



INTERNATIONAL NUCLEAR DATA COMMITTEE

REQUEST LIST OF NUCLEAR DATA FOR SAFEGUARDS DEVELOPMENT PURPOSES AS SUBMITTED TO THE INTERNATIONAL ATOMIC ENERGY AGENCY BY MEMBER STATES

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1. Background

The results of a preliminary survey performed in mid-1970 by the Nuclear Data Section (NDS) on the role of nuclear data in the development of non-destructive and destructive safeguards techniques, were summarized in the draft report INDC(NDS)-21/C and presented to the third meeting of the International Nuclear Data Committee (INDC). The Committee, after examining the results of this initial survey, considered that appropriate steps should be taken in Member States submitting request lists for nuclear data needed for safeguards development so that such requests are examined and filtered by both the national safeguards authorities and the national nuclear data authorities, to ensure that requests are fully justified and officially approved. The official nature of the finally established international request list, which would be guaranteed by such procedures, is an assential prerequisite for providing the necessary motivation required to fulfill those data needs. Towards these ends, appropriate procedures have now been established in certain Member States, and in the case of the U.S.A. these procedures were outlined in the report INDC(USA)-33/C. In accordance with those procedures the Agency has received officially screened and sanctioned requests from the U.S.A., U.S.S.R. and the Federal Republic of Germany.

2. Present Status

The list of nuclear data needs from these three Member States has been merged on the basis of increasing atomic number and are given in Annex IV of this report. The names and addresses of the requestors are listed in Annex I, whilst the priority criteria which were used in assigning priorities to each request are reproduced in Annex II. These priority criteria were used by all of the requestors in the 3 Member States in question and were originally developed by the group at Los Alamos (U.S.A.). The Los Alamos criteria were however modified by an Ad-Hoc Sub-Committee on Safeguards of the USAEC's Nuclear Cross Section Advisory Committee (NCSAC). This Sub-Committee was established after the USAEC's Office of Safeguards and Materials Management (OSMM) responded to a request from the USAEC's Division of Research concerning participation in the nuclear data aspects of safeguards technical development. These modified criteria (Annex II) were subsequently adopted by the INDC at its fourth meeting (July 1971) and have therefore formed the basis for priority assignments in the current request list (Annex IV).

The format of the request list conforms to that used in INDC(NDS)-21/G and the description of the various items in the list is given in Annex III.

3. Summary of the Content of the Request List

The list contains some 23 priority I, 76 priority II and 25 priority III requests for nuclear data needed for the development of active and passive non-destructive assay techniques.

In addition, the half-lives of Zr-95, Ru-106, Cs-134, Cs-137, Ba-140 and Ce-144 and the thermal neutron capture cross sections of Zr-95, Ru-106, Cs-133, Cs-134, Cs-137 and Ba-140 are needed. The fission yield per fission event, resulting from thermal neutron fission of U-235 and Pu-239, of Cs-137, Cs-133, Ru-106, Zr-95, Ba-140 and Ce-144 are also required to within a maximum total uncertainty of 1 %.

4. Conclusions

At the fourth meeting of the INDC (Bombay, 12-16 July 1971), the Committee recommended "that the Agency take the necessary steps to produce as soon as practicable an official list of nuclear data requests for safeguards development purposes". The request list given in Annex IV is therefore being submitted to the Committee for its approval prior to the Secretariat initiating action to have the list of data needs distributed with the scientific and safeguards communities as recommended by the INDC.

The Nuclear Data Section has solicited the views of the Department of Safeguards and Inspection (DSI) on the structure and content of Annexes II-IV of this report and the response of the DSI is given in Annex V. In particular, the DSI commented that regarding the question of terminology it would be better to use the term "nuclear material" rather than "special nuclear material" in the priority criteria (Annex II) since the former is defined internationally whilst the latter is essentially defined by, and used in, the U.S.A. Turning to more substantive matters, the DSI noted that, though it was somewhat apprehensive about too wide a circulation, at an early stage, of the finally approved request list, they had no objection to the distribution of the final list to the parties listed below. However, in such an eventuality it should be made clear that the list has been drawn-up from requests originating in a few Member States and that the DSI is not, at the present time, sponsoring a worldwide circulation of nuclear data needs for safeguards. This the DSI considers important so as to avoid the impression that the DSI are urgently in need of, for their present purposes, the nuclear data requested in the list. Bearing these limitations in mind, it is proposed to have the finally approved list distributed as an INDC document to the following groups:-

- 1. The requestors themselves, their institutes and the national nuclear data and safeguards authorities in their countries.
- 2. Other safeguards development groups in Member States and other relevant international organizations.
- 3. Experimental nuclear physicists and their respective funding agencies, in a position to perform the required measurements.
- 4. Evaluators (both of neutron and non-neutron data) of experimental nuclear data.

Since some of the specialists in groups 3 and 4 above are unlikely to have much notion of the various technical aspects of safeguarding nuclear material, the DSI has agreed to prepare a short introduction to the final approved request list outlining the role of non-destructive measurements in the accounting function of a safeguards system. This summary will highlight a few selected applications of non-destructive techniques at specific fuel cycle points and discuss some of the developmental problems.

Turning to the priority criteria given in Annex II, the DSI observed that these criteria continue to present it with some problems. Since for the time being nuclear data measurements as such have been given a rather low priority in its (DSI) overall development programme, it is somewhat difficult for them (DSI), at the present time, to consider the criteria for assigning priorities to the needed data. This situation may change in the future, when they (the DSI) may be able to form a clearer picture about the needs for better nuclear data to improve existing non-destructive assay or to develop new techniques for safeguards.

One highly relevant point which the DSI recalled was that in most cases of applying safeguards one only makes relative measurements in the field and the accuracy of nuclear data does not matter - unlike the case of reactor core design calculations where one is seeking to calculate absolutely. A standard is available for comparison with the sample under interrogation or an item is chosen as a standard. These factors therefore indicate that one is more concerned with the reproducibility and precision of ones instrument, stability of electronics or background counts, etc. rather than with the accuracy of cross sections, yields or half-lives.

The Committee now has before it an officially screened and sanctioned list of requests from 3 Member States and this, along with the views of the DSI, should enable the committee to pass its judgement on the content of the request list, the distribution category of the finally approved list and such other matters as it may consider to be of relevance.

Acknowledgements

The Nuclear Data Section wishes to express its gratitude to the staff of the Division of Development in the Department of Safeguards and Inspection for their valuable comments during the preparation of this report.

A. Bremsstrahlung and Photon Induced Active Techniques

Lists of nuclear data needs have been formulated by Bramblett (U.S.A.), Markov (U.S.S.R.) and Fröhner (F.R.G.). Bramblett's needs relate to the total neutron yield produced by bremsstrahlung for fertile and fissile nuclear materials as well as for certain non-nuclear materials. In addition, the delayed neutron yield and fission product delayed Y-ray yields produced by bromsstrahlung from fertile and fissile materials are also required. Markov's needs concern the fission product yield, fission cross section and total neutron yield, as functions of the incident Y-ray energy, for Pu-238, Pu-241 and Am-241; whilst Fröhner's requests deal with the photoneutron (Y,n) spectra, for neutron energies between 0-100 eV, for U-235, U-238 and Pu-239. One of the principal characteristics of these requests is that in most cases the data simply do not exist and hence an extensive measurement programme is implied.

B. Neutron Induced Active Techniques

Data on delayed neutron yields resulting from high energy (Mev) incident neutrons are needed by Weisbin and Walton (U.S.A.), Markov (U.S.S.R.) and Stegemann (F.R.G.). Delayed neutron emission probabilities for Rb-92, 93 and 94 and the half-lives of the delayed neutron precursors Rb-92, 93, 94, I-139 and Br-88 resulting from U-235 thermal fission have been requested by Maksyutenko (U.S.S.R.). Weitkamp's (F.R.G.) requests are for data on the thermal and 2 Kev neutron capture Y-ray spectra of fissile and fertile materials. In addition, delayed fission Y-ray spectra and yields as a function of delay time for Mev neutron fission and thermal neutron fission have been requested by Kouts (U.S.A.) and Weitkamp (F.R.G.) respectively. Weitkamp being concerned with delay time intervals of less than 1 second, whilst for Kouts delay times from 10 μ sec. up to 1 hour are of interest.

C. Burn-up Calculations

Neutron cross section data (fission and capture) for Np-237, Pu-238, Pu-241 and Am-241 have been requested by Fischer (F.R.C.) for burn-up calculations.

D. Calorimetry

Decay heat data for Pu-240 and Pu-241 are needed by Schneider (F.R.G.) for calorimetric Pu determinations. In the case of Pu-241 an order-of-magnitude improvement is requested in the total # uncertainty of the specific decay heat (milliwatts/gramme) which is at present only known from direct measurements to about + 5 %.

E. Passive Assay Techniques

Skvortsov and Miller (U.S.S.R.) have formulated a series of data requests for the assay of spent fuel elements by the analysis of γ spectra from fission products. Amongst their data requests are the yields of γ -quanta per β -decay event of Zr-95, Ru-106, Cs-134, Cs-137, La-140 and Ce-144.

Annex I

Names and Address of Requestors: -

Dr. R. Bramblett,	Gulf Energy and Environmental Systems Inc., P.O.Box 608, San Diego California 92112, U.S.A. (formerly Gulf Radiation and Technology Inc.)
Dr. E.A. Fischer,	Institut für Angewandte Reaktortechnik, Gesellschaft für Kernforschung mbH, 75 Karlsruhe, Postfach 3640, Fed.Rep. of Germany.
Dr. F. Fröhner,	Institut für Angewandte Kernphysik, Gesellschaft für Kernforschung mbH, 75 Karlsruhe, Postfach 3640, Fed. Rep. of Germany. Present address: O.E.C.D. Neutron Data Compilation Centre, B.P.No. 9, 91 Gif-sur-Yvette, France.
Dr. H. Kouts,	Brookhaven National Laboratory, Upton, New York 11973, U.S.A.
Dr. B.P. Maksyutenko,	Institute for Physics and Energetics, Obninsk, Kaluga Region, U.S.S.R.
Dr. V.K. Markov,	Institute for Geo- and Analytical Chemistry, Moscow, U.S.S.R.
Dr. O.A. Miller,	I.V. Kurchatov Institute of Atomic Energy, Moscow, U.S.S.R.
Dr. V. Schneider,	ALKEM-Alpha-Chemie and Metallurgie GmbH, 7501 Leopoldshafen, Fed.Rep. of Germany.
Dr. S.A. Skvortsov,	T.V. Kurchatov Institute of Atomic Energy, Moscow, U.S.S.R.
Dr. D. Stegemann,	Lehrstuhl und Institut für Kerntechnik, Technische Universität Hannover, Elbestrasse 38A, 3 Hannover, Fed.Rep. of Germany.
Dr. R.B. Walton,	Los Alamos Scientific Laboratory, P.O.Box 1663, Los Alamos, New Mexico 87544, U.S.A.
Dr. C. Weisbin,	Los Alamos Scientific Laboratory, P.O.Box 1663, Los Alamos, New Mexico 87544, U.S.A.
Dr. C. Weitkamp,	Institut für Angewandte Kernphysik, Gesellschaft für Kernforschung mbH, 75 Karlsruhe, Postfach 3640, Fed.Rep. of Germany.

