidence counting system, which has two separate pulse-processing systems. One system is based on fixed pulse widths. The other is based on veriable pulse widths and an overlap coincidence circuit. The dead time of the beta, gamma and coincidence channels is measured by counting the pulses from a 10 MHZ clock.
The variable pulse width system is useful in measuring the γ-ray emission probabilities of short-lived (< 30 m) fission products, where high count rates are needed.
The γ-ray emission rates are determined by Ge(Li) spectrometers whose efficiencies have been measured to an accuracy of $\pm 1\frac{1}{2}\%$ (1σ) between 0.3 and 2 MeV.

Accuracy: $\pm$ 1% to $\pm$ 5% (1σ uncertainty)

Completion date: Dec. 1977.

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Laboratory: Los Alamos Scientific Laboratory, Group CNC-11, Los Alamos, NM 87545, USA

Names: B. R. Erdal, G. W. Butler, D. W. Barr

Facilities: Absolute fission chamber; Big-10 critical assembly; Omega-West reactor; Cockroft-Walton accelerator; radiochemical laboratory; calibrated Ge(Li) and β-proportional detectors

Experiment: Measurement of true radiometric fission yields for several primary fission monitors from ^{235}U, ^{238}U, ^{239}Pu and ^{240}Pu with thermal-, fission-specturm-, and 14-MeV neutrons

Method: Determination of the number of fissions in sample by use of an NBS fission chamber followed by standard radiochemistry and nuclear measurement techniques

Accuracy: Typical uncertainty in the yields is 1-2% relative to ^{235}U thermal-neutron fission

Completion date: Early 1977

Publications: A. E. Norris and G. P. Ford, Los Alamos Scientific Laboratory Report No. LA-6129 (1976)

Laboratory: Los Alamos Scientific Laboratory, Group CNC-11
Los Alamos, NM 87545, USA

Names: B. R. Erdal, G. P. Ford, K. Wolfsberg, D. C. Hoffman

Facilities: Godiva-IV fast burst reactor; Omega West reactor; Cockroft-Walton accelerator; radiochemical laboratory; calibrated Ge(Li) detectors

Experiment: Measurement of absolute cumulative yields of ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{133g}Xe and ^{135g}Xe from thermal-, fission-spectrum-, and 14-MeV-neutron fission of ^{235}U, ^{238}U, ^{239}Pu, and ^{233}U

Method: Delayed removal of Kr and Xe from irradiated stearates followed by gamma-ray spectrometry of Ge(Li) detectors

Completion date: End of 1977

U. S. A.

Laboratory: Los Alamos Scientific Laboratory, Group CNC-11
Los Alamos, NM 87545, USA

Names: K. Wolfsberg, G. P. Ford, B. R. Erdal, D. C. Hoffman

Facilities: Godiva-IV fast burst reactor; Omega West reactor; Cockroft-Walton accelerator; radiochemical laboratory; calibrated Ge(Li) detectors

Experiment: Fractional independent yields of ^{133m}Xe, ^{133g}Xe, ^{135m}Xe and ^{135g}Xe from thermal-, fission-spectrum-, and 14-MeV-neutron fission of ^{235}U, ^{238}U, ^{239}Pu, ^{242m}Am, and ^{233}U

Method: Quick removal of Xe from irradiated stearates followed by gamma-ray spectrometry on Ge(Li) detectors

Completion date: Early 1977

U. S. A.

CONTRIBUTION I

LABORATORY	Lawrence Livermore Laboratory University of California P.O. Box 808 Livermore, CA 94550, U.S.A.
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. No definite plans have been made for publishing the final results.
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.

U. S. A.

CONTRIBUTION 2

LABORATORY	Lawrence Livermore Laboratory Univeristy of California P.O. Box 808 Livermore, CA 94550, U.S.A.
NAMES	D. R. Nethaway A. L. Prindle W. A. Myers W. C. Fuqua M. V. Kantelo
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 ± 4%.
COMPLETION DATE	The experimental measurements are complete. The final results should be available by Aug. 1977 as a UCRL report, and will also be submitted to The Physical Review.

CONTRIBUTION 3

LABORATORY	Lawrence Livermore Laboratory University of California P.O. Box 808 Livermore, CA 94550, U.S.A.
NAMES	D. R. Nethaway A. L. Prindle W. A. Myers M. V. Kantelo
FACILITY	FLATTOP Critical Assembly (Pu), Los Alamos Scientific Laboratory.
EXPERIMENT	Measure fission yields (both total chain yields and independent yields) for fission of Pu-240 induced by fission-spectrum neutrons.
METHOD	Measurements were made both by doing chemical separations and by direct counting with Ge(Li) detectors. The accuracy of the measurements is about ± 5%. Absolute yields are based on a comparison with U-238 fission yields and on a normalization of the mass-yield curve.
COMPLETION DATE	The experimental measurements are complete, and we are in the process of preparing a report for publication.

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CONTRIBUTION 4

LABORATORY	Lawrence Livermore Laboratory University of California P.O. Box 808 Livermore, CA 94550
NAMES	D. H. Sisson A. L. Prindle D. R. Nethaway M. V. Kantelo L. L. Nolen R. A. Sigg
FACILITY	Livermore ICT Facility (14-MeV neutron source)
EXPERIMENT	Measure fission yields for fission of Am-241 induced by 14.8-MeV neutrons.
METHOD	Measurements will be made both by doing chemical separations on irradiated targets and by using the recoil-catcher method.
COMPLETION DATE	The measurements have been started, but the completion date is uncertain.

U. S. A.

CONTRIBUTION 5

LABORATORY	Lawrence Livermore Laboratory P.O. Box 808, Livermore CA 94550, U.S.A.
NAMES	Manfred Lindner and David W. Seegmiller
FACILITY	Livermore Pool Type Reactor (LPTR) and Germanium (Li) Detector Measurements
EXPERIMENT	Fission-product mass yield measurements in the thermal-neutron induced fission of the long-lived isomer of ^{236}
METHOD	^{235}U and ^{236}Np were irradiated simultaneously in the core (high-flux region) of the LPTR. Ge(Li) gamma-ray spectra on both specimens were recorded and analyzed over a period of approximately one year at fixed intervals. When complete, the analysis will give the mass-yield curve for ^{236}Np by two independent means: (1) by comparison with the ^{235}U thermal fission (R-value method), and (2) from the absolute yields of the fission products derived from the Ge(Li) data. About 30 fission-product mass-yields have been measured. No chemical separations were performed.
ACCURACY	5-10% or better
COMPLETION DATE	Late 1977

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Laboratory: Oak Ridge National Laboratory, Bldg. 6010, P. O. Box X, Oak Ridge, TN 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 - ∿500 keV
Target-isotopes: see Table 1

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 1

Publications:

Table I

Isotopes	Completion date	Publications
$^{86,87,88}Sr$	indefinite	"Valence Neutron Capture in ^{88}Sr", J. W. Boldeman, B. J. Allen, A. R. de L. Musgrove and R. L. Macklin, Nucl. Phys. A269, 397 (1976).
^{89}Y	1976	Data taken, analysis at Lucas Heights, Australia, J. Boldeman et al, submitted to Nuclear Science and Engineering.
$^{90,91,92,94}Zr$	1976	"The 292.4 eV Neutron Resonance Parameters of ^{91}Zr", R. L. Macklin, et al, Nucl. Sci. & Eng 62, 174 (1977). "keV Neutron Capture in Zirconium-91", J. W. Boldeman et al, AAEC/E 367. "The Neutron Total and Capture Cross Sections of $^{92,94}Zr$", J. W. Boldeman, et al., Nucl. Phys. A263, 389 (1976). "Valence Component in the Neutron Capture Cross Section of ^{90}Zr", J. W. Boldeman, et at., Nucl. Phys. A246, 1 (1975). "High Resolution Neutron Transmission and Capture for ^{91}Zr", A. R. de L. Musgrove, et al., Nucl. Phys.
^{93}Nb	Jan. 1976	R. L. Macklin, Neutron Capture Cross Section of Niobium from 2.6 to 700 keV, Nuclear Sci. & Eng. 59, 12-20 (1976).
$^{92,94,95,96,97,98,100}Mo$	1976	O. A. Wasson et al., Neutron Resonance Parameters of ^{92}Mo, Phys. Rev. Revw. C7, 1532-1541 (1973).

