International Atomic Energy Agency

INDC(NDS)-50/U+S



INTERNATIONAL NUCLEAR DATA COMMITTEE

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

Compiled and Edited by Trevor A. Byer Nuclear Data Section

March 1973

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III. List Description

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

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/G 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 essential prerequisite for providing the necessary motivation required to fulfill these data needs. Towards these ends, appropriate procedures have now been established in certain Member States and in accordance with these 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.

The Nuclear Data Section solicited the views of the Department of Safeguards and Inspection (DSI) on the structure and content of Annexes II - IV of this report. DSI replied in May 1972 that nuclear data measurements as such were for the time being given a rather low priority in the overall safeguards development programme and therefore it was difficult for them to comment on the priorities of the data needed. In fact, DSI stressed that they are not urgently in need of the data in this request list for their present purposes. DSI suggested that it should be made clear that this list was drawn up from requests originating in a few Member States and DSI was not sponsoring, at the present time, 'a world-wide circulation of nuclear data needs for safeguards.'

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 ourrent request list (Annex IV).

The format of the request list and the description of the various items in the list is given in <u>Annex III.</u>

2. Introduction

(This section was kindly prepared by S. Sanatani and A.J.Waligura of the Department of Safeguards and Inspection).

The objective of international safeguards is "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection."

Material accountancy is the safeguards measure of fundamental importance with containment and surveillance as important complementary measures. Material accountancy provides information on flow and inventory quantities, form and location of nuclear material.

In order to establish a material balance, accurate measurements of inventory and of all input and output of the particular Material Balance Area (MBA) are necessary. Various methods, destructive (sampling and analysis) and non-destructive (passive and active) are available for measurement of nuclear material which appears in the fuel cycle in most diverse forms(powder, fuel assemblies, pellets, plates, rods, pins, solutions, scrap, waste, etc.). Development effort to improve the existing methods and search for new promising methods is underway in different Member States as well as in the DSI.

Among various measurement techniques for safeguards, (refs. 1,2,3) non-destructive methods have received special attention because they do not destroy the original nature of the material and, secondly, in many cases where representative sampling is impossible, as may be the case of scrap, non-destructive methods offer the only practical solution. Passive gamma ray measurements with scintillation or semi-conductor detectors, spontaneous fission neutron counting with special coincidence circuits, active interrogation with neutron or bremsstrahlung are some of the nondestructive methods commonly being used and further developed to suit individual cases.

As examples of a few applications of non-destructive techniques at different fuel cycle points, we may first consider the assay of standard 55 gallon barrels containing Pu waste. In this case, the taking of representative samples from the heterogeneous content of a sealed barrel (containing filters, gloves, resin etc) is out of the question and one has to depend on either passive or active non-destructive methods. Recent developments at Los Alamos Laboratory and Gulf Radiation Technology have proved the feasibility of estimating gram quantities of Pu in these barrels in a few minutes of scan, using either neutron or photon interrogation. Thus a very difficult problem of nuclear material accounting is gradually becoming amenable to solution by non-destructive techniques (ref. 1).

Another example of non-destructive measurements is offered by inventory taking at the store of a zero-energy fast reactor or at a fast critical facility or, in general, at any location where a large amount of high strategic value nuclear material is found in a very accessible (to a potential diverter) form. Pu coupons or platelets of highly enriched uranium are non-destructively assayed either by passive gamma measurements, using NaI or intrinsic germanium detectors or by neutron coincidence detectors for Pu fuel. Special equipment for rapid and accurate assay of a large number of similar items is being developed and tested. Non-destructive methods have also been successfully used at fuel fabricating plants manufacturing, for example, LWR fuel from enriched UO_2 powder. At the input of the plant the object is to measure a large number of containers (fibre packs) rapidly without hampering the normal working of the plant; preferably at the same time as the items are unpacked and stacked into racks. For this purpose a stabilized single channel gamma ray (NaI) spectrometer can be used together with a weighing machine and a photographing system for recording purposes. Half minute gamma counts of the fibre packs, all placed in front of the detector in identical geometry, are recorded and data are statistically analyzed by simple programmes. It has been found that U-235 enrichment of the UO₂ powder can be found with a high accuracy by this method, sometimes even better than that obtained by destructive chemical methods. It might be noted that for non-destructive methods it is not necessary to open the fibrepacks containing UO₂ powder.

At the output of the plant, the completely assembled fuel assemblies are difficult to measure but the individual fuel rods can be scanned either by passive gamma spectrometry or by active neutron interrogation by sub-threshold neutrons. Several versions of equipment for this type of assay have been developed and tested in the field satisfactorily.

One of the most important problems of non-destructive measurements is to obtain working standards or reference items of similar size, shape and composition as the items to be measured, because most measurements are done <u>relatively</u> rather than absolutely. Another problem for nondestructive measurements in the field is to develop portable instruments (detectors, analyzers etc.) which can be safely and conveniently carried to the site by inspectors. When the instruments are finally set up at the measurement points, some of the practical worries of the inspector are whether the electronics are stable, background counts are as expected, precision is satisfactory and, in short, whether the instrument 'behaves' in the field as perfectly as it did in the testing laboratory or at Headquarters only a short time ago!

Although most methods of nuclear materials assay for safeguards are based on some form of nuclear data, there are few examples where a better or more accurate value of a given quantity would result in an immediate and drastic improvement of the performance of a measurement technique (ref. 4). For example, even the most accurate nuclear data will not meet the accuracy of chemical analytical methods and therefore calibration will always primarily be done by <u>standards</u>. Where standards are not available, e.g. for scrap and waste, there are much larger uncertainties to cope with (effects of matrix material etc.) and improvements in existing nuclear data would not have any impact on the final results.

Notwithstanding what has been said above, one can argue in favour of further work on nuclear data for the development of safeguards techniques for a few cases as discussed in ref.4, where it is concluded that there is a scope for critical investigation of the quantiative role of nuclear data in each individual method to see where additional or better data are required.

3. Summary of the Content of the Request List

The list contains some 23 priority I, 77 priority II and 24 priority III requests for nuclear data needed for the development of active and passive non-destructive assay techniques.

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 bremsstrahlung 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 O-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.G.) for burn-up calculations.

D. <u>Calorimetry</u>

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-ofmagnitude 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. In addition, the half-lives of Zr-95, Ru-106, Cs-134, Cs-137, Ba-140 Cs-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 %.

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.

References:

- 1. L.A. Kull: Catalogue of Nuclear Material Safeguards Instruments (BNL 17165) August 1972.
- J.R. Beyster and L.A. Kull: Information System for Nuclear Materials Assay Techniques. January 1972 (Final Report of IAEA Technical Contract 995/TC).
- 3. V. Beseda et al: Recent IAEA Experience in Development and Demonstration of Non-destructive Assay (NDA) Techniques. November 1972. (Paper presented at ANS Meeting, Washington, November 1972).
- 4. Weitkamp et al: The Role of Nuclear Data in Nuclear Material Safeguards. Paper for the Symposium on the Application of Nuclear Data in Science and Technology. (Paris, 12-16 March 1973).

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<u>Annex I</u>

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. Pröhner,	Institut für Angewandte Kernphysik, Gesellschaft für Kernforschung mbH, 75 Karlsruhe, Fostfach 3640, Fed. Rep. of Germany. <u>Present address</u> : 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,	I.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.
<u>Dr. C. Weitkamp</u> ,	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 Data Requests for Safeguards Furposes. *

First Priority - (I)

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

- 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 nuclear material in amounts that are significant to the safeguards system.

Second Friority - (11)

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

- 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 - (IIJ)

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

- 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 miror sources of error in the assay of 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.
- * These priority criteria were recommended for use by the International Nuclear Data Committee (INDC).

Annex 111.

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.) <u>Target</u>. The atomic number-chemical symbol-mass number are indicated for the target nucleus (for active assay) or the nucleus of interest (for passive assay).

2.) 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 χ -ray spectra as a function of delay time).

3.) <u>Priority</u>. 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.

4.) 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_{μ} and E_{χ} respectively.

5.) <u>Accuracy Required</u>. The accuracy to which the requested nuclear data is needed is indicated in this column. Generally, the accuracy needed for the dev lopment 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 requestors 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.

6.) 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.

7.) 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 χ -ray scanning of spent fuel elements, active photonuclear assay etc.

8.) 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.

		React	tion Type									
	Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year			
	1-D-2	(x y ,n)		I	E _e =Threshold - 10 Mev ∆E _e =1 %	10 %	GRT(OSMM) (USA)	Bramblett	70			
		e 4 TT yield per electron is converter (preferably Ta) of										
		Status:	No useful data	a and calcu	ulations insuffici	ent.						
		Justificat	tion: Standard	for non-de	estructive photonu	clear assay.						
	3-Li-6	(xy,n)		III	E =Threshold - e 10 Mev	20 %	GRT(OSMM) (USA)	Bramblett	70			
- 10					∆E _e = 1 %							
1		<u>Comments</u> : Total neutron yield produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons. Neutron yield may be relative to D-2 (x y, n) yield or may be absolute.										
		Status:	No useful data.	•								
		Justificat	ion: Background	l effect or	n non-destructive	photonuclear	assay.					
-	4-Be-9	(n,p)Li ^{9/}	3- 9* • Be • 4 n	II	14 Mev	10 %	LASL (USA)	Weisbin and Walton	70			
		Comments	Delayed neut	ron yield n	required.							
		Status:	Preliminary mat 16 Mev.	neasurement	ts at LASL; measur	ement of <u>Albu</u>	urger Phys.	Rev., <u>132</u> , 328 (1963)				
		Justifica	tion: Backgroun	nd in delay	ved neutron assays	•						

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Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year			
4-Be-9	(n,p)Li 98-Be	9* P(E _n ;) n!	II	14-16 Mev	10 %	GEOHI (USSR)	Markov	71			
	Comments: D	elayed neutron	yield requ	ired.							
	Status: A	lburger, Phys.R	ev., <u>132,</u>	328 (1963)							
	Justificatio	n: Allowance f	or backgro	und in delayed-neu	utron counting	g•					
4-Be-9	(x y ,n)		II	E _e =Threshold-10M ▲E _e = 1%	ev 20%/	GRT(OSMM) (USA)	Bramblett	70			
	<u>Comments:</u>	Total neutron j (preferably Ta to D-2 (x_{y}, n) j	vield produ) of suffic vield or ma	nced by bremsstrah bient thickness to ay be absolute.	lung required stop electro	. Bremsstra ns. Neutron	hlung converter a yield may be relative				
	Status:	No useful data	•								
	Justificat	ion: Backgrou	nd effect o	on non-destructive	photonuclear	· assay.					
6 -G- 13	(x y, n)		II	$E_e = Threshold - 10M$ $\Delta E_e = 1\%$	ev 20 %	grt (osmm) (usa)	Bramblett	70			
	<u>Comments:</u> Total neutron yield produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons. Neutron yield may be relative to D-2 (xy,n) yield or may be absolute.										
	Status:	No useful data	1.								
	Justificat	ion: Background	l effect or	n non-destructive	photonuclear	assay .					
8-0-17	(xy ,n)	<u></u>	II	$E_{e} = Threshold-10$ $\Delta E_{e} = 1 \%$	Mev 20 %	GRT(OSMM (USA)	!) Bramblett	70			
	Comments:	Total neutron (preferably Ta to D-2 (xy,n)	yield prod a) of suffi yield or m	luced by bremsstra cient thickness t may be absolute.	hlung require o stop electr	d. Bremsstr ons. Neutro	ahlung converter n yield may be relative				
	Status:	No useful data	L.								
	Justificat	ion; Background	l effect or	n non-destructive	photonuclear	assay.					

