International Atomic Energy Agency

INDC-29/L

INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

TECHNICAL MINUTES OF THE NINTH INDC MEETING

Vienna, 16-20 May 1977

Compiled by
H. Motz (Los Alamos, N.M., USA)
(Executive Secretary)

May 1978

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9th INDC MEETING
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LIST OF PARTICIPANTS

I. Members and Advisors (indicated by asterisks)

Canada	W. G. Cross	(Chairman)
France	A. Michaudon	
	*J. Legrand	
Germany	F. Froehner	
India	M. K. Mehta	
Israel	S. Yiftah	
Italy	V. Benzi	
Japan	T. Fuketa	
Romania	S. N. Rapeanu	
	*V. Cuculeanu	
Sweden	H. Condé	
USA	A. B. Smith	
	*J. Decker	
	*H. Motz	(Executive Secretary)
USSR	L. N. Usachev	
	*V. Kulakov	
UK	B. Rose	
	*J. Rowlands	
IAEA	J. J. Schmidt	(Scientific Secretary)
	*A. Lorenz	(Local Secretary)
(Australia)	(W. Gemmell - Absent)	

II. Observers

Austria	H. Vonach	IAEA	N. Shalnov
German Democratic Republic	D. Seeliger		E. Beaty
			G. Lammer
Hungary	D. Berenyi		H. Lemmel
C.E.C. - Geel	H. Liskien		R. Lessler
NEA/CCDN	N. Tubbs		R. Seamon
			M. Vlasov

Ninth Meeting of the International Nuclear Data Committee (INDC)

Vienna, 16-20 May 1977

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Froehner
Michaudon
Cuculeanu
Mehta
Rose
Benzi
Fuketa
Conde
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Schmidt*
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Smith
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Usachev
Rowlands
Schwerer*
Schmidt*

*Ex-officio, NDS

9th INDC
May 16, 1977

I. INTRODUCTORY ITEMS

The Chairman and J. J. Schmidt opened the meeting by introducing the new members and advisors. A new three-year cycle has begun in 1977 and several changes in membership have been made. The List of Participants is given on page (i).

Prof. H. Glubrecht welcomed the committee and stressed the importance that nuclear data in general and the Nuclear Data Section in particular have at the Secretariat of the IAEA. The NDS is not only the largest section in the Division of Research and Isotopes, but it is the fastest growing. There are important fundamental reasons for this activity and this is expected to continue. The area of nuclear data measurement is also directly supported by the IAEA and the educational value of such endeavors leads to a plan to include more and more member nations in such work. Since capacity is available from existing accelerators and reactors, an opportunity for such work by other member countries exists and is encouraged. Prof. Glubrecht thanked the INDC for its interest and advice in all of these efforts.

II. NEUTRON DATA

II.A. Brief Reports from Data Centers

Tubbs announced that the NEA Steering Committee had made a provisional decision to amalgamate the Computer Program Library activity now at Ispra with the CCDN at Saclay. The Council of the OECD will be asked to approve this integration at the first opportunity. Careful plans are being made to minimize the interruption of services both from CCDN and from CPL. It is expected that a combination of a local PDP and more extensive IBM facilities, which are now located at Saclay, would be involved. The earliest that the computer changeover would occur would be October, 1978.

Smith noted that the National Neutron Cross Section Center, NNCSC, had been broadened to include charged particle data and the name has been changed to the National Nuclear Data Center, NNDC. Some important publications have been issued since the last INDC Meeting:

BNL 325 Third Edition, Vol. II Neutron Cross Sections, INDC(US)-58
ENDF/B-IV Dosimetry File, ENDF-216/INDC(US)-70L
ENDF/B Cross Section Standards, ENDF-225/INDC(US)-73L
Light Element Standard Cross Sections for ENDF/B-IV, ENDF-244/INDC(US)-76U
ENDF/B Fission Product Decay Data, ENDF-243

A new version of BNL 325 is now underway and resonance parameters should be available in late 1977. Version V of ENDF/B is now being reviewed and it is expected that a number of the new evaluations will be ready in January of 1978.