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Isotopes	Completion Date	Publications
		"Average Neutron Resonance Parameters and Radiative Capture Cross Sections for the Isotopes of Molybdenum", A. R. de L. Musgrove, et al., Nucl. Phys. A270, 108 (1976).
^{100,101,102,104}Ru	indefinite	Data taken for ^{100,101,102,104}Ru scheduled (5/77).
^{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.
^{106,108,110,111,112,113,114,116}Cd	indefinite	Data taken, analysis being undertaken at Lucas Heights. O. S. Wasson and B. J. Allen, "P-Wave Resonances in ^{111}Cd(n,γ)", 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.
^{134,135,136,137,138}Ba	1976	Data taken, analysis in progress at Lucas Heights, Australia. A. R. Musgrove, B. J. Allen, R. L. Macklin, "keV Neutron Resonance Capture in ^{135}Ba", AAEC/E327 (12/74) (INDC(AUL)-23/L) "keV Neutron Resonance Capture in Barium-137", A. R. de L. Musgrove, et al., Aust. J. Phys. "keV Neutron Capture Cross Sections of ^{134}Ba and ^{136}Ba", Nucl. Phys. A256, 173 (1976). A. R. de L. Musgrove et al. "Neutron Resonance Capture in ^{138}Ba", A. R. de L. Musgrove et al., Nucl. Phys. A252, 1975).
^{139}La	1977	"Resonant Neutron Capture in ^{139}La", A. R. de L. Musgrove, B. J. Allen and R. L. Macklin, Preprint available.
^{140}Ce ^{141}Pr	1977	Data taken, analysis at Lucas Heights.
^{142,143,144,145,146,148}Nd		"Non-Statistical Effects in the Radiative Capture Cross Sections of the Neodymium Isotopes", A. R. de L. Musgrove, et al., AAEC/E 401.
^{159}Tb	indefinite	Data taken, analysis in progress, M. Mitzumoto, JAERI-ORNL (4/77).
^{165}Ho	1976	R. L. Macklin, "The ^{165}Ho(n,γ) Standard Cross Sections from 3 to 450 keV", Nucl. Sci. & Engr. 59, 231-236 (1976).
^{169}Tm	indefinite	Data taken, analysis by D. Drake, J. Malanify LASL and R. Macklin, ORNL, in progress (4/77).

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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: Fast Rabbit Transport Station at Oak Ridge Research Reactor (ORR)

Experiment: Total Beta and Gamma Energy Release for Thermal-Neutron Fission of ^{235}U and ^{239}Pu for Cooling Times of 2 to 14400 secs.

Method: Microgram samples of ^{235}U have been irradiated for short periods with thermal neutrons, and returned pneumatically to a counting area. Beta- and gamma-ray energy spectra of moderate resolution have been 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 have been reduced to differential production cross sections $d\sigma/dE$ and have been integrated to obtain total energy release rates for beta and gamma rays (separately). These data have been summed to obtain the total energy release.

The same experimental program has been initiated for ^{239}Pu.

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

(Expected) Completion Date: May 1977 for ^{235}U, December 1977 for ^{239}Pu

Discrepancies to Other Reported Data: Data are in good agreement with other recent experiments and with results of summation calculations.

Publications: J. K. Dickens, T. A. Love, J. W. McConnell, R. M. Freestone, J. F. Emery, and R. W. Peelle, "Fission Product Beta and Gamma Energy Release Quarterly Progress Report for July-September 1976," ORNL/NUREG/TM-65, (December 1976).

U. S. A.

Laboratory and address: Nuclear Radiation Laboratory
Nuclear Engineering Program
University of Illinois at Urbana-Champaign
Urbana, Illinois 61801
U.S.A.

Names: Bernard W. Wehring

Facilities: Illinois Advanced TRIGA 1.5-MW Nuclear Reactor, HIAWATHA Fission-Fragment Mass Spectrometer.

Experiment: Direct Physical Measurement of the Primary Postneutron-Emission Nuclide Yields in Thermal-Neutron Fission of U-235, Pu-239, and U-233

Method: The fission-fragment recoil mass spectrometer HIAWATHA, consisting of a cylindrical focusing electrostatic analyzer and time-of-flight system, will be used to determine fragment masses while fragment energy loss will be used to identify fragment atomic numbers in a multiparameter experiment. All fragment velocities and charge states will be measured.

Accuracy: 0.5-amu mass resolution achieved,
about 1-Z atomic-number resolution achieved,
1% standard error in largest mass yield achieved,
5% standard error in largest nuclide yield, goal.

Completion date: 1979

Publications:

R. G. Bucher, "An Experimental Study of Stopping Powers for Ions of Intermediate Atomic Numbers," Ph.D. thesis, University of Illinois at Urbana-Champaign, 1975.

B. W. Wehring and R. G. Bucher, "Stopping Power for Ions of Intermediate Atomic Numbers, "Proc. Fourth International Conf. Beam-Foil Spectroscopy and Heavy-Ion Atomic Physics Symposium, Sept. 15-19, 1975, Gatlinburg, Tennessee, pp. 679-686, Plenum Publishing Corp., 1976.

Gino DiIorio and B. W. Wehring, "Performance of HIAWATHA, A Fission-Fragment Mass Spectrometer," Trans. Am. Nucl. Soc. 23, 523 (1976).

Gino DiIorio and B. W. Wehring, "Direct Physical Measurement of Mass Yields for $^{235}U(n^{th}, f)$, Trans. Am. Nucl. Soc. 24, 459 (1976).

R. B. Strittmatter, R. G. Bucher, and B. W. Wehring, "Atomic-Number Dependence of Fission-Fragment Energy Loss: Evidence for Z_1 Oscillations (accepted for publication in Phys. Rev. A, June 1977 issue).

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Laboratory and address: Nuclear Radiation Laboratory
Nuclear Engineering Program
University of Illinois at Urbana-Champaign
Urbana, Illinois 61801
U.S.A.

Names: Bernard W. Wehring

Facilities: Illinois Advanced TRIGA 1.5-MW Nuclear Reactor,
5-μg Cf-252 Fast-Neutron Source,
150-kV Neutron Generator.

Experiment: Determination of Element Yields in Thermal-, Fast-, and 14-MeV-Neutron and Spontaneous Fission from Measured X-Ray Multiplicities

Method: Primary element yields are determined by measuring multiple characteristic x-ray emission rates for each Z split, extrapolating to the case where neither fragment emitted an x ray, and summing over all possibilities for multiple x-ray emission.

Accuracy: 10% standard error in absolute element yields in spontaneous fission of Cf-252 achieved,
5% standard error in absolute element yields in fissions of U-235, Pu-239, U-233, Th-232, and U-238, goal.

Completion date:

Publications:

R. J. Lipinski, Measured X-Ray Multiplicities and Element Yields in the Spontaneous Fission of Californium-252," Ph.D. thesis, University of Illinois at Urbana-Champaign, 1976.

R. J. Lipinski and B. W. Wehring, "Element Yields in Cf-252 Spontaneous Fission Determined from Measured X-Ray Multiplicities," Phys. Letters 66B, 326 (1977).

Laboratory and address: Idaho National Engineering Laboratory
EG&G Idaho, Inc.
P. O. Box 1615
Idaho Falls, Idaho 83401
USA

Name: Y. D. Harker

Experiment: Integral cross section measurements in the fast-reactor-type neutron environments.

Method: A program is in progress to measure integral cross sections of fission-product-class 1 nuclides using Couple Fast Reactivity Measurement Facility (CFRMF) and Experimental Breeder Reactor II (EBRII). Three methods of measurement are being utilized 1) neutron activation/gamma spectrometry 2) reactivity worth and 3) transmutation/isotope dilution mass spectrometry.