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Target	Reactic Quantity	on Type	Variable	Priority	Incident	Energy	% Accuracy	Lab/Org.	Requestor, Comments.etc.	Year
40-Zr- 95	Yield of Y- per B- decay	-quanta v event		II			1 %	IAE (USSR)	Skvortsov and Miller	70
	Comments:	Differe	nt values	are quoted	in the lit	erature.	Determinatio	on to within	n 1 % is required.	
	<u>Status:</u>	N.G. Gu Moscow, R.S. For Vol. 1, S.Hille Nir-El,	<u>sev</u> , "Prot Atomizdat <u>syth et.al</u> p.521 (19 <u>r</u> , Kerntec Israel At	ection aga (1968). ., 1970 IA 70). hnik, <u>12</u> , omic Energ	inst y-ra EA Symposiu No. 11, 485 y Comm. (Re	udiation um on Saf 5 (1970) epts)No.	from fission eguards Techr 1168, 70-71	products," niques, Kar) (1968)	(Manual) sruhe	
	Justificati	on: For	assay of	U and Pu i	n fuel elem	ents fro	m fission pro	oduct 7-rad	liation.	
40Zr-95	Half-Life			II		<u> </u>	1 %	IAE (USSR)	Skvortsov and Miller	70
	Comments:	Differ 1 % is	ent values required.	are quote	l in the li	terature	. Determinati	on to withi	n	
- 12 -	<u>Status:</u>	N.G. G Moscow R.S. F Vol. 1	usev, "Pro Atomizda orsyth et.	tection ag t (1968). <u>al.</u> , 1970 1 970).	ainst y-1 IAEA Sympos	adiation	from fission afeguards Tec	h products," Shniques, Ka	(Manual) urlsruhe	
	Justificati	on: Fo	r assay of	U and Pu	in fuel ele	ments fr	om fission pi	roduct y-1	adiation.	
40-2r-95	σ (n, χ)			III	Thermal	; 0.06 e	v 5%	IAE (USSR)	Skvortsov and Miller	70
	Comments:	Determ	ination to	within 5 9	6 required.	,				
	Status:	Data u	nknown•							
	Justificati	on: Fo	r assay of	U and Pu :	in fuel ele	ments fr	om fission pr	roduct y-r	adiation.	

	Target	React Quantity	tion Type Variable	Prioríty	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
-	4 - Ru-106	Yield of β -per β -deca	-quanta ay event	II		3 %	IAE (USSR)	Skvortsov and Miller	70
		<u>Comments:</u> <u>Status:</u> Justificat	Different values O.A. Miller et.a R.S. Forsyth et. Vol.1, p. 521 (1 cion: For assay o	are quoted <u>1.</u> , Soviet <u>al.</u> ,1970 I. 970). f U and Pu	d in the literature Atomic Energy, <u>27</u> AEA Symposium on Se in fuel elements f	e. Determinat (,281 (1969) afeguards Tec from fission	ion to with hniques, Ka product &-	in 3% required. Irlsruhe, Fradiation.	
	4 - Ru-106	Half-Life	<u></u>	II		1 %	IAE (USSR)	Skvortsov and Miller	70
		Comments:	Different values required.	are quoted	l in the literature	•• Determinat:	ion to with	in 1 % is	
- 13 -		<u>Status</u>	O.A. Miller et.a N.G. Gusev, "Prot Moscow, Atomizda R.S. Forsyth et. Vol. 1, p.521 (1	<u>l.</u> , Soviet ection aga: t (1968). <u>al.</u> , 1970 1 970).	Atomic Energy, <u>27</u> , inst Y-radiation f LAEA Symposium on S	, 281 (1969) from fission ; Safeguards Te	products", chniques,Ka	(Manual) rlsruhe,	
		Justificat	ion: For assay o	f U and Pu	in fuel elements f	from fission ;	product X-	radiation.	
-	44–Ru–106.	5 (n , y)	<u></u>	III	Thermal; 0.06 eV	V 10 %	IAE (USSR)	Skvortsov and Miller	70
		Comments:	Different values 10 % is required	are quoted	l in the literature	e. Determinat:	ion to with	in	
		<u>Status:</u> Justificat	<u>M. Goldberg et.a</u> ion: For assay o	<u>l.</u> , Neutron f U and Pu	n Cross Sections, H in fuel elements f	3NL-325,S.E. Trom fission	V.II B, Sup product 8	pl.No.2 (1966) -radiation.	

Target	Read	tion Type	Priority	Incident Energy	& Accuracy	Lab/Org.	Requestor. Comments. etc.	Veer
								1041
55-Cs-133	σ-(n, χ)	_	II	Thermal; 0.06 eV	3 %	IAE (USSR)	Skvortsov and Miller	70
	Comments:	Different valu is required.	ues are quoi	ted in the literatur	e. Determinat:	ion to with	in 3 %	
	Status:	M. Goldberg e Analytic Chem	<u>t.al.</u> , Neut; •, <u>37</u> , 351	ron Cross Sections, (1965)	BNL-325, S.E.	V. II B, Su	ppl. No. 2 (1965)	
	Justificati	on: For assa	y of U and 1	Pu in fuel elements	from fission y	product X-	radiation.	
55 - Cs-134	σ(n, χ)		II	Thermal; 0.06 eV	3 %	IAE (USSR)	Skvortsov and Miller	70
	Comments:	Different valu	ues are quoi	ted in the literatur	e. Determinati	ion to with	in 3 % is required.	
	Status:	M. Goldberg et	<u>t.al.</u> , Neuti	ron Cross Sections,	BNL-325,S.E.V	. II B, Sup	pl. No. 2 (1966)	
	Justificati	on: For assay	of U and Pu	a in fuel elements f	rom fission p	roduct 8-r	adiation.	
55-Cs-134	Half-Life	<u> </u>	I		1 %	IAE (USSR)	Skvortsov and Miller	70
	<u>Comments:</u>	Different valu required.	ues are quot	ed in the literatur	e. Determinat:	ion to with:	in 1 % is	
	Status:	O.A. Miller et R.S. Forsyth e Vol.1, p.521	<u>t.al.</u> Sovie et.al., 1970 (1970)	t Atomic Energy, <u>27</u>) IAEA Symposium on	, 231 (1969) Safeguards Tec	chniquez K	arlsruhe,	
	Justificati	on: For assay	of U and Pu	a in fuel elements f	rom fission p	roduct 8-r	adiation.	
55 -Cs- 134	Yield of a per β -dec	(-quanta ay event	I		1 %	IAE (USSR)	Skvortsov and Miller	70
	Comments:	Different val is required.	ues are quo	ted in the literatu	re. Determinat	ion to with	in 1 %	
	<u>Status:</u>	R.S. Forsyth Vol. 1, p.521 Nucl.Sci, and	<u>et.al.</u> , 197 (1970) Engin., <u>2</u> 2	0 IAEA Symposium on , 416(1965)	Safeguards Te	chniques, K	arlsruhe,	
	Justificat	ion: For assay	of U and P	u in fuel elements i	from fission p	roduct X-	radiation.	

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		React	ion Type										
	Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year				
-	55-Cs-137	Yield of γ -quanta p β -decay eve	er ent	I		1 %	IAE (USSR)	Skvortsov and Miller	70				
		Comments:	Different val	ues are quo	ted in the literat	ure. Determinati	on to withi	n 1 % is required.					
		Status:	Analytic Chem <u>S. Hiller,</u> Ke <u>R.S. Forsyth</u> Vol. 1, p.521	•, <u>37</u> , 351(rntechnik, et.al., 197 (1970)	1965) <u>12</u> , No. 11, 485(19 O IAEA Symposium o	70) n Safeguards Tecl	hniques, Ka	rlsruhe,					
		Justificati	on: For assa	y of U and	Pu in fuel element	s from fission p	roduct X-r	adiation.					
	55-Cs-137	Half-Life		I	······	1 %	IAE (USSR)	Skvortsov and Miller	70				
		Comments:	Different va	lues are qu	oted in the litera	ture. Determinat:	ion to with	in 1 % is required.					
- 15 -		<u>Status:</u>	V.A. Greshil O to 1 hour" J. of Inorga R.S. Forsyth Vol. 1, p.52	ov et.al.," , (Manual), nic Nucl.Ch <u>et.al.,</u> 1 1 (1970)	Products of prompt Moscow, Atomizdat em., <u>27</u> , 121 (1965 970 IAEA Symposium	fission of U-23 (1969).) on Safeguards Te	5, U-238 and echniques, 1	d Pu-239 from Karlsruhe,					
•		Justification: For assay of U and Pu in fuel elements from fission product γ -radiation.											
	55-Cs-137	σ(n, χ)		II	Thermal; 0.06 eV	10 %	IAE (USSR)	Skvortsov and Miller	70				
		Comments:	Different va	lues are qu	oted in the litera	ture. Determinat:	ion to with:	in 10 % is required.					
		Status:	M.Goldberg e	t.al., Neut	ron Cross Sections	,BNL-325,S.E.V.1	1 B,Suppl.N	0.2 (1966)					
		Justifica	tion: For as	say of U an	d Pu in fuel elemen	nts from fission	product of	-radiation.					
	56 -Ba- 140	Half-Lif	се.	II		_ 1 %	IAE (USSR)	Skvortsov and Miller	70				
		Comments	_ Different va	lues are qu	oted in the litera	ture.D _e terminati	on to withi	h l % is required.					
		<u>Status:</u>	N.G. Gusev," Moscow, Atom	Protection nizdat (1968	against γ-radiati 3).	on from fission	products",	(Manual)					
		Justifica	<u>ation:</u> For as	say of U an	d Pu in fuel eleme	nts from fission	product χ	-radiation.					

Mennet	Reac	tion Type Variable	Daionitu	Traidant	Fromme	A LOONDOON	Isb/Ong	Pequeston Comments ate	Voor
Target	wuantity	Variabie		INCIDENC	Fuergy		Tanl OLR.	Nequestor, comments, etc.	Iear
56 - Ba-140	J(n, y)		III	Thermal;	0.06 eV	5 %	IAE (USSR)	Skvortsov and Miller	70
	Comments:	Determination	to within	5 % require	ed.				
	Status: D	ata unknown.							
	Justificat	ion: For assa	ay of U and 1	Pu in fuel	elements	from fission	product 8	-radiation.	
	W-13-0								
57 -La- 140	lield of X-quanta p β-decay ev	er ent	11			1 %	USSR)	Skvortsov and Miller	70
	Comments:	Different val	lues are quo	ted in the	literatu	re. Determinat	tion to with	in 1 % is required.	
	Status:	<u>N.G. Gusev</u> , " Moscow, Atomi	Protection zdat (1968)	against γ	-radiatio	on from fission	n products",	(Manual)	
	Justificat	ion: For assa	ay of U and I	Pu in fuel	elements	from fission	product J-	-radiation.	
58 -Ce- 144	Half-Life		II	<u></u>		1 %	IAE (USSR)	Skvortsov and Miller	70
	Comments:	Different val	lues are quo	ted in the	literatu	re. Determinat	tion to with	in 1 % is required.	
	Status:	N.G. Gusev, " V.A. Greshild O to 1 hour"	Protection ov et.al., " ', (Manual),	against X-: Products o: Moscow, A	radiation f prompt tomizdat	from fission fission of U-2 (1969).	products", 235,U-238 an	(Manual)Moscow, Atomizdat() d Pu-239 from	1968)
	Justificat	ion: For assay	v of U and P	u in fuel (elements	from fission j	product 8-	radiation.	
58 -Ce- 144	Yield of Y-quanta p A-decay ev	er ent	II			_ 1 %	IAE (USSR)	Skvortsov and Miller	70
	Comments:	Different va required.	alues are qu	oted in the	e literat	ure.Determinat	ion to with	in 1 🖇 is	
	Status:	<u>N.G. Gusev,</u> Moscow, Atom <u>S.Hiller</u> , Ke	Protection mizdat (1968 erntechnik,	against &). 12, No. 11	-radiatio , 485 (19	n from fission 70)	n products",	(Manual)	
	Justificat	ion: For assa	y of U and I	Pu in fuel	elements	from fission	product 8-	radiation.	