Usachev reported that CJD expected to use new computer facilities soon and that new tape units would probably lead to improved tape quality. Since the last meeting of INDC the Agency has received complete files for isotopes on magnetic tape in the SOKRATOR format. These include files on six isotopes of erbium, a short description of which was published in an annex to Nuclear Constants No. 21, INDC(CCP)-102G, a file for ^{240}Pu (a complete report on the evaluation of this has been sent to the Agency), and files for ^{2}H, ^{3}He and ^{4}He.

Nuclear Constants has also published, in issue No. 23, INDC(CCP)-106G, a description of the evaluation of fission and capture cross-sections for ^{238}Pu, ^{243}Am and ^{244}Cm; the numerical data for these were transmitted earlier.

Evaluations have been completed and complete files prepared for chromium and nickel, and the technical work connected with input and checking has also been finished. Work

on a complete file for ^{241}Pu has been concluded in Minsk, and it is expected that by the end of 1977 the work on a complete file for ^{242}Pu will have been finished as well. In Obninsk, work is in progress on complete files for oxygen, sodium and calcium. Calculations of threshold reactions for reactor dosimetry are being undertaken.

There have been a number of partial evaluations. V. I. Popov evaluated inelastic scattering for ^{238}U and the results were presented in April this year at Kiev. V. A. Tolstikov and co-workers evaluated capture cross-sections for ^{238}U in the 0.001 - 7 MeV range (see Nuclear Constants No. 22) and for gold in the 1 - 100 keV range (see Nuclear Constants No. 21). V. N. Kononov and co-workers evaluated alpha for ^{239}Pu and reported their results at the most recent Kiev conference. S. I. Sukhoruchkin has also evaluated alpha for ^{239}Pu.

In addition to the NDS progress report, INDC(NDS)-85/LNA, Schmidt said that the additional staff position supported by INDC at its last meeting was still under review. It is presently being supported and is the only scheduled increase in the IAEA Department of Research and Isotopes during 1978. The majority of new agency posts is now being assigned to Safeguards.

II.B CINDA

H. Lemmel of the NDS summarized the CINDA operations, for which tests have shown that completeness is now good. Three new features have been gradually introduced in the past few years. These are:

1. The "blocking" of all references related to the same experiment.
2. Omitting from the book (though not from the file) superseded progress reports as soon as a more complete paper has been published.

3. Adding to each experiment the pertinent EXFOR accession number.

A questionnaire distributed by NNCSC has proven that the large majority of the CINDA users appreciate these new features.

In 1976 the practice of publishing a cumulative issue each year has been discontinued. For the period 1976/77 one cumulative issue with three cumulative supplements every six months had been planned, and an "archival issue" for older literature was envisaged for 1978. At their meeting in April 1977, the neutron data centres found it more economical and more practical to issue in 1978 a fourth and a fifth supplement to CINDA 76/77. The "archival issue" covering the literature up to about 1975 (the exact cut-off date will be decided later) is thus planned for 1979. The funding authorities of NEA-NDCC and US-NNDC, carrying most of the printing costs, are being asked for their approval for this revised schedule, for which the approval of the Agency's pertinent divisions is also expected.

Motz, Usachev and Rose questioned the necessity to publish an archival volume in 1979 which would have no data beyond 1975. Usachev suggested that the last cumulative index could, at any time, serve as the archival volume and serve the necessary purpose, as could CINDA 76/77. A more polished and perhaps more perfect edition would no doubt result from a four year old data cutoff, but it would also appear to be redundant and probably difficult to sell. Lemmel defended the proposal and noted that if, for example, the 1979 edition were to include current information up to that time, then three volumes would be required rather than two volumes as would apply for the earlier 1975 data cutoff. (Froehner requested three integrated volumes ordered by Z and not split by years, if three volumes were to be issued.) Tubbs agreed with Lemmel that an early date limit was needed to ensure validity of entries in the archival volume.

Motz and Usachev remained unconvinced that this plan was the most efficient, but Smith appealed to the chairman to let the

centers decide this issue themselves. The Chairman asked if the committee had objections to this and no further comments were made on the subject.