Annex II.

Priority Criteria Used in Assigning Priorities to Nuclear 1 ta Requests for Safeguards Purposes.

First Priority - (1)

First priority shall be given to those requests for nuclear data that

- (1) are necessary for the refinement of an existing technique in order to bring its accuracy to within acceptable limits for safeguards purposes, or
- (2) are essential for the development of a new and promising technique for the nondestructive assay and control of Special Nuclear Material in amounts that are significant to the safeguards system.

Second Priority - (II)

Second priority shall be given to those requests for nuclear data that

- (1) are essential for the use or interpretation of an existing or proposed technique for nondestructive assay and that are now obtained either by extrapolation or by an empirical method but for which experimental confirmation is desirable, or
- (2) are necessary for the development of a technique for nondestructive assay that may reasonably be expected to be useful for safeguards purposes.

Third Priority - (III)

Third priority shall be given to those requests for nuclear data that

- (1) may be needed for the nondestructive assay of materials not now included in the safeguards system but that are likely to be in the future, or
- (2) are necessary for the assessment or elimination of minor sources of error in the assay of Special Nuclear Material, or
- (3) are needed for the exploration of new techniques for nondestructive assay for future applications, or
- (4) may be needed for the development of new techniques for nondestructive assay for which the required technology does not now exist but which may reasonably be expected to in the future.

Annex III.

Description of the Headings in the Request List.

The sequence and meaning of the entries in the list given in Annex IV are as follows: -

- 1.) Request Number (Reg. No.). References only certain U.S.A. requests which also occur in the U.S.A. request list for neutron data measurements needed for reactor development.
- 2.) Target. The atomic number-chemical symbol-mass number are indicated for the target nucleus (for active assay) or the nucleus of interest (for passive assay).
- 3.) Reaction Type (Quantity and Variable). The Reaction Type is expressed in terms of the physical Quantity needed (e.g. half-life, fission yield etc.) and, if necessary, the Variable (e.g. fission product Y-ray spectra as a function of delay time).
- 4.) Priority. The priority (I, II or III) assigned to the needed data is indicated in this field. The priority criteria used by all requestors are given in Annex II.
- 5.) Incident Energy. The minimum and maximum energies of the incident particle are indicated in this field. Unless otherwise stated, neutrons are the incident particles. Incident electrons and photons are denoted by the symbols E_{ρ} and E_{χ} respectively.
- 6.) Accuracy Required. The accuracy to which the requested nuclear data is needed is indicated in this column. Generally, the accuracy needed for the development and testing of techniques and instruments may be quite different from that required for the final application. The accuracies have not been broken down by the requesters into the random and systematic components instead they have indicated the total % accuracy required for the needed nuclear data; this has been taken as a quadratic sum of the two components.
- 7.) Laboratory/Organization (Lab./Org.). The abbreviated name of the requesting laboratory, with the organization in parenthesis, is given in this field. The Member State is indicated directly below, also in parenthesis.
- 8.) Requestor. Comments, Status, Justification. The requestors name is first stated. This is followed by relevant Comments in which further specifications about the request are indicated, such as, special experimental conditions in performing the measurements needed to satisfy the request. This is followed by statements regarding the Status of needed data. Under Status, either remarks on existing or forthcoming measurement or evaluation work are given, or a statement made whether no nuclear data exist at all for the reaction in question. Following the Status remarks comes the Justification for the request, such as whether the data are needed for burn-up calculations, passive \(\frac{1}{2} \)—ray scanning of spent fuel elements, active photonuclear assay etc.
- 9.) Year. The year in which the request was originated is indicated in this last column.

Annex IV.

International Request List of Nuclear Data Needed for the Development of Safeguards Techniques.

REQUEST LIST FOR NUCLEAR DATA FOR THE DEVELOPMENT OF SAFEGUARDS TECHNIQUES,

Reaction Type

Req.No.	Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Ye. r
	1-D-2	(x y ,n)		I	E _e =Threshold - 10 Mev AE _e = 1 %	10 %	GRT(OSMM) (USA)	Bramblett	70
		Comments:	required. Emer	rgent neutr				47 yield per electron is onverter (preferably Ta) of	
		Status:	No useful data	a and calcu	lations insufficie	ent.			
		Justificat	ion: Standard	for non-de	strúctive photonuc	lear assay.			
····	3-Li-6	(x y, n)		III	E =Threshold -	20 %	GRT(OSMM) (USA)	Bramblett	7:
				•	3 E _e = 1 %				1 1
				ent thickne	ss to stop electro			lung converter (preferably relative to D-2 (x y, n)	_
		Statusi	No useful data	•					
		Justificat	ion: Background	l effect on	non-destructive p	hotonuclear	assay.		
25	4-Be-9	(n,p)Li 92	}- 9* Ве уп	II	14 Mev	10 %	LASL (USA)	Weisbin and Walton	70
		Comments	Delayed neutr	on yield r	required.				
		Status:	Ŧ			ment of Albu	urger Phys. R	lev., <u>132</u> , 328 (1963)	
		Justifica	tion: Backgrou	nd in delay	ed neutron assays.	•			

Req.No.	Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	?car
	4-Be-9	(n,p)Li H Be	9** P(E _n ;)	II	14-16 Mev	10 %	GEOHI (USSR)	Markov	71
		Comments: D	elayed neutron	yield requ	ired.				
		Status: A	lburger. Phys.R	lev., 132,	328 (1963)				
:		Justificatio	n: Allowance f	or backgro	und in delayed-neu	trop counting	3•		
	4-Be-9	(xy,n)		II	E _e =Threshold-10Me AE _o = 1%	ev 20 %	GRT(OSMM) (USA)	Bramblett	70
		Comments:) of suffic	ced by bremsstrah eient thickness to			blung converter yield may be relative	-
		Status	No useful data	•					
	-	Justificat	ion: Backgrour	nd effect o	on non-destructive	photonuclear	assay.		
	6- C-1 3	(x y, n)		II	E _e =Threshold-10Me Δ E _e = 1%	ev 20 %	CRT (OSMM) (USA)	Bramblett	70 H
		Comments:	(preferably Ta	ı) of suffi	uced by bremsstrat cient thickness to may be absolute.			ahlung converter n yield may be relative	
		Status:	No useful data	l.					
		Justificat	ion: Background	l effect on	non-destructive p	hotonuclear	assay.		
	8-0-17	(xg,n)		II	E _e = Threshold-10 ΔE _e = 1 %	Mev 20 %	GRT (OSMM (USA)) Bramblett	70
		Comments:	(preferably Ta) of suffi	uced by bremsstrat cient thickness to ay be absolute.			ablung converter n yield may be relative	
		Status:	No useful data	.•					

Justification; Background effect on non-destructive photonuclear assay.

Req.No.	Target	Reaction Quantity		le Priority	Incident Energy	% Accuracy	Lat/Org.	Requestor, Comments, etc.	:•∌
	40-2r- 95	Yield of Y-q		II	Prince plant and the second	1 %	IAE (USSR)	Skvortsov and Miller	70
		Comments: D	ifferent valu	es are quoted	in the literature	. Determination	on to Within	n 1 % is required.	
		Mo R.: Vo S	oscow, Atomiz S. Forsyth et ol. 1, p.521 .Hiller, Kerr	dat (1968). 	inst y-radiation EAS; mosium on Sa No. 11, 485 (1970) y Comm. (Repts)No.	feguards Tech	niques, Karl		
•		Justification	n: For assay	of U and Pu i	n fuel elements fr	om fission pro	oduct /-rad	liation.	
	40-2r-95	Half-Life		II.		1 %	IAE (USSR)	Skyortsov and Miller	70
			Different val l % is requir		d in the literatur	e. Determinati	ion to withi	n	
		. 1	Moscow, Atomi	zdat (1968). et.al., 1970	ainst y- radiation				i Garage
		Justification	n: For assay	of U and Pu	in fuel elements f	rom fission pr	roduct X-r	eadiation.	
	40-2r-95	o- (n, y)		III	Thermal; 0.06	eV 5%	IAE (USSR)	Skvortsov and Miller	70
		Comments:	Determination	to within 5 %	frequired.				
		Status:	Data unknown.						
				0.17 3.75-	in fuel elements f	mom figgion no	noduat	andi ati an	

		•									
Req.No.	Target	React Quantity	ion Type Vari	able Pr	iority	Incident En	ar <i>g</i> y	% Accuracy	Lab/Org.	Requester, Comments, etc.	Yec
	44-Ru-106	Yield of Y-		**************************************	II			3 %	IAE (USSR)	Skvortsov and Miller	70
		Comments: Status:	O.A. Miller	et.al.,	.Soviet	in the lite Atomic Energ EA Symposium	sr, <u>27</u> ,2	281 (1969)		in 3% required.	
	•	Justificat	ion: For as	say of U	and Pu	in fuel elem	ents fr	om fission p	product 8-	radiation.	
:	44-Ru-106	Half-Life			II '			1 %	IAE (USSR)	Skvortsov and Miller	70
		Comments:	Different required.	alues are	quoted	in the lite:	rature.	Determinati	on to with	in 1 % is	
		Status:	N.G. Gusev.	"Protecti mizdat (] h.et.al	on agair 1968). 1970 I	Atomic E <u>ne</u> rgy nst %- radia AEA Symposium	tion fr	om fission p			- 12 -
•		Justificat	ion: For as	say of U	and Pu i	in fuel eleme	ents fr	om fission p	roduct X-	radiation.	
	44-Ru-106	5 (n, y)]	III	Thermal; O	.06 eV	10 %	IAE (USSR)	Skvortsov and Miller	7 0
	•	Comments:	Different v		quoted	in the liter	rature.	Determinati	on to with	in	
		Status: Justificat				Cross Section				pl.No.2 (1966) -radiation.	
• *											

Req.No.	Target	Read Quantity	ction Type Variable	Priority	Incident Energy	# Accuracy	Lab/Org.	Pequestor. Comments, esc.
	55-Cs-133	σ-(n, χ)		II	Thermal; 0.06 eV	3 🛠	IAE (USSR)	Skyortsov and Riller
		Comments:	Different values required.	ues are quo	ed in the literatur	e. Determinat	ion to with	in 3 %
		Status:	K. Goldberg e Analytic Chem		ron Cross Sections, (1965)	BNL-325, S.E.	V. II 3, Su	ppl. No. 2 (1966)
		Justificati	on: For assa	y of U and i	du in fuel elements	from fission	product y-	radiation.
	55-Cs-134	σ(n, χ)		II	Thermal; 0.06 eV	3 %	IAE (USSR)	Skvortsov and Miller
		Comments:	Different val	ues are quot	ed in the literatur	e. Determinat	ion to with	in 3 % is required.
		Status:	M. Goldberg e	t.al., Neutr	on Cross Sections,	BNL-325, S.E.V	. II B, Sup	pl. No. 2 (1956)
		Justificati	on: For assay	of U and Fu	i in fuel elements f	rom fission p	roduct 8-r	adiation.
	55-Cs-134	Half-Life		I		1 %	IAE (USSR)	Skvortsov and Miller
		Comments:	Different valuequired.	ues are quot	ed in the literatur	e. Determinat	ion to with	in 3 % is
		Status:	R.S. Forsyth o	et.el., 1970	t Atomic Energy, 27, IAEA Symposium on	, 281 (1969) Safeguards Te	chniques, K	arlaruha,
		Justificati	on: For assay	of U and Pu	in fuel elements f	ron fission p	roduct 8-r	adiation.
	55-Cs-134	Yield of & per \(\beta\)-deca		I		1 %	IAE (USSR)	Skyortsov and Mille
		Comments:	Different val is required.	ues are quo	ted in the literatu	re. Determinat	ion to with	in 1 %
		Status:	Vol. 1, p.521	(1970)	O IASA Symposium on	Safeguards Te	chniques, K	arlsruhe,
			Mucl.Sci, and	. Engin., <u>22</u>	, 416(1965)			