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	Mammat	Reacti	on Type Veriable	Priority	Incident Frence	4 Accuracy	Lab/Org. Re	nuestor Comments etc.	Vect				
	THT.Rec				Incluent Energy	, Accuracy			1041				
	90 - Th-232	(xy, n)		II	$E_e = Threshold - 10 Mev$ $\Delta E_e = 1 \%$	10 %	GRT (OSMM) (USA)	Bramblett	70				
		Comments: 4 m neutron yield (including fission) produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons. Neutron yield may be relative to D-2 (xy,n) yield or may be absolute.											
		Status:	Gozani et.al Katz et.al.,	., Trans. Canadian	American Nucl.Soc., <u>1</u> J. of Physics, <u>35</u> , 4	<u>13</u> , 707 (1970) 470 (1957).	- Relative	lata.					
		Justificat	ion: To allo	w non-des	tructive photonuclear	r assay of Th	mixtures.						
	90 - Th - 232	Delayed-N	-Y N(t)	I	E _e =Threshold-10 Mev △E _e = 1 %	10 %	GRT(OSMM) (USA)	Bramblett	70				
- 11		Comments: Delayed neutron yield produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons.Neutron yield may be relative to D-2 (xy,n) yield or may be absolute.											
ī	<u>Status:</u> <u>Gozani et al.</u> Trans.American Nucl.Soc., <u>13</u> , 707 (1970)-Relative data. <u>Katz et.al.</u> , Canadian J. of Physics, <u>35</u> , 470 (1957).												
		Justificat	ion: To all	low non-dea	structive photonucles	ar assay of Th	mixtures.						
	90-Th-232	Fission Product y-Y(1 mse	P(Ey,t c-l hour)	;) III	$E_{e} \approx 10 \text{ Mev}$ $\Delta E_{e} \approx 5\%$	10 %	GRT (OSMM) (USA)	Bramblett	70				
		<u>Comments:</u>	Absolute f Bremsstrah Emergent	lission pro lung conve Y-ray ene:	oduct delayed &-ray erter (preferably Ta) rgies, E _X = 0.5 - 5.0	yield produce) of sufficien) Mev with ΔE	d by bremssta t thickness t = 3 Kev.	rahlung required. to stop electrons.					
		Status:	Rundquist,	Trans. A	merican Nucl.Soc., <u>13</u>	<u>3</u> , 746 (1970)	- Preliminary	y data.					
		Justifica	tion: For n	ion-destru	ctive photonuclear as	ssay of Th mix	tures.						

Terret	Reactio	on Type Variable	Dri ori tr	Incident France	1 incompany	Lab/Ong	Pequeston Commonte etc	Vece				
		Variable	Friority	Incluent Energy	/ ACCULACY		requestor, comments, etc.	Tear				
90 -Th-232	σ(n,f)		I	1-15 Mev	5%	IKT(TUH) (FRG)	Stegemann	70				
	Comments:	Fission cross	section re	quired to within !	5 %.							
	<u>Status:</u>	Ben-David, IA Bak et al., II 3, 77 (1971).	EA-107, 57 NDC (NDS)-36	(1968) review up (/G (1971) and J. (to 14 Mev. of the Koreau	n Nuclear Sc	ociety,					
	Justificat	ion: Standard f	for non-des	tructive assay of	spherical fu	lel elements	•					
90-Th-232	៴	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.					
	<u>Status:</u> <u>Davey</u> , Nucl. Sci. and Engin, <u>44</u> , 345(1971) evaluation up to 15 Mev. <u>Manero et al.</u> , INDC(NDS)-34/G (1972) evaluation to be published in Atomic Energy Review (1972)											
	Justificat:	ion: Standard f	for non-des	tructive assay of	spherical fu	lel elements	•					
90-Th-232	Delayed-N-Y	P(E _{n'})	I	1-15 Mev	5%	IKT(TUH) (FRG)	Stegemann	70				
	<u>Comments:</u> Status:	Delayed neutro Krick et al, N	on fraction NCSAC-31, 1	, β_λ, required. 56 (1970). Prelimi	.n ary re sults	s up to 15 M	ev.					
	Justificat	ion: Standard	for non-de	structive assay of	spherical f	uel element	S .					

Target	Reac Quantity	tion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments, etc.	Year				
90-Th-232	Delayed -y	γ-γ P(E _χ , T ^{1/2})	II	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69				
	Comments:	Accuracy reque induced fissic to a factor of	ested refer on for Ey 2 also us	rs to relative inter 72 Mev and 10 usec seful.	nsities of dela ZT %22 1 hour.	yed y-r ay: Absolute	s from neutron Y-ray yields					
	<u>Status:</u>	R.Chrien, (BNI N.R. Large and Vienna, p.637	unpublish R.J. Bull (1969); pr	ed) has some data f <u>ock,</u> 1969 IAEA Symp esented some data f	for U-235 and P posium on Physi for U.	ru-239. cs and Cher	nistry of Fission,					
	Justificat	ion: Backgrour	nd effects	in assay of U-233 -	- Th-232.							
92-0-233	(xy,n)		I	E _e = Threshold-10 Me Le _e = 1 %	v √ 10 %	CRT (OSMM) (USA)	Bramblett	70				
	Comments:	omments: Neutron yield (including fission) produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons. Neutron yield may be relative to D-2 (xy,n) yield or may be absolute.										
	Status:	Katz et.al., Canadian J. of Physics, 35, 470 (1957).										
<u></u>	Justificati	ion: To allow	non-destru	ctive photonuclear	assay of U-233	•						
92 - U-233	Delayed-N-	Y N(t)	I A	$E_e = Threshold-10 M$ $E_e = 1 \%$	lev 10 %	GRT (OSMN (USA)	M) Bramblett	70				
	Comments:	Delayed neutro (preferably Ta relative to D-	n yield pr) of suffi 2 (xy,n) y	oduced by bremsstra cient thickness to ield or may be abso	hlung required stop electrons lute.	. Bremåstra . Nøutron y	hlung converter ield may be					
	Status:	No data.										
	Justificati	ion: To allow n	on-destruc	tive photonuclear a	asay of this S	NM •						

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Target	Reac Quantity	tion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year				
92-U-233	Fission Pro	oduct P(Ey,t) l hour)	II	$E_{e} = 10 \text{ Mev}$ $\Delta E_{e} = 5\%$	10 🛠	GRT(OSMM) (USA)	Bramblett	70				
	Comments:	Absolute fissio Bremsstrahlung Emergent y-ray	on product converter energies,	delayed γ -ray yield (preferably Ta) of st E $\chi = 0.5 - 5.0$ MeV y	d produced by ufficient thic with $\Delta E_{f} = 3$	bremsstrahlu kness to sto Kev.	ng required. p electrons.					
	<u>Status:</u> Justificat	No data. ion: For non-des	structive p	hotonuclear assay of	this SNM.							
92-0-233	Delayed-X-	γ P(E _γ , T [×] _L)	I	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69				
	Comments:	<u>Comments:</u> Accuracy requested refers to relative intensities of delayed γ -rays from neutron induced fission for $E_{\gamma} > 2$ Mev and $10 \mu \sec 2 T/2 / 2$ hour. Absolute γ -ray yields to a factor of 2 also useful.										
	<u>Status:</u>	R. Chrien, (BNL N.R. Large and Vienna, p.637 (unpublish R.J. Bullo 1969); pre	ed) has some data fo: <u>ck,</u> 1969 IAEA Sympos: sented some data for	r U-235 and Pu- ium on Physics U.	-239. and Chemist	ry of Fission,					
20	Justificat:	ion: Assay of U	-233 fuels	•								
92-0-234	(xy ,n)		II	$E_{e} = \text{Threshold} - 10$ $\Delta E_{e} = 1\%$)Mev 30 %	GRT (OSMM) (USA)	Bramblett	70				
	<u>Comments:</u>	4 r neutron y iel Bremsstrahlung electrons. Neu	ld (includi converter tron yield	ng fission) produced (preferably Ta) of s may be relative to D	by bremsstrah bufficient thic 0-2 (xy,n) yiel	lung require kness to sta d or may be	od. op absolute.					
	Status:	No data.										
	Justificati	on: Effect on no	on-destruct	ive photonuclear ass	ay of U-233 an	a U-235.						

	Reaction Type											
Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org. Req	uestor,Comments,etc.	Year				
92-U-234	Delayed-N-Y	N(t)	III	E _e =Threshold-10 Mev	30 %	GRT (OSMM) (USA)	Bramblett	70				
				$\Delta E_e = 1\%$								
	<u>Comments:</u>	ments: Delayed neutron yield produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons. Neutron yield may be relative to D-2 (xy,n) yield or may be absolute.										
	Status:	No data.										
	Justificat	tion: Effect on no	on-destruc	tive photonuclear ass	ay of U-233 a	nd U-235.						
92 - U-234	Fission Produ y_y(1 msec-1	act P(E _y ,t) hour)	III	$E_{e} = 10 \text{ Mev}$ $\Delta E_{e} = 5 \%$	30 %	GRT(OSMM) (USA)	Bramblett	70				
	<u>Comments:</u>	Absolute fission Bremsstrahlung c Emergent X-ray	n product o converter energies,	delayed γ-ray yield (preferably Ta) of su E _V = 0.5 - 5.0 Mev wi	produced by b. officient thicks th $\Delta E_y = 3$ Ke	remsstrahlung kness to stop v.	required. electrons.					
	Status:	No data.		v	ŭ							
	Justificat	ion: Effect on r	non-destru	ctive photonuclear as	say of U-233	and U-235.						
92 - U-235	Fission Produ X-ray spectr and yields.	$\begin{array}{c} \text{act} P(E_{\mathcal{F}}) \\ \text{a} \end{array}$	II	Thermal	+ 15 % Absolute yi	LASL eld. (USA)	Weisbin and Walto	n 70				
	<u>Comments:</u>	<u>Comments:</u> Fission product γ -ray spectra for γ -ray energies, $E_{\chi} = 0.25 - 5$ Mev, and yields (photons/fission - Mev - sec) from 1 msec - 12 hours resulting from thermal neutron fission required. Ge(Li) resolution at 1.2 Mev should be 2.5 Kev and absolute yields to + 15 % accuracy.										
	<u>Status:</u>	Walton and Sund, Fisher and Engle F.C. Maienscheir Energy, Vol. 15,	Phys. Re , Phys. Re , et.al., 1 , 366 (1958	v., <u>178,</u> 1894 (1969) ev., <u>134</u> , B796 (1964) 1958 Geneva Conferenc 3).) e on Peaceful	uses of Atomi	.c					
		Better resolutio	on desired	• Associate X-rays w	rith fission p	roducts if pos	sibl e .					