Smith inquired about current coverage and asked if the interlocking dependability of the system upon all centers was perhaps a weakness. Lemmel stated that coverage was very good at this time and he felt that the interdependence and cooperation of various centers was really a strength and not a weakness. Tubbs reassured the committee that CCDN was planning very carefully to protect the CINDA operation during its planned conversion to new computer equipment.

In response to a question, Schmidt and Lemmel estimated that the total reader and center effort to support CINDA was very nearly 6 FTEs (full-time-equivalents). There were no figures available on the estimated costs for CINDA operations and it was noted that this operation is closely connected with EXFOR and is not separately manned at NDS.

II.C Data Tagging and Flagging in INIS

Lemmel reported that a meeting took place with representatives from INIS and from neutron data centers (NDS and NDCC) in April, 1976, to discuss the topic of data tagging and flagging in INIS such that data centers could make better use of the INIS system.

It is the understanding of the data centers that they must continue to scan the more important journals and report series, but that INIS retrievals could be of great value to become aware of data published in theses, exotic report series, and rare journals. For this purpose, NDS has used INIS retrievals for several years. However, the INIS retrievals contain too much "noise" since the INIS retrieval facilities had not been designed for nuclear data. At present, an external INIS specialist is working out a proposal which will be reviewed by an INIS Liaison Officers

Meeting and this will be tested by selected INIS centers and data centers.

Lemmel stated in response to a question that the practical functional overlap between Nuclear Science Abstracts and INIS with CINDA was not very great and a merging of such funtions would not be very productive. Lemmel believed that the Technical Information Division experience at Oak Ridge under Whitehead had verified this in the U.S. On the other hand, the overlap between EXFOR and CINDA is extremely high since one is the actual data and the other the reference for such data. Lemmel stated that the U.S. decision to combine these two operations at the NNDC at Brookhaven was, for this reason, quite successful. Nevertheless, INIS is and can be very useful with respect to obscure or rare journal publications because its coverage is so comprehensive.

Usachev submitted a "Proposal for the Linking of INIS with Data Compilation, Analysis and Dissemination Centers," the English translation of which was provided by IAEA and is included in Appendix II.C. The main thrust of this proposal is to inform readers of INIS output that certain special data centers exist which are correlated with the retrieval in a particular search. Thus, for example, if a keyword search on "neutron cross section" were made, the reader would obtain in his output a list of the neutron cross section data centers and information as how he could contact them for further information. Thus the INIS retrieval would be cross-linked with the data centers. This is a simple proposal in that the special data center information would be automatically read out along with its particular set of keywords for which it would be correlated. The INIS system would treat this added information as if it were only an extra reference being retrieved. Schmidt and Lorenz agreed to discuss this proposal with the INIS representatives including Dr. Beniaminov who was present at the discussion.

II.D. EXFOR Development

EXFOR, the data center exchange format, and its relation to various data categories is discussed in INDC(NDS)-85LNA and was further reported by Lemmel as follows:

> The neutron data centers committed themselves to the "EXFOR agreement" to compile all experimental neutron nuclear data measured since 1969 and to transmit them in the EXFOR format. This has been done to a rather good, though not yet fully satisfactory degree of completeness. Pre-1970 data are available in EXFOR format by automatic or semi-automatic conversion of the old files (SCISRS, NEUDADA, DASTAR). Mistakes and gaps in the old files are gradually being corrected. Thus, in principle, all neutron nuclear data have been transmitted in EXFOR format. However, the completeness of these data is restricted by the limited manpower available. NDS is still working on a backlog accumulated in the 1973/74 period when several Nuclear Data Section posts had to be kept vacant.
>
> Priorities arranged according to data type have been agreed upon. Whereas cross-sections and resonance-parameters are fairly complete (to about 90%), in particular to achieve completeness in the forthcoming NNDC publication of BNL-325, other data types such as neutron-capture-gamma spectra and fission-product yields were still much neglected and are only about 20% complete.
>
> It should be noted that data users in OECD countries do not directly use or see the EXFOR format but rather see CSISRS or NEUDADA output formats, which are EXFOR compatible.

