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W.W. HAVENS Jr.

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REPORT OF THE NCSAC AD-HOC

Subcommittee on Safeguards

Subcommittee Membership

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- Dr. Richard L. Bramblett Gulf Radiation Technology
- Dr. Harold Jackson Argonne National Laboratory
- Dr. B. Leonard Battelle Northwest
- Dr. Eugene V. Weinstock Brookhaven National Laboratory
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I. INTRODUCTION

The safeguarding of nuclear materials in the domestic power programs from illicit use--the production of nuclear explosives, is presently a substantial activity of the AEC and the nuclear industry. As the use of nuclear power grows (by 12 times from 1970 to 1975 and by another 2.4 times from 1975 to 1980) the amount of material to be safeguarded will also grow in proportion. The national need for effective Safeguards is apparent.

There are many problems encountered in the implementation of Safeguards adequate to eliminate the possibility of clandestine production of nuclear explosives. These problems include: complexity of the national reactor fuel system, variable and sometimes long hold up-times in parts of the system, the uncertainty in production and conversion of nuclear materials within the system, inaccessibility of large quantities of fuel in reactors or cooling ponds for verification purposes, and, underlying all these, the uncertainty or high cost of measurements of the amounts of nuclear materials in each part of the nuclear fuel cycle.

In many cases, there do not exist measurement techniques adequate for the problem. In other cases, such as bulk trash containing nuclear materials, new techniques are just now being proven in field tests. The bulk of nuclear materials assay has been, and probably will always be wet chemical techniques. However, the amount of material in the fuel cycle unmeasurable by such techniques is large, roughly a 3% fabrication loss to waste alone.

Despite the existence of possible nondestructive assay techniques for nuclear materials such as measurement of the gamma rays or neutrons emitted spontaneously or neutron activation techniques, they have not been extensively applied for a number of reasons, including economic disincentives, uncertainty of the assay results, uncertain reliability of available instrumentation, and a lack of techniques that have a broad range of application. Refinement of long existing techniques such as those measuring passive radiations is called for, but enough information on those techniques exists to know that many nuclear materials measurement problems cannot be solved with sufficient accuracy by them. Newer techniques, such as bremsstrahlung or neutron iterrogation, can cover a broader range of problems with higher accuracy, and warrant more intensive development.

The need for nuclear data in the Safeguards R&D programs spans a broad range and has a highly variable priority. Useful data would include high-resolution gamma ray spectra, half-lives for β decay and spontaneous fission, $\bar{\nu}$, delayed neutron yields and spectra, neutron- and photo-fission cross sections.

The Office of Safeguards and Materials Management (OSMM) of the AEC has asked the NCSAC to use its auspices to promote measurements of nuclear data relevant to the Safeguards Program. Mr. W. Bartels from OSMM and Dr. R. L. Bramblett from GKT presented a review of nuclear data needed for the

Safeguards Program at the December 1970 meeting of the NCSAC in Livermore, Ca. (The NCSAC had already received requests for nuclear data informally through its various laboratory representatives.) It was established at the meeting that, in the future, the OSMM will forward a list of requests, after internal deliberations, to the NCSAC for inclusion in a request compilation.

In order to review the existing requests, a nuclear safeguards committee was established with Charles D. Bowman as chairman. In addition the committee was to review the requests submitted to the IAEA by individual requesters in this country.

The membership of the committee consisted of:

R. L. Bramblett	Gulf Radiation Technology
H. E. Jackson	Argonne National Laboratory
B. R. Leonard, Jr.	Battelle Northwest
E. V. Weinstock	Brookhaven National Laboratory
C. R. Weisbin	Los Alamos Scientific Laboratory

The first meeting of the committee with all members present was hosted by R. L. Bramblett at La Jolla on February 18 and 19, 1971. In addition, Mr. L. R. Norderhaug of the OSMM of the AEC attended and Dr. M. P. Fricke of GRT served as recording secretary to the group.

II REVIEW OF THE REQUEST LIST

A major portion of the meeting was devoted to a review of the requests for data needed by the Safeguards program. The requests included all of those data requests submitted to the IAEA by U.S. organizations and any other requests which the NCSAC has reviewed.

The committee began its work in this area with a review of the criteria which were adopted by the IAEA for this purpose. After some discussion the committee modified these criteria slightly to the form given as follows:

Priority I

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

(1) are essential for the development of a new and promising technique for the nondestructive assay and control of Special Nuclear Material in amounts that are significant to the Safeguards System.

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(2) are necessary for the refinement of an existing technique in order to bring its accuracy to within acceptable limits for Safeguards purposes.

Priority II

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.

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) 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.

Even in their slightly modified form the committee found these criteria difficult to work with, particularly with regard to experiments which might form the basis for new techniques. Nevertheless for lack of time, the commit-. tee chose to work with these criteria. We feel that there was sufficient balance in the committee that no gross errors were made in our consideration of priority. Of the 50 requests in the list, which is attached as Appendix A-1, only 8 were given priority I status.

As a result of its experience, the committee has decided that in the future a new list of criteria, which are presented in Appendix A-2, would be easier to work with. We urge the OSMM to adopt these criteria for the use of review committees and of those requesting measurements.

The committee soon found that the WASH-1144 format was somewhat cumbersome and difficult to use for two reasons. First, the committee felt that many measurements requested were new or unusual enough as to be quite confusing unless considerable information was provided in the comment column Second, many measurer would be unfamiliar with many of the intended applications since Safeguards is still a relatively new field to many experimentalists. A section was therefore added for each request in terms if the intended use for the information; in the request list this becomes "justification."

The additional information required made the WASH-1144 format somewhat inconvenient, since only one request could be made per page in many cases. The IAEA format, which is more suitable for the purpose of the Safeguards' requests, was therefore adopted for this request list. Many of the requests reviewed by the committee were incomplete at the time of our meeting. Nearly every requester has supplied additional information requested by the committee which was not available for the meeting. The committee found that it could not make reasonable judgments on the requests of Dr. Larry Kull of Science Applications Incorporated owing to the lack of information. After a written request for more information was not answered, the committee concluded that those requests should be omitted from the request list.

III GENERAL DISCUSSION OF REQUESTS

In general the requests appear to be reasonable in the sense that techniques either already exist or could almost certainly be developed to obtain the needed data. No new facilities, such as reactors or accelerators are required to carry out these measurements. The requests are related to either of two means of interrogation; (1) bremsstrahlung-induced reactions under consideration at GRT and (2) neutron-induced reactions under consideration at LASL and BNL.

