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International Atomic Energy Agency

INDC(NDS)-50/U+S

INDC

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
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Nuclear Data Section

March 1973

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

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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/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 current request list (Annex IV).

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

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 non-destructive 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 UO_2 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 UO_2 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 relatively rather than absolutely. Another problem for non-destructive 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 standards. 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 photo-neutron (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.G.) 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 $\pm$ 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.

2. 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).

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,	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.
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 Data Requests for Safeguards Purposes. *

First Priority - (I)

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 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 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 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.) 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).

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 γ-ray spectra as a function of delay time).

3.) 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.

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_e and E_γ respectively.

5.) 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 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 γ-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.

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
1-D-2	$(x\gamma,n)$		I	E_e=Threshold - 10 Mev $\Delta E_e = 1\%$	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: Total neutron yield produced by bremsstrahlung required. Absolute 4π yield per electron is required. Emergent neutron flat-energy response. Bremsstrahlung converter (preferably Ta) of sufficient thickness to stop electrons.

Status: No useful data and calculations insufficient.

Justification: Standard for non-destructive photonuclear assay.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
3-Li-6	$(x\gamma,n)$		III	E_e =Threshold - 10 Mev $\Delta E_e = 1\%$	20 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 $(x\gamma,n)$ yield or may be absolute.

Status: No useful data.

Justification: Background effect on non-destructive photonuclear assay.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
4-Be-9	$(n,p)Li^{9} \xrightarrow{\beta^-} Be^{9*} \rightarrow n$		II	14 Mev	10 %	LASL (USA)	Weisbin and Walton	70

Comments: Delayed neutron yield required.

Status: Preliminary measurements at LASL; measurement of Alburger Phys. Rev., 132, 328 (1963) at 16 Mev.

Justification: Background in delayed neutron assays.

Target	Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
4-Be-9	$(n,p)Li^{9} \xrightarrow{\beta^-} Be^{9*} \rightarrow n'$	$P(E_{n'})$	II	14-16 Mev	10 %	GEOHI (USSR)	Markov	71

<u>Comments:</u> Delayed neutron yield required.

<u>Status:</u> <u>Alburger</u>, Phys.Rev., <u>132,</u> 328 (1963)

<u>Justification:</u> Allowance for background in delayed-neutron counting.

4-Be-9	$(x\gamma,n)$		II	E_e=Threshold-10Mev ΔE_e = 1%	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 $(x\gamma,n)$ yield or may be absolute.

<u>Status:</u> No useful data.

<u>Justification:</u> Background effect on non-destructive photonuclear assay.

6-C-13	$(x\gamma,n)$		II	E_e=Threshold-10Mev ΔE_e = 1%	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 $(x\gamma,n)$ yield or may be absolute.

<u>Status:</u> No useful data.

<u>Justification:</u> Background effect on non-destructive photonuclear assay.

8-0-17	$(x\gamma,n)$		II	E_e= Threshold-10 Mev ΔE_e = 1 %	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 $(x\gamma,n)$ yield or may be absolute.

<u>Status:</u> No useful data.

<u>Justification:</u> Background effect on non-destructive photonuclear assay.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
40-Zr-95	Yield of γ-quanta per β- decay event		II	————	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 1 % is required.

Status: N.G. Gusev, "Protection against γ-radiation from fission products," (Manual) Moscow, Atomizdat (1968).
R.S. Forsyth et.al., 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe Vol. 1, p.521 (1970).
S.Hiller, Kerntechnik, 12, No. 11, 485 (1970)
Nir-El, Israel Atomic Energy Comm. (Repts)No. 1168, 70-71 (1968)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
40-Zr-95	Half-Life		II	————	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 1 % is required.

Status: N.G. Gusev, "Protection against γ-radiation from fission products," (Manual) Moscow, Atomizdat (1968).
R.S. Forsyth et.al., 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe Vol. 1, p.521 (1970).

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
40-Zr-95	$\sigma(n,\gamma)$		III	Thermal; 0.06 eV	5 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Determination to within 5 % required.

Status: Data unknown.

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
44-Ru-106	Yield of γ-quanta per β-decay event		II	———	3 %	IAE (USSR)	Skvortsov and Miller	70

<u>Comments:</u> Different values are quoted in the literature. Determination to within 3% required.

<u>Status:</u> <u>O.A. Miller et.al.,</u> Soviet Atomic Energy, <u>27</u>,281 (1969)
<u>R.S. Forsyth et.al.,</u>1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol.1, p. 521 (1970).

<u>Justification:</u> For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
44-Ru-106	Half-Life		II	———	1 %	IAE (USSR)	Skvortsov and Miller	70

<u>Comments:</u> Different values are quoted in the literature. Determination to within 1 % is required.

<u>Status:</u> <u>O.A. Miller et.al.,</u> Soviet Atomic Energy, <u>27</u>, 281 (1969)
<u>N.G. Gusev,</u>"Protection against γ-radiation from fission products", (Manual) Moscow, Atomizdat (1968).
<u>R.S. Forsyth et.al.,</u> 1970 IAEA Symposium on Safeguards Techniques,Karlsruhe, Vol. 1, p.521 (1970).

<u>Justification:</u> For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
44-Ru-106	$\sigma(n,\gamma)$		III	Thermal; 0.06 eV	10 %	IAE (USSR)	Skvortsov and Miller	70

<u>Comments:</u> Different values are quoted in the literature. Determination to within 10 % is required.

<u>Status:</u> <u>M. Goldberg et.al.,</u> Neutron Cross Sections, BNL-325,S.E. V.II B, Suppl.No.2 (1966)

<u>Justification:</u> For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
55-Cs-133	$\sigma(n,\gamma)$		II	Thermal; 0.06 eV	3 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 3 % is required.

Status: M. Goldberg et.al., Neutron Cross Sections, BNL-325,S.E. V. II B, Suppl. No. 2 (1966)
Analytic Chem., 37 , 351 (1965)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
55-Cs-134	$\sigma(n,\gamma)$		II	Thermal; 0.06 eV	3 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 3 % is required.

Status: M. Goldberg et.al., Neutron Cross Sections, BNL-325,S.E.V. II B, Suppl. No. 2 (1966)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
55-Cs-134	Half-Life		I	______	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 1 % is required.

Status: O.A. Miller et.al. Soviet Atomic Energy, 27, 281 (1969)
R.S. Forsyth et.al., 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol.1, p.521 (1970)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
55-Cs-134	Yield of γ-quanta per β-decay event		I	______	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 1 % is required.