Lemmel stated that the EXFOR system is now in smooth routine operation during the past year and that a lot of essential improvements had been implemented, in particular, easier compilation of complex data sets such as double differential

cross sections and resonance parameters. At the same time the system was generalized so that it can now include types of nuclear reaction data other than just neutron data.

Smith commented that although the EXFOR system seems to be significantly improved for center-to-center communications, what was happening to help the users to obtain data in a more useful form? Lemmel stated that the user formats into which EXFOR is transformed for user use is up to the local data centers. He agreed that somehow the double-differential cross sections seem to have been neglected in the U.S. system and seem to be better handled in the European NEUDADA format. The U.S. activity, on the other hand, has very advanced systems for evaluation of processed EXFOR data at the NNDC center. This ability is particularly important to the NNDC in preparing publications like BNL-325 and BNL-400. CCDN and NDS have developed a common and useful printed listing of EXFOR information, a sample of which had been sent to Smith because of his interest in the Dresden double-differential data. This transformation has not been available at NNDC at Brookhaven only because of their different computer requirements. Smith thanked the NDS for the Dresden data transmission and said it was extremely useful and well done, but it was, unfortunately, an exception. Smith asked that if EXFOR is a stable system, why is not more user oriented development being undertaken by the centers? Ms. Attree replied that the definition of EXFOR is now stabilized as of the last Four Centers Meeting in April, 1977, but now all centers had to implement this agreed upon scope. Now fewer ad-hoc modifications to EXFOR would result and a concentration of more stable programming for a generalized EXFOR would be undertaken. This will involve expanded checking programs, expanded editing programs and severe modifications to the indexing system, and then the centers would proceed with computation formats. Froehner and Smith inquired about the extent of the perturbation to EXFOR caused by the inclusion of charged particle data. The necessary changes were made in order to accommodate new data categories and new parameters which were necessary for charged particle data. If

A+M data were to be included at some later time, it was recognized that considerable additions to key words to describe yet new properties would certainly have to be included for an A+M experimental data base. No plans for such a new data base are now being made.

II.E.1. Status of Neutron Data Compilation

Smith and Liskien emphasized that the overall quality and completeness of data files, even for the most crucial reactions and for standards, leaves much to be desired.* Smith cited the fission cross sections which had to be summarized and plotted for the 1976 ANL Meeting. Liskien mentioned the case of ^{10}B. They appealed especially for the results of these detailed efforts at ANL and Geel to improve the files to be used by the centers and not lost. It was also felt that the centers should somehow collectively manage to improve the situation. One of the confusing details is that early data were always compiled as a cross section set even though the original data were stated as a cross section ratio. Not only are the original ratio values thus lost (especially when the reference cross section changes!), but the important errors of the ratio are difficult or impossible to obtain from the tapes. Currently, this sort of problem is supposed to be cleared up by the usual experimenter's review of the preliminary read out before the data are distributed by a center. Unfortunately, this type of quality control is not perfect and leads to a number of confused data sets. Smith and Liskien agreed to assemble a list of problems encountered in their individual experiences and to make these comments available to the committee and to the appropriate centers.

Liskien expressed concern that the entire neutron data center system and its many users seem to rely almost completely on the BNL-325 publication for its general information base in the form of hard copy. The highly selective and very

*See IX.A, page 38.

limited size of the graphical plots left much to be desired. Smith responded that this format had been subject to much debate and indicated that, although some compromises on completeness and size must obviously be made, the U.S. representatives were most willing to convey suggestions and comments on these matters to see what improvements might be made.

Usachev appealed to the committee members and to the data centers to persuade experimenters to submit detailed point data to the centers and not merely convenient averages. He felt that the centers are often content to compile the data exactly as published even though much more point detail might well have been obtained during an experiment. Although it was recognized that all point data cannot be compiled, it was agreed to attempt to obtain complete data in important cases when at all possible. Such an example would be alpha for ^{239}Pu.