Accuracy: Activation Measurements 2% - 20% depending on the quality of decay data available for the activation products.

Reactivity Worth Measurements ~5% for total worth

Transmutation Measurements 5%-15%

Measurements Completed: Integral capture cross sections have been completed for ~50 reactions and results are summarized and compared with ENDF/BIV calculated results in Table I. A comprehensive set or reactivity worth measurements have been completed and will be reported by October 1977. Transmutation measurements are in progress and results are expected by August 1977.

Publications:

- Y. D. Harker, "Fast-Neutron Capture Integral Measurements of ^{99}Tc, ^{109}Ag and Other Fission Products" Proceedings of the Third Conference Neutron Cross Sections and Technology, Knoxville, Tenn., March 15-17, 1971, USAEC CONF. Report No. CONF-710301, August 1971, pp113-119.

TABLE I

FISSION PRODUCT REACTION RATE

Reaction	Sample Description	Sample Mass	$\hat{\sigma}_c(A,Z) / \hat{\sigma}_f(235,92)$ Measured[a]	$\hat{\sigma}_c(A,Z) / \hat{\sigma}_f(235,92)$ Calculated[b]	Measured/Calculated
$^{87}Rb(n,\gamma)^{88}Rb$	RbCl powder in a disk shape 1 cm diameter x 1.6 mm thick	62.6 mg	8.50×10^{-3}(± 12%)	7.46×10^{-3}	1.14
$^{89}Y(n,\gamma)^{90m}Y$	Metal chips		2.20×10^{-4}(± 7.7%)	- - -	- - -
$^{93}Nb(n,\gamma)^{94m}Nb$	Nb Metal foil .79 cm square x .13 mm thick	69 mg	1.15×10^{-1}(± 50%)	7.65×10^{-2}	1.50
$^{99}Tc(n,\gamma)^{100}Tc$	Tc powder in a disk shape 1 cm diameter x 1.6 mm thick	99.2 mg	1.72×10^{-1}(± 11%)	1.74×10^{-1}	.99
$^{98}Mo(n,\gamma)^{99}Mo$	Mo metal foil ≈1 cm diameter x 0.13 mm thick	99.0 mg	3.81×10^{-2}(± 11%)	4.36×10^{-2}	.87
$^{100}Mo(n,\gamma)^{101}Mo$	Mo metal foil ≈1 cm diameter x 0.13 mm thick	99.0 mg	2.24×10^{-2}(± 8.7%)	3.11×10^{-2}	.72
$^{102}Ru(n,\gamma)^{103}Ru$	Ru powder in a disk shape 1 cm diameter x 1.6 mm thick	87.5 mg	5.55×10^{-2}(± 8.1%)	7.84×10^{-2}	.71
$^{104}Ru(n,\gamma)^{105}Ru$	Ru powder in a disk shape 1 cm diameter x 1.6 mm thick	75.4 mg	5.18×10^{-2}(± 6.3%)	5.50×10^{-2}	.94
$^{103}Rh(n,\gamma)^{104m}Rh$	Rh wire 0.254 mm diameter	6.3 mg per cm length	2.02×10^{-2}(± 12%)	- - -	- - -

TABLE I (Continued)

Reaction	Sample Description	Sample Mass	$\tilde{\sigma}_c(A,Z) / \tilde{\sigma}_f(235,92)$ Measured[a]	Calculated[b]	Measured/Calculated
$^{103}Rh(n,\gamma)^{104g}Rh$	Rh wire 0.254 mm diameter	6.3 mg per cm length	2.15×10^{-1}(± 26%)	- - -	- - -
$^{103}Rh(n,\gamma)^{104}Rh$	- - -	$\sum$=	2.35×10^{-1}(± 24%)	2.64×10^{-1}	.89
$^{107}Ag(n,\gamma)^{108g}Ag$	Ag metal foil ≈ 1 cm diameter x .13 mm thick	100 mg	2.75×10^{-1}(± 15%)	2.65×10^{-1}	1.04
$^{109}Ag(n,\gamma)^{110g}Ag$	Ag metal foil ≈ 1 cm diameter x .13 mm thick	100 mg	3.11×10^{-1}(± 12%)	- - -	- - -
$^{109}Ag(n,\gamma)^{110m}Ag$	Ag metal foil ≈ 1 cm diameter x .13 mm thick	100 mg	1.80×10^{-2}(± 6.6%)	- - -	- - -
$^{109}Ag(n,\gamma)^{110}Ag$	- - -	$\sum$=	3.29×10^{-1}(± 11%)	1.92×10^{-1}	1.71
$^{108}Pd(n,\gamma)^{109}Pd$	Pd metal foil ≈ 1 cm diameter x .13 mm thick	98.1 mg	7.81×10^{-2}(± 25%)	- - -	- - -
$^{110}Pd(n,\gamma)^{111}Pd$	Pd metal foil ≈ 1 cm diameter x .13 mm thick	98.1 mg	3.06×10^{-3}(± 10%)	- - -	- - -
$^{115}In(n,\gamma)^{116m}In$	In metal foil .13 mm thick	63.7 mg	1.67×10^{-1}(± 7.9%)	1.92×10^{-1}	.94
$^{121}Sb(n,\gamma)^{122}Sb$	Sb powder in a disk shape 1 cm diameter x 1.6 mm thick	132.1 mg	1.74×10^{-1}(± 6.3%)	1.93×10^{-1}	.90

TABLE I (Continued)

Reaction	Sample Description	Sample Mass	$\hat{\sigma}_c$ (A,Z) / $\hat{\sigma}_f$(235,92) Measured[a]	Calculated[b]	Measured/Calculated
$^{123}Sb(n,\gamma)^{124}Sb$	Sb powder in a disk shape 1 cm diameter x 1.6 mm thick	132.1 mg	9.65×10^{-2}(± 8.9%)	1.05×10^{-1}	.92
$^{127}I\ (n,\gamma)^{128}I$	AgI powder evenly distributed over 1 cm x 1.5 cm area	(^{127}I) 5.51 mg	1.85×10^{-1}(± 19%)	2.14×10^{-1}	.86
$^{129}I\ (n,\gamma)^{130}I$	$Ag^{129}I$ powder evenly distributed over 1 cm x 1.5 cm area	(^{129}I) 5.29 mg	1.14×10^{-1}(± 8.6%)	1.46×10^{-1}	.78
$^{132}Xe(n,\gamma)^{133m}Xe$	^{132}Xe implanted in Al foil over area 13.1 cm x 5 cm	(^{132}Xe) 286.8 µg	1.52×10^{-3}(± 15%)	- - -	- - -
$^{132}Xe(n,\gamma)^{133g}Xe$	^{132}Xe implanted in Al foil over area 13.1 cm x 5 cm	(^{132}Xe) 286.8 µg	2.45×10^{-2}(± 8.0%)	- - -	- - -
$^{132}Xe(n,\gamma)^{133}Xe$	- - -	$\sum$=	2.60×10^{-2}(± 7.6%)	- - -	- - -
$^{134}Xe(n,\gamma)^{135}Xe$	^{134}Xe implanted in Al foil over area 13.2 cm x 5 cm	(^{134}Xe) 106.0 µg	9.29×10^{-3}(± 6.6%)	1.51×10^{-2}	.61
$^{133}Cs(n,\gamma)^{134m}Cs$	Cs_2SO_4 powder in a disk 1 cm diameter x 1.6 mm thick	69.6 mg	3.47×10^{-2}(± 16%)	- - -	- - -
$^{133}Cs(n,\gamma)^{134}Cs$	$CsNO_3$ powder in bottom of quartz vial-hemispherical 6.4 mm diameter	9.01 mg	1.72×10^{-1}(± 6.4%)	1.89×10^{-1}	.91

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International Atomic Energy Agency

Second Advisory Group Meeting on Fission Product Nuclear Data

Petten, Netherlands, 5 - 9 September 1977

INFORMATION SHEET

1. Introduction

Fission product nuclear data (FPND) play an important role in the calculation and control of the effects of fission products in all stages of the nuclear fuel cycle, in considerations of environmental safety and waste management, and in industrial and other application areas. Recognizing this importance, the International Atomic Energy Agency (IAEA) had convened a Panel Meeting on FPND in Bologna, Italy, in November 1973, which was the first one to review the requirements and status of FPND on an international level. Many technical recommendations aiming at the improvement of the knowledge and accuracy of FPND resulted from this meeting which helped to strengthen, coordinate and focus the research work on FPND in the ensuing years. In the foresight of this development the Bologna Panel had recommended, with the later concurrence of the International Nuclear Data Committee (INDC), to convene another specialists meeting on FPND after an appropriate elapse of time.