For the photonuclear interrogation the γ -ray transport is well known and no experiments are required; however, the reactions that these γ -rays or bremsstrahlung induce are less well known than the neutron reactions. The requests on bremsstrahlung-induced data can be divided into three classes: prompt-neutron yield, prompt-fission neutrons, and delayed neutrons and γ -rays from fission. Measurements are requested using a tantalum electron-to-bremsstrahlung converter and are made relative to deuterium which is to be used as a standard. The prompt-neutron-yield measurements are needed mainly for determining background for the other experiments. The prompt-fission neutrons allow assay of fissile material when its composition is identified. The delayed neutrons and γ -rays not only permit assav but often will permit discrimination between different fissile materials.

For the neutron interrogation, neutrons are derived primarily from (d,d) or (d,t) generators and often moderated in varying degree depending on the reaction which is of primary interest. The data of interest for neutron interrogation techniques concern both the slowing down process in the sample and the interaction cross section used as the "signature". The neutron reactions of interest consist mainly of delayed neutron and γ -rays from fissile materials. Committee-member Weisbin strongly expressed the feeling that for neutron transport studies in safeguards, evaluations are more urgently needed than any single new piece of data. However the "signature" cross sections need more work. This technique promises to assay known materials with high accuracy and also to identify different materials on the basis of intensities of delayed neutrons and γ -rays.

IV ROLE OF EVALUATION AND DATA COMPILATION

The committee considered the questions regarding the role of evaluation and data compilation in the Safeguards program and the degree of concern which the NCSAC should show in these matters. Evaluations appear to be particularly important for the cross sections required for transport of neutrons used for interrogation and also, to some degree, delayed neutrons. However, since the NCSAC has not concerned itself in the past with evaluations to any significant extent, it seems appropriate for the OSMM to take requests for evaluation, which it cannot handle "in-house," directly to the National Neutron Cross Section Center (NNCSC). The most useful evaluations are almost certainly to be obtained by direct OSMM funding where those aspects of the cross sections of greatest sensitivity to the OSMM are emphasized.

The NNCSC also handles compilation and evaluation of microscopic isotopic neutron data. However, since the evaluations are funded primarily by DRDT, the emphasis of the evaluation of data might not be the most appropriate for safeguards purposes.

For photonuclear data, no active data evaluation or compilation group exists anywhere in this country. With the increasing interest in application of photonuclear reactions for example in isotope production, activation analysis, defense, and Safeguards, it seems appropriate that the subcommittee urge the NCSAC to use its auspices to promote the evaluation and compilation of photonuclear data.

V PROMOTION OF MEASUREMENTS

Each committee member submitted comments on actions which the committee could take or recommend which would promote the measurements required for Safeguards. The committee recommended that the Safeguards requests be included with WASH 1144. The neutron-induced reactions should be included along with the rest of the neutron reaction requests. However, the photonuclear requests should be included as a separate section of the report. Also the committee felt that the Safeguards program would benefit if photonuclear requests from other agencies besides OSMM were also included since greater attention might then be focussed on the photonuclear measurements as a group.

The committee also proposed that the Safeguards requests be published as a group by OSMM or AEC. These requests, with some portions of this report, should be sent to the Safeguards Data Requesters, to the NCSAC request list distribution AEC supporting agencies, and the AEC Safeguards Advisory Committee.

The distribution should also be sent to all institutions with facilities suitable for measuring the requested data. The committee listed the following facilities; electron LINACs, microtrons, betatrons, van de Graaffs, reactors, 14-MeV-neutron generators, cyclotrons and ²⁵²Cf sources. The committee was particularly anxious that the nuclear engineering and applied science departments, with suitable facilities, should have these needs for nuclear data brought to their attention.

The degree of effort required for these measurements is significant in the sense that one can use this as the basis of determining when the requests will be satisfied. If we assume that the requests represent only 1/2 the challenge as the average request for neutron cross sections on heavy elements, which were considered by the NCSAC subcommittee on fission, one estimates about 1 man-year of scientific effort per request. For the 50 requests included in this report, approximately 50 man years of effort are estimated to satisfy these requests. At a total cost of about \$40,060 per man year, this works out to a funding level from some source of about two million dollars. It therefore appears that twelve scientists working for 4 years and funded at a level of \$500,000 per year could satisfy these requests. This figure can be compared with the OSMM funding for FY 1971 of \$835,000 for development of active interrogation techniques.

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Committee-member Weisbin of Los Alamos expressed a <u>minority</u> view that new data might not be needed for the Safeguards program. The second paragraph of a letter received on this subject follows:

"At the present time there are, in my opinion, at least three factors to be considered before actively embarking upon a measurement program for nuclear safeguards. Foremost among these is the reliance upon standards during the actual assay. For the cases of well defined samples (feed, product material etc.) such a procedure, to first order, effectively eliminates the need for detailed knowledge of cross section behavior. The second point relates to the case for which reliance upon standards might be readily challenged, i.e., the assay of scrap and waste. Here, however, refinement of cross section information usually appears as a second order correction because the materials contained in the sample are frequently unknown. Finally, to my knowledge, there have not been any calculations to indicate the sensitivity of a particular assay result to specific cross section features. The cross section requests reviewed by our committee, including LASL's, were based primarily upon intuition of what probably is important. The limited sensitivity investigations begun at our laboratory indicate that certain specific knowledge relating to the sample is important, e.g., the presence of hydrogen; on the other hand, we have not yet found limitations arising from a lack of fundamental data. I believe that the above three factors played an important part in what seemed to me a general downgrading of priorities for the requests reviewed, i.e., very few priority 1 requests."

The full text of his letter on this subject is included as Appendix A-3. He also pointed out that LASL has facilities and OSMM funds to carry out any measurements of data which it really needs.

In summary the subcommittee feels that the most effective way to promote these measurements is to circulate the request list with attached supporting material to as wide a distribution as possible. This should accomplish the purpose of alerting the nation's scientists to these needs and of ordering the priority.

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VI. HANDLING OF FUTURE SAFEGUARDS REQUESTS

The present collection of safeguards requests is a somewhat casual list by comparison to the Wash-1144 compilation and also as evidenced by the changes already made by the committee. A more systematic review by a group representing the requesting organization would give the list more impact and status. A suggested procedure for such requests which is analogous to that used by DRDT would include review by a committee in OSMM which would consider the list from the point of view of the requestors. A subcommittee in the NCSAC would then be charged with determining the status and capability for making the measurement. Presumably the ad hoc NCSAC subcommittee would be replaced by a standing subcommittee on safeguards requests.

The following recommendation was actually made at the last NCSAC committee meeting. "Future safeguard requests should be considered within OSMM by an appropriate review group and priorities established. The resulting list will then be formally transmitted to NCSAC for review by a standing subcommittee." After such a review the requests would be included in the NCSAC cross section compilation and also returned to OSMM to receive whatever additional distribution the OSMM might want to provide.