Schmidt said that the remaining EXFOR neutron data yet to be compiled amounts to some 10 to 20 percent of the available data. Because of manpower considerations, it is necessary to determine priorities for these remaining data. An action on the NDS was assigned at the Four Centers Meeting to list the highest priority items. Neutron capture gamma-ray spectra, for example, will receive low priority. Schmidt asked for comment on this and offered to send the participants the priority list for their consideration.

II.E.2 Evaluated Data

Lemmel noted that a comprehensive listing of the evaluated data available from NDS can be found in CINDU-11. There are now a large number of general purpose evaluations as well as special purpose libraries of evaluated data. Since CINDU-11 was issued, a number of libraries have been revised (e.g. KEDAK, the Livermore Library) and others have been supplemented (e.g. SOKRATOR, the Bologna Library), so that a

supplement to CINDU-11 is in print.* NDS has recently received a fission-product data library prepared by the Skoda works in Czechoslovakia and expects to obtain some new elements of ENDF/B-V in the near future.

Users of these data for reactor purposes are the East European countries, the South Asian countries from Iraq via Iran, Pakistan, India, Bangladesh to Thailand, Republic of Korea, the Philippines, Australia, South Africa, Israel, some of the Latin American countries. Many of them need not only the data but also further advice for data handling, and it is hoped that the new NDS post foreseen for 1978 will allow more emphasis to be given to render such advice. More emphasis must also be given to finding and maintaining contacts with data users in other fields such as various applications of activation analysis, etc.

NDS is compiling some evaluated data in a special EXFOR series when these data are important and not available in other computerized formats. For example, the Riga dosimetry library was distributed in this way.

Rowlands suggested that a comparison of different evaluations would be valuable. It was not clear how much of such work could be accomplished by the centers, but certainly some coordination and encouragement might help. In order to formulate this possibility, an INDC Recommendation was formulated and later approved. This Recommendation is given in the Appendix.

*Supplement 1, April 1977.

III. OTHER NUCLEAR REACTION DATA

III.A. Status of Charged Particle Nuclear Data Compilation and Dissemination

Lemmel summarized the CPND effort which involves only coordination and dissemination activities at the NDS. The most important data are integral cross sections or yields and these data are compiled now mainly by the centers KACHAPAG at Karlsruhe and CAJaD at the Kurchatov Institute in Moscow. These data are supplemented by the charged particle data index produced by NNDC in CINDA-type format and will be published regularly. The NNDC also plans to compile some detailed and unpublished U.S. data files. Microscopic data have been discussed and differential data will probably be compiled in EXFOR format. Japan has stated an interest in such a compilation of Japanese data, which may later be expanded into some high-priority areas. Poland and India have also expressed some interest in such data.

Rose mentioned the needs for data related to applications in the field of surface analysis and said that Dearnaley at Harwell was attempting to produce a user-oriented compilation or handbook. Smith inquired as to the level of effort for CPND and the real needs of users and questioned if the effort was aimed at and matched to the important areas of need. The NNDC is trying now to evaluate user requirements. Schmidt responded that the Karlsruhe effort had started as a national effort, but he agreed that it was proper and timely to ask the centers to analyze the user needs and estimate the corresponding level to support these needs. Such an inquiry should aid in outlining appropriate user oriented compilations that would be both useful and generally available. Actions were placed on Schmidt and representatives of countries having data centers to consider the CPND activities as related to user needs.

III.B. Photonuclear Data

Lemmel noted that EXFOR can now incorporate photonuclear data and NNDC is entering parts of the Fuller data library. Abramov is also considering a similar activity at Obninsk. It was noted that the Berman Atlas of photonuclear data, UCRL-7842, has been issued in a new edition and a supplement to the Bibliographic Index of Photonuclear Reaction Data (NBS SP-380) is also in preparation. The U.S. has transmitted the LLL/Berman photonuclear data library on tape to Vienna, as noted in CINDU-11, page 38.