The present Advisory Group Meeting on FPND convened by the IAEA represents thus a follow-up of the Bologna Panel with the principal objective to review the present stage of requirements of FPND, the progress and achievements in FPND research since that Panel, and to work out recommendations for future work on FPND. The expected number of scientists participating in this meeting is about 50.

2. Objectives

The detailed objectives of the meeting will be as follows:

- to bring together users, measurers and evaluators of FPND;
- to review the progress in international cooperation and co-ordination of FPND activities achieved since the Bologna Panel;
- to review the user requirements for improved FPND needed in practical applications, starting from the conclusions drawn at the Bologna Panel. This Panel had strongly recommended that all future requirements for more accurate data should be well supported by sensitivity studies and take into account the latest status of the available data;
- to review the status of available compilations and evaluations;
- to review the status of microscopic FPND requested by users and its improvement since the Bologna Panel. Results of new experiments, calculations or evaluations should be reported and critically discussed;
- to discuss FPND user needs and issue conclusions about the priority and urgency of the requirements;
- to identify further measurements, calculations, compilations and evaluations required to satisfy the needs of FPND users; and
- to issue specific recommendations for future work.

The data types to be covered by the meeting will be the same as those of the Bologna Panel, namely:

- FP yields;
- FP neutron cross sections;
- FP decay data;
- delayed neutron data; and
- FP integral data.

3. Organization

In order to meet the objectives, the organization of the meeting is proposed to be as follows:

The first part of the meeting (two to three days) will be devoted to the presentation of 15 comprehensive review papers covering the full scope of the meeting, followed by general discussions on the open problems.

The proposed titles of the review papers together with some specifications of their contents are listed in Annex I. For each

of these papers a suitable expert has been selected and proposed as reviewer (see Annex I). Apart from his own contribution, his paper should incorporate a broad variety of views and results from different authors and laboratories which will be submitted to him in the form of oral or written contributions. The review papers should thus supply the participants of the meeting with all information they need for critical considerations and fruitful discussions.

After the general discussions working groups will be formed, which should summarize the results of the meeting in each subject area and draft conclusions and recommendations (one to two days).

A plenary session on the last day of the meeting will discuss and approve the working group reports including the conclusions and recommendations. The summary of the meeting's conclusions and recommendations as well as the proceedings of the meeting will be published by the IAEA and given a wide distribution.

4. Participation

The nomination of a participant will be accepted only if it is presented by the Government of a Member State of the International Atomic Energy Agency or by an international organization invited to participate.

Participants will receive official invitations from the scientific secretaries of the meeting, G. Lammer and J.J. Schmidt.

Annex I

List of review papers (RP) and suggested reviewers

RP 1 Introductory paper

G. Lammer, IAEA Vienna, Austria

RP 2 Needs and accuracy requirements for FPND of impact to the environment

D. Beninson, UNSCEAR (UN Scientific Committee on Effects of Atomic Radiation), Vienna, Austria

RP 3 Needs and accuracy requirements for FPND in the physics design of power reactor cores

J.L. Rowlands, AEE Winfrith, UK

RP 4 Needs and accuracy requirements in the engineering design and operation of reactors

C. Devillers, CEN/Saclay, France

RP 5 Needs and accuracy requirements for FPND in the out-of-pile fuel cycle

H.A.C. McKay, AERE Harwell, UK

RP 6 FPND requirements for investigations on irradiated nuclear fuel material: burnup, neutron dosimetry, safeguards

W.J. Maeck, Allied Chemical Corp., Idaho Falls, USA

RP 7 Status of neutron reaction cross sections of fission products in the energy ranges of resolved and unresolved resonances

E. Fort, CEN/Cadarache, France

RP 8 Impact of integral measurements on the capture cross-section evaluations of individual fission product isotopes

H. Gruppelaar, ECN Petten, Netherlands

RP 9 Status of fast neutron reaction cross-sections of fission products

S. Iijima, NAIG Nuclear Research Lab., Japan

RP 10 Status of fission product yield data

J.G. Cuninghame, AERE Harwell, UK

RP 11 Prediction of unmeasured fission yields by nuclear theory or systematics

J.O. Denschlag, Institut für Kernchemie, Universität Mainz, FRG.

RP 12 Status of decay data of fission products

J. Blachot, CEN/Grenoble, France

RP 13 Status of delayed neutron data

G. Rudstam, Swedish Research Council's Laboratory, Sweden

RP 14 Integral determination of FP neutron cross-sections

M. Bustraan, ECN Petten, Netherlands

RP 15 Integral determination of fission product inventory and decay power

R.E. Schenter , HEDL, Richland, USA

INEL (continued)

TABLE I (Continued)

Reaction	Sample Description	Sample Mass	$\hat{\sigma}_c(A,Z)/\hat{\sigma}_f(235,92)$ Measured[a]	$\hat{\sigma}_c(A,Z)/\hat{\sigma}_f(235,92)$ Calculated[b]	Measured/Calculated
$^{139}La(n,\gamma)^{140}La$	La_2O_3 powder in a disk 1.27 cm diameter x 3.2 mm thick	416 mg	1.14×10^{-2} (± 6.3%)	- - -	- - -
$^{140}Ce(n,\gamma)^{141}Ce$	CeO_2 powder in a disk 1.27 cm diameter x 3.2 mm thick	431 mg	5.45×10^{-4} (± 8.7%)	8.71×10^{-3}	.063
$^{142}Ce(n,\gamma)^{143}Ce$	CeO_2 powder in a disk 1.27 cm diameter x 3.2 mm thick	431 mg	1.16×10^{-2} (± 11%)	1.56×10^{-2}	.74
$^{141}Pr(n,\gamma)^{142}Pr$	Pr powder in a disk 1 cm diameter x 1.6 mm thick	79.8 mg	4.75×10^{-2} (± 10%)	6.39×10^{-2}	.74
$^{147}Pm(n,\gamma)^{148m}Pm$	$^{147}Pm_2O_3$ powder evenly distributed over 1 cm diameter area	13.6 mg	2.21×10^{-1} (± 13%)	- - -	- - -
$^{147}Pm(n,\gamma)^{148g}Pm$	$^{147}Pm_2O_3$ powder evenly distributed over 1 cm diameter area	13.6 mg	2.69×10^{-1} (± 18%)	- - -	- - -
$^{147}Pm(n,\gamma)^{148}Pm$	- - -	$\sum$ =	4.90×10^{-1} (± 12%)	4.87×10^{-1}	1.01
$^{146}Nd(n,\gamma)^{147}Nd$	Nd_2O_3 powder in a disk 1.25 cm diameter x 1.7 mm thick	84.63 mg	4.15×10^{-2} (± 14%)	5.72×10^{-2}	.72
$^{148}Nd(n,\gamma)^{149}Nd$	Nd_2O_3 powder in a disk 1 cm diameter x 1.6 mm thick	60.82 mg	6.67×10^{-2} (± 9.1%)	1.02×10^{-1}	.66

U. S. A.

TABLE I (Continued)