The subcommittee feels that the justification for its existence is somewhat marginal if the OSMM provides the review outlined above. If the role of this ad hoc committee were expanded to include also the review and promotion of related measurements such as photonuclear cross sections or simply general nuclear data other than cross sections essential to applied programs, there probably would be adequate justification for it to continue to function.

VII. COMMENTS AND RECOMMENDATIONS

1) The committee feels that both neutron and photonuclear reactions will play a significant role both in the discovery and refinement of new techniques useful to the Safeguards Program. The committee urges the NCSAC to use its auspices to promote measurements in both these areas.

2) Neutron cross sections evaluations should play a significant role in the Safeguards Program. However, evaluations funded by agencies other than OSMM probably frequently will be very useful since they will be relevant to those aspects of the cross section related to OSMM needs. The OSMM should fund any evaluations it decides are directed to problems peculiar to Safeguards.

3) Requests for evaluations or information on evaluations should be handled by direct contact between OSMM and the NNCSC.

4) For photonuclear data no active evaluation or compilation group exists anywhere in the country. With the increasing interest in application of photonuclear reactions for example in isotope production, activation analysis, defense and Safeguards, it seems appropriate that the NCSAC actively encourage the evaluation and compilation of photonuclear data.

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5) Future requests for nuclear data should be reviewed for accuracy and priority by OSMM before forwarding the requests to the NCSAC. To implement this the OSMM might consider formation of a group of experts similar to ACRP.

6) The criteria or priority of Appendix 2 appear to be appropriate to Safeguards needs and, in the opinion of the subcommittee, are easy to use in practice.

7) The neutron data requests for Safeguards should be included in NCSAC 35 along with other neutron data requests. The photonuclear requests should be broken out into another section which includes these requests as well as other requests for photonuclear data from other agencies.

8) The committee urges the OSMM to issue its own document which includes all requests for nuclear data relative to Safeguards and distribute it as widely as possible. The requests <u>must</u> be published to attract the measurers' attention to these experiments.

9) The committee estimates that about 50 man-years of effort and an expenditure of two million dollars would be sufficient to satisfy these 50 requests. This works out to the support of about twelve scientists and their support for four years for a total of \$500,000 per year.

APPENDIX A-J.

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COMMENTS

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BNLReq. #392Subcommittee assigned priority II, requesterused I.Used requester's priority.BNLReq. #448Same comment.

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New 1-D-2	$(x\gamma, n)$ I E_e =threshold- 10% GRT(OSMM) Bramblett 7 10 MeV ΔE_e =1%	70
	Comments: Total neutron yield produced by bremsstrahlung required. Absolute 4π yield per electron is required. Emergent neutron energy-flat 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.	مر یے رہے معیست میں
New 4-Be-9	(xy,n) II E_e =threshold- 20% GRT(OSMM) Bramblett 7 10 MeV ΔE_e =1%	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(x, y, n) yield or may be absolute.	
	Status: No useful data. Justification: Background effect on non-destructive photonuclear assay.	
New 6-C-13	(xy,n) II $E_e = threshold - 20\%$ GRT(OSMM) Bramblett 74 10 MeV $\Delta E_e = 1\%$	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(x, γ, n) yield or may be absolute. Status: No useful data. Justification: Background effect on non-destructive photonuclear assay.	
New 3-Li-6	(xy,n) III E _e =threshold- 20% GRT(OSMM) Bramblett 70 10 MeV)
	ΔE _e =1% 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(x, y, n) yield or may be absolute.	
	Status: No useful data. Justification: Background effect on non-destructive photonuclear assay.	

Req.		· Reaction	а Туре	•	Incident	. %				
No.	Target	Quantity N	/ariable	Priority	y Energy	Accuracy	/ Lab/Org.	Requestor, Cor	mments, Status	Year
New	8-0-17	(xy, n)		II	E _e =threshold- 10 MeV ∆E _e =1%	20%	GRT(OSMM)	Bramblett		70
		Comments:	(prefera	bly Ta) of	d produced by b	kness to s		Bremsstrahlung (Neutron yield may		
		Status:	No usefu Backar		ct on non-destr	uctivo pho				
New	90-Th-232		-		E _e =threshold- 10 MeV	10%	GRT(OSMM)	Bramblett		70
		Comments:			∆E _e =1% ncluding fission ably Ta) of suff			ahlung required. B		
								stectrons. Neutron	i yield may be	
		Status:	Relative Can. J.	to D(x,γ, data of G Physics	n) yield or may Jozani, Trans. 35, (470) 1957.	y be absolu Am. Nuc.	ute. Soc. <u>13</u> , p. 70	7 (1970). Data of K		
		Justification	Relative Can. J. To allo	to D(x,γ, data of C Physics w non-des	n) yield or may Jozani, Trans. 35, (470) 1957. structive photor	y be absolu Am. Nuc. nuclear as	ute. Soc. <u>13</u> , p. 70 say of Th mixt	7 (1970). Data of K ures.		
New	90-Th-232		Relative Can. J. To allo	to D(x, γ, data of O Physics w non-des I	n) yield or may ozani, Trans. 35, (470) 1957. structive photor E _e =threshold - 10 MeV	y be absolu Am. Nuc. nuclear as	ute. Soc. <u>13</u> , p. 70	7 (1970). Data of K		70
New	90-Th-232	Justification Delayed-N- Comments:	Relative Can. J. <u>t: To allo</u> Y N(t) Delayed to (prefer to D(x,	to D(x, γ, data of C Physics w non-des I neutron yi ably Ta) γ, n) yield	n) yield or may 35, (470) 1957. E_e =threshold - 10 MeV ΔE_e =1% field produced by of sufficient this d or may be abs	y be absolu Am. Nuc. <u>nuclear as</u> 10% y bremsst ckness to solute.	ute. Soc. <u>13</u> , p. 70 <u>say of Th mixt</u> GRT(OSMM) rahlung require stop electrons.	7 (1970). Data of K ures. Bramblett ed. Bremsstrahlun Neutron yield ma	Katz, et al, ng converter ay be relative	70
New	90-Th-232	Justification Delayed-N- Comments: Status:	Relative Can. J. <u>To allo</u> Y N(t) Delayed r (prefer to D(x, .Relativ Can. J	to D(x, γ, data of C Physics w non-des I neutron yi ably Ta) γ, n) yield e data of Physics	n) yield or may 35, (470) 1957. 35, (470) 1957. E_e =threshold - 10 MeV ΔE_e =1% field produced by of sufficient this d or may be abs Gozani, Trans. 35, (470) 1957	y be absolu Am. Nuc. <u>nuclear as</u> 10% y bremsst ckness to solute. Am. Nuc	soc. <u>13</u> , p. 70 <u>say of Th mixt</u> GRT(OSMM) rahlung require stop electrons. c. Soc. <u>13</u> , p. 7	7 (1970). Data of K ures. Bramblett ed. Bremsstrahlun Neutron yield ma 707 (1970). Data of	Katz, et al, ng converter ay be relative	70
		Justification Delayed-N- Comments: Status:	Relative Can. J. <u>to allo</u> Y N(t) Delayed to (prefer to D(x, .Relative Can. J to allo d. E _v , t	to D(x, γ, data of C Physics W non-des I neutron yi ably Ta) o γ, n) yield ce data of Physics w non-des III	n) yield or may 35, (470) 1957. 5, (470) 1957. E_e =threshold - 10 MeV ΔE_e =1% field produced by of sufficient this d or may be abs Gozani, Trans.	y be absolu Am. Nuc. <u>nuclear as</u> 10% y bremsst ckness to solute. Am. Nuc	soc. <u>13</u> , p. 70 <u>say of Th mixt</u> GRT(OSMM) rahlung require stop electrons. c. Soc. <u>13</u> , p. 7	7 (1970). Data of K ures. Bramblett ed. Bremsstrahlun Neutron yield ma 707 (1970). Data of	Katz, et al, ng converter ay be relative	70 70
		Justification Delayed-N- Comments: Status: Justification Fission Pro y-Y 1ms-1h	Relative Can. J. <u>To allo</u> Y N(t) Delayed r (prefer to D(x, Relativ Can. J : To allo d. E _Y , t r Absolute Brems	to D(x, γ, data of C Physics w non-des I neutron yi ably Ta) o γ, n) yield e data of Physics w non-des III fission pu strahlung	n) yield or may 35, (470) 1957. 35, (470) 1957. E_e =threshold - 10 MeV $\Delta E_e = 1\%$ field produced by of sufficient this d or may be abs Gozani, Trans. 35, (470) 1957 structive photom $E_e = 10$ MeV $\Delta E_e = 5\%$ roduct delayed a	y be absolu Am. Nuc. <u>nuclear as</u> 10% y bremsst ckness to solute. Am. Nuc <u>nuclear as</u> 10% gamma-ra ferably Ta	ute. Soc. <u>13</u> , p. 70 <u>say of Th mixt</u> GRT(OSMM) rahlung require stop electrons. c. Soc. <u>13</u> , p. 7 <u>say of Th mixtu</u> GRT(OSMM) y yield produce	7 (1970). Data of K ures. Bramblett ed. Bremsstrahlun Neutron yield ma 207 (1970). Data of ares. Bramblett ed by bremsstrahlur thickness to stop eld	Katz, et al, ng converter ay be relative Katz, et al, ng required.	