Req.No.	Target	Reaction Quantity	on Type Variable	Priority	Incident	Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	:ear
	55-Cs-137	Yield of Y-quanta paragraph before y-decay even		Ž			1 %	IÆ (USSR)	Okvortsov and Miller	70
		Comments: D	ifferent val	nas sīa d.10	ted in the	literatu	re. Determination	on to with:	n 1 % is required.	
		S	malytic Chem - Hiller, Ker - S. Fersyth - Cl. 1, p.521	rntecinik, et-al., 197	12, No. 11,	, 485(197 posium on	0) Safeguards Tech	iniquos, Ka	rlacuhe.	
		Justification	ror assa	y of U and	Pu in fuel	elemento	from fission pa	rodust Y-r	adiation.	
	55-Cs-137	Falf-Life		Ĭ			1 \$	IAZ (USSR)	Ekvortsev and Miller	70
		Comments:	Different va	lues are qu	oted in the	e literat	ure. Determinati	on to with	in 1 ≸ is required.	
) to 1 hour". J. of Inorgan	, (Manual), nic Nacl.Ch et.al., 1	Moscow, Atem., 27, 12	omizdat 21 (1965)				- 14
	•	Justification	n: For ass	my of U and	Fu in fuel	l element	s from fission p	roduct 3-	radiation.	
	55-Cs-13?	σ(n, χ)		II	Thermal:	0.06 eV	10 %	IAE (USSE)	Skvortsov and Willer	70
		Comments: 1	Different val	lues are qu	oted in the	literat	ure. Determinati	on to with	in 10 % is required.	
		Status:	.Goldberg et	t.al., Neut	ron Cross S	Sections,	BNL-325,S.E.V.11	B, Suppl. Re	2.2 (1966)	
		Justificati	on: For ass	ay of U an	d Pu in fue	el elemen	ts from fission	product 3	-radiation.	
	56-Ba-140	Half-Life		II			1 %	IAE (USBR)	Skvortsov and Miller	70
		Comments:	Different va	lues are qu	oted in the	e literat	ure.D _e terminati	on to withi	h 1 % is required.	
	•		N.G. Gusev." Moscow, Atom			-rediatio	on from fission	products",	(Manual)	
		Justificat	ion: For es	say of U an	nd Pu in fu	el elemer	ts from fission	product y	-radiation.	

Req.No.	Target	Quantity	tion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Crg.	Requestor, Comments, etc.	
	56-Ba-140	5(n, x)		III	Thermal; 0.06 eV	5 %	IÆ (USSR)	Skvortsov and Killer	
		Comments:	Determination	n to within	5 % required.				
		Status: D	ata unknown.						
		Justificat:	ion: For assa	ey of U and	Pu in fuel elements	from fission	product 8	-radiation.	
	57-La-140	Yield of X-quanta p B-decay even		II		1 %	IAE (USSR)	Skvortsov and Miller	
		Comments:	Different val	lues are quo	ted in the literatu	re. Determina	tion to with	in 1 % is required.	
		Status:			against y-radiatio	n from fissio	n products".	(Manual)	
		Tugtificati	Moscow, Atomi		Do in Sual alamenta	for firsten			
		Justilicat.	toni for assa	ay or c and .	Pu in fuel elements	Trom 118810n	product 8-	radiation.	_
	58-Ce-144	Half-Life		II		1 %	IAE (USSR)	Skvortsov and Miller	
					7:	re. Determinat		in 1 % is mosuimed	
		Comments:			ted in the literatu				
		Comments: Status:	N.G. Gusev. "V.A. Greabile	'Protection a		from fission fission of U-2	products".	(Manual)Moscow, atomizdat (3
		Status:	N.G. Gusev. " V.A. Greshild O to 1 hour"	'Protection and et. El., "I', (Manual),	against y- radiation Products of prompt	from fission fission of U-2 (1969).	products". 235,U-238 am	(Kanual)Moscow, utomizdat(d Pu-239 from	1
	58 - Ce-144	Status:	N.G. Gusev. " V.A. Greshild O to 1 hour" tion: For assay	'Protection and et. El., "I', (Manual),	against y-radiation Products of prompt Koscow, Atomizdat	from fission fission of U-2 (1969).	products". 235,U-238 am	(Kanual)Moscow, utomizdat(d Pu-239 from	1
	58 - Ce-144	Status: Justificat: Yield of Y-quanta po	N.G. Gusev. " V.A. Greshild O to 1 hour" ion: For assay	'Protection and entered to the state of U and Protection of U and	against y-radiation Products of prompt Koscow, Atomizdat	from fission fission of U-2 (1969). from fission p	products". 235, U-238 an product y IAE (USSR)	(Manual)Moscow, utomizdat(d. Pu-239 from radiation. Skyortsov and Miller	-
	58 - Ce-144	Status: Justificat: Yield of Y-quanta positions of the decay even	M.G. Gusev. " V.A. Greshild O to 1 hour" tion: For assay er ent Different var required. N.G. Gusev." Moscow, Atom	'Protection and Protection and Prote	against Y-radiation Products of prompt Moscow, Atomizdat in fuel elements: oted in the literat against Y-radiation	from fission fission of U-2 (1969). from fission p 1 % were.Determinate from fission	products". 235, U-238 and product 3 IAE (USSR)	(Manual)Moscow, utomizdat(d Pu-239 from radiation. Skyortsov and Miller in 1 % is	1

.No. Target	Quantity	ion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org. Requ	estor, Comments, etc.	Year
90-Th-232	(xy, n)		II	E _e =Threshold-10 Mev Δ E _e = 1 %	10 %	GRT(OSLM) (USA)	Bramblett	<i>7</i> ¢
	Comments:	Bremsstrahl	ung conver	luding fission) produ ter (preferably Ta) o eld may be relative to	f sufficient	thickness to	प्रदेश	
	Status:	Gozani et.a. Katz et.al.	l., Trans. Canadian	American Nucl.Soc., $\frac{1}{4}$. J. of Physics, $\frac{35}{4}$.	3, 707 (1970) 70 (1957).) - Relative da	ata.	
	Justificat	tion: To allo	ow non⊷≟eś	tructive photonuclear	assay of Th	mixtures.		
90-Th-232	De layed-l	Y-Y N(t)	I	SeThreshold-10 Mev	10 %	CRT(OSMM) (USA)	Bramblett	70
	Comments:			d produced by bremsst: lung converter (prefe:			: Olerwan	
•			ctrons.Ne	utron yield may be re				1
•	Status:	to stop ele be absolute Cozani et a	ectrons.Ne . Trans.		lative to D-2	(xy,n) yield	or may	1 25
		to stop ele be absolute Gozani et a Katz et.al.	ectrons.Ne d. Trans. ., Canadia	utron yield may be re: American Nucl.Soc., 1	lative to D-2 3, 707 (1970) 470 (1957).	! (xy,n) yield	or may	
90-Th-232	Justificat Fission Product	to stop ele be absolute Gozani et a Katz et.al.	ctrons.Ne	utron yield may be red American Nucl.Soc., 1 n J. of Physics, 35,	lative to D-2 3, 707 (1970) 470 (1957).	! (xy,n) yield	or may	
90-Th-232	Justificat Fission Product	Cozani et a Katz et.al. Cozani et a Katz et.al. F(Ey, t co-1 hour) Absolute f Bremsstrah	ctrons.Ne cl. Trans. Canadia low non-de low non-de	American Mucl.Soc., 1 n J. of Physics, 35, 2 structive photonuclear Ee = 10 Mev	Intive to D-2 3, 707 (1970) 470 (1957). r assay of Th 10 % yield produce of sufficien	(xy,n) yield -Relative data mixtures. GRT (CSMM) (USA) d by bremsstra at thickness to	Pramblett	16 -

Req.No. Target	React: Quantity	ion Type Variable	Priority	Incident Energy	% Accurac	Lab/Org.	Requestor, Comments, etc.	Year
90 -Th-232	♂(n,f)		I	1-15 Mav	5%	IKT(TUH) (FRG)	Stegemann	70
	Comments:	Fission cross	section re	equired to within	5%.			
	Status:	Ben-David, IAI Bak et al., II 3, 77 (1971).	NDC (NDS)~36	(1968) review up 1 5/G (1971) and J. (to 14 Mev. of the Kore	an Nuclear So	ociaty,	
·	Justificat	ion: Standard i	for non-des	structive assay of	spherical i	uel elements		
90-Th-232	$\overline{\mathbf{v}}$	Prompt	I	1-15 Mev	3%	IKT(TUH) (FRG)	Stegemann	70
	Comments:	Average number	r of prompt	neutrons per neut	ron induced	fission req	uired.	
	Status:	Davey, Nucl. S Kanero et al., Energy Review	, INDO(NDS)	egin, <u>44</u> , 345(1971) -34/G (1972) evalu	evaluation to be	up to 15 Me published i	v. n Atomic	- 17
	Justificat	ion: Standard f	for non-des	tructive essay of	spherical f	uel elements		ı
90-Th-232	Delayed-X-Y	P(E _{n'})	I	1-15 Mev	5%	IKT(TUH) (FRG)	Ste gemann	70
	Comments:	Delayed neutro	on fraction	, Bi, required.				
	Status:	** * - \ - * - \ *	10042 23 3	56 (1970). Prelimi		i- 1E 16		

Rq.No. Terget	Reaction Quantity	~ ~ .	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.					
348 90-Th-232	Delayed -X-Y	P(E, T 1/2)	II	2 and 14 Mev	35 €	BRL(OSYM) (USA)	Kouts					
	ir	induced fission for Ey72 Nev and 10 Asec ZT1/221 hour. Absolute y-ray yields to a factor of 2 also useful.										
	<u> </u>	Status: R.Chrien. (BNL unpublished) has some data for U-235 and Pu-239. N.B. Large and R.J. Bullock, 1969 IAEA Symposium on Physics and Chemistry of Pission, Vienna, p.637 (1969); presented some data for U.										
	Justification	i Backgroun	d effects	in assay of U-233 -	Th-232.							
92 - V-233	(xý,n)		I	E = Threshold-10 Me	10 %	ORT(OSMM) (USA)	Bramblett	-				
	co	nverter (pre	forably Ta	fission) produced to of sufficient thic xy,n) yield or may to	kness to stop							
	Status: Ka	tz et.al., C	anadian J.	of Physics, 35, 470	(1957).							
	Justification	To allow	non-destri	ctive photonuclear	assay of U-233	•						
92 - U - 233	Delayed-N-Y	N(t)		E = Threshold-10 Me E = 1 %	ev 10 %	GRT(OSLY (USA)	2.) Bramblett					
	q)	referably Ta) of suffi	oduced by bremsstrak cient thickness to s field or may be absol	stop electrons							
	Status: No	data.										
				tive photonuclear as								