Reaction	Sample Description	Sample Mass	$\sigma_c(A,Z) / \sigma_f(235,92)$ Measured[a]	Calculated[b]	Measured/Calculated
$^{150}Nd(n,\gamma)^{151}Nd$	Nd_2O_3 powder in a disk 1 cm^3 diameter x 1.6 mm thick	60.82 mg	6.02×10^{-2}(± 21%)	9.15×10^{-1}	.66
$^{152}Sm(n,\gamma)^{153}Sm$	Sm O powder in a disk 1 cm diameter x 1.6 mm thick	87.39 mg	7.33×10^{-1}(± 4.5%)	9.78×10^{-1}	.75
$^{151}Eu(n,\gamma)^{152m_1}Eu$ ($I_{\frac{1}{2}}$ = 9.3h)	$^{151}Eu_2O_3$ powder in hemispherical bottom of quartz vial (6.4 mm diameter) 4 mm deep	15.33 mg	6.75×10^{-1}(± 8.4%)	- - -	- - -
$^{151}Eu(n,\gamma)^{152m_2}Eu$ ($I_{\frac{1}{2}}$ = 96 m)	$^{151}Eu_2O_3$ powder in polyethylene container	15.49 mg	1.39×10^{-3}(± 9.5%)	- - -	- - -
$^{151}Eu(n,\gamma)^{152g}Eu$	$^{151}Eu_2O_3$ powder in hemispherical bottom of quartz vial (6.4 mm diameter) 4 mm deep				
$^{151}Eu(n,\gamma)^{152}Eu$	- - -	$\sum$=	1.64 (± 6.3%)	1.43	1.15
$^{153}Eu(n,\gamma)^{154}Eu$	$^{153}Eu_2O_3$ powder in hemispherical bottom of quartz vial (6.4 mm diameter) 4 mm deep	14.87 mg	9.49×10^{-1}(± 7.9%)	8.90×10^{-1}	1.07
$^{158}Gd(n,\gamma)^{159}Gd$	Gd metal foil 1 cm diameter x 0.051 mm thick	30 mg	1.12×10^{-1}(±12%)	1.15×10^{-1}	.98

TABLE I (Continued)

Reaction	Sample Description	Sample Mass	$\hat{\sigma}_c(A,Z) / \hat{\sigma}_f(235,92)$ Measured[a]	$\hat{\sigma}_c(A,Z) / \hat{\sigma}_f(235,92)$ Calculated[b]	Measured/Calculated
$^{160}Gd(n,\gamma)^{161}Gd$	Gd metal foil 1 cm diameter x 0.051 mm thick	30 mg	5.75×10^{-2}(± 8.5%)	8.97×10^{-2}	.64
$^{169}Tm(n,\gamma)^{170}Tm$	Tm metal foil .13 mm thick	78 mg	2.93×10^{-1}(± 12%)	- - -	- - -
$^{181}Ta(n,\gamma)^{182m}Ta$	Ta metal foil .05 mm thick	142.05mg	4.70×10^{-4}(± 22%)	- - -	- - -
$^{181}Ta(n,\gamma)^{182g}Ta$	Ta metal foil .05 mm thick	142.05mg	3.29×10^{-1}(± 9.0%)	- - -	- - -
$^{181}Ta(n,\gamma)^{182}Ta$	- - -	$\sum$ =	3.29×10^{-1}(± 9.0%)	3.46×10^{-1}	.95
$^{186}W(n,\gamma)^{187}W$	W metal foil .127 mm thick	258 mg	9.00×10^{-2}(± 13%)	- - -	- - -

[a] $\phi\hat{\sigma}_f(235,92)$ was measured using NBS fission chamber, run to run normalization based on gold flux monitors included with each irradiation run.

[b] Calculated ratios are based on ENDF/B IV cross section data. Neutron spectrum used in obtaining spectral averages was derived from one-dimension transport theory (SCAMP-72/271) from ENDF/B IV data.

$[\hat{\sigma}_f(235,92)]$ calc. = 1.595 barn/atom

U. S. A.

II. COMPILATIONS AND EVALUATIONS

FRANCE

LABORATORY AND ADRESS : DRE/SPNR - CEN/CADARACHE
B.P. N° 1
13115 - SAINT-PAUL-LEZ-DURANCE -

NAMES : E. FORT, TRAN QUOC THUONG, J. BLUET

EVALUATIONS :

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

Method : Selection of resonance parameters - Calculation by BW single and multi-level formalism
Criticism of the experimental data
Adjustments on these data using statistical and optical model.
Elaboration of local or total systematics for the mean parameters.

Major sources of information : Neutron physics literature, BNL 325, Nuclear Data Sheets (level scheme), ENDF/B files, CINDA, NEUDADA library.

Deadline of litterature coverage : None

Status : Participation to 40 fission products evaluation (list given in INDC (NDS) - 75/G+P in CNEN-Bologna contribution) and to revision of the 22 P.F. evaluation completed in 1975 (magnetic tape - available at CCDN SACLAY).

Cooperation : CNEN/BOLOGNA

Computer file of evaluated data : Evaluation of 62 F.P. (22 revised) on magnetic tape (ENDF/B format) will be available at CCDN SACLAY

Compilation date : 1978

Publication : Common publication CNEN/CEA at the IV National Soviet Conference on Neutron Physics. KIEV 18-22 Avril 1977. "Neutron Cross Sections for 22 most important fission products"
E. FORT, J. KREBS, P. RIBON, Tran QUOC THUONG - CEA
E. MENAPACE, M. MOTTA, G. REFFO - CNEN/BOLOGNA

Laboratory and address: Max-Planck-Institut für Kernphysik
Postfach 103980, 6900 Heidelberg, Germany

Name: H.V. Klapdor

Evaluation: Shape of beta-strength function S_β in β^--decay of neutron-rich fission products.

Purpose: Knowledge of S_β is important for calculation of β-decay half-lives, of β-delayed neutron yield and of production rates for heavy nuclides by astrophysical processes and thermo-nuclear explosions.

Method: Information on the relevant part of $S_\beta(E^*)$, i.e. the structure in the lower tail of the Gamow-Teller giant resonance (GTGR), is obtained from the strengths of the M1-γ-decay of isobaric analogue states (in nuclei near the β-stability line) to anti-analogue, core-polarized and spin-flip configurations.

Deadline of literature coverage: April 1977

Status and results: The results are of qualitative nature, clearly indicating, however, existence, rough energy position, and importance of a resonance - like shape of S_β in the low-energy tail of the GTGR. Agreement of the predictions is found with recent experimental data[1,2].

Cooperation: with Institut für Kernchemie, Mainz

Discrepancies encountered: To assumptions S_β = const, or $\sim \rho(E)$ or of structureless GTGR, as used, e.g. in refs.[2-5].

Completion date: August 1976

Publications: H.V. Klapdor, CERN-Report CERN 76-13 (1976) 311
H.V. Klapdor, Phys. Lett. 65B (1976) 35

References:

1) K.-L. Kratz et al., Phys.Lett. 65B (1976) 231 and Proceed. Int. Workshop V on Gross Properties of Nuclei, Hirschegg (1977) 208

2) B. Jonson et al., CERN-Report 76-13 (1976) 277

3) S. Shalev, G. Rudstam, Nucl. Phys. A230 (1974) 153

4) J.C. Hardy, CERN-Report 76-13 (1976) 277

5) T. Kodama and K. Takahashi, Nucl. Phys. A239 (1975) 489

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 for thermal neutron induced fission compiled by Meek and Rider[3] have been used as input values for the computational procedure.

(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 Fast Binary Fission, Phys. Rev. C 40 (1976), 181.

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).

(ii) Sharma, D.N., Iyer, M.R., and Ganguly. A.K., Charge Distribution, Neutron Evaporation and Energy Distribution in Fast Binary Fission. B.A.R.C./I-408 (1976).

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.

ITALY

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

Names: F. Fabbri, T. Martinelli, E. Menapace, A. Montaguti, M. Motta, G.C. Panini, G. Reffo, M. Vaccari, A. Ventura.