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Target	Reactio Quantity	n Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	6 (n,f)		I	Thermal-15 Mev	3%	IKT(TUH) (FRG)	Stegemann	70
	Comments:	Fission cr	oss sectio	n required to within	n 3 %.			
	<u>Status:</u>	Sowerby et WARD-4210 (Steen, WA) Boroughs et	<u>al.</u> , AERE- I4-1 (1972 RD-TM-691 t al., GA-	-M-2497 (1972) simul) recent evaluation (1969) evalua tion fi -8854 (1968) evaluat	ltaneous evalu for ENDF/B-I rom thermal u tion from 0.0	uation from II library. p to 14 Mev. 1 - 10 Mev.	100 eV - 20 Mev.	
	Justificati	on: Standa	rd for non	-destructive assay (of fuel eleme	nts.		
92 - U - 235	 ت	Prompt	I	Thermal-15 Mev	3%	IKT (TUH) (FRG)	Stegemann	70
	Comments:	Average nur	nber of pro	ompt neutrons per ne	autron induced	d fission re	quired.	
1 22 22 1	<u>Status:</u>	Davey, Nuc Manero et a Review (19 Mather et a Boroughs et Colvin, 196 up to 14 Me	l. Sci. and al., INDC(1 72) evalua al, AWRE-O t al., GA-85 59 IAEA Syn ev.	A Engin ., <u>44</u> , 345 (NDS)-34/G (1972) and tion up to 15 Mev. -55/71 (1971) evalua 354(1968) evaluation mposium on Physics a	(1971) evalua d to be publis ation up to 1 n up to 15 Mer and Chemistry	tion up to l shed in Atom 5 Mev. v. of Fission,	5 Mev. ic Energy p. 930 (1969) evaluation	
	Justificati	on: Standard	l for non-	destructive assay of	fuel element	ts.		
92 - U-235	Delayed-N-Y	P(E _n ;)) I	Thermal-15 Mev	r 5%	IKT(TUH) (FRC)	Stegemann	70
	Comments:	Delayed ne	utron frac	tion, Bi, required.	,			
	<u>Status:</u>	Amiel, 196 review fro Krick et a Manero et (1972).	59 IAEA Syn om thermal- al., WASH-1 al., INDCO	nposium on Physics a -15 Mev. 1155, 156(1970) prel NDS)-34/G (1972) ar	and Chemistry iminary resul ad to be publi	of Fission, lts ished in Ator	p. 569 (1969); nic Emergy Review	
	Justificat	tion: Standa	rd for nor	-destructive assay	of fuel eleme	ents.		

	React	ion Type											
Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year					
92-U-235	Delayed-N-Y	\bar{v}_{p}	II	5 - 14 Mev	5 %	LASL (USÅ)	Weisbin and Walton	70					
	Comments:	Delayed neutro	Delayed neutron yield required. Data desired for extrapolation to 15 Mev.										
	<u>Status:</u>	Masters et.al. Krick and Evan	American Is, Prelimi	n Nucl.Soc., <u>ll,</u> l inary data (LASL),	79; measurem 0.1 - 6.7 M	ents at 3 a ev.	nd 14 Mev.						
	Justificat	ion: Calculati	ons of mod	lerating assemblie	s for U-235	assays.							
92 - U - 235	Delayed-N	Precursor Half-Lives	III	Thermal	5 %	FEI (USSR)	Maksyutenko	71					
	Comments:	The half-lives half-lives of fission, shoul	The half-lives of Rb-92, Rb-93 and Rb-94, I-139 and Br-88 are anomalous. The ulf-lives of these delayed neutron precursors, resulting from thermal neutron ssion, should be measured more accurately - to 5% .										
	Status:	<u>S. Amiel</u> , 1969 p. 569 (1969).) IAEA Symp	osium on Physics	and Chemistr	y of Fissio	n, Vienna,						
	Justificat	<u>ion:</u> For inter	pretation	of delayed-neutro	on data.								
92 - U-235	Delayed-N	Emission probabilit	III ies	Thermal	5 %	FEI (USSR)	Maksyutenko	71					
	<u>Comments:</u>	The delayed n contradiction determinations fission.	eutron emi with data are neede	ssion probabiliti from nuclear syst d for these isoto	es for Rb-92 ematics. Mor ppes resultin	, Rb-93 and e accurate g from ther	Rb-94 are in (5 %) mal neutron						
	Status:	<u>S. Amiel,</u> 1969 p. 569 (1969). The emission p) IAEA Symp robabiliti	oosium on Physics es quoted by diff	and Chemistr	y of Fissic s vary by f	n, Vienna, actors of 1.5-2.0						
	Justificat	ion: For the i	nterpretat	ion of delayed ne	utron data.		-						

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	React	ion Type									
Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	• Year			
92-0-235	Delayed-X-Y	Р(Е ₈ , Т/2)	III	Thermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70			
	Comments:	Delayed fissi interesting f of - 50 % to	on Y- ray or interva + 100 % fo	y spectra as a fur als < 1 sec. Accu or T $\underline{\mathcal{K}}$ acceptable.	nction of del Mracy refers	lay time red to y-ray	quired. Particularly intensities. Errors				
	Status:	No data.									
	Justificati	<u>on</u> : For non-d fission p	estructive roducts.	e assay of fission	able materia	rl pà X- si	pectroscopy of short liv	7ed			
92-U-235	Delayed-y-y	Р(Е _х , Т ½)	I	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69			
	Comments:	Accuracy requested refers to relative intensities of delayed χ -rays from neutron induced fission for Ey>2 Mev and 10 μ sec $\gtrsim T_{\chi} \gtrsim 1$ hour. Absolute χ -ray yields to a factor of 2 also useful.									
	<u>Status:</u>	tatus: R. Chrien, (BNL unpublished) has some data for U-235 and Pu-239. <u>N.R. Large and R.J. Bullock,</u> 1969 IAEA Symposium on Physics and Chemistry of Fission, Vienna, p.637 (1969); presented some data for U.									
	Justificati	on: Assay of	U-235 fu	els.							
92 - U-235	(n, X)	P(E &)	I	Thermal; 2 Kev	25 🛠	IAK(C)	GfK) Weitkamp 3)	70			
	Comments:	Capture X-	ray spectr	a required.							
	Status: Experimental determination of P(Ey) for high energy y's (Ey) 2 Mev) resulting from thermal neutrons nearly completed at Karlsruhe to an accuracy of -50% to + 100% or better. Final report to be published in 1972. Preliminary data published at 1970 IAEA Symposium on Safeguards Techniques. Karlsruhe.										

Vol. 2, p.113 (1970) and at 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol. 2, p.113 (1970) and at 1971 Ispra meeting on Non-Destructive Measurement and Identification Techniques in Nuclear Safeguards and at 1972 Berlin meeting of Deutsche Physikalische Gesellschaft.

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

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Target	Reaction Ty Quantity	pe Variable	Priority	Incident	Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year	
92-U-235	Fission Yield of 55-Cs-133		I	Thermal		1 %	IAE (USSR)	Skvortsov and Miller	70	
	Comments: Fis U-2	sion produ 35 require	act yield p ed to withi	er fission n l % accur	event of acy. Dif	f 55-Cs-133 : fferent value	resulting f es are quo	from thermal fission of ted in the literature.		
	Status: 0.A	. Miller e	et.al., Sovi	iet Atomic 1	Energy,	<u>27,</u> 281 (196	8)			
	Justification:	For assay	r of U and	Pu in spent	fuel e	lements by th	ne fissio n	product y-rays.		
92 - U-235	Fission Yield of 44-Ru-106		II	Thermal		1 %	IAE (USSR)	Skvortsov and Miller	70	
	<u>Comments:</u> Fis: U-2	sion produ 35 require	uct yield p ed to withi	er fision e n 1 % accur	vent of acy. Dif	44-Ru-106 re ferent value	esulting fi es are quoi	com thermal fission of ed in the literature.		
	<u>Status:</u> <u>I.P</u> U-2.	Hiller, Ke . Grechush 35, U-238	erntechnik, <u>ukina,</u> "Tab and Pu-239	<u>12</u> , No. 11 les showing fission",	, 485 (: the con Moscow,	1970) nposition of Atomizdat (1	prompt fis 1964).	ssion products from		
	Justification:	For assay	of U and	Pu in spent	fuel e	lements by th	ne fission	product y-rays.		
92-0-235	Fission Yield of 40-2r-95		II	Thermal		1 %	IAE (USSR)	Skvortsov and Miller	70	
	<u>Comments:</u> Fis: U-2	sion produ 35 require	act y ield p ed to withi	er fission n 1 % accur	event of acy. Dif	f 40-Zr-95 re fferent value	esulting fi es are quot	com thermal fission of ed in the literature.		
	Status: 0.A R.S Vol S.H	Miller et Forsyth 1, p.521 iller, Ker	<u>t.al.</u> , Sovie <u>et.al.</u> , 19 (1970) ntechnik,	t Atomic Er 70 IAEA Sym <u>12</u> , No.ll,	nergy, <u>2</u> posium (485 (197	<u>7</u> ,281 (1969) on Safeguards 70).	3 Technique	es, Karlsruhe,		
	Justification:	For assa	ay of U and	Pu in spen	t fuel e	elements by t	he fission	product f-rays.		
92-0-235	Fission Yield of 55-Cs-137		I	Thermal		1 %	IAE (USSR)	Skvortsov and Miller	70	
	<u>Comments:</u> Fiss of U	ion produc -235 requ	ct yield pe ired to wit	r fission e hin 1 % acc	event of uracy.	55-Cs-137 r Different va	esulting f lues are q	rom thermal fission uoted in the literature.		
	Status: O.A.Miller et.al., Soviet Atomic Energy, <u>27</u> , 281 (1969). <u>R.S. Forsyth et.al.</u> , 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol.l p.521 (1970). <u>S.Hiller</u> , Kerntechnik, <u>12</u> , No. 11, 485 (1970).									
	Justification:	For assay	of U and F	u in spent	fuel el	ements by th	e fission	product Y-rays.		

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Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year			
92 - U-235	Fission Yi of 56-Ba-	.eld 140	II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70			
	Comments:	Fission producture U-235 required	t yield per f to within l	ission event of 56 % accuracy. Differe	-Ba-140 resul ent values ar	ting f ro m e quoted i	thermal fission of n the literature.				
	<u>Status:</u>	<u>N.G. Gusev</u> , "Pr Atomizdat (1966 <u>V.A. Greshilov</u> (Manual).Mosco	rotection aga 3). <u>et.al.</u> , "Pro w,Atomizdat (inst y-radiation f ducts of prompt fig (1969). J. of Inorg	from fission ssion of U-23 anic Nucl.Che	products", 5, U-238 a em., <u>27</u> , 12	(Manual) Moscow, nd Pu-239 from 0 to 1 hour 21 (1965)	, II 			
	Justificat	ion: For assay	of U and Pu	in spent fuel eleme	ents by the f	ission pro	duct Y-rays.				
92 - U - 235	Fission Yi of 58-Ce-1	.eld .44	II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70			
	Comments:	<u>Comments:</u> Fission product yield per fission event of 58-Ce-144 resulting from thermal fission of U-235 required to within 1 % accuracy. Different values are quoted in the literature.									
	<u>Status:</u>	N.G. Gusev, "Protection against y-radiation from fission products", (Manual) Moscow, Atomizdat (1968). <u>S. Hiller</u> , Kerntechnik, <u>12</u> , No. 11, 485 (1970).									
	Justification: For assay of U and Pu in spent fuel elements by the fission product -rays.										
92-U-235	(Y,n)Spec	tra	III	$E_{f} = 5-8$ Mev	10 %	IAK(GfK (FRG)) Fröhner	70			
	<u>Comments:</u>	Photon eu tron sy required. Accur be helpful. Pho	pectra with r racies refer oton energy r	esolwed resonances to shape and absolu esolution should be	and neutron ite values to better than	energies b within 20 100 Kev.	etween 0-100 eV % accuracy would				
	Status:	No active work	known.								
	Justification: Needed for the exploration of new techniques for non-destructive assay whose potential usefulness is unknown.										