Req. No.	Target	Reaction 7 Quantity Va		Priority	Incident Energy	% Accurac	y Lab/Org.	Requestor.	Comments, Status	3 Yea
New	92-U-233	(xy,n)			E _e =threshold - 10 MeV ∆E _e =1%	10%	GRT(OSMM)	Bramblett		70
			convert relativ	vield (incl ter (prefe e to D(x,γ	uding fission) p rably Ta) of su ,n) yield or ma	fficient t ay be abs	hickness to stop olute	· ·	Bremsstrählung eutron yield may bo	2
		Status: Justification:			al, Can. J. Ph tructive photon					
New	92 - U-233	Delayed-N-Y	N(t)		E _e =threshold - 10 MeV AE _e =1%	10%	GRT(OSMM) ,	Bramblett		70
·		Comments: D	(prefer	eutron yi ably Ta) (eld produced by	ckness to			ahlung converter d may be relative t	o
		Status: Justification:	No data	Le .		•	ssay of this SNM	[· · · · · · · · · · · · · · · · · · ·	
New	9 2-U- 233	Fission Prod. y-Y lms-lhr	Ey,t		E _e =10 MeV AE _e =5%	10%	GRT(OSMM)	Bramblett		70
		Comments:	Bremss	strahlung	converter (pret	ferably 1	-ray yield produce ray of a sufficien -5) MeV, with Δ	t thickness to	strahlung required. stop electrons.	
		Status: Justification:	No data		ive photonuclea		-			
	92-U-234	(xy, n)	•		E _e =threshold - 10 MeV	30%	GRT(OSMM)	Bramblett		70
New	•									
New .		Comments: 4	convert	n yield (in er (prefe		ficient t	nickness to stop		. Bremsstrahlung eutron yield may be	

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Req. No. Targ	Reaction t Quantity Va		Incident ty Energy	% Accuracy	Lab/Org.	Requestor,	Comments, Status	Year
New 92-U-23	4 Delayed-N-Y		E _e =threshold - 10 MeV ΔE _e =1%	·	GRT(OSMM)	Bramblett	_	70
	Status.		of sufficient this or may be absolu	ckness to : ite	stop electrons.	Neutron yield	alung converter may be relative to	
New 92-11-23	Justification: 4 Fission Prod.		E _e =10 MeV		GRT(OSMM)	 Bramblett		70
New 72-0-23	γ -Y, lms-lhr		$\Delta E_e = 5\%$	5070	GRI(OSMMI)	Diampien		• •
	Comments: A		product delayed g na-ray energies- erably Ta) of sui	-E=(0.5-) MeV, with ΔE	=3 keV. Brea		
	Status: Justification:	No data. Effect on non-de	structive photon	uclear as	ay of 233 U and	²³⁵ U.		
New 92-U-23		11	E _e =threshold- 10 MeV		GRT(OSMM)	Bramblett		70
	Comments: 4	converter (pref	erably Ta) of suf	ficient thi	ckness to stop e		Bremsstrahlung atron yield may be	
	Status:	Relative data of (γ, n) data above	γ,n) yield or ma Gozani, et al,T 7 MeV of Bown	rans. Am nan, et al,	Nuc. Soc. <u>13</u> , Phys. Rev. <u>13</u>			
New 92-U-23		For non-destruc N(t) II	E_{e} =threshold -		GRT(OSMM)	Bramblett		70
	Comments: D	elayed neutron y	10 MeV ΔE _e =1% ield produced by	bremsstr	ahlung required	. Bremsstrah	lung converter	
							may be relative to	
			or may be absolu		top creentone.			