Status: R.S. Forsyth et.al., 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol. 1, p.521 (1970)
Nucl.Sci, and Engin., 22, 416(1965)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
55-Cs-137	Yield of γ-quanta per β-decay event		I	______	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 1 % is required.

Status: Analytic Chem., 37, 351(1965)
S. Hiller, Kerntechnik, 12, No. 11, 485(1970)
R.S. Forsyth et.al., 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol. 1, p.521(197o)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
55-Cs-137	Half-Life		I	______	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 1 % is required.

Status: V.A. Greshilov et.al.,"Products of prompt fission of U-235, U-238 and Pu-239 from 0 to 1 hour", (Manual), Moscow, Atomizdat (1969).
J. of Inorganic Nucl.Chem., 27, 121 (1965)
R.S. Forsyth et.al., 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol. 1, p.521 (1970)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
55-Cs-137	$\sigma(n,\gamma)$		II	Thermal; 0.06 eV	10 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 10 % is required.

Status: M.Goldberg et.al., Neutron Cross Sections,BNL-325,S.E.V.11 B,Suppl.No.2 (1966)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
56-Ba-140	Half-Life		II	______	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature.Determination to withih 1 % is required.

Status: N.G. Gusev,"Protection against γ-radiation from fission products", (Manual) Moscow, Atomizdat (1968).

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
56-Ba-140	$\sigma(n,\gamma)$		III	Thermal; 0.06 eV	5 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Determination to within 5 % required.

Status: Data unknown.

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
57-La-140	Yield of γ-quanta per β-decay event		II	————	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 1 % is required.

Status: N.G. Gusev, "Protection against γ-radiation from fission products", (Manual) Moscow, Atomizdat (1968)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
58-Ce-144	Half-Life		II	————	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 1 % is required.

Status: N.G. Gusev, "Protection against γ-radiation from fission products", (Manual) Moscow, Atomizdat (1968)
V.A. Greshilov et.al., "Products of prompt fission of U-235, U-238 and Pu-239 from 0 to 1 hour", (Manual), Moscow, Atomizdat (1969).

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
58-Ce-144	Yield of γ-quanta per β-decay event		II	————	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Different values are quoted in the literature. Determination to within 1 % is required.

Status: N.G. Gusev, "Protection against γ-radiation from fission products", (Manual) Moscow, Atomizdat (1968).
S.Hiller, Kerntechnik, 12, No. 11, 485 (1970)

Justification: For assay of U and Pu in fuel elements from fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
90-Th-232	$(x\gamma,n)$		II	E_e=Threshold-10 Mev ΔE_e = 1 %	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 $(x\gamma,n)$ yield or may be absolute.

Status: Gozani et.al., Trans.American Nucl.Soc., 13, 707 (1970) - Relative data.
Katz et.al., Canadian J. of Physics, 35, 470 (1957).

Justification: To allow non-destructive photonuclear assay of Th mixtures.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
90-Th-232	Delayed-N-Y	N(t)	I	E_e=Threshold-10 Mev ΔE_e= 1 %	10 %	GRT(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 $(x\gamma,n)$ yield or may be absolute.

Status: Gozani et al. Trans.American Nucl.Soc., 13, 707 (1970)-Relative data.
Katz et.al., Canadian J. of Physics, 35, 470 (1957).

Justification: To allow non-destructive photonuclear assay of Th mixtures.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
90-Th-232	Fission Product γ-Y(1 msec-1 hour)	$P(E_\gamma,t)$	III	E_e = 10 Mev ΔE_e = 5 %	10 %	GRT (OSMM) (USA)	Bramblett	70

Comments: 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 ΔE_γ= 3 Kev.

Status: Rundquist, Trans. American Nucl.Soc., 13, 746 (1970) - Preliminary data.

Justification: For non-destructive photonuclear assay of Th mixtures.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
90 -Th-232	σ(n,f)		I	1-15 Mev	5%	IKT(TUH) (FRG)	Stegemann	70

Comments: Fission cross section required to within 5%.

Status: Ben-David, IAEA-107, 57 (1968) review up to 14 Mev.
Bak et al., INDC(NDS)-36/G (1971) and J. of the Korean Nuclear Society, 3, 77 (1971).

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
90-Th-232	$\bar{\nu}$	Prompt	I	1-15 Mev	3%	IKT(TUH) (FRG)	Stegemann	70

Comments: Average number of prompt neutrons per neutron induced fission required.

Status: Davey, Nucl. Sci. and Engin, 44, 345(1971) evaluation up to 15 Mev.
Manero et al., INDC(NDS)-34/G (1972) evaluation to be published in Atomic Energy Review (1972)

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
90-Th-232	Delayed-N-Y	$P(E_n,)$	I	1-15 Mev	5%	IKT(TUH) (FRG)	Stegemann	70

Comments: Delayed neutron fraction, β_i, required.

Status: Krick et al., NCSAC-31, 156 (1970). Preliminary results up to 15 Mev.

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

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
90-Th-232	Delayed -γ-Y	$P(E_\gamma, T^{1/2})$	II	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69

Comments: Accuracy requested refers to relative intensities of delayed γ-rays from neutron induced fission for $E_\gamma > 2$ Mev and 10 μsec $< T^{1/2} <$ 1 hour. Absolute γ-ray yields to a factor of 2 also useful.

Status: R.Chrien, (BNL unpublished) has some data for U-235 and Pu-239.
N.R. Large and R.J. Bullock, 1969 IAEA Symposium on Physics and Chemistry of Fission, Vienna, p.637 (1969); presented some data for U.

Justification: Background effects in assay of U-233 - Th-232.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-233	$(x\gamma, n)$		I	E_e = Threshold-10 Mev ΔE_e = 1 %	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 $(x\gamma, n)$ yield or may be absolute.

Status: Katz et.al., Canadian J. of Physics, 35, 470 (1957).

Justification: To allow non-destructive photonuclear assay of U-233.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-233	Delayed-N-Y	N(t)	I	E_e = Threshold-10 Mev ΔE_e = 1 %	10 %	GRT(OSMMM) (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 $(x\gamma, n)$ yield or may be absolute.

Status: No data.

Justification: To allow non-destructive photonuclear assay of this SNM.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
92-U-233	Fission Product γ-γ(1 msec- 1 hour)	$P(E_\gamma, t)$	II	E_e = 10 Mev ΔE_e = 5 %	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 ΔE_γ = 3 Kev.