Evaluation: The complete evaluation and compilation in ENDF/B format of the 40 FP, listed in the last progress report (No. 2,INDC(NDS)75/G+P) continues.

Purpose: Estimate of long term reactivity changes and FP accumulation in fast reactor.

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: December 1976.

Status: The evaluation and file compilation of 30 isotopes of the above mentioned list has been completed at the date April 30, 1977.

Cooperation: CEA - Cadarache and Saclay and ECN Petten.

Other relevant details: 25 group cross sections at infinite dilution and 0°K temperature have been generated for each evaluated isotope.

Computer file of evaluated data: ENDF/B format.

Expected completion date: 1977 for the evaluation of the 40 isotopes.

Laboratory and adress : Japanese Nuclear Data Committee/ FPND W.G.,
Japan Atomic Energy Research Institute,
Tokai-mura, Naka-gun, Ibaraki-ken, Japan.

Names : S. Iijima, M. Kawai, T. Yoshida, T. Murata (Nippon Atomic Industry Group Co.)
S. Igarasi, T. Nakagawa, Y. Kikuchi, Z. Matsumoto (JAERI)
H. Matsunobu (Sumitomo Atomic Industries)
H. Sasaki (Mitsubishi Atomic Industries, Inc.)
T. Aoki (Fuji Electric Co.)
K. Maki (Hitachi Ltd.)
T. Watanabe (Kawasaki Heavy Industries)
I. Otake (PNC)
R. Nakasima (Hosei Univ.)

1. Compilation : Level scheme and neutron cross section.
Se-82, Br-81, Kr-(83,84,85,86), Rb-(85,87), Sr-(88,89,90), Y-(89,91), Zr-(90,91,92,93,94,95,96), Nb-(93,95), MO-(95,96,97,98,100), Tc-99, Ru-(100,101,102,103,104,106), Rh-(103,105), Pd-(104,105,106,107,108,110), Ag-(107,109,110m), Cd-(110,111,112,113), Te-(127m,128,129m, 130), I-(127,129,131), Xe-(131,132,133,134,135,136), Cs-(133,134,135,137), Ba-(138,140), La-139, Ce-(140,141,142,144), Pr-(141,143), Nd-(142,143,144, 145,146,147,148,150), Pm-(147,148m,148g), Sm-(147,148, 149,150,151,152,154), Eu-(151,153,154,155), Gd-(155,156,157).

Purpose: For evalauation of neutron cross sections.

Source: Recent reference list and Nuclear Data Sheet (level scheme). CINDA and NEUDADA (neutron cross section).

Deadline of literature coverage: Mid 1976

Computer file of compiled data:
A modified file based on ORNL nuclear structure data file (level scheme, under test).
NESTOR file (cross section).

cont'd

JAPAN

cont'd

Completion date: May 1977

Publication: JAERI-M5752(1974) for 28 isotopes.
Report is in preparation for other isotopes. (Level scheme by Matsumoto, Murata, Nakasima. Cross sections by Matsunobu, Watanabe.)

2. Evaluation : Neutron cross sections of the 100 isotopes listed above.

Purpose: For entry to JENDL-2.

Method: Calculation with optical model and statistical theory, adjusted by capture data. Strength function model in unresolved resonance region. Single- and multilevel BW formula in thermal and resolved resonance regions.

Source: Present compilation (level scheme, capture and inelastic cross sections).
BNL-325, 3rd edition(resonance parameter).

Deadline of literature coverage: Mid 1976

Status: Evaluation was completed for 27 isotopes in April 1975.
Evaluation is in progress for other 63 isotopes.
Capture data are being re-examined.

Computer file of evaluated data: JENDL (ENDF/B-4 format).

Expected completion date: June 1977

Publication: JAERI-M5752(1974), S. Igarasi et al.
S. Iijima et al., J. Nucl. Sci. and Technol. 14 161 (1977).

JAPAN

Japanese Nuclear Data Committee / Decay Heat Nuclear Data Working Group

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

1. Compilation : Decay data and delayed neutron data

Purpose : For summention calculation of decay heat
Major Sources of Information : Journals and Nuclear Data Sheets
Deadline of Literature Converge : None
Cooperation : None
Computer File : Nuclear structure data file NDFILE for decay information and level scheme data; Retrieval program ABEG is used with NDFILE.
Expected Compilation Date : Continuous compilation
Publication : T. Hojuyama, K. Tasaka, Z. Matumoto, and R. Nakasima, "JNDC Nuclear Structure Data File - NDFILE", JAERI-M 6846 (1976), (in Japanese)

2. Evaluation : Estimation of decay heat nuclear data

Purpose : Making more reliable estimation of the released beta and gamma energies for short-lived fission products, for which experimental data are scarce
Method : Application of gross theory of beta decay
Major Sources of Information : Several Works of K. Takahashi and M. Yamada, for example, Atom. Data and Nucl. Data Tables, 12, (1973) 101; Several compilations of half-lives and Q-values
Deadline of Literature Coverage : Early 1976
Status : Estimation of released beta and gamma energies completed; Study on the gamma spectra is in plan.
Cooperation : Yamada's group at Waseda University at the early stage of the work
Computer File of Evaluated Data : in plan
Discrepancy Encountered : Some problems found in 1^+ odd-odd nuclides
Publications : T. Yoshida, tobe published in Nucl. Sci. Eng.
T. Yoshida, JAERI-M 6313 (1976), (code manual, in Japanese)

NETHERLANDS

Laboratory and address

Netherlands Energy Research Foundation (ECN)
(formerly: Reactor Centrum Nederland)
Petten (N.H.), The Netherlands.
telephone: (02246) - 6262, telex: 57211 reacp nl

Names

J.W.M. Dekker, H. Gruppelaar, R.J. Heyboer and A.J. Janssen

Evaluation

(1) RCN-2 evaluation of neutron cross sections (σ_t, σ_e, $\sigma_{n\gamma}$, $\sigma_{nn'}$-matrix, σ_{n2n}) for about 60 fission products in the energy range of 10^{-3} eV to 15 MeV, in KEDAK type format, for the following elements, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd, Te, I, Xe, Cs, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb.
(2) Generation of group cross sections for fast reactor calculations based on RCN-2 evaluation in the 26 group ABBN scheme with a fast reactor flux weighting spectrum and error files for capture group constants, including 26×26 covariance matrices.
(3) Adjustment of capture group constants based on (2) and integral STEK measurements.
(4) Generation of an adjusted point cross section library based on STEK integral data.

Purpose

Fast breeder power reactor data needs.

Method

Calculation with multilevel Breit-Wigner formula, optical model and revised statistical model, taking into account all available experimental information.

Major sources of information

BNL-325, NEUDADA, CINDA, Nuclear Data Sheets, recent literature, integral data from STEK.

Status

(1-3) Completed and published for 24 isotopes; new results obtained for ^{103}Rh, ^{107,109}Ag, ^{127,129}I; nearly finished: Sm isotopes;
planned for 1977: ^{147}Pm, Nd-isotopes, ^{137}Cs;
planned for 1978: 20 other isotopes.
(4) Planned for 1978.

Computer file

(1) KEDAK type format, will be sent to NEA Saclay.

Completion date

1978/1979.

Recent publications

(1) H. Gruppelaar, Tables of RCN-2 fission-product cross section evaluation, part 1 (24 nuclides), ECN-13 (1976).
(1) H. Gruppelaar, A.J. Janssen and J.W.M. Dekker, Intercomparison of recent evaluations for the capture cross sections of some fission-product nuclides, ECN-12 (1976).
(2,3) J.W.M. Dekker, Tables and figures of adjusted and unadjusted capture group cross sections based on the RCN-2 evaluation and integral measurements in STEK, part 1, ECN-14 (1977).

UNITED KINGDOM

(Editor: J.C. McKean, Secretary UK Chemical Nuclear Data Committee)

Laboratory and Address:	AERE Harwell	UKAEA AERE, Harwell, Oxfordshire, OX11 ORA
Name:	E.A.C. Crouch	
Compilation:	Chain, Cumulative and Independent 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, Project reports if the work is complete but unlikely to be published.	
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.	
Completion Date:	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.	