Req. <u>No. Target</u>	Reaction Quantity V		Priorit	Incident ty Energy	% Accura	cy Lab/Org.	Requestor, C	Comments, S	Status Year
New 92-U-235	Status:	r Absolute fi Emergen verter (p Prelimin	ssion pr nt gamm preferab nary data		-E=(0.5) lent thick Trans. A	-5) MeV, with (ness to stop ele Am. Nuc. Soc.			
New 92-U-236	(xy, n)			E _e =threshold - 10 MeV ΔE _e =1%	30%	GRT(OSMM)	Bramblett		70
	Comments: 4	converte	yield (in r (prefe	ncluding fission rably Ta) of su	ficient th	ickness to stop	hlung required. I electrons. Neutr		
	Status:	No data		(,n) yield or ma	•	225			
		No data		(,n) yield or ma	•	225			
New 92-U-236		No data Effect on	non-des III	structive photon E _e =threshold - 10 MeV	•	225	Bramblett		70
New 92-U-236	Justification: Delayed-N-Y Comments:	No data Effect on N(t) Delayed : (preferat D(x, γ, n)	non-des III neutron oly Ta) o	structive photon E _e =threshold - 10 MeV ΔE _e =1% yield produced	uclear as 30% by brems ckness to	GRT(OSMM)	Bramblett ired. Bremsstrah Neutron yield m		rter
New 92-U-236	Justification: Delayed-N-Y Comments:	No data Effect on N(t) Delayed : (preferat D(x, γ, n) No data.	non-dea III neutron oly Ta) o yield or	structive photon E _e =threshold - 10 MeV ΔE _e =1% yield produced of sufficient thic	uclear as 30% by brems ckness to tte.	GRT(OSMM) GRT(osmM) sstrahlung requ stop electrons.	ired. Bremsstrak		rter
New 92-U-236 New 92-U-236	Justification: Delayed-N-Y Comments: Status:	No data Effect on N(t) Delayed : (preferat D(x, y, n) No data. Effect on Ey, t Absolute Emergen	non-des III neutron oly Ta) o yield on non-de III fission t gamma	structive photon E_e =threshold - 10 MeV ΔE_e =1% yield produced of sufficient thic r may be absolut structive photon E_e =10 MeV ΔE_e =5% product delayed	by brems 30% by brems ckness to te. <u>auclear as</u> 30% l gamma- E = (0.5)	GRT(OSMM) sstrahlung requi- stop electrons. ssay of ²³⁵ U. GRT(OSMM) ray yield produ- -5) MeV, with	Framblett AE = 3 keV. Brem	hlung requi	rter ve to 70 red.

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New	92-U-238	(xy, n)		п	E _e =threshold - 10 MeV ∆E _e =1%	10%	GRT(OSMM)	Bramblett		70
		Comments:	converte	er (pref	d (including fissi	fficient t	hickness to stop	trahlung required. electrons. Neutron		g
		Status:	Relative Can. J.	e data of Physic	f Gozani, Trans. s <u>35</u> , (470) 1957	Am. Nu	ic. Soc. <u>13</u> , p. 7	707 (1970). Data of	Katz, et al,	
		Justification:	For non	-destru	ctive photonucle	ar assay	of uranium.	·····		
New	92-U-238	Delayed-N-Y	N(t)	II	E _e =threshold - 10 MeV ΔE _e =1%	10%	GRT(OSMM)	Bramblett		70
		Comments:	(prefera	bly Ta)		ckness to		ired. Bremsstrahlu Neutron yield may		
		Status: Justification:	Relative	data of	Gozani, Trans. ctive photonucle	Am. Nu		07 (1970).		
New	92 - U-238	Fission Prod. y-Y, 1ms-lhr		II	E _e =10 MeV ∆E _e =5%	10%	GRT(OSMM)	Bramblett		70
		Comments: A	Bremss	trahlung		ferably T	a) of sufficient	ed by bremsstrahlun thickness to stop ele E=3 keV.		
		Status:			ta of Rundquist,					
_	•			-	ctive photonucles		-		·	
New	94-Pu-239	(xy,n)		Π	E _e =threshold - 10 MeV ∆E _e =1%	10%	GRT(OSMM)	Bramblett		70
		Comments: 4	converte	er (pref	including fission	ficient th	nickness to stop	hlung required. Br electrons. Neutron		
	•	Status:	Relative	data of	Gozani, Trans.	Am. Nu	c. Soc. <u>13</u> , p. 7	07 (1970).		
		Justification:	For non-	-destru	ctive photonucles	ir assay	of Pu-239.		······································	

Req. No.	Target	Reaction T Quantity Var	••	Incident y Energy	% Accuracy	Lab/Org.	Requestor,	Comments, Status	Yea
New	94-Pu-239	Delayed-N-Y	N(t) II	E _e =threshold 10 MeV	- 10%	GRT(OSMM)	Bramblett		70
		Status:		of sufficient the d or may be ab f Gozani, Trans	ickness to solute • Am. Nuc	stop electrons. Soc. <u>13</u> , p. 70	Neutron yield	ahlung converter I may be relative	
New	94-Pu-239	Fission Prod.	I	E _e =10 MeV	10%	GRT(OSMM)	Bramblett		70
		Status:	bsolute fission p Emergent gami	ma-ray energie Terably Ta) of s ta of Rundquist	sE=(0.05 ufficient th , Trans. A	5-5) MeV, with hickness to stop Am. Nuc. Soc.	AE=3 keV. Br electrons.	ahlung required. emsstrahlung	
New	94-Pu-240	(m n)	II	E _thesehold	- 10%	CD TIOCLAN	D. 11.44		-
	,. <u>.</u>	(11	E _e =threshold 10 MeV	- 1070	GRT(OSMM)	Bramblett		70
	,	Comments:	4π neutron yiel converter (pref	10 MeV ΔE _e =1% d (including fiss ferably Ta) of s	ion) produc ufficient th	ced by bremsst ickness to stop	rahlung require	ed. Bremsstrahlung eutron yield may be	
	,		4π neutron yiel converter (pref relative to D(x, No data.	10 MeV $\Delta E_e = 1\%$ d (including fiss ferably Ta) of s γ , n) yield or n	ion) produc ufficient th aay be abso	ced by bremsst ickness to stop plute. 229	rahlung require electrons. Ne		
		Comments: Status:	4π neutron yiel converter (pref relative to D(x, No data. Effect on non-d	10 MeV $\Delta E_e = 1\%$ d (including fiss ferably Ta) of s γ , n) yield or n	ion) produc ufficient th nay be abso onuclear a	ced by bremsst nickness to stop plute.	rahlung require electrons. Ne		
		Comments: Status: Justification: Delayed-N-Y for t<100sec Comments:	4π neutron yiel converter (pref relative to D(x, No data. Effect on non-d N(t) II Delayed neutron (preferably Ta) to D(x, γ, n) yiel	10 MeV $\Delta E_e = 1\%$ d (including fiss ierably Ta) of s γ , n) yield or n lestructive phot E_e =threshold 10 MeV $\Delta E_e = 1\%$ n yield produce of sufficient th	ion) produc ufficient th hay be abso onuclear a - 10% d by brems ickness to	ced by bremsstr nickness to stop blute. <u>ssay of ²³⁹Pu.</u> GRT(OSMM) sstrahlung requi	rahlung require electrons. Ne Bramblett ired. Bremsst		5
		Comments: Status: Justification: Delayed-N-Y for t<100sec	4π neutron yiel converter (pref relative to D(x, No data. Effect on non-d N(t) II Delayed neutron (preferably Ta)	10 MeV $\Delta E_e = 1\%$ d (including fiss ierably Ta) of s γ , n) yield or n destructive phot E_e =threshold 10 MeV $\Delta E_e = 1\%$ in yield produce of sufficient th ld or may be ab	ion) produc ufficient th hay be abso onuclear a - 10% d by brems ickness to solute.	ced by bremsstr nickness to stop olute. <u>ssay of ²³⁹Pu.</u> GRT(OSMM) sstrahlung requistop electrons. 239	rahlung require electrons. Ne Bramblett ired. Bremsst	eutron yield may be	5