Req.No.	Target	Reac Quantity	tion Type Variable	Priority	Incident Energy	\$ Accuracy	Lab/Org.	Requestor, Comments, etc	
	92-0-233	Fission Pr	roduct P(Ey,t) 1 hour)	II	E _e = 10 Mev ΔE _e = 5 %	10 %	GRT(OSMA) (USA)	Bramblett	
		Comments:	Bremsstrahlung	converter	delayed Y-ray yield (preferably Ta) of s Ey= 0.5 - 5.0 New of	ufficient thic	kness to sto		
		Status: Justificat	No data. ion: For non-des	tructive p	hotonuclear assay of	this SMM.			
364	92-0-233	Delayed-X-	Y P(EX, TX)	I	2 and 14 Kev	35 %	BNL(OSMI) (USA)	Kouts	
		Comments:	Accuracy reque induced fission to a factor of	for Ey>2	s to relative intens: Mev and $10 \mu \sec \frac{\pi}{2} T$	ities of delay 1/2 Z l hour. A	ed y-reys f bsolute y-	rom neutron roy yields	
		Status	N.R. Large and	R.J. Bullo	ed) has some data for ck, 1969 IAEA Symposi sented some data for	lum on Physics		ry of Fission,	
		Justificat	ion: Assay of U	-233 fuels	•				
	92-U-234	(xy,n)		II	$\Xi_{e} = \text{Threshold} - 10$ $\Delta \Xi_{e} = 1 \%$	Kev 30 %	ORT(OSKM) (USA)	Bramblett	
		Comments:	Bremsstrahlung	converter	ng fission) produced (preferably Ta) of s may be relative to D	ufficient thic	kness to ato	PF	
1		Status:	No data.						
					ive photonuclear ass				

Req.No.	Target	Reac Quantity	tion Type Variable	Priority	Incident Energy	% Acouracy	lab/Crg. B	Requestor, Comment	s,etc. Year
	92 - U - 234	Delayed-N-Y	N(t)	III	E_=Threshold-10 Mev	30 %	CRT(OSLM)) Bramblett (USA)	70
					ΔE _e = 1 %			(ODR)	
		Comments:	Brems	strahlung	duced by bremsstrahlu converter (preferably n yield may be relati	Ta) of suffi			
,		Status	No data.						
		Justificat	ion: Effect on n	on-destruc	tive photonuclear ass	ay of U-233 a	and U-235.		
	92-U-234	Fission Produ	hour) P(Ey,t)	III	E = 10 Mev AE = 5 %	30 %	GRT(OGMA) • (USA)	Bramblett	70
		0							-
		Comments:	Bremsstrahlung	converter	delayed y -ray yield. (preferably Ta) of su Ey= 0.5 - 5.0 Mev wi	fficient thic	kness to st		ī
		Status:	Bremsstrahlung	converter	(preferably Ta) of su	fficient thic	kness to st		20
		Status:	Bremsstrahlung Emergent Y-ray No data.	converter energies,	(preferably Ta) of su	fficient thic th $\Delta E_{\chi^{\pm}}$ 3 Ke	kness to st		
	92 - U - 235	Status:	Bremsstrahlung Emergent Y-ray No data. ion: Effect on ot P(E _Y)	converter energies,	(preferably Ta) of su Ey= 0.5 - 5.0 Mev wi	fficient thic th ΔE_{γ} 3 Ke say of U-233 \pm 15 %	kness to st	op electrons. Weisbir and	20 ·
	92 - U-235	Status: Justificat Fission Produ Y-ray spectr	Bremsstrahlung Emergent Y-ray No data. ion: Effect on ot P(Ey) a Fission product and yields (pho- from thermal ne	converter energies, non-destru II X-ray sp tons/fissi	(preferably Ta) of su Ey= 0.5 - 5.0 Mev wi ctive photonuclear as	say of U-233 + 15 % Absolute yi gies, Ex = 0. 1 msec - 12 bresolution at	and U-235. LASL eld. (USA) 25 - 5 Mev, ours result	op electrons. Weisbir and	20 ·
	92 - U - 235	Status: Justificat Fission Produ Y-ray spectr and yields.	Bremsstrahlung Emergent Y-ray No data. ion: Effect on ot P(Ey) a Fission product and yields (pho from thermal ne should be 2.5 K Walton and Sund Fisher and Engle F.C. Malenscheit Energy, Vol. 15	II X-ray sp tons/fissi utron fiss ev and aos Phys. Re p. Phys. R tons/fissi	(preferably Ta) of sure; and the sure of t	say of U-233 ± 15 % Absolute yi gies, Ex = 0. 1 msec - 12 h resolution at accuracy. e on Peaceful	ekness to st and U-235. LASL eld. (USA) 25 - 5 Mev, ours result 1.2 Mev	Weisbir and	2C ·

Req.No. Target	Reaction Quantity	n Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-0-235	o (n,f)		I	Thermal-15 Mev	3%	IKT(TUH) (FRG)	Stegemenn	70
	Comments:	Fission cro	ess section	required to within	3 %.			
	Status:	WARD-4210 T Steen, WAR	4-1 (1972) D-TM-691 (M-2497 (1972) simul recent evaluation 1969) evaluation fr 8854 (1968) evaluat	for ENDF/B-II om thermal up	I library.	160 eV - 20 Mev.	
	Justification	on: Standar	d for non-	destructive assay o	f fuel elemen	its.		
92-U-235	₹	Prompt	I	Thermal-15 Kev	3%	IKT (TUH) (FRG)	Stegemann	70
	Comments:	Average num	bor of pro	mpt neutrons per ne	utron induced	. fission red	quired.	
	<u>Status:</u>	Manero et a Review (197 Mather et a Boroughs et	1., INDC(N 2) evaluat 1. AWRE-0- al., GA-38 9 IAEA Sym	Engir ., 44. 345 (DS)-34/G (1972) and ion up to 15 Mev. 55/71 (1971) evaluation posium on Physics a	to be publis tion up to 15 up to 15 Mev	hed in Atom Mev.	Nev. ic Energy p. 930 (1969) evaluation	1 21 .
•	Justification	on: Standard	for non-d	estructive assay of	fuel element	S •		
92-0-235	Delayed-N-Y	P(E _n ;)	I	Thermal-15 Mev	5 %	IKT(TUE) (FRG)	Stegemenn	70
	Comments:	Delayed ne	utron frac	tion, \mathcal{P}_i , required.				
	Status:	review from	m thermal- l. WASH-1	posium on Physics a 15 Mev. 155, 156(1970) prel NDS)-34/G (1972) an	iminary resul	ts		
		ion: Standa:						

Req.No.	Target	React Quantity	ion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Y5 '.2'
	92-0-235	Delayed-N-Y	$ar{ u}_{\scriptscriptstyle D}$	II	5 - 14 Mev	5 %	LASL (USA)	Weisbin and Walton	7.1
		Comments:	Delayed neutro	n yield re	quired. Data desi	red for extra	apolation t	o 15 Mev.	
•		Status:	Masters et.al.	American	tion to 2.5 Mev. Nucl.Soc., <u>11,</u> 1 nary data (LASL),			and 14 Mev.	
		Justificat	ion: Calculati	ons of mod	derating assemblie	s for U-235	assays.		
	92-U-235	Delayed-N	Precursor Half-Lives	III	Thermal	5 %	FEI (USSR)	Maksyutenko	7,1
		Comments:	half-lives of	these dels	Rb-93 and Rb-94, wed neutron precured more accurate	rsors, result			
		Status:	S. Amiel, 1969 p. 569 (1969).		osium on Physics	and Chemistry	of Fissio	n, Vienna,	
		Justificat	ion: For inter	pretation	of delayed-neutro	n data.			•
	92-0-235	Delayed-N	Emission probabilit	III	Thermal	5 %	FEI (USSR)	Maksyutenko	73
	·	Comments:	contradiction	with data	ssion probabiliti from nuclear syst d for these isoto	ematics. More	accurate	(5 %)	
		Status:	p. 569 (1969).		osium on Physics es quoted by diff			n, Vienna,	
		Justificat	ion: For the i	nterpretat	ion of delayed ne	utron data.			

		React	ion Type						
Req.No.	Target	Quantity		Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comment	ts,etc. You
	92-U - 235	Delayed-X-Y	P(Eg,T%)	III	Thermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	,
	· · · · · . · · · · · · · · · · · · · ·	Comments:	interesting f	or interv	y sp s ctra as a fur rals < 1 sec. Accu for T ½ acceptable.	racy refers	lay time re to Y-ray	quired. Particular intensities. Erro	rly ors
		Status:	No data.						
		Justificati	ion: For non-de fission p		e assay of fission	able materi	el by X-s	pectroscopy of sho	ort lived
392	92-U-235	Delayed-7->	P(E _X , T ½)	I	2 and 14 Mev	35 %	BNL(OSLM) (USA)	Kouts	÷ ·
		Comments	Accuracy requesinduced fission to a factor of	on for	ers to relative in Ex>2 Mev and 10 puseful.	tensities of sec 2 形。	f delayed } Zl hour. A	-rays from neutro bsolute y -ray yi	on ields
		Status:	N.R. Large and	d R.J. Bu	ished) has some da <u>llock,</u> 1969 IAEA S presented some dat	ymposium on			ssion,
		Justification	on: Assay of	U-235 fu	els.				
	92-U-235	(n, g)	P(E &)	I	Thermal; 2 Kev	25 9	iak(c		70
		Comments	Capture y -r	ay spects	ra required.				
		Status:	Experimental thermal neutrobetter. Final Preliminary of Vol. 2, p.113	determinations near l report d lata public 3 (1970) a	ation of P(E _V) for ly completed at Ka to be published in ished at 1970 IAEA and at 1971 Ispra lues in Nuclear Sa	risruhe to a 1972. Symposium o meeting on N	n accuracy on Safeguard Jon-Destruct	of -50% to + 100 s Techniques, Kar ive Measurement a	% or lsruhe, nd
			Physikalische	Gesells	ohaft.			_	
		Justifica	tion: For non-	destructi	ive assay of nuclea	ar meterial	by neutron	capture & -ray spe	ectrometry.