Status: No data.

Justification: For non-destructive photonuclear assay of this SNM.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
92-U-233	Delayed-γ-γ	$P(E_\gamma, T^{1/2})$	I	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69

Comments: Accuracy requested refers to relative intensities of delayed γ-rays from neutron induced fission for $E_\gamma > 2$ Mev and 10 μsec $\lesssim T_{1/2} \lesssim$ 1 hour. Absolute γ-ray yields to a factor of 2 also useful.

Status: R. Chrien, (BNL unpublished) has some data for U-235 and Pu-239.
N.R. Large and R.J. Bullock, 1969 IAEA Symposium on Physics and Chemistry of Fission, Vienna, p.637 (1969); presented some data for U.

Justification: Assay of U-233 fuels.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
92-U-234	$(x\gamma, n)$		II	E_e = Threshold - 10 Mev ΔE_e = 1 %	30 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 $(x\gamma, n)$ yield or may be absolute.

Status: No data.

Justification: Effect on non-destructive photonuclear assay of U-233 and U-235.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-234	Delayed-N-Y	N(t)	III	E_e=Threshold-10 Mev ΔE_e = 1 %	30 %	GRT(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 ($x\gamma$,n) yield or may be absolute.

Status: No data.

Justification: Effect on non-destructive photonuclear assay of U-233 and U-235.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-234	Fission Product γ-γ (1 msec-1 hour)	$P(E_\gamma,t)$	III	E_e = 10 Mev ΔE_e = 5 %	30 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 ΔE_γ= 3 Kev.

Status: No data.

Justification: Effect on non-destructive photonuclear assay of U-233 and U-235.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Fission Product γ-ray spectra and yields.	$P(E_\gamma)$	II	Thermal	± 15 % Absolute yield.	LASL (USA)	Weisbin and Walton	70

Comments: Fission product γ-ray spectra for γ-ray energies, E_γ = 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.

Status: Walton and Sund, Phys. Rev., 178, 1894 (1969)
Fisher and Engle, Phys. Rev., 134, B796 (1964)
F.C. Maienschein et.al., 1958 Geneva Conference on Peaceful uses of Atomic Energy, Vol. 15, 366 (1958).
Better resolution desired. Associate γ-rays with fission products if possible.

Justification: Non-destructive assay of U-235.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	$\sigma(n,f)$		I	Thermal-15 Mev	3%	IKT(TUH) (FRG)	Stegemann	70

Comments: Fission cross section required to within 3 %.

Status: Sowerby et al., AERE-M-2497 (1972) simultaneous evaluation from 100 eV - 20 Mev.
WARD-4210 T4-1 (1972) recent evaluation for ENDF/B-III library.
Steen, WARD-TM-691 (1969) evaluation from thermal up to 14 Mev.
Boroughs et al., GA-8854 (1968) evaluation from 0.01 - 10 Mev.

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

92-U-235	$\bar{\nu}$	Prompt	I	Thermal-15 Mev	3%	IKT(TUH) (FRG)	Stegemann	70

Comments: Average number of prompt neutrons per neutron induced fission required.

Status: Davey, Nucl. Sci. and Engin., 44, 345 (1971) evaluation up to 15 Mev.
Manero et al., INDC(NDS)-34/G (1972) and to be published in Atomic Energy Review (1972) evaluation up to 15 Mev.
Mather et al, AWRE-O-55/71 (1971) evaluation up to 15 Mev.
Boroughs et al., GA-8854 (1968) evaluation up to 15 Mev.
Colvin, 1969 IAEA Symposium on Physics and Chemistry of Fission, p. 930 (1969) evaluation up to 14 Mev.

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

92-U-235	Delayed-N-Y	$P(E_n,)$	I	Thermal-15 Mev	5 %	IKT(TUH) (FRG)	Stegemann	70

Comments: Delayed neutron fraction, β_i, required.

Status: Amiel, 1969 IAEA Symposium on Physics and Chemistry of Fission, p. 569 (1969); review from thermal-15 Mev.
Krick et al., WASH-1155, 156(1970) preliminary results
Manero et al., INDC(NDS)-34/G (1972) and to be published in Atomic Energy Review (1972).

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Delayed-N-Y	$\bar{\nu}_D$	II	5 - 14 Mev	5 %	LASL (USA)	Weisbin and Walton	70

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

Status:

Masters et.al., American Nucl.Soc., 11, 179; measurements at 3 and 14 Mev.
Krick and Evans, Preliminary data (LASL), 0.1 - 6.7 Mev.

Justification: Calculations of moderating assemblies for U-235 assays.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Delayed-N	Precursor Half-Lives	III	Thermal	5 %	FEI (USSR)	Maksyutenko	71

Comments: The half-lives of Rb-92, Rb-93 and Rb-94, I-139 and Br-88 are anomalous. The half-lives of these delayed neutron precursors, resulting from thermal neutron fission, should be measured more accurately - to 5 %.

Status: S. Amiel, 1969 IAEA Symposium on Physics and Chemistry of Fission, Vienna, p. 569 (1969).

Justification: For interpretation of delayed-neutron data.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Delayed-N	Emission probabilities	III	Thermal	5 %	FEI (USSR)	Maksyutenko	71

Comments: The delayed neutron emission probabilities for Rb-92, Rb-93 and Rb-94 are in contradiction with data from nuclear systematics. More accurate (5 %) determinations are needed for these isotopes resulting from thermal neutron fission.

Status: S. Amiel, 1969 IAEA Symposium on Physics and Chemistry of Fission, Vienna, p. 569 (1969).
The emission probabilities quoted by different authors vary by factors of 1.5-2.0

Justification: For the interpretation of delayed neutron data.

Target	Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Delayed-γ-Y	$P(E_\gamma, T½)$	III	Thermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70

Comments: Delayed fission γ-ray spectra as a function of delay time required. Particularly interesting for intervals < 1 sec. Accuracy refers to γ-ray intensities. Errors of - 50 % to + 100 % for T ½ acceptable.

Status: No data.

Justification: For non-destructive assay of fissionable material by γ-spectroscopy of short lived fission products.

Target	Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Delayed-γ-Y	$P(E_\gamma, T½)$	I	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69

Comments: Accuracy requested refers to relative intensities of delayed γ-rays from neutron induced fission for E_γ>2 Mev and 10 μ sec $\lesssim$ T½ $\lesssim$ 1 hour. Absolute γ-ray yields to a factor of 2 also useful.