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	Reaction Type							
Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org. 1	Requestor, Comments, etc.	Year
92-0-235	(xy ,n)		II	E _e = Threshold - 10 Mev	10 %	GRT (OSMM) (USA)	Bramblett	70
				$\Delta E_{e} = 1 \%$				
	<u>Comments:</u>	4 m neutron yiel converter (pref be relative to 1	d (including erably Ta) of D-2 (xy,n) yf	fission) produced f sufficient thickn ield or may be abso	by bremsstr ness to stop plute.	ahlung requip electrons.	ired. Bremsstrahlung Neutron yield may	
	Status:	<u>Gozani et.al.</u> , Bowman et.al.,	Trans.Americ Phys.Rev.,	can Nucl.Soc., <u>13</u> , 133, B676 (1964) -	707 (1970) (χ,n) data	- Relative (above 7 Mev	iata.	
	Justificat	ion: For non-de	structive pho	otonuclear assay of	this SNM.			
92-0-235	Delayed-N-Y	N(t)	II	E _e =Threshold -10 Mev	10 %	GRT (OSMM) (USA)	Bramblett	70
				∆E _e = 1 %				
	Status	(preferably Ta) relative to D-2	(xy,n) yield	nt thickness to sto 1 or may be absolut ican Nucl-Soca, 13	p electrons te. 707 (1970)	- Relative (leid may de	
	Status	relative to D-2	(iy,n) yield	l or may be absolut	e. 707 (1970)	- Relative (lata.	
	Justifics	tion: For non-de	estructive pl	notonuclear assay o	of U-235.			
92 - U-235	Fission F X-Y(1 mse	Product P(Ey c-lhour)	,t) II	$E_e = 10 \text{ Mev}$ $\Delta E_e = 5\%$	10 %	GRT (OSMM) (USA)	Bramblett	70
	<u>Comments</u> :	Absolute fissio: Bremsstrahlung Emergent∦-ray (n product de converter (pu energies, E x	layed y-ray y ield referably Ta) of su v= 0.5-5.0 Mev with	produced by ifficient the $\Delta E \chi = 3$ K	bremsstrahl Lickness to s Lev.	lung required. stop electrons.	
	Status:	Rundquist, Trans	s.American Nu	ucl.Soc., <u>13</u> , 746 ((1970)-Preli	minary data		
	Justifica	tion: For non-de	estructive pl	notonuclear assay o	of this SNM.			
92-U-236	Fission Spectrum	Neutron	II	One energy ab fission threa	ove 10 %	LASL (USA)	Weisbin and Walton	70
	Status:	none						
	Justific	ation: Backgrou	nd correction	as in U-235 spent f	uel assav.			
				epine _				

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Target	Reactic Quantity	n Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year					
92 - U - 236	Delayed-N-	۲ آ ^۲ ک	I	3 and 14 Mev	10 %	LASL (USA)	Weisbin and Walton	70					
	<u>Status</u> M Justificat	lo experimenta <u>ion:</u> Backgro	l work to da und correcti	te. Data have been on in U-235 spent f	obtained empi uel ass ay.	rically.							
92- U- 236	(xy ,n)		II	E =Threshold - e 10 Mev	30 %	GRT (OSMM) (USA)	Bramblett	70					
				$\Delta E_{\mu} = 1\%$									
	<u>Comments:</u>	4 ¶ neutron ; Bremsstrahlu électrons. N	y ield (inclung converter eutron yield	ding fission) produ (preferably Ta) of may be relative to	sufficient t D-2 (XY,n) y	trahlung rec bickness to rield to may	quired. stop be absolute.						
	Status:	No data.			•								
	Justificat	ion: Effect	on non-destr	uctive photonuclear	assay of U-2	235•							
92 U - 236	Delayed-N-)	N(t)	II	E _e =Threshold - 10 Mev	30 %	GRT (OSMM (USA)) Bramblett	70					
				$\Delta E = 1\%$									
	Comments:	Delayed neut converter (p yield may be	ron yield pr referably Ta relative to	oduced by bremsstra) of sufficient thi D-2 (12,n) yield o	hlung require ckness to sto or may be abso	d. Bremsstra p electrons lute.	ahlung Neutron						
	Status:	No data.		U									
	Justificat	ion: Effect	on non-destr	uctive photonuclear	assay of U-2	35.							
92-u-236	Fission Pro X-Y (1 msec-	duct P(Ey l hour)	,t) III	$E_{e} = 10 \text{ Mev}$ $\Delta E_{e} = 5\%$	30 %	GRT(OSM (USA)	() Bramblett	70					
	Comments:	<u>Comments:</u> Absolute fission product delayed γ -ray yield produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons. Emergent γ -ray energies. Eve 0.5-5.0 Mev with $\Delta E_{\rm c} = 3$ Kev.											
	Status:	No data.		•	0		J						
	Justificat	ion: Effect	on non-destr	uctive photonuclear	assay of U-2	35.							

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Target	Reactio Quantity	n Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year					
92 - U-238	ሯ	Prompt	II	1-15 Mev	5 %	IKT (TUH) (FRC)	Ste gemenn	70					
	Comments:	Average num	ber of pro	mpt neutrons per n	eutron induced	l fission r	equired.						
	<u>Status:</u>	Status: Davey, Nucl.Sci. and Engin., 44, 345 (1971) evaluation up to 15 MeV. <u>Manero et al.</u> , INDC(NDS)-34/G (1972) evaluation up to 15 MeV; to be published in Atomic Energy Review (1972). <u>Mather et al.</u> , AWRE-0-44/71 (1971) evaluation up to 15 MeV.											
	Justificat	tion: Standa	rd for non	-destructive assay	of fuel eleme	ents.							
92-U-238	Delayed-N-	и Р(Е _л ,)	II	1-15 Mev	5 %	IKT (TUH) (FRG)	Stegemann	70					
	Comments:	<u>Comments</u> : Delayed neutron fraction, \mathcal{P}_i , required.											
	<u>Status:</u>	Status: Maksyutenko et al., Soviet J. of Nucl. Physics, 7, No. 2, 189 (1968) experiments up to 21 Mev. Krick et al., NCSAC-31, 156 (1970)											
	Justification: Standard for non-destructive assay of fuel elements.												
238	T (n,f)		II 1	- 15 Mev	5% IKT (F	(тин) RG)	Stegemenn	70					
	Comments: Fis	sion cross s	ection requ	aired to within 5%.	I.								
	Status: Bak eva Sil Sow	et al., IND luation up to bert et al., erby et al.,	C(NDS)-36/C 20 Mev. BNL-50298, AERE-M-249	+ (1971) and J. of 112(1971). 7 (1972), simultar	the Korean Nu eous evaluati	clear Socie on up to 20	ty, <u>3</u> , 77(1971) Mev.						

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

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Req.No.	Target	Reacti Quantity	on Type Variable	Priority	Incident Energ	y % Accuracy	Lab/Org.	Requestor,Comments,etc.	Tenr			
417	92-0-238	Delayed	γ P(E g, T)	() 11	2 and 14 Mey	y 35 %	BNL(OSALL) (USA)	Kouts	<u>,</u> :			
		Comments:	Accuracy re from neutro Absolute y	quested re n induced -ray yield	efers to relative fission for Ey> is to a factor of	e intensities of 2 Mev and 10µse 2 also useful.	delayed 省一ri c ぞ下火 Z 1 1	ays hour				
		<u>Status:</u>	R. Chrien, N.R. Large of Fission,	(BNL Unpub and R.J. E Vienna, p	lished) has some <u>Bullock,</u> 1969 IAE 5.637 (1969); pre	e data for U-235 CA Symposium on P esented some data	and Pu-239. Physics and Cl for U.	hemistry				
		Justificati	<u>on:</u> Assay o	f U fuels.								
	92 - U-238	(y,n)Spect	ra	III	Ey= 3-8 Kev	10 %	IAK(GfK) (FRG)	Fröhner	70			
		<u>Comments:</u>	<u>Comments:</u> Photoneutron spectra with resolved resonances and neutron energies between 0-100 eV required. Accuracies refer to shape and absolute values to within 20 % accuracy would be helpful. Photon energy resolution should be better than 100 Kev.									
		Status:	No active w	ork known.	,							
		Justification: Needed for the exploration of new techniques for non-destructive assay whose potential usefulness is unknown.										
	92-U-2 3 8	(xy,n)		II	$E_e = Threshold$ $\Delta E_e = 1\%$	-10 Mev 10 %	GRT (OSMA) (USA)	Eramblett	70			
		Comments:	4 m neutron Bremsstrahl electrons. absolute.	yield (in ung conver Neutron yi	cluding fission) ter (preferably eld may be relat	produced by bre Ta) of sufficien ive to D-2 (Xy,n	msstrahlung 1 t thickness () yield or n	required. to stop may be				
		<u>Status:</u>	<u>Gozani et.a</u> Katz et. al.	<u>l.,</u> Trans. , Canadian	American Mucl.S J. of Physics,	oc., <u>13</u> , 707 (19 <u>35</u> , 470 (1957).	70) - Relativ	ve data.				
		Justificatio	on: For non-	destructiv	e photonuclear a	ssay of U.						

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Target	Reactio Quantity	on Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-u-238	Delayed-N-Y	N(t)	II	$E_e = Threshold - 10 Mev \Delta E_e = 1 \%$	10 %	GRT (OSMM) (USA)	Bramblett	70
	Comments:	Delayed neut: (preferably ' relative to 1	ron yield p Ta) of suff D-2 (xy,n)	roduced by bremsstrah icient thickness to s yield or may be absol	nlung required stop electrons lute.	1. Bremsstra s. Neutron j	hlung converter rield may be	
	Status:	Gozani et.al	, Trans. A	merican Nucl.Scc., <u>13</u>	<u>3</u> ,707 (1970) -	- Relative d	lata	
	Justificati	on: For non-	-destructiv	e photonuclear assay	of U.			
92-0-238	Fission Pr g-y(lmsec	oduct P(Ey -1 hour)	,t) II	$E_e = 10 \text{ MeV}$ $\Delta E_e = 5 \%$	10 %	GRT (OSMM) (USA)) Bramuleit	70
	Comments:	Absolute fin Bremsstrahl Emergent X	ssion produ ung convert -ray energi	t delayed χ -ray yie er (preferably Ta) of es, E χ = 0.5-5.0 Mev	ald produced by sufficient twith $\Delta E_{\chi} = 3$	by bremsstra thickness to Kev.	hlung required. stop electrons.	
	Status:	Rundquist,	Frans. Amer	ican Nucl. Soc., <u>13</u> ,	746 (1970)- H	Preliminary	data.	
	Justificat	ion: For not	n-destructi	ve photonuclear assay	of U.			
92 - U - 238	Delayed-N-	-r 7 _D	II	5-14 Mev	5 %	LASL (USA)	Wèisbin and Walton	70
	Comments:	Delayed neu	tron yield	required. Data desire	ed for extrap	olation to	15 Mev.	
	<u>Status:</u>	Masters et. Krick and E	<u>al.,</u> Ameri vans, Preli	can Nucl. Soc., <u>11</u> , minary data (LASL),	179; measurem 0.1 - 6.7 Mev	ents at 3 a •	nd 14 Mev.	
	Justificat	tion: Calcul of U-2	ations of m 35.	oderating assemblies	for backgrou	nd effects	on assays	
92-u-238	(n, x)	P(E	() II	Thermal; 2 K	ev 25 %	IAK(GfK) (FRG)	Weitkamp	70
	Comments:	Capture &	-ray spectr	a required.				
	Status:	No useful	lata for th	ermal or 2 keV incide	ent neutrons }	known.		
	Justifica	tion: For n spect	on-destruct rometry.	ive assay of nuclear	material by 1	neutron capt	ure X-ray	

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	Keac	tion Type							
Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year	
93-Np-237	5 (n ,y)		II	0.001 eV-1 Kev	3-10 %	IAR(GfK) (FRG)	Fischer	70	
	Comments:	Accuracy of 3	% from them the form the form the form the form the form the form and the form the f	ermal - 10 eV need - 1 Kev.	ed. Accuracy of 5	5 % 🔓 and	accuracy		
Status:Paya, (Saclay) has $G^{-}(n,f)$, $G^{-}(n,total)$ and resonance parameters up to 2 Kev.Gavrilov, Atomic Energy, 28, 362 (1970) up to 10 Kev.Simons et.al., BNWL-1312 (1970); Evaluation up to 20 Mev.Brown et.al., Nuclear Physics, A156, 609 (1970) data up to 2.2 Kev and from100 Kev - 2.8 Mev.Hoffman, WASH-1136 preliminary data from 25 eV - 100 Kev.									
	Justifica	tion: For bur	n-up calcu	lations.					
93 -Np- 237	♂(n,f)	- <u> </u>	II	l Kev - 5 Mev	10 %	IAR (GfK) (FRG)	Fischer	70	
	Comments	Fission cros	s section	required.					
	<u>Status:</u> <u>Pava.</u> (Saclay) has G (n, r), G (n, total) and resonance parameters up to 2 Kev. <u>Gavrilov</u> , Atomic Energy, <u>28</u> , 362 (1970) up to 10 Kev. <u>Simons et.al.</u> , BNWL-1312 (1970); Evaluation up to 20 Mev. <u>Brown et.al.</u> , Nuclear Physics, A156, 609 (1970) data up to 2.2 Kev and from 100 Kev - 2.8 Mev.								
	Justifica	tion: For bu	rn-up calc	ulations.					
93-Np-237	σ(n,X)]	[]	l Kev-5 Mev	10 % IAR((FR	GfK) G)	Fischer	70	
	Comments:	Capture cross	s section	required to within	10 %.				
	Status:	Nagle et al. 259 (1971) Smith et al.	, Third C , IN-1182	onf. on Neutron Cro (1969) evaluation	up to 15 Mev.	Technology,	Knoxville (U.S.A.),		
	Justificat	ion: For burn	n-up calcu	lations.					