Req.No.	Target	Reactio Quantity	n Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
	92 - V-235	Fission Yiel of 55-Cs-133		I	Thermal	1 %	IAE (USSR)	Savortsov and Miller	7
		Comments:						row thermal fission of ed in the literature.	
		Status:	O.A. Miller	et.al., Sovi	et Atomic Energy;	27. 281 (196	8)		
		Justificati	oni For ass	ay of U and 1	Pu in spent fuel o	lements by th	e fiarion	product Y-rays.	
	92-0-235	Fission Yie of 44-Ru-10		II	Phermal	1 %	IAB (USSR)	Exyphtsov and Miller	-
		Comments:						or ibermal fission of ed in the literature.	
		Status:			12, No. 11, 485 (ı
					les showing the co fission", Koscow,			ಕಾರಣ ಕಾಸ್ತ್ಯಾಗಿಯ ಕ್ರಾಮ	7.
		Justificat			Pu in spent fuel s			product Y-rays.	i
5	72-4-235	Fission Yie of 40-Zr-95	ld	II	Thermal	1 %	IAE (USSR)	Jkventsov and Miller	7
		Comments:						or thereal fission of ed in the literature.	
		Statusi	R.S. Forsyth Vol. 1, p.52	1 et.al., 19°	t Atomic Energy, <u>2</u> 70 IAEA Symposium <u>12</u> , No.11, 485 (19	on Safeguards	Technique:	s. Karlaruha,	
		Justificat:	ion: For as:	say of U and	Pu in spent fuel	elements by t	he fission	product &-rays.	
9:	2-U-235	Fission Yiel of 55-Cs-137		1	Thermal	1 %	IAE (neeu)	Skvortsov and Miller	70
•		Comments:	Fission prod of U-235 req	uct yield pe uired to wit	r fission event of hin 1 % accuracy.	55-Cs-137 re Different val	esulting fr lues are qu	on thermal fission cted is the literature.	
			R.S. Forsyth p.521 (1970)	et.ai., 197		n Safeguards). Techniques	. Harlsmuhe, Vol.1	
			3.Hiller, Ke	rntechnik, 1	<u>2</u> , No. 11, 485 (19	((U) •			

Req.No.	Target	Reaction Quantity	on Type Variable	Priority	Incident Energy	% Accuracy	Lat/Crg.	Requestor, Comments, etc.	'ar
	92-U-235	Fission Yield of 56-Ba-140		II	Thermal	1 %	IAE (USSR)	Skvortsov and Killer	<u> </u>
,					ission event of 56- % accuracy. Differe				
		X.	omizdat (196 .A. Greshilov Manual).Mosco	8). <u>et.al.</u> , "Pro w, Atomizdat ((1969). J. of Inorg	ssion of U-23 anic Nucl.Che	5, U-238 s m <u>27</u> . 12	nd Pu-239 from O to 1 hour 1 (1965)	, 11 _.
		Justification	For assay	of U and Pu	in spent fuel eleme	ents by the f	issien pre	duos y-rays.	
grander as and refer that the party	92-U-235	Fission Yield of 58-Ce-144]	II	Thermal	1 %	IAE (USSE)	Skvortsov and Miller	:0
					ission event of 58- % accuracy. Differe				
		At	omizdat (196	8).	inst %-radiation f		products ⁿ ,	(Manual) Moscow,	₹ % "n
		Justification	For assay	of U and Pu	in spent fuel eleme	enta by the f	ission pro	duct -rays.	
	92-U-235	(Y,n)Spectre	1	III	E y = 5-8 Kev	10 %	IAK (GE) (FRG)) Frönner	70
		re	quired. Accu	racies refer	esolved resonances to shape and absolu esclution should be	te values to	within 20;		
		Status: No	active work	known.					
	- (1) - (2) - (4) (4) (4) (5) (7) (7) (7) (7) (7) (7) (7) (7) (7) (7	Justification		or the explor l usefulness	ation of new techni is unknown.	ques for non-	-destructi	ve assay whose	-

Reg.No.	Target	React Quantity	ion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Tomments, etc.	Year
92	2-0-235	(xy,n)		II	E _e = Threshold - 10 Mev	10 %	GRT(OSEE) (USA)	Bramblett	<u> 20</u>
					∆E _e = 1 %				
		Comments:	converter (pre:	ferably Ta) of		ess to stop		uired. Bremestrahlung . Neutron yield may	
		Status:	Gozani et.al Bowman et.al.,	Trans.Americ Phys.Rev.,	ean Mucl.Soc., <u>13</u> , 133, E676 (1964) -	707 (1976) (%,n) data	- Relative above 7 Mer	data. V	
		Justificat	ion: For non-de	estructive pho	stonuclear assay of	this SIM.			
92	?-0-235	Delayed-N-Y	N(t)	II	E _e -Threshold -10 Mev	10 %	GRT (OSEM) (USA)	Branblett	ិព
					ΔE _e = 1 %				
		Comments:	(preferably Ta) of sufficier	ed by bremastrablu to thickness to sto t or may be absolut	p electrons			i N
		Status:	Gozani et.al.,	Trans. Ameri	can Nucl.Soc., 13,	707 (1970)	- Relative	data.	e I
		Justifica	tion: For non-	lestructive pl	notonuclear assay o	f U-235.		-	
92	!-U-235	Fission P y-y(1 mse	roduct P(E)	nt) II	E _e = 10 Mev ΔE _e = 5 %	10 %	GRT (OSMM) (USA)	Bramblett	70
		Comments:	Bremsstrahlung	converter (pr	ayed Y-ray yield referably Ta) of su = 0.5-5.0 Mev with	fficient th	ickness to		
		Status:	Rundquist, Tran	s.American Nu	icl.Soc., <u>13</u> , 746 (1970)-Preli	minary data	1.	
		Justifica	tion: For non-d	lestructive ph	otonuclear assay o	f this SNM.			
92	-U-236	Fission Spectrum	Neutron	II	One energy ab fission thres		LASI. (USA)	Weisbin and Walton	70
		Status:	Parker, AWRE-0-	30/64 (1964);	evaluation.				

Justification: Background corrections in U-235 spent fuel assay.

Raq.No.	Target	Reaction Quantity	Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org. Re	ones.or, Comments, ato.	22
	92-U-236	Delayed-N-y	r,	I	3 and 14 Mev	10 %	LASL (USA)	Weisbin and Walton	71
			-		te. Data have been on in U-235 spent f	_	rically.		
	92-0-236	(xy,n)	Nagarakakan dipelangan 1980 kanada di Produktion	II	E =Threshold - 10 Kev	30 %	GRT (OSMAL) (USA)	Bramblest	70
					$\Delta E_{\mu} = 1\%$				
			Bremsstrahlu	ng converter	ding fission) produ (preferably Ta) of may be relative to	sufficient t	hickness to a	top	
		Status:	No data.			Ü			
		Justification	on: Effect	on non-destr	uctive photonuclear	assay of U-2	35•		
	92-U-236	Delayed-N-Y	N(t)	III	E _e =Threshold -	30 ≉	GRT (OSMI) (USA)	Bramblett	70
				′	ΔE = 1 %				
			converter (pr	referably Ta	oduced by bremsstra) of sufficient thi D-2 (xy,n) yield o	ckness to sto	p electrons.		,
		Status: 1	No data.		U				
		Justification	on: Effect of	on non-destr	uctive photonuclear	assay of U-2	35•		
	92-U-236	Fission Produ X-Y (1 msec-1	et P(Ey	,t) III	E _e = 10 Mev AE _e = 5 %	30 %	GRT (OSMM)	Bramblett	75
		1	required. Bro	emsstrahlung	delayed y -ray yie converter (prefera y -ray energies, E	bly Ta) of su	fficient thic	eness to	
			io data.			•	Q		
		Justification	m: Effect	on non-destr	uctive photonuclear	assay of U-2	35•	•	

Req.No.	Target	React Quantity	ion Type Variable	Priority	Incident Energ	y % Accuracy	Lab/Org.	Requestor, Comments, etc	sel
9	2-U-238	ᠮ	Prompt	II	1-15 Kev	5 %	IKT(TUH) (FRG)	Stegemenn	70
		Comment	: Average num	ber of pro	mpt neutrons per	neutron induce	d fission r	equired.	
		Status:	Manero et s published i Mather et s	il., INDC(N n Atomic E il., AWRE-0	Engin., 44, 345 DS)-34/G (1972) nergy Review (19 -44/71 (1971) ev	evaluation up t 72). Caluation up to	o 15 Mev; t 15 Mev.	Mev. o be	
	·	Justifi	cation: Standa	rd for non	-destructive ass	ay of fuel elem	ents.		
	92-U-238	Delayed-	$N-Y$ $P(E_{n'})$) II	1-15 Me v	5 %	IKT(TUE) (FRG)	Stegemann	70
		Comment	B: Delayed neu	tron fract	ion, \mathcal{P}_{i} , require	d.			
		Status:	experiments	up to 21	oviet J. of Nucl Mev. 31, 156 (1970)	• Physics, 7, N	o. 2, 189 (1968)	28
		Justifi	cation: Standa	ird for non	-destructive ass	ay of fuel elem	ents.		1
92-	J - 238	(n.f)		II 1	- 15 Mev		'(TUH) 'RG)	Stegemann	70
		Comments: F	ission cross s	ection requ	ired to within	5%•			
		6	valuation up to ilbert et al.,	o 20 Mev. BNL-50298,	(1971) and J. (112(1971). 97 (1972), simul				

Justification: Standard for non-destructive assay of fuel elements.

Req.No.	Target	Reacti Quantity	ion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	ಿತು
417	92-U-238	Delayed -}-	- y P(E & ,T)	() II	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	59
		Comments:	from neutro	n induced	fers.to relative in fission for Ey>2 & s to a factor of 2	lev and 10 # sec			
		Status:	N.R. Large	and R.J. B	lished) has some da ullock, 1969 IAEA S .637 (1969); presen	ymposium on P	hysics and Ch	emistry	
		Justificati	on: Assay o	f U fuels.					
	92-U-238	(Y,n)Spect	ra	III	Ey= 3-8 Mev	10 %	IAK(GfK) (USA)	fröhner	70
	•	Comments:	between 0-1	00 eV requ 0 % accura	with resolved reson ired. Accuracies re cy would be helpful v.	fer to shape a	and absolute	values	
		Status:	No active w	ork known.					
		Justificati			ploration of new te sefulness is unknow		non-lestructi	ve assay	
	92 - U-238	(₇ y,n)		II	E _e =Threshold-10 Δ E _e = 1%	Mev 10 %	GRT(OSMM) (USA)	hramolest	3
		Comments:	Bremsstrahl	ung conver	cluding fission) pr ter (preferably Ta) eld may be relative	of sufficient	thickness t	o stop	
		Status:	Gozani et.a Katz et. al.	l., Trans. , Canadian	American Nucl.Soc. J. of Physics, 35,	, <u>13</u> , 707 (197 470 (1957).	70) - Relativ	e data.	
		Justificati	on: For non-	destructiv	e photonuclear assa	y of J.			