Status: R. Chrien, (BNL unpublished) has some data for U-235 and Pu-239. N.R. Large and R.J. Bullock, 1969 IAEA Symposium on Physics and Chemistry of Fission, Vienna, p.637 (1969); presented some data for U.

Justification: Assay of U-235 fuels.

Target	Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	(n, γ)	$P(E_\gamma)$	I	Thermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70

Comments: Capture γ-ray spectra required.

Status: Experimental determination of $P(E_\gamma)$ for high energy γ's (E_γ > 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.

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

Target	Reaction Type Quantity	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: Fission product yield per fission event of 55-Cs-133 resulting from thermal fission of U-235 required to within 1 % accuracy. Different values are quoted in the literature.

Status: O.A. Miller et.al., Soviet Atomic Energy, 27, 281 (1968)

Justification: For assay of U and Pu in spent fuel elements by the fission product γ-rays.

92-U-235	Fission Yield of 44-Ru-106		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Fission product yield per fision event of 44-Ru-106 resulting from thermal fission of U-235 required to within 1 % accuracy. Different values are quoted in the literature.

Status: S. Hiller, Kerntechnik, 12, No. 11, 485 (1970)
I.P. Grechushkina, "Tables showing the composition of prompt fission products from U-235, U-238 and Pu-239 fission", Moscow, Atomizdat (1964).

Justification: For assay of U and Pu in spent fuel elements by the fission product γ-rays.

92-U-235	Fission Yield of 40-Zr-95		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Fission product yield per fission event of 40-Zr-95 resulting from thermal fission of U-235 required to within 1 % accuracy. Different values are quoted in the literature.

Status: O.A.Miller et.al., Soviet Atomic Energy, 27,281 (1969)
R.S. Forsyth et.al., 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol. 1, p.521 (1970)
S.Hiller, Kerntechnik, 12, No.11, 485 (1970).

Justification: For assay of U and Pu in spent fuel elements by the fission product γ-rays.

92-U-235	Fission Yield of 55-Cs-137		I	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Fission product yield per fission event of 55-Cs-137 resulting from thermal fission of U-235 required to within 1 % accuracy. Different values are quoted in the literature.

Status: O.A.Miller et.al., Soviet Atomic Energy, 27, 281 (1969).
R.S. Forsyth et.al., 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol.1 p.521 (1970).
S.Hiller, Kerntechnik, 12, No. 11, 485 (1970).

Justification: For assay of U and Pu in spent fuel elements by the fission product γ-rays.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Fission Yield of 56-Ba-140		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Fission product yield per fission event of 56-Ba-140 resulting from thermal fission of U-235 required to within 1 % accuracy. Different values are quoted in the literature.

Status: N.G. Gusev, "Protection against γ-radiation from fission products", (Manual) Moscow, Atomizdat (1968).
V.A. Greshilov et.al., "Products of prompt fission of U-235, U-238 and Pu-239 from 0 to 1 hour", (Manual).Moscow, Atomizdat (1969). J. of Inorganic Nucl.Chem., 27, 121 (1965)

Justification: For assay of U and Pu in spent fuel elements by the fission product γ-rays.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Fission Yield of 58-Ce-144		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: 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.

Status: N.G. Gusev, "Protection against γ-radiation from fission products", (Manual) Moscow, Atomizdat (1968).
S. Hiller, Kerntechnik, 12, No. 11, 485 (1970).

Justification: For assay of U and Pu in spent fuel elements by the fission product -rays.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	(γ,n) Spectra		III	E_γ = 5-8 Mev	10 %	IAK(GfK) (FRG)	Fröhner	70

Comments: 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 work known.

Justification: Needed for the exploration of new techniques for non-destructive assay whose potential usefulness is unknown.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	(γ,n)		II	E_e = Threshold - 10 Mev ΔE_e = 1 %	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 (γ,n) yield or may be absolute.

Status: Gozani et.al., Trans.American Nucl.Soc., 13, 707 (1970) - Relative data.
Bowman et.al., Phys.Rev., 133, B676 (1964) - (γ,n) data above 7 Mev .

Justification: For non-destructive photonuclear assay of this SNM.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Delayed-N-Y	N(t)	II	E_e=Threshold -10 Mev ΔE_e = 1 %	10 %	GRT(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 (γ,n) yield or may be absolute.

Status: Gozani et.al., Trans. American Nucl.Soc., 13, 707 (1970)- Relative data.

Justification: For non-destructive photonuclear assay of U-235.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-235	Fission Product γ-Y(1 msec- 1 hour)	$P(E_\gamma,t)$	II	E_e = 10 Mev ΔE_e = 5 %	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 ΔE_γ = 3 Kev.

Status: Rundquist, Trans.American Nucl.Soc., 13, 746 (1970)-Preliminary data.

Justification: For non-destructive photonuclear assay of this SNM.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-236	Fission Neutron Spectrum		II	One energy above fission threshold	10 %	LASL (USA)	Weisbin and Walton	70

Status: none

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
92-U-236	Delayed-N-ν	$\bar{\nu}_D$	I	3 and 14 Mev	10 %	LASL (USA)	Weisbin and Walton	70

Status: No experimental work to date. Data have been obtained empirically.

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

92-U-236	(γ,n)		II	E_e=Threshold - 10 Mev ΔE_e = 1%	30 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 (γ,n) yield to may be absolute.

Status: No data.

Justification: Effect on non-destructive photonuclear assay of U-235.

92-U-236	Delayed-N-ν	N(t)	II	E_e=Threshold - 10 Mev ΔE_e = 1 %	30 %	GRT(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 (γ,n) yield or may be absolute.

Status: No data.

Justification: Effect on non-destructive photonuclear assay of U-235.

92-U-236	Fission Product γ-ν (1 msec-1 hour)	$P(E_\gamma, t)$	III	E_e = 10 Mev ΔE_e = 5 %	30 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 ΔE_γ = 3 Kev.

Status: No data.

Justification: Effect on non-destructive photonuclear assay of U-235.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc	Year
92-U-238	$\bar{\nu}$	Prompt	II	1-15 Mev	5 %	IKT(TUH) (FRG)	Stegemann	70

<u>Comments:</u> Average number of prompt neutrons per neutron induced fission required.

<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 up to 15 Mev; to be published in Atomic Energy Review (1972).
<u>Mather et al.</u>, AWRE-O-44/71 (1971) evaluation up to 15 Mev.