Req. No.	Target	eaction T Quantity Var		Incident ity Energy	% Accuracy	Lab/Org.	Requestor, Comme	ats, Status Year
New	94-Pu-240	Fission Prod. γ-Υ, 1ms-SF background	E _y ,t II	E _e =10 MeV ∆E _e =5%	10%	GRT(OSMM)	Bramblett	70
		Comments:	Bremsstrahl Emergent ga		eferably T	a) of sufficient	uced by bremsstrahlung thickness to stop elect ME=3 keV.	
		Status: Justification:	No data. Effect on nor	-destructive phot	conuclear a	ssay of ²³⁹ Pu.		
New	94-Pu-241	(xy, n)	. III	E _e =threshold 10 MeV ∆E _e =1%	- 30%	GRT(OSMM)	Bramblett	. J
		Comments:		eld (including fis			trahlung required. Bre electrons. Neutron yi	
			relative to D	•			,	, <u>,</u>
·	*** **	Status: Justification:	No data.	x, y, n) yield or r -destructive phot	nay be abso	olute.	· · · · · · · · · · · · · · · · · · ·	
New	94-Pu-241		No data. Effect on non	x,γ,n) yield or r - <u>destructive phot</u> E _e =threshold 10 MeV	nay be abso conuclear as	olute.	Bramblett	70
New	94 - Pu-241	Justification:	No data. Effect on non N(t) III Delayed neut. (preferably T	x, γ, n) yield or n <u>-destructive phot</u> E _e =threshold 10 MeV ΔE _e =1% con yield produce	nay be abso conuclear as - 30% d by brems hickness to	olute. ssay of Pu. GRT(OSMM) strahlung requi	·····	70 converter
New	94-Pu-241	Justification: Delayed-N-Y	No data. Effect on non N(t) III Delayed neut. (preferably T to $D(x, \gamma, n)$ y No data.	x, γ, n) yield or n <u>-destructive phot</u> E _e =threshold 10 MeV ΔE _e =1% con yield produce a) of sufficient th	nay be abso conuclear as - 30% d by brems nickness to osolute.	olute. ssay of Pu. GRT(OSMM) strahlung requi stop electrons.	Bramblett ired. Bremsstrahlung	70 converter
		Justification: Delayed-N-Y Comments: Status: Justification: Fission Prod. y-Y, 1ms-1hr	No data. Effect on non N(t) III Delayed neut: (preferably T to $D(x, \gamma, n)$ y No data. Effect on non E_{γ} , t III	x, γ , n) yield or n <u>-destructive phot</u> E_e =threshold 10 MeV ΔE_e =1% con yield produce a) of sufficient thield or may be al <u>-destructive phot</u> E_e =10 MeV ΔE_e =5%	nay be abso conuclear as - 30% d by brems nickness to psolute. conuclear as 30%	olute. <u>ssay of Pu.</u> GRT(OSMM) strahlung requi- stop electrons. <u>ssay of Pu.</u> GRT(OSMM)	Bramblett ired. Bremsstrahlung Neutron yield may be Bramblett	70 converter e relative 70
		Justification: Delayed-N-Y Comments: Status: Justification: Fission Prod.	No data. Effect on non N(t) III Delayed neut. (preferably T to $D(x, \gamma, n)$ y No data. Effect on non E_{γ}, t III Absolute Fiss Emergent gau	x, γ , n) yield or n <u>-destructive phot</u> E_e =threshold 10 MeV ΔE_e =1% con yield produce a) of sufficient this ield or may be al <u>-destructive phot</u> E_e =10 MeV ΔE_e =5% sion product delay	nay be abso conuclear as - 30% d by brems nickness to osolute. <u>conuclear as</u> 30% yed gamma sE=(0.05	Solute. SSAY OF Pu. GRT(OSMM) Strahlung requision stop electrons. SSAY OF Pu. GRT(OSMM) -ray yield prod -5) MeV, with	Bramblett ired. Bremsstrahlung Neutron yield may be Bramblett uced by bremsstrahlung ΔE=3 keV. Bremsstrah	70 converter e relative 70 g required.