Req.No.	Target	Reaction Quantity		Pricrity	Incident Energy	% Accuracy	Lab/Org.	Requestor, Jomments, etc.	Year
. 9	2-1-238	Delayed-N-Y	%(t)	II	E_e =Threshold-10 MeV ΔE_e = 1 %	10 %	GRT(OSMA) (USA)	Bramblett	76
			(preferably	Ta) of suf	produced by bremsstrah ficient thickness to s yield or may be absol	top electrons			
		Status: (Bozani et.al	., Trans.	American Nucl.Soc., 13	<u>,</u> ,707 (1970) -	- Relative	data.	
		Justification	n: For non-	-destructi	ve photomuclear assay	of U.			
9	2-11-238	Fission Pro	oduct P(Ey	,t) II	E _e = 10 Mev ΔE _e = 5 %	10 %	GRT(OSIM (USA)) Bramblett	70
			Bremsstrahl	ung conver	uct delayed Y-ray yle ter (preferably Ta) of den, Ey= 0.5-5.0 Mev	sufficient t	hickness t	ablung required. o stop electrons.	ŧ
,					rican Nucl. Soc., <u>13</u> , ive photonuclear assay		Preliminary	data.	
412 9	92-4-238	Delayed-N-	r VD	II	5-14 Mev	5 %	LASL (USA)	Weispin and Walton	70
		Comments:	Delayed neu	tron yield	l required. Data desire	ed for extrapo	olation to	15 Kev.	
		Status:	Masters et.	al. Ame:	lustion to 2.5 Mev. rican Nucl. Soc., 11, 1 liminary data (LASE),			and 14 Mev.	
		Justificat	ion: Galcul of U-2		moderating assemblies	for backgrous	nd effects	on assays	
9	92-0-238	(n, y)	P(E	8) II	Thermal; 2 Ke	ev 25 %	IAK(GfK) (FRG)	Weitkamy	70

Comments: Capture Y -ray spectra required.

Status: No useful data for thermal or 2 keV incident neutrons known.

Justification: For non-destructive assay of nuclear material by neutron capture // -ray spectrometry.

Req.No.	Target	Reac Quantity	tion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Crg.	Requestor, Commensa, etc
	93-Np-237	5 (n, y)		II	0.001 eV-1 Ke	y 3-10 %	IAR(GFK) (PRG)	Tischer
		Comments:	Accuracy of 3	% from them them them the state of the state	nermal - 10 eV ne - 1 Kev.	eded. Accuracy of 5	% The and	l accuracy
		Status:	Simons et.al. Brown et.al., 100 Kev - 2.3	nic Energy , BNWL-13 Nuclear F Mev.	7, 28, 362 (1970) 312 (1970); Evalua Physics, A156, 60) and resonance para up to 10 Kev. ation up to 20 Mev. (1970) data up to a 25 eV - 100 Kev.	-	
		Justifica	tion: For burn	n-up calcu	lations.	·		
9)3-Np-237	o-(n,f)		II	1 Kev - 5 Wev	10 %	IAR (GfK) (FRG)) Fischer
		Comments	: Fission cros	s section	required.			
5. 5.		Status:	Gavrilov, Ato Simons et al	omic Energ ., BNWL-13 , Nuclear	gv, <u>28</u> , 362 (1970 312 (1970); Evalu	and resonance parameters) up to 10 Kev. ation up to 20 Mev. 1970) data up to		
		Justifica	ation: For bur	n-up calc	ulations.			
	93-Np-237	σ(n,χ)	I	I.	l Kev-5 Mev	10 % IAR(G		Fischer
		Comments:	Capture cross	section	required to withi	n 10 %.		
		Status:	Nagle et al., 259 (1971) Smith et al.,		onf. on Neutror S		echnology,	Knoxville (U.S.A.),
		Justificat	ion: For burn	-up calcu	lations.			

•

94-	-Pu-238	O (n,f)		II		1 - 10 Mev]	10 %	IAR(GfK) (FRG)	Pischer	70
		Comments:	Fission	cross secti	on requi	red.			·		
		Status:	Silbert, Drake, I	LA-4108 (1 A-4420 (197	1969) and 70) - Data	LA-4674 (1971) a up to 2.6 Mev	- Data up	o to 3	Mev.		
		Justification	on: For	burn-up cal	culations	3.					
94-	-Pu-238	σ(n, χ)		II	Tì	nermal-10 Mev	1	10 %	IAR (GfK) (FRG)	Fischer	70
94-	-Pu-238	U	Carture	II cross secti]	10 %		Fischer	70
94-	-Pu-238	U	Young, N Silbert Dunford	cross secti et.al., NCS uclear Sci. et.al., WAS et.al., NAA	on required and Engine (1984) and Engine (1984) (1984) (1984) (1984) (1984) (1984) (1984) (1984) (1984) (1984)		ry data fr esonance p l Mev prel ation from	com 10 paramet liminar n therm	(FRG) - 100 Kev. ers to 190 e' y. al to 10 Mev	T.	70

Req.No.	Target	Reactio Quantity		Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
,9	4-Fu-238	(n, X)	P(E X)	II	Thermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weithamp	70
		Comments:	Capture /-ra	y spectra	required.				
		Status:	No useful data	for ther	mal or 2 keV incident	neutrons.			
		Justificati	on: For non-d	estructiv	re assay of nuclear ma	terial by neu	tron captu	re Y-ray spectrometry.	
9	4-Pu-238	Fission Yi and or(%		II	Ex = Threshold - 1	OMev 10%	GROHI (USSR)	Markov	71
		Comments:	The energy dep	endence (sion cros	as a function of incies section) resulting	dent & energ	y) of the ced fissio	fission fragment n is required to	
		Status:	Data unknown.						۱ س
		Justificati	on: Por photo	nuclear a	ssay of Pu+				<i>€</i>
9.	4-Pu-238	(y,n)		II	E = Threshold-10	Mev 10%	GEORI (USSR)	Markov	7.1
					as a function of inci		y) of the	neutron yield	
		Status:	Data unknown.	J					
	,	Justification	on: For photon	uclear as	say of Pu.				
94	4-Pu-239	Delayed-X-	y $\overline{\gamma}_{\mathfrak{d}}$	II	3 - 14 Kev	10 %	LASL (USA)	Weisbin and Walton	75
		Comments:	Delayed neutro	on yield	required. Data desire	d for extrapo	lation to	15 Yev.	
		Status:	Maksyntenko, Petrzak, Atom	ICD-1,256 ic Ener <i>m</i> y	can Nucl.Soc., <u>11</u> , 17; measurement at 3.8, <u>11</u> , 539. minary data (LASL), 0	and 15 Mev.	ts at 3 and	1 14 Kev.	
		Justificat	ion: Calculat	ions of m	oderating assemblies	for Pu-239 as	savs.		

Req.No.	Target	Reaction Quantity	on Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,	. Comments, etc	
	94-Pu-239	(n, y) Spectra an Nields	rd Ξ ڳ ⊃ 1.2 ⅓ P(Ξ ڳ)	III Mev	Thermal-100 eV	See Comments	Lasl (USA)	Weisbin	and Walton	_
		Comments:			and yields of %-ray 71.2 Mev. Ge(Li) re					
		Status:			ogress report-see als ra from 3 - 6 Mev.	30 BNL-50276,152 ((1970). R	ecent čata	for thermal	
		Justificat	tion: Developm	ment of new	Pu-239 assay techniq	lue.				
	94-Pu-239	(n, y)	P(E X) Capture X -ra	II	Thermal; 2 Kev	25 %	IAK (GfK)	Weitkamp		_
		STRINGS								
			2 Kev (scandiu + 100% or bett Symposium on S Non-Destructiv	m filtered er. Final r afeguards T e Measureme	on of F(Ey) for high beim) neutrons nearl seront to be published to be publish	y completed at Ka d in 1972.Prelimi Vol.2, p.113 (19 n Techniques in N	rlsruhe t nary data 70) and a uclear Sa	to an accur: 1 published 11 1971 Isp: 2fegnards 6	acy of -50% to at 1970 IAEA ra meeting on nd at 1972	
· ·			2 Kev (scandiu + 100% or bett Symposium on S Ron-Destructiv Berlin meeting 152 (1970). ion: For non-d	er. Final r lafeguards T le Measureme of Leutsch estructive	beim) neutrons nearleprort to be published echniques, Karlsruhe, ent and Identification	y completed at Ka d in 1972.Prelimi Vol.2, p.113 (19 n Techniques in N llschaft.Also pre	risruhe t nary data 70) and a uclear Sa liminary	to an accurate published at 1971 Ispande at determined at	acy of -50% to at 1970 IABA ra meeting on nd at 1972 rney, FNL-50276	
448	94 - Pu-239		2 Kev (scandiu + 100% or bett Symposium on S Ron-Destructiv Berlin meeting 152 (1970). ion: For non-d Product P(2 yestra	er. Final r lafeguards T le Measureme of Leutsch estructive	beim) neutrons nearleport to be publishe echniques, Karlsruhe, ent and Identificatione Physikalische Gese	y completed at Ka d in 1972.Prelimi Vol.2, p.113 (19 n Techniques in N llschaft.Also pre	risruhe inary data 70) and a uclear Sa liminary capture	to an accurrate published at 1971 Ispaire mards as data of Jun Yeray spec	acy of -50% to at 1970 IABA ra meeting on nd at 1972 rney, FNL-50276	
448	94-Pu-239	Justif Lat Fission I	2 Kev (scandiu + 100% or bett Symposium on S Ron-Destructiv Berlin meeting 152 (1970). ion: For non-deroduct P(E & Pectra ds Pission prod (photons/fis	er. Final r lafequards T lafequards T lafequards T lafequards T lafequards lestructive II luct Y-ray ssion-Mev-se (Li) resolu	beim) neutrons nearleprort to be published echniques, Karlsruhe, and Identification e Physikalische Gese assay of nuclear mat	y completed at Ka d in 1972.Prelimi Vol.2, p.113 (19 n Techniques in N llschaft.Also pre erial by neutron ± 15 \$ Absolute Yield energies, Er = 0.2 cours resulting fr	risruhe inary date 70) and a fuciear Saliminary capture (USA)	te an accurrence published at 1971 Ispuring and special and specia	acy of -50% to at 1970 IASA ra meeting on at 1972 rney, SNL-50276 ctrometry. n and Walton fission	
448	94-Pu-239	Justif Lat Fission I Y-ray sp and yield	2 Kev (scandiu + 100% or bett Symposium on S Non-Destructiv Berlin meeting 152 (1970). ion: For non-d Product P(2 y bectra ds Fission prod (photons/fis required. Get 15% accurated walton and Gister and Sister and Sis	m filtered er. Final r lafeguards T e Measureme of Leutsch estructive () II luot Y-ray ssion-lev-se (Li) resolutory. Duni, Phys. lagic. Phys. (1958).	beim) neutrons nearleport to be publishe echniques, Karlsruhe, ent and Identificatione Physikalische Gese assay of nuclear mat Thermal spectra for Y-ray ec) from lmsec - 12 h	y completed at Ka d in 1972.Prelimi Vol.2, p.113 (19 n Techniques in N llschaft.Also pre erial by neutron + 15 % Absolute Yield energies, Er = 0.2 hours resulting froid be 2.5 Kev and (9) 1964) on Peaceful Uses of	risruhe in nary date 70) and a fuciear Saliminary capture (te an accurrence and published at 1971 Ispaire and special and yields and reutron e yields to Energy,	acy of -50% to at 1970 IABA ra meeting on at 1972 rney, FNL-50276 ctrometry. n and Walton fission	