<u>Justification:</u> Standard for non-destructive assay of fuel elements.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc	Year
92-U-238	Delayed-N-Y	$P(E_n,)$	II	1-15 Mev	5 %	IKT(TUH) (FRG)	Stegemann	70

<u>Comments:</u> Delayed neutron fraction, β_i, required.

<u>Status:</u> <u>Maksyutenko et al.</u>, Soviet J. of Nucl. Physics, <u>7</u>, No. 2, 189 (1968) experiments up to 21 Mev.
<u>Krick et al.</u>, NCSAC-31, 156 (1970)

<u>Justification:</u> Standard for non-destructive assay of fuel elements.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc	Year
92-U-238	σ(n,f)		II	1 - 15 Mev	5%	IKT(TUH) (FRG)	Stegemann	70

<u>Comments:</u> Fission cross section required to within 5%.

<u>Status:</u> <u>Bak et al.,</u> INDC(NDS)-36/G (1971) and J. of the Korean Nuclear Society, <u>3</u>, 77(1971) evaluation up to 20 Mev.
<u>Silbert et al.</u>, BNL-50298, 112(1971).
<u>Sowerby et al.</u>, AERE-M-2497 (1972), simultaneous evaluation up to 20 Mev.

<u>Justification:</u> Standard for non-destructive assay of fuel elements.

Req.No.	Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
417	92-U-238	Delayed -γ- γ	P(E_γ, $T_{1/2}$)	II	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	[illegible]

__Comments:__ Accuracy requested refers to relative intensities of delayed γ-rays from neutron induced fission for $E_\gamma > 2$ Mev and 10 μsec $\lesssim T_{1/2} \lesssim$ 1 hour Absolute γ-ray yields to a factor of 2 also useful.

__Status:__ __R. Chrien,__ (BNL Unpublished) has some data for U-235 and Pu-239. __N.R. Large and R.J. Bullock,__ 1969 IAEA Symposium on Physics and Chemistry of Fission, Vienna, p.637 (1969); presented some data for U.

__Justification:__ Assay of U fuels.

Req.No.	Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
	92-U-238	(γ,n)Spectra		III	E_γ= 3-8 Mev	10 %	IAK(GfK) (FRG)	Fröhner	70

__Comments:__ 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 work known.

__Justification:__ Needed for the exploration of new techniques for non-destructive assay whose potential usefulness is unknown.

Req.No.	Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
	92-U-238	($x\gamma$,n)		II	E_e=Threshold-10 Mev ΔE_e = 1%	10 %	GRT(OSMM) (USA)	Bramblett	70

__Comments:__ 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 ($x\gamma$,n) yield or may be absolute.

__Status:__ __Gozani et.al.,__ Trans. American Nucl.Soc., __13__, 707 (1970) - Relative data. __Katz et. al.,__ Canadian J. of Physics, __35__, 470 (1957).

__Justification:__ For non-destructive photonuclear assay of U.

Target	Reaction Type Quantity	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 ΔE_e= 1 %	10 %	GRT(OSMM) (USA)	Bramblett	70

<u>Comments:</u> 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 (γ,n) yield or may be absolute.

<u>Status:</u> <u>Gozani et.al.,</u> Trans. American Nucl.Soc., <u>13</u>,707 (1970) - Relative data.

<u>Justification:</u> For non-destructive photonuclear assay of U.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
92-U-238	Fission Product γ-γ (1msec-1 hour)	P(E_γ,t)	II	E_e= 10 Mev ΔE_e= 5 %	10 %	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 ΔE_γ= 3 Kev.

<u>Status:</u> <u>Rundquist,</u> Trans. American Nucl. Soc., <u>13</u>, 746 (1970)- Preliminary data.

<u>Justification:</u> For non-destructive photonuclear assay of U.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
92-U-238	Delayed-N-Y	$\bar{\nu}_D$	II	5-14 Mev	5 %	LASL (USA)	Weisbin and Walton	70

<u>Comments:</u> Delayed neutron yield required. Data desired for extrapolation to 15 Mev.

<u>Status:</u>

<u>Masters et.al.,</u> American Nucl. Soc., <u>11</u>, 179; measurements at 3 and 14 Mev.
<u>Krick and Evans,</u> Preliminary data (LASL), 0.1 - 6.7 Mev.

<u>Justification:</u> Calculations of moderating assemblies for background effects on assays of U-235.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
92-U-238	(n,γ)	P(E_γ)	II	Thermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70

<u>Comments:</u> Capture γ-ray spectra required.

<u>Status:</u> No useful data for thermal or 2 keV incident neutrons known.

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
93-Np-237	$\sigma(n,\gamma)$		II	0.001 eV-1 Kev	3-10 %	IAR(GfK) (FRG)	Fischer	70

Comments: Accuracy of 3 % from thermal - 10 eV needed. Accuracy of 5 % Γ_n and accuracy 10 % Γ_γ from thermal - 1 Kev.

Status: Paya, (Saclay) has $\sigma(n,f)$, $\sigma(n,total)$ 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 from 100 Kev - 2.8 Mev.
Hoffman, WASH-1136 preliminary data from 25 eV - 100 Kev.

Justification: For burn-up calculations.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
93-Np-237	$\sigma(n,f)$		II	1 Kev - 5 Mev	10 %	IAR (GfK) (FRG)	Fischer	70

Comments: Fission cross section required.

Status: Paya, (Saclay) has $\sigma(n,f)$, $\sigma(n,total)$ 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 from 100 Kev - 2.8 Mev.

Justification: For burn-up calculations.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
93-Np-237	$\sigma(n,\gamma)$		II	1 Kev-5 Mev	10 %	IAR(GfK) (FRG)	Fischer	70

Comments: Capture cross section required to within 10 %.

Status: Nagle et al., Third Conf. on Neutron Cross Sections and Technology, Knoxville (U.S.A.), 259 (1971)
Smith et al., IN-1182 (1969) evaluation up to 15 Mev.

Justification: For burn-up calculations.

Target	Reaction Type Quantity Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year.
94-Pu-238	σ(n,f)	II	1 - 10 Mev	10 %	IAR(GfK) (FRG)	Fischer	70

Comments: Fission cross section required.

Status: Silbert, LA-4108 (1969) and LA-4674 (1971) - Data up to 3 Mev.
Drake, LA-4420 (1970) - Data up to 2.6 Mev.

Justification: For burn-up calculations.