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Req. No.	Target	Reaction Type Quantity Variable	Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, St	atus Year
New	92-0-235	Delayed-N-Y vd	II	5-14 MeV	5	LASL	Weisbin & Walton	70
		ANS <u>11</u> , 1	179. Preli tion to 15 M	minary data o MeV.	of Krick and	d Evans, LAS	of Masters, et al., 3 and 14 Me L to 0.1 to 6.7 MeV. Data des	
New	94-Pu-239	Delayed-N-Y v	II	3-14 MeV	10	LASL	Weisbin & Walton	70
		266 3. 8 ai	nd 15 MeV. 9.1 - 6.7 M	Also Petrza IeV. Data de	ak AE 11, 5 sired for ea	39. Prelimit strapolation to		D-1,
412	92-U-238	Delayed-N-Y v	II	5-14 MeV	5 [′]	LASL	Weisbin and Walton	70
	·						of Masters et al., at 3 and 14 M L to 0.1 - 6.7 MeV. Data desi	
		•	tion to 15 M	AeV.			l effects on assays of U-235.	
457	94-Pu-240	Justification: Calcu	tion to 15 M	AeV.	semblies fo			70
457	94-Pu-240	Justification: Calcu Delayed-N-Y v _d Status: Evaluation v	ion to 15 M lations of 1 II up to 2.5 M Vienna 1, 1	MeV. moderating as 0.75-14 Me IeV by Hunter 149. Data des	<u>semblies fo</u> V 20 LA-3528. Sired for ex	or background LASL 613 MeV data trapolation to	l effects on assays of U-235. Weisbin and Walton a of 9 15 MeV	
	94-Pu-240 94-Pu-241	Justification: Calcu Delayed-N-Y v _d Status: Evaluation v Diven 61	ion to 15 M lations of r II up to 2.5 M Vienna 1, 1 lations of r	MeV. moderating as 0.75-14 Me IeV by Hunter 149. Data des	semblies fo V 20 LA-3528. Sired for ex semblies fo	or background LASL 613 MeV data trapolation to	l effects on assays of U-235. Weisbin and Walton a of 9 15 MeV	
		Justification: Calcu Delayed-N-Y $\bar{\nu}_d$ Status: Evaluation u Diven 61 Justification: Calcu Delayed-N-Y $\bar{\nu}_d$	ion to 15 M lations of r II up to 2.5 M Vienna 1, 1 lations of r III T t thermal.	MeV. <u>moderating as</u> 0, 75-14 Me leV by Hunter 149. Data des <u>moderating as</u> Chermal-14Me See Keepin N	semblies for LA-3528. Sired for ex semblies for V 10 Nuc 20 8 15	Dr background LASL 613 MeV data trapolation to Dr Pu assays LASL 0 8/62. Data	l effects on assays of U-235. Weisbin and Walton a of 15 MeV of spent fuel.	70
471		Justification: Calcu Delayed-N-Y $\bar{\nu}_d$ Status: Evaluation u Diven 61 Justification: Calcu Delayed-N-Y $\bar{\nu}_d$ Status: Only work a	ion to 15 M lations of r II up to 2.5 M Vienna 1, 1 lations of r III T t thermal.	MeV. <u>moderating as</u> 0, 75-14 Me leV by Hunter 149. Data des <u>moderating as</u> Chermal-14Me See Keepin N	semblies for LA-3528. Sired for ex semblies for V 10 Nuc 20 8 15	Dr background LASL 613 MeV data trapolation to Dr Pu assays LASL 0 8/62. Data	l effects on assays of U-235. Weisbin and Walton a of 15 MeV of spent fuel. Weisbin and Walton	70
471	94-Pu-241	Justification: Calcu Delayed-N-Y $\bar{\nu}_d$ Status: Evaluation u Diven 61 Justification: Calcu Delayed-N-Y $\bar{\nu}_d$ Status: Only work a Justification: Calcu	ion to 15 M lations of r II up to 2.5 M Vienna 1, 1 lations of r III T t thermal. lations of r I ental work	MeV. <u>moderating as</u> 0.75-14 Me leV by Hunter 149. Data des <u>moderating as</u> Chermal-14Me See Keepin N <u>moderating as</u> 3, 14 MeV to date. Data	semblies for LA-3528. Sired for ex semblies for V 10 Nuc 20 8 15 semblies for 10 have been	Dr background LASL 613 MeV data trapolation to Dr Pu assays LASL 0 8/62. Data Dr Pu assays. LASL DASL obtained emp	l effects on assays of U-235. Weisbin and Walton a of 15 MeV of spent fuel. Weisbin and Walton needed for extrapolation to 15 Weisbin and Walton	70 70 MeV.
471 New	94-Pu-241	Justification: Calcu Delayed-N-Y $\bar{\nu}_d$ Status: Evaluation v Diven 61 Justification: Calcu Delayed-N-Y $\bar{\nu}_d$ Status: Only work a Justification: Calcu Delayed-N-Y $\bar{\nu}_d$ Status: No experime Justification: Backg	ion to 15 M lations of r II up to 2.5 M Vienna 1, 1 lations of r III T t thermal. lations of r I ental work	MeV. <u>moderating as</u> 0.75-14 Me leV by Hunter 149. Data des <u>moderating as</u> Chermal-14Me See Keepin N <u>moderating as</u> 3, 14 MeV to date. Data	semblies for LA-3528. Sired for ex semblies for V 10 Nuc 20 8 15 semblies for 10 have been 35 spent fur	Dr background LASL 613 MeV data trapolation to Dr Pu assays LASL 0 8/62. Data Dr Pu assays. LASL DASL obtained emp	l effects on assays of U-235. Weisbin and Walton a of 15 MeV of spent fuel. Weisbin and Walton needed for extrapolation to 15 Weisbin and Walton	70 70 MeV.

Req. No. · Target	Reaction Quantity V		Priority	Incident Energy	% Accuracy	Lab/Org.	Requestor, Comments, 50	atus Y
94-Pu-239	ray spectra (also yield y rays per	P(E _g) E ₅ 1.2 ^g MeV	III	Thermal to 100 eV	Ge(Li) re- solution (2.5 keV at 1.2 MeV)	LASL	Weisbin and Walton	
• ·	capture to $\sim 20\%$)				írom Jurney <u>ew Pu~239 as</u>		progress report) γ-ray spect 20.	ra 3-6 1
·····								
25 4-Be-9	$(n, p) \operatorname{Li}^9 \to I$	9 3e'+n	II	14 MeV	10.	LASL	Weisbin and Walton	
25 4-Be-9	(n, p) Li ⁹ → I	Status:	Preliminary PR 132,	y measurem 128 (1963)	ents at LASL	, measurem	Weisbin and Walton ent of Alburger	

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Req.			on Type		Incident	%					
No.	Target	Quantity	Variable	Priority	Energy	Accuracy	Lab/Org.	Requestor,	Comments,	Status	Year
	92 - U-235	Fission- product y- spectra (0. 25-5 M and yield (photons/f (1 ms - 12	eV) ission-MeV	II (-sec)	Thermal	Ge(Li) resolution 2.5 keV at 1.2 MeV ± 15% for absolute yield	LASL	Weisbin and	l Walton		70
		Status: Se						Engle, Phys. , 366. Better i			04/i
		Justificati	Associa	teγ rays w		roducts if pos				<u>estrea.</u>	
 448	94-Pu-239	Fission- product γ- spectra (0. 25-5 M and yield	Associa on: Nondes ray eV) ission-MeV	te γ rays w structive as II	ith fission p	roducts if pos		Weisbin and			70