Req.No.	Target	React: Quantity	lon Type Variable	Priority	Incident Energy	% Accurac	y Lab/Org.	Requestor, Comments, etc	ar
448	94-Pu-239	Delayed -X-	у Р(Еу, Т½)	I	2 and 14 Mev	35 %	EHL(OSMW) (USA)	Kouts	7
		Comments:	neutron induce	d fission	s to relative inter for Ex>2 Mev and to a factor of 2 al	10 µ sec 2 7 1/2			
		Status:	N.R. Large and	R.J. Bull	hed) has some data ock, 1969 IAEA Symp 1969); presented so	osium on Physi		stry of	
		Justification	on: Assay of H	Pu-fuels.					
	94-Pu-239	Fission Yiel of 55-Cs-137		I	Thermal	1 %	TAE (USSR)	Skvortsov and Miller	.0
		Comments:		239 requir	r fission event of ed to withir 1 % a				
		Status:	R.S. Forsyth Vol. 1, p.521	et.al., 19 (1970)	viet Atomic Energy, 70 IAEA Symposium o 12. No. 11, 485 (19	n Safeguards T		ærlsruhe,	
		Justification	on: For assay o	of U and Pu	in spent fuel elem	ents by the fi	ssion produc	t Y-rays.	•
	94-Pu-239	Fission Yiel of 55-Cs-133		I	Thermal	1 %	IAR (USSR)	Skvortsov and Miller	¯0
		Comments:		-239 requir	er fission event of red to within 1% ac				
		Status:	O.A. Miller et	.al., Sovi	et Atomic Energy, 2	<u>7</u> , 281 (1969).			
		Justificatio	n: For assay	of U and P	u in spent fuel ele	ments by the f	is sio n produ	ct f-rays.	

Req.No.	Target	Reaction Quantity		Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Frar
	94-Pu-239	Fission Yield of 44-Ru-106		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	~O
-					er fission event of atthin 1 % accuracy.			thermal fission oted in the literature.	
		I	P. Grechush	kina, "Tab	12, No. 11, 485 (197 les showing the componut, Koscow, Atomizdat	osition of pro	mpt fissio	n products from U-235,	
		Justification	: For assa	y of U and	Pu in spent fuel ele	ements by the	fission pr	oduct Y-rays.	
	94-Pu-239	Fission Yield of 40-Zr-95	1	II	The rmal	1 %	IAE (USSR)	Skvortsov and Miller	70
					er fission event of a thin 1% accuracy. Di			thermal fission ed in the literature.	
		R.	S. Forsyth 521 (1970)	et.al., 197	t Atomic Energy, 27. 70 IASA Symposium on 12, No. 11, 485 (19)	Safeguards Te	chniques.	Karlsruhe, Vol. 1.	ا ل
		Justification	For assa	y of U and	Pu in spent fuel ele	ements by the	fission pr	oduct / -rays.	1
	94-Pu-239	Fission Yiel of 56-Ba-140		II	Thermal	i %	IAE (USSR)	Skvortsov and Miller	١.
					er fission event of 5 thin 1 % accuracy. I			thermal fission ted in the literature.	
			G. Gusev,		against Y -radiati	on from fissi.	on product	s," (kanual)	
		<u>v.</u>	A. Greshilo to 1 hour",	(Manual),	Products of prompt f Moscow, Atomizdat (1 em., 27, 121 (1965)		35, V - 238	and Pu-239 from	
		Justification	For assa	y of U and	Pu in spent fuel ele	ements by the	fission pr	oduct / -rays.	

eq.lio.	Target	Quant i ty	on Type Variable	Priority	Incident Energy	% Accuracy	Lat/Org.	Reguestor, Comments, etc	ar
	94-Pu-239	Fission Yie of 58-Ce-14		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	
		Comments:		u-239 requir	r fission event of 5 ed to within 1 % acc				
		Status:	Moscow, Atom	izdat (1968)	gainst & -radiatio • 12, No. 11, 485 (197	_	on products"	, (Vanual)	
. =		Justificati	on: For assa	y of U and P	u in spert fuel elem	ents by the f	`ission prod	uct X-rays.	
	94-Pu-239	(χ ,n) Spect	ra	111	E _K = 5-8 Mev	10 %	IAK(GfK) (FRG)	Pröhner	
		Comments:	0-100 eV req	uired. Accur	h resolvel resonance acies refer to shape l. Photon energy res	and absolute	values to	within 20 %	
		Status:	No active wor	rk known.					., :
		Justificati	on: Needed for potential use	or the explored	ration of new technic unknown.	ques for non-	destructive	assay whose	
l di	94 - Pu - 239	$(x_{f,n})$		II	E_e =Threshold-10 M ΔE_e = 1 %	ev 10 %	GRT(OSIM) (USA)	Bramblett	0
		Comments:	Bremsstrahlu	ng converter	ing fission) produce (preferably Ta) of may be relative to	sufficient th	ickness to	stor	
		Status:			rican Nucl. Soc., 13	•			
		Justificati	on: For non-	destructive p	photonuclear assay o	f Pu-239.			

Req.No.	Target	Reacti Quantity	on Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
	94-Pu-239	Delayed-N-1	K(t)	II	E = Threshold - 10 Kev	10 %	GRT(USLLI) (USA)	Framblett	70
					∆ E _e = 1 %				
-			onverter (p	referably T	roduced by bremsstrain a) of sufficient thic o D-2 (xx,n) yield o	kness to stop	electrons.		
					merican Nucl. Soc., <u>l</u>			data.	
		Justificatio	n: For non	-destructiv	e photonuclear assay	of Pu-239.			
	94-Pu-239	Fission Product % - Y(lmsec-	F(Ey,t)	II	E _e = 10 lev ΔE _e = 5 %	10 %	GRT(OSMA) (USA)	Erambles:	70
		r	equired. Br o stop elec	emsstrahlun trons. Emer	t delayed & -ray yie g converter (preferab gent &-ray energies,	ly Ta) of suf $E_{\chi}=0.5-5.0$	ficient thic -Mev with A	Pkness P.= 3 Kev.	1
		Status: R	undquist, F	runs.Americ	an Nucl. Sec., 13, 74	6 (1970) - Pr	eliminary ds	ita.	. پړ
		Justificatio	n: For non	-destructiv	e photonuclear assay	of Pu-239.			ı
	94-Pu-23	Delayed-	γ- γ P(E ,	TA) II	I Phermal;2 Kev	25 %	IAK(GfK) (FRG)	Weitkan;	70
	•	Comment	interes	ting for in	-ray spectra as a fun tervals < l sec. Accu 5 for T 1/2 acceptable	racy refers t	y time requi o } -ray in	red. Particularly stensities. Errors	
		Status:	No data	•					
		Justifi		r non-destr	uctive assay of fissi ucts.	onable materi	al by } -sp	ectroscopy of short	
457	94-Pu-240	Delayed-N-	r V _D	II	0.75-14 Mev	20 %	Lasl (USA)	Weisbin and Walton	70

Comments: Delayed neutron yield required. Data desired for extrapolation to 15 Mev.

Status: Runter, LA-3528 (1968); evaluation up to 2.5 Mev.

Diven, 1961 IAEA Symposium on Physics of Fast and Intermediate Reactors, Vienna, Vol. 1, p. 149 (1961). Data at 6.3 Mev.

Justification: Calculations of moderating assemblies for Pu assays of spent feel.

Req.No. Target	Reacti Quantity	on Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments,	eta. Yen
94-Pu-240	Decay Heat		II		0.2 %	ALKEN (FRG)	Schneider	70
	Comments:	Specific dec	ay heat, in by long-rang	e.g. Hatts/gramme requ ge particles (x-rays, &	ired. Percenta -rays) would b	ge of heat e useful.		
	Status:	Energ., 6, 7, the decay her	4 (1959) - T at of 7.008	y half-life - most rec 14 = 6620 ± 50 years. ± 0.76 % milliWatts/ g	This yields,	t by <u>Pokuch</u>	sev. Atomnaya 5255.3 ± 0.7 ke7.	
	Justificat	lon: For ca	lorimetric :	Pa determination.				
462 94-Pu-240	Delayed-y	-y F(Ey.T)	(<u>)</u> II	2 and 14 Mev	35 %	BNL (OSMA) (USA)	Fouts	69
	Comments:	neutron indu	ced fission	rs to relative intensit for Eyy 2 Mev and 10 to a factor of 2 also	Masc ZTh	y-rays froz 1 hour.	om	
	Status:	H. Chrier, (1 N.R. Large as	END Unpublis nd R.J. Bull	hed) has some data for ock. 1969 TAEA Symposi (1909); presented some	U-235 and Pu-2 um on Physics a		ry of	- 39
	Justificat	ion: Assay o	f Pu fuels.					*
94-Pu~240	(xy,n)		11	$E_{\rm g}$ =Threshold-10 MeV Δ $E_{\rm g}$ = 1 $\%$	10 %	GRT(OSMM) (USA)	Pramblett	70
	Comments:	Bremsstrahlu	ng converter	ding fission) produced (preferably Ta) of su ative to D-2 (xy,n) y	fficient thicks	ness to stor	ed. o electrona.	
	Status:	No data.		ď				
	Justificat:	lon: Effect o	on non-destr	uctive photonaclear as	say of Pu-239.			
94-Pu-240	Delayed-N- for $t < 100$		II	E _e =Threshold- 10 i	lev 10 %	GRT(OSMA) (USA)) Framblett.	70
	Comments:	(preferably	Ta) of suff	oroduced by bremsstrahl ficient thickness to st yield or may be absol	op electrons.			
	Status:	No data						

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Req.No.	Target	Quantity	VALIANIE	Priority	····	nt Energy	MACOURACY		Requestor, Comments, etc	Year			
	94-Pu-241	o (n, y)		11	Thermai ·	30 Kev	3 %	IAR(GFK) (FRG)	Fischer	70			
		Comments:	Capture cros	ss section	or alpha	(A) require	d. Accuracy	to 3 % in (ata (η).				
		Status:					15 Kev. Thi ENDF/B libr		on being revised.				
-		Justificat	tion: For bur	rn-up calcu	lations.								
·	94-Pu-241	Alpha	σ (n, χ) σ (n, f)	II	l Kev	- 2 Kev	20 %	IAR(GfK) (FRG)	Fischer	70			
		Comments:	Alpha (5 (n,	x)/5 (n,f))) needed 1	but capture	cross sectio	n would be	equally useful.				
		Status:	Davey, 1970 p. 119 (1970	IAEA Confe)); review	rence on l paper 100	Nuclear Data Kev - 10 Ke	for Reactor	s, Helsinki	i, Vol. 2,				
		Justificat	tion: For bur										
	94-Pu-241	Decay Heat	t	II			0.5 %	ALKEM (FRG)	Schneider	70			
		Comments: Specific decay heat, in e.g. Watts/gramme required. Percentage of heat carried- off by long-range particles (X-rays, X-rays) would be useful).											
		Status:	Uncertainty	mainly det	ermined b	v average /	i-energy the	refore dire	ect calorimetric measurem 62 <u>+</u> 5.0 % milliwetts/gre	ent ume •			
		Justificat	tion: For cal	lorimetric	Pu determi	ination.							
	94-Pu-241	Fission Yi and $\sigma(\chi,f)$	ielā	II	E X	= Threshold-	10 Kev 10	% CEOHI (USSR)	Markov)	71			
e e e e e e e e e e e e e e e e e e e		Comments:	The energy d fragment yie is required	eld (and fi	asion cros								
		Status:	Data unknown	1.									
		-			asay of Pu								