Target	Reaction Type Quantity Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year.
94-Pu-238.	σ(n,γ)	II	Thermal-10 Mev	10 %	IAR (GfK) (FRG)	Fischer	70

Comments: Capture cross section required.

Status: Silbert et.al., NCSAC-31 (1970). Preliminary data from 10 - 100 Kev.
Young, Nuclear Sci. and Engin., 30, 365; resonance parameters to 190 eV.
Silbert et.al., WASH-1124 (1968); 30 eV - 1 Mev preliminary.
Dunford et.al., NAA-SR-12271 (1967); evaluation from thermal to 10 Mev.
Hinkelmann, KFK-1186 (1970); evaluation from thermal-10 Mev

Justification: For burn-up calculations.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments,etc	Year
94-Pu-238	(n,γ)	P(E γ)	II	Thermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70

Comments: Capture γ-ray spectra required.

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

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments,etc	Year
94-Pu-238	Fission Yield *and* σ(γ, f)		II	Eγ = Threshold - 10Mev	10%	GEOHI (USSR)	Markov	71

Comments: The energy dependence (as a function of incident γ energy) of the fission fragment yield (and fission cross section) resulting from γ -induced fission is required to within 10 %.

Status: Data unknown.

Justification: For photonuclear assay of Pu.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments,etc	Year
94-Pu-238	(γ,n)		II	E = Threshold-10 Mev	10%	GEOHI (USSR)	Markov	71

Comments: The energy dependence (as a function of incident γ- energy) of the neutron yield resulting from γ irradiation is required to within 10 %.

Status: Data unknown.

Justification: For photonuclear assay of Pu.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments,etc	Year
94-Pu-239	Delayed-N-Y	$\bar{\nu}_D$	II	3 - 14 Mev	10 %	LASL (USA)	Weisbin and Walton	70

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

Status: Masters et.al., American Nucl.Soc., 11, 179; measurements at 3 and 14 Mev.
Maksyntenko, ICD-1,266; measurement at 3.8 and 15 Mev.
Petrzak, Atomic Energy, 11, 539.
Krick and Evans, Preliminary data (LASL), 0.1 - 6.7 Mev.

Justification: Calculations of moderating assemblies for Pu-239 assays.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments,etc	Year
94-Pu-239	(n, γ) Spectra and Yields	P(E γ) E γ > 1.2 Mev	III	Thermal-100 eV	See Comments	LASL (USA)	Weisbin and Walton	70

Comments: Capture γ-ray spectra and yields of γ-rays per capture required to ≈ 20 % accuracy, for γ-rays of energy > 1.2 Mev. Ge(Li) resolution at 1.2 Mev should be 2.5 Kev.

Status: Jurney, LASL (1970) Progress report-see also BNL-50276,152 (1970). Recent data for thermal neutrons; γ-ray spectra from 3 - 6 Mev.

Justification: Development of new Pu- assay technique.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments,etc	Year
94-Pu-239	(n, γ)	P(E γ)	II	Thermal; 2 Kev	25 %	IAK (GfK)	Weitkamp	70

Comments: Capture γ-ray spectra required.

Status: Experimental determination of P(Eγ) for high energy γ's (Eγ>2 Mev) resulting from thermal and 2 Kev (scandium filtered beam) 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.Also preliminary data of Jurney,BNL-50276, 152 (1970).

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments,etc	Year
94-Pu-239	Fission Product γ-ray spectra and yields	P(E γ)	II	Thermal	± 15 % Absolute Yield	LASL (USA)	Weisbin and Walton	70

Comments: Fission product γ-ray spectra for γ-ray energies, Eγ = 0.25-5 Mev, and yields (photons/fission-Mev-sec) from 1msec - 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.

Status: Walton and Sund, Phys. Rev., 178, 1894 (1969)
Fisher and Engle, Phys. Rev., 134, B796 (1964)
F.C. Maienschein, 1958 Geneva Conference on Peaceful Uses of Atomic Energy, Vol. 15, 366 (1958).
Better resolution desired. Associate γ-rays with fission products if possible.

Justification: Non-destructive assay of Pu-239.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
94-Pu-239	Delayed -γ- γ	$P(E_\gamma, T_{1/2})$	I	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69

<u>Comments:</u> Accuracy requested refers to relative intensities of delayed γ -rays from neutron induced fission for $E_\gamma > 2$ Mev and $10\,\mu\text{sec} < T_{1/2} < 1$ hour. Absolute γ -ray yields to a factor of 2 also useful.

<u>Status:</u> <u>R. Chrien,</u> (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.

<u>Justification:</u> Assay of Pu- fuels.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
94-Pu-239	Fission Yield of 55-Cs-137		I	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	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> <u>O.A. Miller et.al.,</u> Soviet Atomic Energy, <u>27</u>, 281 (1969).
<u>R.S. Forsyth et.al.,</u> 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol. 1, p.521 (1970)
<u>S.Hiller,</u> Kerntechnik, <u>12</u>, No. 11, 485 (1970)

<u>Justification:</u> For assay of U and Pu in spent fuel elements by the fission product γ-rays.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc	Year
94-Pu-239	Fission Yield of 55-Cs-133		I	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

<u>Comments:</u> Fission product yield per fission event of 55-Cs-133 resulting from thermal fission of Pu-239 required to within 1% accuracy. Different values are quoted in the literature.

<u>Status:</u> <u>O.A. Miller et.al.,</u> Soviet Atomic Energy, <u>27</u>, 281 (1969).

<u>Justification:</u> For assay of U and Pu in spent fuel elements by the fission product γ-rays.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-239	Fission Yield of 44-Ru-106		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: 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, Kerntechnik, 12, No. 11 , 485 (1970)
I.P. Grechushkina, "Tables showing the composition of prompt fission products from U-235, U-238 and Pu-239 fission", Moscow, Atomizdat (1964).

Justification: For assay of U and Pu in spent fuel elements by the fission product γ-rays.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-239	Fission Yield of 40-Zr-95		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Fission product yield per fission event of 40-Zr-95 resulting from thermal fission of Pu-239 required to within 1% accuracy. Different values are quoted in the literature.

Status: O.A.Miller et.al., Soviet Atomic Energy, 27, 281 (1969).
R.S. Forsyth et.al., 1970 IAEA Symposium on Safeguards Techniques, Karlsruhe, Vol. 1, p. 521 (1970).
S. Hiller, Kerntechnik, 12, No. 11, 485 (1970).