UNITED KINGDOM

Laboratory and Address:	AERE Harwell	UKAEA AERE Harwell Oxfordshire OX11 ORA
Name:	E.A.C. Crouch	
Evaluation:	(1) Neutron induced fission product yields for all fissile nuclides at neutron energies up to 15 MeV; chain yields and indepent yields. (2) Adjustments of the chain yields and the calculated independent yields to force agreement with the conservation laws i.e. to form a 'consistent set'.	
Purpose:	UKND File to be used in Reactor design and operation.	
Method:	(1) The individual yields for a given reaction (both chain and independent), are examined, weighted and the means calculated together with the errors. (2. The evaluated yields are augmented by interpolation to fill missing values or in the case of independent yields by calculation based on parameters estimated from known values. The results are fitted by least squares to the conservation conditions to give adjustments for chain yields and independent yields.	
Sources:	Compilation mentioned above.	
Deadline:	No results prior to 1950 are collected. Compilations believed to be complete up to end 1975, some 1976 results included.	
Status:	(1) and (2) Evaluation and Consistent set complete at January 1977.	
Co-operation:	We are prepared to exchange files with other groups.	
Computer Files of Compiled Data:	Compilation as above.	
Computer File of Evaluated data:	Magnetic tape or punched cards of the consistent set in ENDF/BIV format.	
Discrepancies found:	To be discussed by J.G. Cuninghame at the Petten 1977 FPND Panel.	
Publication:	It is hoped to publish in "Atomic Data and Nuclear Data Tables" during 1977.	

UNITED KINGDOM

Laboratory and Address: AERE Harwell

UKAEA
AERE, Harwell,
Oxfordshire OX11 ORA

Working Group:
B.S.J. Davies, A. Tobias — CEGB Berkeley
V. Barnes, J.R. Parkinson — BNFL Windscale
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, updated data file of radioactive decay data, including half-lives, Q-values, branching ratios, mean α, β and γ energies, α,β and γ energies and intensities, with associated uncertainties.

progress: the FPND of A. Tobias (partially reported in CEGB RD/B/M2669) has been used to produce a reasonably comprehensive decay data file of 561 nuclides in ENDF/B4 format, but without any associated uncertainties. An updating of this data (1973) has not been possible, but is in hand. This data has been merged with the equivalent U.S. ENDF/B4 decay data file to produce an enlarged FP data set containing over 800 FP nuclides.

major sources of information : the recent literature and NDS (particularly the mass-chain evaluation file in ENSDF format) are being surveyed in preparation for a series of updatings of the UK decay data file.

Cooperation: comparisons may be made between the U.K. file and the French file (J. Blachot), pinpointing anomalies and data errors in both files.

relevant details: the decay data can be produced in ENDF/B4 format using a computer program, with some effort being made to produce ENDF/B5 formatted data. This program calculates the mean beta energies of the individual transitions, Auger electrons, internal conversion electrons and X-ray emission contributions.

Although the first priority continues to be FPND, the decay data for specific activation products are also available in ENDF/B4 format.

expected completion date: a U.K. data file in ENDF/B4 format is now a reality. It is difficult to estimate when a comprehensively updated file will be available. The updating is being done in stages, and the aim is for a complete updating by June 1978.

(continued)

2) Decay scheme calculations

purpose: to compare experimental data with decay data calculated from a more basic data set (e.g. U.S. ENSDF file), and to produce mutually consistent catalogues of emission data for different radiation types.

progress: the CASCADE code has been modified to handle any number of decay levels, up to the maximum allowed by the core limitation imposed by the computer system used. Modifications are underway for inclusion of neutron and proton emission and spontaneous fission.

The procedure for cataloging the output data from CASCADE has been set up using a merging facility. These are listed in terms of energy and nuclide mass for each radiation type. A similar step will shortly be added to produce a listing in terms of half-life of each radiation type.

A code for converting ENSDF and NSDF data into CASCADE input data format has been written and is under test.

Major sources of information : ORNL (U.S. ENSDF file) data containing the various parameters of decay levels. Theoretical internal conversion coefficient data of Trusov, and Hager and Saltzer are being used.

Cooperation: Department of Nuclear Technology, Imperial College, London

Expected completion date : late 1977

U.S.A.

LABORATORY: Argonne National Laboratory
Argonne, Illinois 60439, USA
and SOREQ Nuclear Research Centre
Yavneh, Israel

NAMES: D. Saphier, D. Ilberg, S. Shalev, and S. Yiftah

EVALUATION: The Delayed Neutron (DN) emission spectra from thermal-neutron fission of ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu, from fast-neutron fission of ^{232}Th, ^{235}U, ^{238}U and ^{239}PU and from high-energy neutron (14.7-MeV) fission of ^{235}U and ^{238}U for six groups of delayed neutrons were evaluated.

METHOD: The evaluation is based on the measured DN spectra of the following individual fission products ^{85}As, ^{87}Br, ^{88}Br, ^{89}Br, ^{90}Br, ^{91}Br, ^{93}Rb, ^{94}Rb, ^{95}Rb, ^{134}Sn, ^{135}Sb, ^{136}Te, ^{137}I, ^{138}I, ^{139}I, ^{140}I, ^{141}Cs, ^{142}(Xe+Cs), ^{143}Cs and ^{144}Cs. By combining the spectra of the above isotopes, and using a least square method to fit the isotope Pn values and fission yields, DN spectra for the various fissile isotopes were obtained. The spectra were evaluated for six delayed neutron groups. Continuous spectra as well as a 54 energy group tabulation are available.

MAJOR SOURCES OF INFORMATION:

1. S. Shalev and G. Rudstam, Phys. Rev. Lett., 28, 687 (1972).
2. S. Shalev and G. Rudstam, Nucl. Phys. A230, 153 (1974).
3. S. Shalev and G. Rudstam, Nucl. Phys. A235, 397 (1974).
4. M. E. Meek and B. F. Rider, "Compilation of Fission Product Yields", NEDO-12154 (1972), and NEDO-12154-1 (1974), General Electric Company.

DEADLINE OF LITERATURE COVERAGE: 1976

STATUS: Compilation and Evaluation Terminated.

PUBLICATION: Nuclear Science Engineering, 62, 660 (1977).

U.S.A.

Laboratory and address	:	General Electric Company Vallecitos Nuclear Center P. O. Box 460 Pleasanton, California 94566
Name	:	B. F. Rider
Compilation	:	Fission Product Yields (from thermal, fast, 14 MeV neutron induced fission in U, Pu, Th, Np, and Cf nuclides).
Purpose	:	For burnup and fission rate and decay heat calculations. Basis for ENDF/B-V FP yields.
Major sources of information	:	CINDA, Nuclear Science Abstracts, INIS Atom Index, correspondence.
Deadline of Literature Coverage:		Ongoing
Cooperation	:	Brookhaven National Laboratory, Cross-Section Working Evaluation Group (CSWEG), Evaluated Nuclear Data File (ENDF/B-V), Fission Product Decay Heat Task Force, Fission Yield Subcommittee
Other relevent details	:	Approximately 18,000 entries from 1030 references.
Computer File	:	Tape available as ENDF/B-V from the USA National Nuclear Data Center, Brookhaven National Lab., Upton, New York 11973, USA
Expected completion date	:	June, 1977
Publications	:	"Compilation of Fission Product Yields", NEDO-12154-2 (1977) available from General Electric Company, P. O. Box 460, Pleasanton, California 94566, USA, Attention: B. F. Rider

U.S.A.