IV. NUCLEAR STRUCTURE AND DECAY DATA

Lorenz outlined the internationally coordinated mass chain evaluation effort as described in INDC(NDS)-85/LNA, pages 41-44. The NDS is functioning as the international coordinating center for the many centers involved in this work and is maintaining a referral service for NSDD. Two issues of the Compendium of Compilations Nuclear Structure and Decay Data and Evaluations have been distributed (INDC(NDS)-80/LN and -83/LN). The present status of the interim agreement on international cooperation for mass-chain evaluations is given in the Appendix. The efforts involve five centers in the U.S., which are committed to about 2/3 of the effort, and seven centers in seven different countries who have tentatively agreed to the remaining third. Smith showed a summary of the isotopes which have now been entered in the Nuclear Data Project files at ORNL which was quite impressive.

Kulakov mentioned a number of activities in the USSR including the 27th Conference on Nuclear Spectroscopy held in Tashkent, 22-25 March, 1977. The abstracts for more than 700 papers are available in the proceedings of this meeting. Included in these is a comprehensive review of some 100 nuclides by Karnov. The full manuscript for this work is expected in 1977.

Detailed isotopes covered are listed (in INDC/P(77)-10T which is reproduced) in Appendix VI.A.

A meeting of the NSDD centre network was planned to be convened at the Oak Ridge National Laboratory November 14-18, 1977.

V. ATOMIC AND MOLECULAR DATA FOR FUSION

The Chairman gave a brief introduction to this topic. The original request that this new area be considered by IAEA came from the International Fusion Research Council, IFRC, and this question was discussed during the 8th Meeting of the INDC. Because of the NDS experience in data compilation the question was put to the INDC in spite of the Committee's somewhat limited expertise in A&M data. At its 8th Meeting the INDC agreed to an initial trial period of two years and suggested that a Joint IFRC/INDC Subcommittee be formed to monitor this new activity. This Joint Subcommittee had now met twice.

V.A. Report of the Culham Meeting on A&M Data for Fusion

The first international meeting on Atomic and Molecular Data for Fusion held by IAEA/NDS at Culham in November, 1976, is reported in INDC(NDS)-82/GB issued in February, 1977. A summary of this meeting appears in INDC(NDS)-85LNA, page 16.

V.B. Status of the IAEA A&M Data Program

Beaty reported that the three professional staff (Beaty, Seamon and Katsonis) have been with the IAEA Vienna for periods varying from a few weeks to a few months. Two main areas of effort have been defined: the publication of a Bulletin on A&M Data for Fusion and the generation of a Data Index. The first Bulletin was available in draft form (it was later issued in July, 1977). The Joint Subcommittee had asked that the scope of the Bulletin be limited to topics considered directly relevant

to fusion. This closer limitation of subject matter was yet to be done before the first publication.

The Index is planned to cover data in a CINDA-like format and available information from several existing centers is to be utilized. These centers are: The Controlled Fusion Atomic Data Center at the Oak Ridge National Laboratory; the Atomic Collision Cross Section Information Center of the Joint Institute for Laboratory Astrophysics, JILA, at Boulder, Colorado; the Plasma Physics Laboratory at Orsay, France; and possibly the Queens University Center in Belfast, Ireland. Although tapes will be available from all four of these centers, a considerable amount of review and selection of appropriate material will probably be required. It is expected that the new centers in the USSR and Japan will also contribute to this effort.

No plans are presently being made for actual data compilation and no changes to compilation systems like EXFOR are envisaged during this initial phase. Concerns were expressed that, if data compilation were to be included, it should be carefully considered and should not affect the neutron data compilation activities of NDS.

V.C. Report from the Joint IFRC/INDC Subcommittee

The preliminary version of the Conclusions and Recommendations of the May 14 Meeting of the Joint Committee was distributed and is included in the Appendix V.C-2. It contains 11 points which relate to the A&M effort in the NDS. Also in the Appendix is a list of the attendees of that Joint Subcommittee Meeting. (The Official Minutes of the May 14 meeting were later issued as INDC(SEC)-63/GA.)

Schmidt iterated that the Subcommittee stressed the necessary selective nature of the Bulletin and of the Index. In the case of the Index, for example, a general atomic Index would probably be up to four times as large as CINDA 76/77, whereas an

index limited to fusion-related data would probably be more like one-half of CINDA 76/77. This is, nevertheless, a sizable job and requires careful and knowledgeable selection of the available information mentioned by Beaty, as well as of new publications.