Justification: For assay of U and Pu in spent fuel elements by the fission product γ-rays.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-239	Fission Yield of 56-Ba-140		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Fission product yield per fission event of 56-Ba-140 resulting from thermal fission of Pu-239 required to within 1 % accuracy. Different values are quoted in the literature.

Status: N.G. Gusev, "Protection against γ-radiation from fission products," (Manual) Moscow, Atomizdat (1968).
V.A. Greshilov et.al., "Products of prompt fission of U-235, U-238 and Pu-239 from 0 to 1 hour", (Manual), Moscow, Atomizdat (1969).
J. of Inorganic Nucl.Chem., 27, 121 (1965)

Justification: For assay of U and Pu in spent fuel elements by the fission product γ-rays.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc	Year
94-Pu-239	Fission Yield of 58-Ce-144		II	Thermal	1 %	IAE (USSR)	Skvortsov and Miller	70

Comments: Fission product yield per fission event of 58-Ca-144 resulting from thermal fission of Pu-239 required to within 1 % accuracy. Different values are quoted in the literature.

Status: N.G. Gusev, "Protection against γ-radiation from fission products", (Manual) Moscow, Atomizdat (1968).
S. Hiller, Kerntechnik, 12, No. 11, 485 (1970)

Justification: For assay of U and Pu in spent fuel elements by the fission product γ-rays.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc	Year
94-Pu-239	(γ,n) Spectra		III	E_γ = 5-8 Mev	10 %	IAK(GfK) (FRG)	Fröhner	71

Comments: 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 work known.

Justification: Needed for the exploration of new techniques for non-destructive assay whose potential usefulness is unknown.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc	Year
94-Pu-239	(xγ,n)		II	E_e=Threshold-10 Mev ΔE_e = 1 %	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 (xγ,n) yield or may be absolute.

Status: Gozani et.al., Trans. American Nucl. Soc., 13. 707 (1970) - Relative data.

Justification: For non-destructive photonuclear assay of Pu-239.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-239	Delayed-N-Y	N(t)	II	E_e = Threshold - 10 Mev ΔE_e = 1 %	10 %	GRT(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 $(x\gamma,n)$ yield or may be absolute.

Status: Gozani et.al., Trans. American Nucl. Soc., 13, 707 (1970) - Relative data.

Justification: For non-destructive photonuclear assay of Pu-239.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-239	Fission Product γ-Y(1msec-1 hour)	$P(E_\gamma,t)$	II	E_e = 10 Mev ΔE_e = 5 %	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 ΔE_γ = 3 Kev.

Status: Rundquist, Trans. American Nucl. Soc., 13, 746 (1970) - Preliminary data.

Justification: For non-destructive photonuclear assay of Pu-239.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-239	Delayed-γ Y	P(E ,T½)	III	Thermal;2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70

Comments: Delayed fission γ-ray spectra as a function of delay time required. Particularly interesting for intervals < 1 sec. Accuracy refers to γ-ray intensities. Errors of -50 % to + 100 % for T½ acceptable.

Status: No data.

Justification: For non-destructive assay of fissionable material by γ-spectroscopy of short lived fission products.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-240	Delayed-N-Y	$\bar{\nu}_D$	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: Hunter, 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 fuel.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-240	Decay Heat		II	________	0.2 %	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, γ-rays) would be useful.

Status: Uncertainty determined by half-life - most recent measurement by Dokuchaev, Atomnaya Energ., 6, 74 (1959) - $T_{1/2}$ = 6620 $\pm$ 50 years. This yields, with Q_α = 5255.3 $\pm$ 0.7 keV, the decay heat of 7.008 $\pm$ 0.76 % milliWatts/ gramme.

Justification: For calorimetric Pu determination.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-240	Delayed-γ-Y	$P(E_\gamma, T_{1/2})$	II	2 and 14 Mev	35 %	BNL(OSMM) (USA)	Kouts	69

Comments: Accuracy requested refers to relative intensities of delayed γ-rays from neutron induced fission for $E_\gamma > 2$ Mev and 10 μsec $\lesssim T_{1/2} \lesssim$ 1 hour. Absolute γ-ray yields to a factor of 2 also useful.

Status: R. Chrien, (BNL Unpublished) has some data for U-235 and Pu-239. N.R. Large and R.J. Bullock, 1969 IAEA Symposium on Physics and Chemistry of Fission, Vienna, p. 637 (1969); presented some data for U.

Justification: Assay of Pu fuels.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-240	($x\gamma$,n)		II	E_e=Threshold-10 Mev ΔE_e = 1 %	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 ($x\gamma$,n) yield or may be absolute.

Status: No data.

Justification: Effect on non-destructive photonuclear assay of Pu-239.

Target	Reaction Type Quantity	Reaction Type Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-240	Delayed-N-Y for $t < 100$ sec	N(t)	II	E_e =Threshold- 10 Mev ΔE_e = 1 %	10 %	GRT(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 ($x\gamma$,n) yield or may be absolute.

Status: No data

Justification: Effect on non-destructive photonuclear assay of Pu-239.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-240	Fission Product γ-γ (1msec- 1 hour)	$P(E_\gamma, T)$	II	E_e = 10 Mev ΔE_e = 5 %	10 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 ΔE_γ = 3 Kev.

Status: No data.

Justification: Effect on non-destructive photonuclear assay of Pu-239.

94-Pu-240	(n, γ)	$P(E_\gamma)$	II	Thermal; 2 Kev	25 %	IAK (GfK) (FRG)	Weitkamp	70

Comments: Capture γ -ray spectra required.

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

Justifcation: For non-destructive assay of nuclear material by neutron capture γ-ray spectrometry.

94-Pu-241	Delayed-N-Y	$\bar{\nu}_D$	III	Thermal - 14 Mev	10 %	LASL (USA)	Weisbin and Walton	70

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

Status: Only work at thermal energy. See Keepin Nucleonics, 20, 8, 150 (1962).

Justification: Calculations of moderating assemblies for Pu assays.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	%Accuracy	Lab/Org.	Requestor,Comments,etc	Year
94-Pu-241	$\sigma(n,\gamma)$		II	Thermal - 30 Kev	3 %	IAR(GfK) (FRG)	Fischer	70

<u>Comments:</u> Capture cross section or alpha (α) required. Accuracy to 3 % in eta (η).