Target	Reactio Quantity Va	n Type ariable	Priority	Incident	Energy	% Accuracy		Lab/(Org. Re	equestor, Comments,	etc	Year.
94-Pu-238	0 (n,f)		II		1 - 10 Mer	7	10	\$	IAR(GfK) (FRG)) Fischer		70
	Comments:	Fission	cross sect	ion requi:	red.							
	Status:	<u>Silbert</u> Drake,	<u>,</u> LA-4108 (LA-4420 (19	(1969) and 970) - Data	LA-4674 (1 a up to 2.6	.971) - Data 5 Mev.	up	to 3 1	Mev.			
	Justificati	ion: For	burn-up ca	lculation	B•							
94 - Pu-238.	σ(n,y)		[]	. TI	hermal-10 1	lev	10	%	IAR (Gf (FRG)	2K) Fischer		70
	Comments:	Capture	Capture cross section required.									
	<u>Status:</u>	Silbert Young, Silbert Dunford Hinkelm	et.al., NC Nuclear Sci et.al., WA et.al., NA ann, KFK-11	SAC-31 (1) and Eng SH-1124 (1 A-SR-1227) 86 (1970)	970). Preli in., <u>30</u> , 36 1968); 30 e 1 (1967); e ; evaluatio	minary data 5; resonance V - 1 Mev provaluation from there	fro e pai relia rom ⁻ mal-	m 10 - ramete minary therma 10 Mer	- 100 Kev. ers to 190 y. al to 10 M y) 9V. Mev.		
	Justificat	ion: Fo	r burn-up c	alculatio	ns .							

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	Target	Reactio Quantity	n Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org. R	equestor, Comments,etc	Year
94-	-Pu-238	(n, X)	P(E X)	II	Thermal; 2 Kev	25 %	IAK(CfK) (FRG)	Weitkamp	70
		Comments:	Capture 🖌-r	ay spectra	a required.				
		Status:	√ No useful dat	a for ther	mal or 2 këV incident	neutrons.			
		Justificati	on: For non-	destructiv	e assay of nuclear ma	terial by neu	tron captur	e y- ray spectrometry.	
94•	-Pu-238	Fission Yi and T(k f	eld	II	Ey = Threshold - 1	0Mev 10%	GEOHI (USSR)	Markov	71
		Comments:	The energy de yield (and fi within 10 %.	pendence (ssion cros	as a function of inci- s section) resulting	dent & energ from & -indu	y) of the f aced fission	ission fragment is required to	
		Status:	Data unknown.						
1		Justificatio	on: For phot	onuclear a	ssay of Pu v				
 K 94-	-Pu-238	(y,n)		II	E = Threshold-10	Mev 10%	GEOHI (USSR)	Markov	71
		<u>Comments:</u>	The energy depresent the resulting from	pendence (m % irrad	as a function of incidiation is required to	ient &- energ within 10 %.	y) of the n	eutron yield	
		Status:	Data unknown.						
		Justificatio	on: For photo	nuclear as	say of Pu.				
94-	-Pu-239	Delayed-N-	r r _d	II	3 - 14 Mev	10 %	LASL (USA)	Weisbin and Walton	70
		Comments:	Delayed neut:	ron vield	required. Data desire	l for extrapo	lation to 1	5 Mev.	
		Status:	Masters et.a Maksyntenko, Petrzak, Ator Krick and Ev	1., Ameri ICD-1,266 nic Energy ans, Preli	can Nucl. S oc., <u>11,</u> 179 ; measurement at 3.8 ; <u>11</u> , 539. minary data (LASL), O	9; measuremen and 15 Mev. .1 - 6.7 Mev.	nts at 3 and	14 Mev.	
		Justificat	ion: Calcula	tions of π	oderating assemblies :	for Pu-239 as	says.		

Target	Reaction Quantity	Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,	Comments,etc	Year
94-Pu-239	(n, X) Spectra and Yields	Р(ЕУ) ЕУ71.2 Ме	III	Thermal-100 eV	See Comments	LASL (USA)	Weisbin	and Walton	70
	Comments:	Capture y -ra for y -rays	y spectra of energy	and yields of ∦-ray 71.2 Mev. Ge(Li) re	s per capture req solution at 1.2 M	uired to ev should	≈20 % ac i be 2.5 Ke	curacy, v.	
	Statuss	Jurney, LASL neutrons; X -	(1970) Pro -ray spectr	gress report-see als a from 3 - 6 Mev.	o BNL-50276,152 (1970) . Re	ecent data	for thermal	
	Justificati	on: Developme	ent of new	Pu- assay techniq	ue.				
94-Pu-239	(n, y)	P(E X)	II	'thermal; 2 Kev	25 %	IAK (GfK)	Weitkamp	<u> </u>	70
	2	Kev (scandium 100% or bette	filtered r. Final r	beam) neutrons nearly eport to be publishe	y completed at Kar d in 1972.Prelimin	rlsruhe t nary data	o an accur published	acy of -50% t at 1970 IAEA	0
	Sy No Bo Justificatio	ymposium on Sa on-Destructive erlin meeting 52 (1970). on: For non-de	feguards T Measureme of Deutsch structive	echniques,Karlsruhe, nt and Identificatio e Physikalische Gese assay of nuclear mat	Vol.2, p.113 (19 n Techniques in Nu llschaft.Also prej erial by neutron (70) and a uclear Sa liminary capture	at 1971 lsp: ifeguards and data of <u>Jun</u> y -ray spe r	ra meeting on nd at 1972 rney,BNL-5027 ctrometry.	6,
94-Pu-239	Justification Fission Pr X-ray spe and yields	ymposium on Sa on-Destructive erlin meeting 52 (1970). on: For non-de oduct P(E g) ctra	feguards T Measureme of Deutsch structive	echniques,Karlsruhe, nt and Identificatio e Physikalische Gese assay of nuclear mat Thermal	Vol.2, p.113 (19 n Techniques in Nu llschaft.Also pres erial by neutron o 	70) and a uclear Sa liminary capture LASL (USA)	at 1971 lsp: ffeguards a data of <u>Ju</u> <u>y</u> -ray spectrum Weisbi	ra meeting on nd at 1972 <u>rney</u> ,BNL-5027 ctrometry. n and Walton	6, 70
94 - Pu - 239	Justification Fission Pr &-ray spe and yields Comments:	ymposium on Sa on-Destructive erlin meeting 52 (1970). on: For non-de oduct P(E y) ctra Fission produ (photons/fiss required. Ge(+ 15% accurate	feguards T Measureme of Deutsch structive II ion-Y-ray pion-Mev-se [L1) resolu	echniques, Karlsruhe, nt and Identificatio e Physikalische Gese assay of nuclear mat Thermal spectra for Y-ray e c) from Imsec - 12 h tion at 1.2 Mev shou	Vol.2, p.113 (19 n Techniques in Nu llschaft.Also pres erial by neutron of <u>+</u> 15 % Absolute Yield nergies, E = 0.2 ours resulting fr ld be 2.5 Kev and	70) and a uclear Sa liminary capture LASL (USA) 5-5 Mev, om therma absolute	at 1971 lsp: feguards at data of <u>Ju</u> y -ray spec- Weisbi and yields al neutron y ields to	ra meeting on nd at 1972 <u>rney</u> ,BNL-5027 ctrometry. n and Walton fission	6, 70
94 - Pu-239	Justification Fission Pr Y-ray spe and yields Comments: Status:	ymposium on Sa on-Destructive erlin meeting 52 (1970). on: For non-de oduct P(E y) ctra Fission produ (photons/fiss required. Geo <u>+</u> 15% accurate Walton and Su Fisher and Er F.C. Maiensch Vol. 15, 366 Better resolu	feguards T Measureme of Deutsch structive II ion-Mev-se Li) resolu y. und, Phys. <u>igle</u> , Phys <u>iein, 1958</u> (1958). ution desir	echniques, Karlsruhe, nt and Identificatio e Physikalische Gese assay of nuclear mat Thermal spectra for Y -ray e c) from 1msec - 12 h tion at 1.2 Mev shou Rev., <u>178</u> , 1894 (196 . Rev., <u>134</u> , B796 (1 Geneva Conference o ed. Associate Y-ray	Vol.2, p.113 (19 n Techniques in Nu llschaft.Also present erial by neutron of <u>+</u> 15 % Absolute Yield nergies, E = 0.2 ours resulting fr ld be 2.5 Kev and 9) 964) n Peaceful Uses o s with fission pr	70) and a uclear Sa liminary capture LASL (USA) 5-5 Mev, om therma absolute f Atomic oducts in	At 1971 lsp: ffeguards a data of <u>Ju</u> y -ray spec- Weisbi and yields al neutron e yields to Energy, f possible.	ra meeting on nd at 1972 <u>rney</u> , BNL-5027 ctrometry. n and Walton fission	6 , 70

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Target	React Quantity	ion Type Variable	Priority	Incident Energy	% Accurac	Lab/Org.	Requestor, Comments, etc	Year			
94-Pu-239	Delayed -X-	Υ P(E _χ , T ½)	I	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69			
	Comments:	Accuracy requineutron induc Absolute X -:	ested refer ed fission ray yields	s to relative intens for $E_{\chi} > 2$ Mev and to a factor of 2 als	ities of delay 10µsec Z T火 10 useful.	ed & -rays	from				
	<u>Status:</u>	R. Chrien, (Bi <u>N.R. Large an</u> Fission, Vien	NL Unpublis <u>d R.J. Bull</u> na, p.6 3 7 (hed) has some data f <u>ock.</u> 1969 IAEA Sympo 1969); presented som	or U-235 and D sium on Physic he data for U.	Pu-239. cs and Chemi	stry of				
	Justificati	on: Assa y of .	Pu- fuels.								
94 - Pu-239	Fission Yie of 55-Cs-13	91d 97	I	Thermal	1 %	IAE (USSR)	Skvortsov and Mille	r 70			
	<u>Comments:</u> Fission product yield per fission event of 55-Cs-137 resulting from thermal fission of Pu-239 required to within 1 % accuracy. Different values are quoted in the literature.										
	<u>Status:</u>	O.A. Miller R.S. Forsyth Vol. 1, p.52 S.Hiller, Ke:	<u>et.al.</u> , Sc <u>et.al.</u> , 19 1 (1970) rntechnik,	viet Atomic Energy, 70 IAEA Symposium on 12, No. 11, 485 (197	<u>27</u> , 281 (1969 Safeguards Te). echniques, K	arlsruhe,				
	Justificati	on: For assay (of U and Pu	in spent fuel eleme	onts by the fis	sion produc	t J-rays.				
94-Pu-239	Fission Yie of 55-Cs-13	1d 3	I	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70			
	Comments:	Fission produ fission of Pu in the liters	uct yield p u-239 requi ature.	er fission event of red to within 1% acc	55-Cs-133 resu Suracy, Differe	alting from Ant values a	thermal re quoted				
	<u>Status:</u> Justificati	<u>O.A. Miller et</u> on: For assay	t <u>al.</u> Sovi of U and P	et Atomic Energy, <u>27</u> u in spent fuel elem	. 281 (1969). Ments by the fi	s s ion produ	ct J-rays.				