The most crucial parts of the Subcommittee report, and the subsequent INDC discussion, evolved around the need for additional staff during the trial period, point # 5, and the necessary conversion of temporary to permanent staff, point # 11, if the A&M effort is continued. Point # 5, the addition of two temporary staff, required a statement of support by October 1, 1977, if Schmidt was to defend it to the IAEA Administration. It was not clear to the INDC, as well as to the Joint Subcommittee, what the justification and need for additional temporary staff was at the time since the program and scope were just being formulated and outlined. Similarly, since the program was just beginning, it was not clear how the INDC could, at this time, endorse a continuation of the program on a permanent basis when it was just in the initial stages of operation.

The Chairman asked that the three Joint Subcommittee members present (Mehta, Decker and Fuketa) along with an NDS representative (Schmidt) prepare a draft INDC paper on these matters. This was accomplished later in the meeting and the approved version appears in Appendix V.C-3.

The INDC did not want to impair the possibility of continuing the program but at the same time felt it could not give its full endorsement to permanence until the latter part of 1978 (# 11). It was agreed that the additional temporary staff matter (# 5) should receive detailed attention by the NDS and a written justification be distributed to the Joint Subcommittee and to the INDC and IFRC Chairmen as soon as possible. INDC members would be asked to respond. A schedule was worked out so that Schmidt could have the required response before October 1, 1977, as reflected in the Actions.

The terms of reference for the new Joint Subcommittee had not been formulated during the last INDC Meeting and had been arranged by the past INDC Chairman, Gemmell, and the IFRC Chairman at the time, Pease, and by Schmidt. There had occurred a real possibility that the Joint Subcommittee would, in the natural course of its business, want to interact with other organizations. Cross, as INDC Chairman, wanted to ensure that this sort of action be done through the IFRC and INDC Chairmen and that the Joint Subcommittee did not bypass its parent committees. This was addressed in point # 8 and agreed to during the Joint Subcommittee Meeting and at the INDC Meeting.

Underlying this entire matter are several basic points which tend to complicate the INDC considerations:

- Timing is crucial in budget defenses, but some reasonable time period is required to establish a program before it can be defended,

- The eventual justification and detailed definition of this A&M effort falls primarily on the fusion community itself and thus upon IFRC,

- The INDC is most willing to cooperate in any way that it can do so, but at the same time it has a responsibility to ensure that the neutron data efforts of NDS are not impaired.

The committee expressed a sincere desire to balance these issues as best it was able to do, but at the same time recognized that a difficult situation was developing.

VI. PROGRESS REPORTS

Participants received a preliminary version of the Consolidated Progress Report for 1976 on Nuclear Data Activities in the NDS Service Area, INDC(SEC)-61/L. Detailed reports from Bangladesh, Bulgaria, Hungary, India, Israel, Pakistan, Romania and South Africa are contained in that document.

The Chairman requested that all countries try to limit their remarks to relevant items not already available and that any remarks be given to the Executive Secretary in writing. The accuracy and completeness of the following entries tend to reflect these considerations.

AUSTRALIA

In Gemmell's absence, the Chairman reminded the committee that the Australian Progress Report for the period 1 Oct., 1975 - 30 Sept., 1976 had been issued as INDC(AUL)-26/G.

CANADA

W. Cross distributed a detailed account of recent work (INDC(Can)-18G) included in which were the following items:

^{59}Ni(n,α) Reaction: Measurements of the ^{59}Ni(n,α) thermal neutron cross section have been repeated using a "^{6}Li-free" surface barrier alpha detector and the data do not confirm the presence of additional peaks at 0.9 and 1.82 MeV as reported by McDonald and Sjostrand. However, the low energy background continuum observed with the α detector made it difficult to resolve statistically low-intensity peaks at energies below 2 MeV; the source of the background continuum was γ rays from neutron capture in surrounding materials. A better signal to background ratio could be obtained using an external neutron beam from the NRU crystal spectrometer.