<u>Status:</u> <u>Yiftah</u>, IA-1152 (1967); evaluation 0.1 eV - 15 Mev. This evaluation being revised.
<u>Smith</u>, WASH-1136, 70 (1969): evaluating for ENDF/B library.

<u>Justification:</u> For burn-up calculations.

94-Pu-241	Alpha	$\frac{\sigma(n,\gamma)}{\sigma(n,f)}$	II	1 Kev - 2 Mev	20 %	IAR(GfK) (FRG)	Fischer	70

<u>Comments:</u> Alpha ($\sigma(n,\gamma)/\sigma(n,f)$) needed but capture cross section would be equally useful.

<u>Status:</u> <u>Davey</u>, 1970 IAEA Conference on Nuclear Data for Reactors, Helsinki, Vol. 2, p. 119 (1970); review paper 100 Kev - 10 Mev.

<u>Justification:</u> 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/gramme required. Percentage of heat carried-off by long-range particles (X-rays, γ-rays) would be useful).

<u>Status:</u> 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 $\pm$ 5.0 % milliwatts/gramme.

<u>Justification:</u> For calorimetric Pu determination.

94-Pu-241	Fission Yield and $\sigma(\gamma,f)$		II	E_γ= Threshold-10 Mev	10 %	GEOHI (USSR)	Markov	71

<u>Comments:</u> The energy dependence (as a function of incident γ energy) of the fission fragment yield (and fission cross section) resulting from γ-induced fission is required to within 10 %.

<u>Status:</u> Data unknown.

<u>Justification:</u> For photonuclear assay of Pu.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
94-Pu-241	(γ,n)		II	E_γ= Threshold-10 Mev	10 %	GEOHI (USSR)	Markov	71

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

Status: Data unknown.

Justification: For photonuclear assay of Pu.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
94-Pu-241	Fission Yield of Ce, Cs, Zr and Ru, isotopes		III	Thermal	5 %	IAE (USSR)	Skvortsov and Miller	70

Comments: The fission fragment yield of Ce, Cs, Zr and Ru fission products for fission by thermal neutrons is required to within 5 %.

Status: Data unknown.

Justification: For assay of U and Pu in fuel elements by means of the fission product γ-radiation.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
94-Pu-241	Delayed -γ- γ	$P(E_\gamma, T_{1/2})$	III	Thermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	71

Comments: Delayed fission γ-ray spectra as a function of delay time required. Particularly interesting for intervals < 1 sec. Accuracy refers to γ-ray intensities. Errors of - 50 % + 100 % for $T_{1/2}$ acceptable.

Status: No data.

Justification: For non-destructive assay of fissionable material by γ-spectroscopy of short-lived fission products.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor,Comments,etc.	Year
94-Pu-241	$(\gamma\gamma,n)$		III	E_e= Threshold-10 Mev ΔE_e = 1 %	30 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 4 π 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 $(\gamma\gamma,n)$ yield or may be absolute.

Status: No data.

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-241	Delayed-N-Y	N(t)	III	E_e = Threshold - 10 Mev ΔE_e = 1 %	30 %	GRT(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 (γ,n) yield or may be absolute.

Status: No data.

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-241	Fission Product γ-γ(1msec-1 hour)	$P(E_\gamma, t)$	III	E_e = 10 Mev ΔE_e = 5 %	30 %	GRT(OSMM) (USA)	Bramblett	70

Comments: 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 ΔE_γ = 3 Kev.

Status: No data.

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

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-241	σ(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.

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 σ(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.

Justification: For burn-up calculations.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-241	(n,γ)	$P(E_\gamma)$	II	Thermal; 2 Kev	25%	IAK(GfK) (FRG)	Weitkamp	70

__Comments:__ Capture γ-ray spectra required.

__Status:__ Experimental determination of $P(E_\gamma)$ for high energy γ's ($E_\gamma > 2$ 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.

__Justification:__ For non-destructive assay of nuclear material by neutron capture γ-ray spectrometry.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-242	(n,γ)	$P(E_\gamma)$	III	Thermal; 2 Kev	25 %	IAK(GfK) (FRG)	Weitkamp	70

__Comments:__ Capture γ-ray spectra required.

__Status:__ No useful data for thermal and 2 Kev neutrons.

__Justification:__ For non-destructive assay of nuclear material by neutron capture γ-ray spectrometry.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
94-Pu-242	Delayed-N-ν	$\bar{\nu}_D$	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.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
95-Am-241	$\sigma(n,f)$		II	20 Kev - 10 Mev	10 %	IAR(GfK) (FRG)	Fischer	70

__Comments:__ Fission cross section required to 10 % accuracy.

__Status:__ __Seeger et.al.__, Nucl.Phys., __A96__, p. 605; 20 eV to 1 Mev data.
__Hinkelmann__, KFK-1186 (1970); evaluation to 10 Mev.
__Spivak et.al.__, INDC(CCP) - 8/U, p.6 (1970); from 8 Kev to 3.3 Mev.
__Fomushkin__, INDC (CCP) - 7/U, p. 28 (1970); from 440 Kev to 3.6 Mev.

__Justification:__ For burn-up calculations.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
95-Am-241	$\sigma(n,\gamma)$		II	Thermal - 10 Mev	see Comments	IAR(GfK) (FRG)	Fischer	70

Comments: Capture cross section required to accuracy of 10 % from thermal to 1 Kev; accuracy of 50 % from $\approx$ 100 eV to 300 Kev and accuracy of 20 - 30 % from $\approx$ 100 Kev to 10 Mev.

Status: Dovbenko et.al., INDC(CCP) - 9/U, p.7 (1970); Thermal value.
Hinkelmann, KFK-1186 (1970); evaluation.
Jungclaussen, Izv. Akad. Nauk SSSR, 33, 695 (1969)
Flerov et.al., Nucl. Phys., A102, 443 (1967).

Justification: For burn-up calculations.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
95-Am-241	Fission Yield and $\sigma(\gamma,f)$		II	E_γ = Threshold-10 Mev	10 %	GEOHI (USSR)	Markov	71

Comments: The energy dependence (as a function of incident γ energy) of the fission fragment yield (and fission cross section) resulting from γ-induced fission is required to within 10 %.

Status: 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, 11, 54 (1970)

Justification: For photonuclear assay of Pu.

Target	Reaction Type Quantity	Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, etc.	Year
95-Am-241	(γ,n)		II	E_γ = Threshold-10 Mev	10 %	GEOHI (USSR)	Markov	71

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

Status: Data unknown.

Justification: For photonuclear assay of Pu.