Req.No.	Target	React Quantity	ion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year				
	94-Pu-241	(X,n)		II	Ey= Threshold-10 Mev	10 %	GEOHI (USSR)	Karkov	71				
		Comments:	The energy Y-irradiat	dependence ion by Y-r.	of the neutron yield i ays of different energ	s required	to within 1	0 % for					
		Status:	Data unknow	n.									
		Justificat	ion: For ph	otonuclear	assay of Pu.								
	94-Pu-241	Fission Yield of Cs, Zr and	•	III	The rmal	5 %	IAE (USSR)	Skvortsov and Miller	70				
		isotopes Comments:			yield of Ce, Cs, Zr an s required to within 5		n products	for fission	t				
		Status:	Jata unkno	wn.					42				
		Justificat	ion: For ass	ay of U and	Fu in fuel elements by	y means of	the fission	product & -radiation.	ī				
	94-Pu-241	Delayed	-β- γ P(Ξβ,	7 ½) III	Ihermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	71				
		Comments:	teresting f	or interval:	spectra as a function of the second of the s								
		Statusi	No data.										
	<u> </u>	Justification: For non-destructive assay of fissionable material by & -spectroscopy of short-lived fission products.											
	94-Pu-241	(1x,n)		III	E_e = Threshold-10 Me ΔE_e = 1 %	v 30 %	(1920) (120)	Eramblett	7!				
		Comments:	strahlung c	onverter (p	luding fission) product referably Ta) of suffice elative to D-2 (xy,n);	cient thick	ness to sto	p electrons.					
		Status:	No data.		0								

Justification: Effect on non-destructive photonuclear assay of Pu.

Req.N	lo. Target	Reac Quantity	tion Type Variable	Priority	Incident Energy	% Accuracy	lab/Org.	Requestor, suments, etc.) ur
	94-Pu-241	Delayed-N-	Y N(t)	III	E _e = Threshold - 10 ΔE _e = 1 %) Mev 30 %	GRT(OSLM) (USA)	branclett	75
		Comments:	(preferably	Ta) of su	produced by bremsstr fficient thickness to) yield or may be abs	stop electro			
		Status:	No data.	V					
		Justifica	tion: Effect	on non-de	structive photonuclea	ur assay of Pu	•		
	94-Pu-241	Fission Product y-y(lmsec-	P(Ey,t) l hour)	III	E _e = 10 Mev ΔE _e = 5 %	30 %	GRT (OSMMA) (USA)	Bramblett	.0
		Comments:	Bremsstrahlı	ung conver	uct delayed Y-ray yi ter (preferably Ta) o ies, Ey= 0.5-5.0 Mev	f sufficient	thickness to		
	,	Status:	No data.		Ť	·			ű
		Justifica	tion: Effect	on non-de	structive photonuclea	r assay of Pu	•		i
	94-Pu-241	5 (n,f)	/ to -2 17 valor	II	Thermal-10 Mev	3-10 %	IAR(GfK) (FRG)	Fischer	3
			from 10 eV to	30 Kev; a	equired. Accuracy to nd to 5-10 % from 30 would be useful.	3 % from them Kev to 10 Me	mal to 10 eV v. Ratio to 3	; and to 10 % U-235 or Fu-239	
			evaluation to	20 Kev. O IAEA Con				ABRE-M-2157 (Rev.) , Vol. 2, p.77 (1976).	
			Blons et.al. (1970). Data	1970 IABA from 1 eV	Conference on Nuclear		•	nki, Vol. 1, p.469	
		Justificati	on: For burn	-up calcu	lations.				

	Target	Quantity	variao	e Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
	94- P u-241	(n, y)	b(E ¹)	II	Thermal; 2 Kev	25%	IAK(GfK) (FRG)	Weitkamp	7C
		Comments:	Capture y	-ray specti	a required.				
		<u>Status:</u>	from therm + 100 % or Preliminar Vol. 2, p. Identifica	al neutrons better. Fin data publi 113 (1970)	and at 1971 Ispra mues in Nuclear Safe	Karlsruhe to Dished in 19 Symposium on S Meeting on No	o an accurac 72. Safeguards T n-Destructiv	y of -50 % to	
		Justificat	ion: For no	-destructiv	e assay of nuclear	material by m	neutron capt	ure f-ray spectrometry.	
	94-Pu-242	(n, g)	P(E ₹)	III	Thermal;2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70
	- .	Comments:	Capture Y	-ray spects	ra required.				
		84 4		3.4. B.m. 41.					
		Status:	No userui	iata for the	rmal and 2 kev neul	rons.			
		Status:			ermal and 2 Kev neut		mautnan aant	uno le more	44
				n-destructi	ermal and 2 kev neur		neutron capi	sure y-ray	44 -
473	94-Pu-242		on: For no	n-destructi			neutron capt LASL (USA)	Weisbir and Walton	44
478	94-Pu-242	Justificati	on: For no spectromet	n-destructively.	ve assay of nuclear	material by	LASL		44 -
473	94-Pu-242	Justificati Delayed-N-y Comments: De	on: For no spectromet	n-destructively.	ve assay of nuclear	material by	LASL		44 -
478	94-Pu-242	Justificati Delayed-N-y Comments: De Status: No	on: For no spectromet	n-destructivry. III 3	ve assay of nuclear	material by	LASL (USA)		44 -
473	94-Pu-242 95-Am-241	Justificati Delayed-N-y Comments: De Status: No	on: For no spectromet	n-destructivry. III 3	ve assay of nuclear and 14 Kev	material by	LASL (USA)	Weisbin and Walton	44 -
478		Justification Delayed-N-y Comments: De Status: No Justification G (n,f)	Spectromet TD clayed neutro data. n: Galculat	III 3	re assay of nuclear and 14 Mev quired.	20 % For Pu-assays	LASL (USA)	Weisbin and Walton	70
478		Justification Delayed-N-y Comments: De Status: No Justification G(n,f) Comments: F Status: S	cons For no spectromet To data. cons: Calculat cons: Calcul	III s section recommendations of mode II section recommendations of mode	re assay of nuclear and 14 Mev quired.	20 % For Pu-assays 10 % aracy. eV to 1 Mev of 10 Mev. from 8 Kev	LASL (USA) IAR(GfK) (FRG)	Weisbin and Walton Fischer	70

Req.No. Target	React: Quantity	ion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org. Requ	destor, Comments, etc.	Year
95-Am-241	0(n, y)		II	Thermal - 10 Mev	see Comments	IAR(GfK) (FRG)	Fiscaer	70
	Comments:	Capture cros	ss section m & 100 e	required to accuracy V to 300 Kev and accu	of 10 % from racy of 20 - 3	thermal to 1 k $^{\circ}$ $^{\circ}$ $^{\circ}$ $^{\circ}$ $^{\circ}$ $^{\circ}$ $^{\circ}$	Kev; accuracy 00 Kev to 10 Mev.	
	Status	Hinkelmann, Jungclausser	KFK-1186 (n, Izv. Ak	CCP) - 9/U, p.7 (1970 1970); evaluation. ad. Nauk SSSR, <u>33</u> , 69 hys., <u>AlO2</u> , 443 (1967	5 (1969)	ue •		
	Justificat	ion: For bu			•			
95-Am-241	Fission Yield and G(y,f)		II	Eχ = Threshold-10	Mev 10 %	GEOHI (USSR)	Markov	7:
	Comments:		fission cr	(as a function of incoss section) resulting				1 4
	Status:	p. 188 (195	58).	Geneva Conference on I			rgy. Vol. 15,	5
	Justificat	ion: For ph	notonuclear	assay of Pu.				
95-Am-241	(y,n)		IJ	E g = Threshold-10 1	lev 10 %	GEOHI (USSR)	Markov	73
	Comments:	The energy	dependence	of the neutron yield	is required to	c within 10 %		

Comments: The energy dependence of the neutron yield is required to within 10 % for y-irradiation by y-rays of different energies.

Status: Data unknown.

Justification: For photonuclear assay of Pu.



INTERNATIONAL ATOMIC ENERGY AGENCY

INTEROFFICE MEMORANDUM

70 .

Mr. J. J. Schmidt

DATE 31 May 1972

Mr. T. Hyor

Bholear Data Section Division of Research and

Laboratories

Through:

Mr. E. Löpen-Menchere

Director

Division of Developmen

From:

Mr. A. J. Waligura

Mr. S. Sanatani

Methods & Techniques Section

Division of Development

SUBJECT:

International Request List of Muclear Data Housed for Safeguards Development Purvoses

We have received your latest list, comprising about 124 requests from the USA, USSR and the Federal Republic of Germany. The memorardum accompanying the list and the entries under the item 'Justification' helped us to form a clumber picture as to why certain nuclear data are requested by the scientists concenned.

Our response to the points raised by you could be triefly formulated as follows:

- A. The priority criteria continue to present us with some problems. For the time being nuclear data measurements as such have been given a rather low priority in our overall development programme; it is, therefore, rather difficult for us, at the present time, to consider the criteria for priorities of data needed. The situation might change in the future, when we might be able to form a clearer idea about the needs of better nuclear data to improve existing techniques of non-destructive assay or to develop new techniques for safeguards.
- B. The list seems to have been prepared in the format usual for such lists; we do not have any comments. Brevity, essential for such lists, might sometimes cause doubts, especially in the minds of nevices; but one might always ask the requestor or approach a more knowledgeable person for clarification if required.

- C. We are a little apprehensive of too wide a circulation at an early stage. Apart from this thought we see no objection to distribution of the request list to the parties listed by you, provided it is made clear that the list has been prepared from requests from a few Member States and that the IAMA or DSI is not at the present time sponsoring a world wide circulation of data needs for safeguards. We should be very careful not to give an impression that DSI or the Division of Development for their present purposes are urgently in need of the data requested in the list.
- D. Various review articles on non-destructive techniques for safeguards have been written. We do not mind preparing another short summary highlighting a few selected applications and discussing some of the developmental problems, if you wish.
- E. We agree it might be better to use the term 'nuclear materials' rather than the expression 'special nuclear material' (SNM).
- F. A thought which has now and then crossed our minds but which need not be discussed in the list you plan to circulate is the following:

In most cases of safeguards application you only make relative measurements in the field and the accuracy of nuclear data does not matter. A standard is available for comparison or an item is chosen as a standard. You are more concerned with the reproducibility and precision of your instrument, stability of electronics or background counts, etc. rather than with the accuracy of cross sections, yields or half lives.

co: Mr. Rometsch

Mr. Finkelstein

Mr. Ferronsky

Mr. López-Menchero

Mr. Waligura

Mr. Hough

Mr. Sanatani

DSI