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Target	Reacti Quantity	on Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year			
94-Pu-239	Fission Yiel of 44-Ru-106	1	Il	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70			
	<u>Comments:</u> Fission product yield per fission event of 44 Ru-106 resulting from thermal fission of Pu-239 required to within 1 % accuracy. Different values are quoted in the literature.										
	Status:	S.Hiller, Ker I.P. Grechush U-238 and Pu-	ntechnik, <u>1</u> <u>kina</u> , "Table 239 fission"	2, No. 11 , 485 (197 es showing the compo ", Moscow, Atomizdat	0) sition of pro (1964).	mpt fissio	n products from U-235,				
	Justificati	on: For assa	y of U and I	Pu in spent fuel ele	ments by the	fission pr	oduct Y-rays.				
94-Pu-239	Fission Yie of 40-Zr-95	1d	II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70			
	<u>Comments</u> : Fission product yield per fission event of 40-2r-95 resulting from thermal fission of Pu-239 required to within 1% accuracy. Different values are quoted in the literature.										
	<u>Status:</u>	0.A.Miller et R.S. Forsyth p. 521 (1970) S. Hiller, Ke	<u>et.al.</u> , Soviet et.al., 1970 erntechnik,	t Atomic Energy, <u>27</u> , D IAEA Symposium on 1 <u>2</u> , No. 11, 485 (197	281 (1969). Safeguards Te 0).	chniques,	Karlsruhe, Vol. 1,				
	Justificati	on: For assa	y of U and I	Pu in spent fuel ele	ments by the	fission pr	oduct y-rays.				
94-Pu-239	Fission Yi of 56-Ba-1	eld 40	II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70			
	Comments:	Fission produ of Pu-239 reg	ot yield per uired to wit	r fissicn event of 5 thin 1 % accuracy. I	6-Ba-140 resu ifferent valu	lting from es are quo	thermal fission ted in the literature.				
	<u>Status:</u>	N.G. Gusev, Moscow, Atomi V.A. Greshilo O to 1 hour", J. of Inorgan	"Protection zdat (1968) <u>ov et.al.</u> " (Manual), H hic Nucl.Cher	against Y -radiati Products of prompt f Moscow, Atomizdat (1 n., <u>27</u> , 121 (1965)	on from fissi ission of U-2 969)。	on product 35, U-238	s," (Manual) and Pu-239 from				
	Justificati	on: For assa	y of U and I	Pu in spent fuel ele	ments by the	fission pr	oduct Y-rays.				

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Target	Reacti Quantity	on Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year				
94-Pu-239	Fission Yie of 58-Ce-14	91d 14	II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70				
	<u>Comments</u> :	Fission prod fission of P in the liter	uct yield per u-239 require ature.	r fission event of 5 ed to within 1 % acc	8-Ca-144 resu Suracy. Differ	lting from ent values	thermal are quoted					
	<u>Status:</u>	<u>Status:</u> <u>N.G. Gusev, "Protection against</u> y-radiation from fission products", (Manual) Moscow, Atomizdat (1968). <u>S. Hiller</u> , Kerntechnik, <u>12</u> , No. 11, 485 (1970)										
	Justificati	on: For assa	y of U and P	u in spent fuel elem	ents by the f	ission prod	uct X-rays.					
94 - Pu-239	(y ,n) Spect	ira	III	E y = 5-8 Mev	10 %	IAK(GfK) (FRG)	Fröhner	71				
	<u>Comments:</u>	Photoneutron O-100 eV req accuracy wou	spectra with uired. Accura ld be helpful	n resolved resonance acies refer to shape 1. Photon energy res	s and neutron and absolute olution shoul	energies b values to d be better	within 20 % than 100 Xev.					
	Status:	No active wo	rk known∙									
	Justificati	on: Needed fo potential use	or the explor efulness is u	ation of new techni mknown.	ques for non-c	lestructive	assay whose					
94-Pu-23	9 (x /,n)		II	E _e =Threshold-10 M	lev 10 %	GRT (OSMM)	Bramblett	70				

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v	$\Delta E_{e} = 1 \% \tag{USA}$
<u>Comments:</u>	4π neutron yield (including fission) produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons. Neutron yield may be relative to D-2 (xx,n) yield or may be absolute.
Status:	<u>Gozani et.al.</u> , Trans. American Nucl. Soc., <u>13</u> . 707 (1970) - Relative data.
Justificati	on: For non-destructive photonuclear assay of Pu-239.

M e	Reacti	on Type	D	To a state the second	đ	1.1.	December 2	
Target	Quantity		Priority	incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Iear
94-Pu-239	Delayed-N-Y	(N(t)	II	E = Threshold - e 10 Mev	10 🖋	GRT (OSMM) (USA)	Bramblett	70
				$\Delta E_e = 1\%$				
	<u>Comments:</u> I c y	Delayed neut converter (prield may be	ron yield preferably relative	produced by bremsstrah Ta) of sufficient thic to D-2 $(\chi \chi, n)$ yield o	lung required kness to stop or may be abso	. Bremsstrah electrons.	llung Neutron	
	Status:	ozani et.al	., Trans.	American Nucl. Soc., 1	<u>3</u> , 707 (1970)) - Relative	data.	
	Justificatio	on: For nor	-destructi	ve photonuclear assay	of Pu-239.			
94-Pu-239	Fission Product X-Y(1msec-	P(Ey,t) l hour)	II	$E_{e} = 10 \text{ Mev}$ $\Delta E_{e} = 5 \%$	10 %	GRT (OSMM) (USA)	Bramblett	70
	<u>Status:</u> Justificatio	equired. Br o stop elec <u>undquist</u> , T	ssion produ emsstrahlu trons. Eme 'rans.Ameri -destructi	ct delayed & -ray yie ing converter (preferab ingent & -ray energies, can Nucl. Soc., <u>13</u> , 74 ve photonuclear assay	Id produced b ly Ta) of suf $E \zeta = 0.5-5.0$ 6 (1970) - Pr of Pu-239.	y bremsstraf ficient thic Mev with Д eliminary da	Extra strategy in the second strategy is the second strategy in the second strategy is the second strategy in the second strategy is the	
94-Pu-23	9 Delayed-	γγ P(E,	т %) I	II Thermal;2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70
	Comment	Delayed interes of -50	fission ting for i % to + 100	✓-ray spectre as a fun ntervals < 1 sec. Accu 0 % for T /2 acceptable	ction of dela racy refers t •	y time requi o y -ray in	red. Particularly htensities. Errors	
	Justifi	<u>cation</u> : Fo	or non-dest 'ission pro	ructive assay of fissi ducts.	onable materi	al by }- si	pectroscopy of short	
94-Pu-240) Delayed-N-	Υ ϔ D	II	0.75-14 Mev	20 %	LASL (USA)	Weisbin and Walton	70
	Comments:	Delayed neu	tron yield	required. Data desired	l for extrapol	lation to 15	Mev.	
	Status:	Hunter, LA- Diven, 1961 Vol. 1, p.	3528 (1968 IAEA Sympo 149 (1961)); evaluation up to 2.5 osium on Physics of Fas . Data at 6.3 Mev.	5 Mev. st and Interme	ediate React	ors, Vienna,	
	Justificati	on: Calcul	ations of a	noderating assemblies f	for Pu assays	of spent fu	el.	

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Target	Reacti Quantity	on Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments,	etc. Yea
94-Pu-240	Decay Heat		II		0.2 %	ALKEM (FRG)	Schneider	70
	Comments:	Specific dec carried-off	ay heat, in by long-rang	e.g. Watts/gramme requ ge particles (x-rays,χ	ired. Percenta, -rays) would be	ge of heat e useful.		
	Status:	Uncertainty Energ., <u>6,</u> 7 the decay he	determined b 4 (1959) - T at of 7.008	y half-life - most rec 2 = 6620 + 50 years. + 0.76 % milliWatts/ g	ent measurement This yields, w ramme.	t by <u>Dokucha</u> with $Q_{\alpha} = \frac{1}{2}$	<u>aev</u> ,Atomnaya 5255•3 <u>+</u> 0•7 keV,	
	Justificat	ion: For ca	l orimetr ic H	Pu determination.				
94-Pu-240	Delayed-y	- Y P(Ex, T)	¥2) II	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69
	Comments:	Accuracy req neutron indu Absolute X	uested refer ced fission -ray yields	rs to relative intensit for $E_y \nearrow 2$ Mev and 10 to a factor of 2 also	ies of delayed µsec 2T火 2 useful.	γ-rays fro ζ l hour.	m	
	Status:	R. Chrien, (N.R. Large a Fission, Vie	BNL Unpublis	shed) has some data for Lock, 1969 IAEA Symposi	U-235 and Pu-2 um on Physics a data for U-	239. and Chemistr	ry of	
	Justificat	ion: Assay o	of Pu fuels.	(-,-,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				
94-Pu-240	(xy,n)		II	$E_e = Threshold - 10 Mev$ $\Delta E_e = 1\%$	10 %	GRT(OSMM) (USA)	Bramblett	70
	Comments:	4 m neutron Bremsstrahlu Neutron yiel	yield (inclu ang converter d may be rel	ading fission) produced (preferably Ta) of su lative to D-2 (χ_V, n) y	by bremsstrahl fficient thickn ield or may be	lung require mess to stop absolute.	d. 9 electrons.	
	Status:	No data.	-	0				
	Justificat	ion: Effect	on non-destr	ructive photonuclear as	say of Pu-239.			
94 - Pu-240	Delayed-N for t < 10	-Y N(t) O sec	II	$E_{e} = Threshold = 101$ $\Delta E_{e} = 1\%$	Mev 10 %	GRT (OSMM) (USA)) Bramblett	70
	Comments	Delayed new (preferably relative to	tron yield p Ta) of suff D-2 $(\chi \chi, n)$	produced by bremsstrahl ficient thickness to st) yield or may be absol	ung required. op electrons. ute.	Bremsstrahl: Neutron yie	ung converter ld may be	
	Status:	No data	Ű					
	Justifica	tion: Effect	; on non-dest	tructive photonuclear a	ssay of Pu-239	•		

	Target	Reaction Quantity	Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
	94-Pu-240	Fission Pro- X-Y (lmsec-	duct P(Ey,T) 1 hour)	II	$E_{e} = 10 \text{ Mev}$ $\Delta E_{e} = 5 \%$	10 %	GRT (OSMM) (USA)	Bramblett	70
		Comments:	Absolute fis: Bremsstrahlur Emergent X-	sion produ ng convert ray energi	act delayed χ -ray j ter (preferably Ta) c tes, $E\chi = 0.5 - 5.0$ M	vield produced of sufficient Nev with ΔE_{χ}	by bremas thickness y = 3 Kev.	trahlung required. to stop electrons.	
		Status:	No data.		-				
		Justificat	ion: Effect	on non-de	estructive photonucle	ear assay of P	u-239.		
	94-Pu-240	(n, y)	P(E &)	II	Thermal; 2 Kev	25 %	IAK (GfK (FRG)) Weitkamp	70
		Comments:	Capture 🗙 -:	ray specti	ra required.				
		Status	No useful da	ata for th	ermal or 2 keV neutr	ons.			
- 41		Justifcatio	on: For non-de	estructive	assay of nuclear ma	terial by neu	tron captur	e V-ray spectrometry.	
I	94-Pu-241	Delayed-N-Y	$m{arphi}_{ extsf{D}}$	III	Thermal - 14 Mev	10 %	LASL (USA)	Weisbin and Walton	70
		Comments:	Delayed neutr	on yield	required. Data neede	d for extrapol	lation to l	5 Mev.	
		Status:	Only work at	thermal e	nergy. See <u>Keepin</u> Nu	cleonics, 20,	8, 150 (19	62).	
		Justificati	on: Calculat	ions of m	oderating assemblies	for Pu assays	3.		