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Req	•	Reaction '		
No.	Target	Quantity Va	ariable Priority Energy Accuracy Lab/Org. Requestor, Comments, St	atus 'iea
348	90-Th-232	Delayed-y-Y	$P(E_{\gamma}, T_{\frac{1}{2}})$ II 2 and 35% BNL(OSMM) Kouts 14 MeV	69
		Comments:	Accuracy requested refers to relative intensities of delayed gamma rays from neutron induced fission for $E_{\chi} > 2$ MeV and 10 $\mu \sec \gtrsim T_{\frac{1}{2}} \gtrsim 1$ hr. Absolute gamma ray yields to	
		Status:	factor of 2 also useful. R. Chrien (BNL, unpublished) has some data for U ²³⁵ and Pu ²³⁹ ; N. R. Large and R. J. Bullock, Proc. 2nd Symp. on Phys. & Chem. of Fission (Vienna, 1969), presen	t
	<u> </u>	Justification:	some data for U. Background effects in assay of U ²³³ - Th ²³²	
364	92-U-233	Delayed-y-Y	$\begin{array}{c cccc} P(E_{\gamma},T_{\frac{1}{2}} & I & 2 \text{ and} & 35\% & BNL(OSMM) & Kouts \\ & & 14 \text{ MeV} \end{array}$	69
		Comments:	Accuracy requested refers to relative intensities of delayed gamma rays from neutron induced fission for $E > 2$ MeV and 10 $\mu \sec \gtrsim T_{\frac{1}{2}} \gtrsim 1$ hr. Absolute gamma ray yields to 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, Proc. 2nd Symp. on Phys. & Chem. of Fission (Vienna, 1969), presen some data for U.	t
		Justification:		
392	92 - U-235	Delayed-y, Y	$P(E_{\gamma}, T_{\frac{1}{2}}) $ I Z and 35% BNL(OSMM) Kouts 14 MeV	69
		Comments: >	induced fission for E > 2 MeV and 10 $\mu sec \approx T_{1} \approx 1$ hr. Absolute gamma ray yields to	,
		Status:	factor of 2 also useful. R. Chrien (BNL, unpublished) has some data for U ²³⁵ and Pu ²³⁹ ; N. R. Large and R. J. Bullock, Proc. 2nd Symp. on Phys. & Chem. of Fission (Vienna, 1969), present some data for U.	, :
		Justification:	Assay of U ²³⁵ fuels	••
				69
.417	92-U-238	Delayed-y-Y	N X	07
.417	92-U-238	Delayed-y-Y Comments:	Y $\stackrel{?}{\stackrel{?}{2}}$ 14 MeV Accuracy requested refers to relative intensities of delayed gamma rays from neutron induced fission for E > 2 MeV and 10 µsec $\stackrel{?}{\underset{\sim}{\sim}}$ T $\stackrel{?}{\underset{\sim}{\sim}}$ 1 hr. Absolute gamma ray yields to	07
.417	92-U-238		Y 2 Accuracy requested refers to relative intensities of delayed gamma rays from neutron	

Req.		Reaction	Туре		Incident	%				
No.	Target	Quantity Va	riable F	Priority	Energy	Accuracy	Lab/Org.	Requestor,	Comments, Status	Year
448	94 - Pu-239	Delayed-y-Y	P(E,T1) I	2 and 14 MeV	35%	BNL(OSMM)	Kouts		69
		Comments:	induced f factor of	ission for 2 also use	E > 2 MeV	and 10 µsee	$\simeq \gtrsim T_{\frac{1}{2}} \gtrsim 1 \text{ hr.}$	Absolute gam	ys from neutron ma rays yields to	
		Status:		llock, Pro			ata for U ²³⁵ and & Chem. of Fis		. Large and , 1969), present	
	······	Justification:	Assay of	Pu fuels						
462	94-Pu-240	Delayed-y-Y	P(E, T) II	2 and 14 MeV	35%	BNL(OSMM)	Kouts		69
		Comments:	induced f		$E_{v} > 2 MeV$				ys from neutron- ma ray yields to	
		Status:		llock, Pro			ta for U ²³⁵ and & Chem. of Fis		. Large and , 1969), present	
		Justification:		Pu fuels.						

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APPENDIX A-2

PRIORITIES FOR REQUESTS FOR NUCLEAR DATA FOR SAFEGUARDS PURPOSES

First Priority

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

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

Second Priority

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

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

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

APPENDIX A-3

Weisbin's Letter

"Our experience has shown that a large majority of practical nuclear safeguards problems can be treated by either passive assay or active interrogation with a neutron source. The nuclear data required for the development of instrumentation based upon these techniques is, with some few exceptions, generally available from a technology which is now more than twenty five years old."

"At the present time there are, in my opinion, at least three factors to be considered before actively embarking upon a measurement program for nuclear safeguards. Foremost among these is the reliance upon standards during the actual assay. For the cases of well defined samples (feed, product material etc.) such a procedure, to first order, effectively eliminates the need for detailed knowledge of cross section behavior. The second point relates to the case for which reliance upon standards might be readily challenged, i.e., the assay of scrap and waste. Here, however, refinement of cross section information usually appears as a second order correction because the materials contained in the sample are frequently unknown. Finally, to my knowledge, there have not been any calculations to indicate the sensitivity of a particular assay result to specific cross section features. The cross section requests reviewed by our committee, including LASL's, were based primarily upon intuition of what probably is important. The limited sensitivity investigations begun at our laboratory indicate that certain specific knowledge relating to the sample is important, e.g., the presence of hydrogen; on the other hand, we have not yet found limitations arising from a lack of fundamental data. I believe that the above three factors played an important part in what seemed to me a general downgrading of priorities for the requests reviewed, i.e., very few priority 1 requests."

"I do feel, however, that it is vital to keep an up-to-date evaluated data file for the materials of interest to nuclear safeguards. Such an evaluated file is presently kept by the National Neutron Cross Section Center at Brookhaven supported by DRDT. Newer evaluations are presently available for most of the fissionable and fertile isotopes but, in some cases, information of interest to safeguards (e.g., delayed neutron properties, fission product yield data) has been omitted. Furthermore, the present evaluations for some materials (e.g., Be, Pb, C) could use some re-examination. I under Pb is presently being evaluated by Oak Ridge but possibly with different support and thus different emphasis on certain cross section features. For example, depending upon who is doing the evaluation, more emphasis might be placed on (n,γ) than (n,2n) spectra. One possible future role for this subcommittee might be to try and influence the choice of materials and description of the type of evaluation desired."

"Finally, a possible role for the subcommittee, in addition to review of fundamental nuclear data request might be to consider the problem of data handling and manipulation in general. This could, in principal, include a library of evaluated microscopic and selectively group averaged neutron and photon information of interest to people working in the safeguards field. This should not require an extensive amount of work since most of the information is presently available but scattered throughout several labs across the country. Such a program might be mutually beneficial to all concerned."

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