Laboratory and address:	Idaho National Engineering Laboratory EG&G Idaho, Inc. P. O. Box 1625 Idaho Falls, Idaho 83401 USA
Names:	C. W. Reich, R. L. Bunting, R. G. Helmer
Compilation:	Decay data for fission products. quantities treated include: $T_{1/2}$; $Q\beta$; branching fractions for the various decay modes; energies and intensities of all emitted radiations (e.g., β, γ, c.e., x-ray); K-, L- and total ICC; delayed-neutron energy spectra for individual precursors; uncertainties in all measured values.
Purpose:	Decay data file for ENDF/B.
Major sources of information:	Nuclear Data Sheets, journals and preprints of recent work.
Deadline of literature coverage:	Ongoing. For Version V of ENDF/B, cut-off date is Sept. 1977.
Computer File:	Decay data are included in ENDF/B Fission Product File. Tapes available through normal ENDF/B procedures.
Publications:	C. W. Reich, R. G. Helmer and M. H. Putnam, "Radioactive-Nuclide Decay Data for ENDF/B", U. S. AEC Report ANCR-1157 (ENDF/210), (1974).

U.S.A.

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Names:

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D. G. Madland
M. G. Stamatelatos
W. B. Wilson

Compilations:

A) Nuclide Parameter Evaluated Compilations

1) β and γ decay energies, branching fractions [decay and (n,γ)], halflives, Q-values and cross sections for 824 fission products are tabulated in Ref. 1. This is a basic data set that includes the major types of parameters, with corrections, from ENDF/B-IV, except for yields and the energy dependence of cross sections.

This reference data was compiled in cooperation with R. E. Schenter of the Hanford Engineering Development Laboratory, P. O. Box 1970, Richland, Washington 99352.

2) Multigroup β and γ spectra are tabulated in Ref. (2) for 180 fission product nuclides. The β spectra are given in 75 groups and the γ spectra in 150 groups. These data are based on ENDF/B-IV.

3) Multigroup cross sections are compiled in Ref. 11.

B) Evaluations

1) Yield distribution (pairing effects) and branching to isomeric states are evaluated and modeled in Ref. 3 and 4. Estimated values from the modeling are also included in these references.

2) Ternary fission is evaluated and compiled in Ref. (5).

3) β and γ spectra, decay heating and absorption buildup are evaluated by comparison with experiment in Ref. 6-11.

C) Purpose

Research by the Los Alamos nuclear data group (t-2) is directed at improvement in the national data file ENDF/B and at the use of these data in, e.g., determining a new decay heat standard.

References

1. T. R. England and R. E. Schenter, "ENDF/B-IV Fission Product Files: Summary of Major Nuclide Parameters," Los Alamos Scientific Laboratory report LA-6116-MS [ENDF-223] (Oct. 1975).

2. T. R. England and M. G. Stamatelatos, "Multigroup Beta and Gamma Spectra of Individual ENDF/B-IV Fission-Product Nuclides," Los Alamos Scientific Laboratory report LA-NUREG-6622-MS (Dec. 1976).

3. D. G. Madland and T. R. England, "The Influence of Pairing on the Distribution of Independent Yield Strengths in Neutron-Induced Fission," Los Alamos Scientific Laboratory report LA-6430-MS [ENDF-240] (July 1976).

4. D. G. Madland and T. R. England, "Distribution of Independent Fission-Product Yields to Isomeric States," Los Alamos Scientific Laboratory report LA-6596-MS [ENDF-241] (Nov. 1976).

5. D. G. Madland and Leona Stewart, "Light Ternary Fission Products: Probabilities and Charge Distributions," Los Alamos Scientific Laboratory report LA-6783-MS [ENDF-247) (April 1977).

6. D. G. Foster, Jr. and T. R. England, "Time-Dependent Spectra of Photons and Spontaneous-Fission Neutrons for Applied Problems," Invited Paper, Trans. Am. Nucl. Soc. 23, 551 (1976).

7. T. R. England and M. G. Stamatelatos, "Beta and Gamma Spectra and Total Decay Energies from Fission Products," Trans. Am. Nucl. Soc. 23, 493 (1976).

8. M. G. Stamatelatos and T. R. England, "Fission-Product Gamma-Ray and Photoneutron Spectra and Energy-Integrated Sources," NUREG-0155 [LA-NUREG-6345-MS] (Issued Dec. 1976) (See also Addendum 1, March 1977).

9. R. J. LaBauve, T. R. England, M. G. Stamatelatos, and D. G. George, "Approximations to Summation Calculations of Delayed Energy and Spectra," Los Alamos Scientific Laboratory report LA-6684-MS (Jan. 1977).

10. M. G. Stamatelatos and T. R. England, "Short Irradiation Fission-Product Beta Spectra and Total Energy: Calculations Versus Experiment," (ANS Summary accepted for ANS Annual Meeting June 12-17, 1977).

11. T. R. England, W. B. Wilson, and M. G. Stamatelatos, "Fission-Product Data for Thermal Reactors
Part 1
A Data Set for EPRI-CINDER Using ENDF/B-IV
Part 2
Users Manual for EPRI-CINDER Code and Data" Los Alamos Scientific Laboratory reports LA-6745-MS and LA-6746-MS (Dec. 1975) [To be issued by EPRI ~ March 1977].

U.S.A.

Laboratories	Washington University, Dept. of Chemistry, St. Louis, MO., USA Los Alamos Scientific Laboratory, Group CNC-11, Los Alamos, NM USA
Names	A. C. Wahl and K. Wolfsberg
Compilation and Evaluation	Independent yields and other data related to nuclear charge distribution in fission are being compiled and evaluated for low-energy fission processes (excitation energies up to $\sim$ 20 MeV).
Purpose	Development of systematics that will allow reliable estimates to be made for unmeasured independent yields and that will increase understanding of the fission mechanism.
Sources	Journals, reports, preprints, and personal communications
Method	Data from various types of measurements are compared for evaluation of the reliability of the newer methods.
Cooperation	We are prepared to exchange files with other groups.
Computer File	Information is held in standard forms on computer files.
Completions	Continuous compilation
Publications	A. C. Wahl, A. E. Norris, R. A. Rouse, and J. C. Williams, in Proceedings of the Second International Atomic Energy Symposium on Physics and Chemistry of Fission, Vienna, Austria, 1969 (I.A.E.A.), p. 813. K. Wolfsberg, Los Alamos Scientific Laboratory Report No. LA-5553-MS (1974).

III. DISCREPANCIES

The following discrepancies have been reported in this issue.

p. 9: Zp of primary fragments with masses 100, 101, 103 in fission of U235 is smaller than expected from systematics ($Zp \gtrsim Z_{UCD}$);
Half-life of Y^{99}, Nb^{103}, Y^{98}, Zr^{99}.

p. 24: mass distribution in U^{238} (n_{14MeV}, f), yields in the valley are about 20% higher than those given in NEDO-12154-1 (Meek and Rider, 1974). Strong symmetry with respect to $A_o = 117.3$, no fine structure.

p. 37: neutron binding energy of Xe^{137} was found to be considerably higher than the value reported in Phy. Rev. 175 (1968) 1516, P.A. Moore et al.

p. 45: absolute delayed neutron yield from Pu^{239}(n_{fast}, f) is by 10% lower than the datum evaluated by Tuttle (0.00598 ± 3.7% against 0.00664 ± 1.9% del. neutrons/fission).

p. 53: lower limit of resonance integral of Pm^{149} as determined from reactivity experiments is 20 000 b, which is a factor of 15 higher than present estimates;
neutron-absorption resulting from transient Xe^{135} was found to be 7.5% higher than that resulting from calculation with ENDF/B-IV data.

p. 60: fission product yields from U^{235} and Pu^{239} (n_{th}, f):
Pu^{239}: Ba^{138} yield is 14% higher than the presently recommended value.
Xe yields are 8.5% " " "
U^{235} and Pu^{239}: Nd^{148} yield is lower than the presently recommended value.

p. 67: independent yields of Nb^{96} and Cs^{136} from Th^{232} (n_{14MeV}, f) are in serious disagreement with the values reported by S.A. Rao (Phys. Rev. C5, 171(1972)).

p. 77: a comparison of integral fast capture cross section measurements for many fission products with the values calculated from ENDF/B-IV data is given in a table (Table I, pp. 78-83).