Target	Rea Quantity	ction Type Variable	Priority	Incident Energy	%Accuracy	Lab/Org.	Requestor,Comments,etc	Year			
94-Pu-241	5 (n,y)		II	Thermal - 30 Kev	3 %	IAR(GfK) (FRG)	Fischer	70			
	<u>Comments:</u> Capture cross section or alpha ($lpha$) required. Accuracy to 3 % in eta (η).										
	Status: Yiftah, IA-1152 (1967); evaluation 0.1 eV - 15 Mev. This evaluation being revised. Smith, WASH-1136, 70 (1969): evaluating for ENDF/B library.										
	Justificat	Justification: For burn-up calculations.									
94-Pu-241	Alpha	$\frac{\sigma(n, \delta)}{\sigma(n, f)}$	II	l Kev - 2 Mev	20 %	IAR(GfK) (FRG)	Fischer	70			
	Comments:	Comments: Alpha $(\sigma(n,\chi)/\sigma(n,f))$ needed but capture cross section would be equally useful.									
	Status:	Status: Davey, 1970 IAEA Conference on Nuclear Data for Reactors, Helsinki, Vol. 2, p. 119 (1970); review paper 100 Kev - 10 Mev.									
	Justificat	Justification: For burn-up calculations.									
94-Pu-241	Decay Heat		II		0.5 %	ALKEM (FRG)	Schneider	70			
	<u>Comments</u> : Specific decay heat, in e.g. Watts/gramm ^e required. Percentage of heat carried- off by long-range particles (X-rays, χ -rays) would be useful).										
	Status: Uncertainty mainly determined by average β -energy therefore direct calorimetric measurement of decay heat made by <u>Oetting</u> , Phys.Rev., <u>168</u> , 1388-result was 3.62 ± 5.0 % milliwatts/gramme.										
	Justification: For calorimetric Pu determination.										
94 - Pu-241	Fission Yi and $\sigma(\chi, f)$	eld	II	E X= Threshold-	10 Mev 10	% GEOHI (USSR)	Markov)	71			
	Comments:	<u>Comments</u> : The energy dependence (as a function of incident Y energy) of the fission fragment yield (and fission cross section) resulting from Y -induced fission is required to within 10 %.									
	Status:	Data unknown	•								
	Justificat	Justification: For photonuclear assay of Pu.									

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Target	React Quantity	ion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Yea	
94 - Pu-241	(x, n)	·····	II	Ey Threshold-10 Mer	10 %	GEOHI (USSR)	Markov		
	Comments:	The energy Y−irradiat	dependence ion by 🎖-r	of the neutron yield i ays of different energy	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 isotopes	Ce, Ru,	III	Thermal	5%	IAE (USSR)	Skvortsov and Miller	7	
	Comments:	The fissio by thermal	n fragment neutrons i	yield of Ce, Cs, Zr and s required to within 5	d Ru fissic 5 %.	on products	for fission		
	Status:	Data unkno	wn.						
	Justificat	ion: For ass	ay of U and	. Pu in fuel elements b	y means of	the fission	product γ -radiation.		
94-Pu-241	Delayed	-х-у _{Б(Е} х,	т /2) III	Thermal; 2 Key	25 %	IAK(GfK) (FRG)	Weitkamp	7	
	<u>Comments</u> : Delayed fission γ -ray spectra as a function of delay time required. Particularly in- teresting for intervals < 1 sec. Accuracy refers to γ -ray intensities. Errors of - 50 % + 100 % for T $\frac{1}{2}$ acceptable.								
	Status:	No data.		-					
	Justificat	ion: For nor fission	n-destructi n products.	ve assay of fissionabl	e mat er ial	by X -spec	troscopy of short-lived		
94-Pu-241	(Yy,n)		III	$E_e = Threshold-10 Me$ $\Delta E_e = 1 \%$	v 30 %	GRT(OSMM) (USA)	Bramblett	7'	
	Comments:	4 π neutron strahlung c Neutron yie	yield (inc onverter (p ld may be r	luding fission) produc referably Ta) of suffi elative to D-2 (xy,n)	ed by brems cient thick yield or ma	strablung r ness to sto y be absolu	equired. Brems- p electrons. te.		
	0 + +	NT 3 1		U					
	Status:	No data.							

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	Reaction Type											
Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year				
94-Pu-241	Delaycd-N	-Y N(t)	III	$E_e = Threshold - 10$ $\Delta E_e = 1\%$) Mev 30 %	CRT(OSMM) (USA)	Bramblett	70				
	Comments: Delayed neutron yield produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons. Neutron yield may be relative to D-2 (x, n) yield or may be absolute.											
	Status:	Status: No data.										
	Justific	Justification: Effect on non-destructive photonuclear assay of Pu.										
94-Pu-241	Fission Product	P(E,t) -1 hour)	III	$E_{e} = 10 \text{ MeV}$ $\Delta E_{e} = 5 \%$	30 %	GRT(OSMM (USA)) Bramblett	70				
	<u>Comments</u> : Absolute fission product delayed γ -ray yield produced by bremsstrahlung required. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons. Emergent γ -ray energies, E γ = 0.5-5.0 Mev with Δ E χ = 3 Kev.											
	Status:	No data.		U	9							
	Justification: Effect on non-destructive photonuclear assay of Pu.											
94-Pu-241	5 (n,f)		II	Thermal-10 Mev	3-10 %	IAR(GfK) (FRG)	Fischer	70				
	Comments: Fission cross section required. Accuracy to 3 % from thermal to 10 eV; and to 10 % from 10 eV to 30 Kev; and to 5-10 % from 30 Kev to 10 Mev. Ratio to U-235 or Pu-239 fission cross sections would be useful.											
	<u>Status:</u>	Status:James, AERE-R-6676 (1971); evaluation from thermal to 20 eV; see also AERE-M-2157 (Rev.) evaluation to 20 Kev. Käppeler, 1970 IAEA Conference on Nuclear Data for Reactors, Helsinki, Vol. 2, p.77 (1970). Ratio to \mathfrak{O} (n,f) U-235. Blons et.al. 1970 IAEA Conference on Nuclear Data for Reactors, Helsinki, Vol. 1, p.469 (1970). Data from 1 eV to 3 Kev. Smith et.al. , IN-1407, 57 (1970); evaluation for ENDF/B library.										
	Justificat	ion: For burn	u-up calcu	lations.								

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Target	React Quantity	ion Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year		
94 -B u-241	(n, y)	P(E _y)	II	Thermal; 2 Kev	25%	IAK(CfK) (FRG)	Weitkamp	70		
	Comments:	Capture y -	ray spectr	a required.						
	Status: Experimental determination of P(Ex) for high energy y 's (Ex) 2 Mev) resulting from thermal neutrons nearly completed at Karlsruhe to an accuracy of -50% to + 100% or better. Final report to be published in 1972. Preliminary data published at 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol. 2, p. 113 (1970) and at 1971 Ispra meeting on Non-Destructive Measurement and Identification Techniques in Nuclear Safeguards and at 1972 Berlin meeting of Deutsche Physikalische Gesellschaft.									
	Justificat	ion: For non-d	lestructiv	e assay of nuclear	material by r	neutron capt	are &-ray spectrometry.			
94-Pu-242	(n , X)	Р(Е Қ)	III	Thermal;2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70		
	Comments: Capture Y -ray spectra required.									
	Status: No useful data for thermal and 2 Kev neutrons.									
	Justificati	ion: For non- spectrometry	destructiv •	e assay of nuclear	material by :	neutron capt	ure y-ray			
94-Pu-242	Delayed-N-Y	\widehat{r}_{D}	III 3	and 14 Mev	20 %	LASL (USA)	Weisbin and Walton	70		
	Comments: Delayed neutron yield required.									
	Status: No data.									
	Justification: Calculations of moderating assemblies for Pu-assays.									
95-Am-241	T (n,f)		II	20 Kev - 10 Mev	10 %	IAR(GfK) (FRG)	Fischer	70		
	<u>Comments:</u> Fission cross section required to 10 % accuracy.									
	<u>Status:</u> <u>Seeger et.al.</u> , Nucl.Phys., <u>A96</u> , p. 605; 20 eV to 1 Mev data. <u>Hinkelmann</u> , KFK-1186 (1970); evaluation to 10 Mev. <u>Spivak et.al.</u> , INDC(CCP) - 8/U, p.6 (1970); from 8 Kev to 3.3 Mev. <u>Fomushkin</u> , INDC (CCP) - 7/U, p. 28 (1970); from 440 Kev to 3.6 Mev.									
	Justificatio	on: For burn-u	up calcula	tions.						

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	React	ion Type									
Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org. Requ	estor,Comments,etc.	Year			
95-Am-241	5 (n, y)		II	Thermal - 10 Mev	see Comments	IAR(GfK) (FRG)	Fischer	70			
	<u>Comments</u> :	Capture cros of 50 % from	ss section m ᄎ 100 e	required to accuracy o V to 300 Kev and accur	f 10 % from acy of 20 - 3	thermal to 1 K O % from \approx 10	ev; accuracy O Kev to 10 Mev.				
	<u>Status:</u>	3: Dovbenko et.al., INDC(CCP) - 9/U, p.7 (1970); Thermal value. <u>Hinkelmann, KFK-1186 (1970); evaluation.</u> <u>Jungolaussen, Izv. Akad. Nauk SSSR, 33, 695 (1969)</u> <u>Flerov et.al.</u> , Nucl. Phys., <u>Al02</u> , 443 (1967).									
	Justifica	tion: For b	urn-up calc	ulations.							
95-Am-241	Fission Yield and $\mathfrak{S}(\chi, f)$		II	$E_{\chi} = Threshold-10 M$	ev 10 %	GEOHI (USSR)	Markov	71			
	Comments:	The energy dependence (as a function of incident γ energy) of the fission fragment yield (and fissic, cross section) resulting from γ -induced fission is required to within 10 %.									
	<u>Status:</u>	L. Katz et.al., 1958 Geneva Conference on Peaceful Uses of Atomic Energy, Vol. 15, p. 188 (1958). Yu.P. Gangrsky et.al., Soviet Journal of Nucl. Physics, <u>11</u> , 54 (1970)									
	Justification: For photonuclear assay of Pu.										
95-Am-241	(y ,n)		II	$E_{\delta} = Threshold-10 M$	ev 10 %	GEOHI (USSR)	Markov	71			
	Comments:	The energy for X-irra	dependence adiation by	of the neutron yield : χ -rays of different	is required t energies.	o within 10 %					
	Status:	Data unkno	own.	-							
	Justificat	tion: For pl	notonuclear	assay of Pu.							

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