Thermal Neutron Cross Section for ^{125}I: The activity depletion method was used to measure the thermal neutron capture cross sections for ^{125}I and ^{131}I, ion-implanted into super-pure Al foils. ^{131}I was chosen as an experimental control because it

should show little activity depletion. The integrated neutron flux was determined by measuring the ^{60}Co production in 0.1% Co in Al wires. Irradiations in the NRU reactor for about 33 days gave an integrated flux of 7.3×10^{20} neutrons/cm^2 with depletion ratios of 2.2 for ^{125}I and 1.037 for ^{131}I. Calculated cross sections based on these depletion ratios are 1030 $\pm$ 300 barns for ^{125}I and 85 $\pm$ 50 barns for ^{131}I. The measurements will be repeated using an improved system.

Thermal Neutron Capture in ^{16}O: The thermal neutron capture cross section and the gamma-ray branching ratios for the $^{16}O(n,\gamma)^{17}O$ reaction were measured in a coincidence experiment with two Ge(Li) detectors. H_2O and D_2O targets were used. Gamma rays of energies 870.89 $\pm$ 0.22, 1087.88 $\pm$ 0.17, 2184.47 $\pm$0.12 and 3272 $\pm$ 1 keV were observed in the singles and the coincidence spectra. The branching ratios of the M1 transition to the 871 keV $1/2^+$ level and the E1 transition to the 3055 keV $1/2^-$ level were determined to be (18 $\pm$ 3)% and (82 $\pm$ 3)% respectively. A total capture cross section of 202 $\pm$ 27 μb for the $^{16}O(n,\gamma)^{17}O$ reaction was determined relative to the $D(n,\gamma)T$ reaction cross section of (521 $\pm$ 9 μb). The measured branching ratios and the capture cross section for ^{16}O are in good agreement with the M1 branching ratio (19%) and the total capture cross section (178 $\pm$ 25 μb) reported by Jurney and Motz.

^{237}Np Dosimetry Corrections: While $^{237}Np(n,f)$ is a particularly useful threshold reaction for neutron dosimetry, its sub-threshold cross section is large enough to affect dose measurements in a spectrum containing a substantial low-energy component. To simplify the correction of measurements in such spectra, the recent cross section data of Plattard et al. and others, between 1 eV and 200 keV, were fitted by an analytical function of energy, in a manner similar to that used to fit cross sections in the MeV range. This expression was used to derive mean cross sections of spectra of fission neutrons transmitted by various thicknesses of H_2O, D_2O, Fe, Cu, U and concrete. For most of these spectra, the contribution of sub-threshold fission is less than 3% but, for neutrons transmitted by heavy elements and then

moderated by hydrogen, it can exceed 10%. The calculated resonance integral, between 1 eV and 100 keV, is 0.28 barns.

FEDERAL REPUBLIC OF GERMANY

The recent report for Jan., 1976 to March 31, 1977 has been issued as INDC(Ger)-19/L.

FRANCE

Evaluation of fission products is being completed at Cadarache in cooperation with CNEN Bologna and information on 21 fission products will be presented at the Petten Meeting in September, 1977. Results from the irradiation of fuels in the fast fluxes at Phenix and at Rhapsodie are also being incorporated into these studies. Microscopic evaluations are also being made for ^{237}U, ^{239}U, ^{237}Np, ^{239}Np, ^{236}Pu, ^{238}Pu and for the heavier transactinides of americium and curium. It has been found that adjustments to decrease the fission cross section of ^{241}Am of around 40 to 50% are necessary.

The activities at Bruyeres le Chatel have been issued in INDC(FR)-14/L for the year 1976. Recent work includes n,2n reactions on ^{203}Tl, ^{205}Tl, $^{206,207,208}Pb$ and ^{151}Eu; fission cross section measurements of $^{235,238}U$ at 13.9 MeV and the kinetic energy of fission fragments from ^{232}Th at 1 MeV. Boldeman's work at Australia and Bruyeres le Chatel involves further corrections to $\bar{\nu}$ for ^{235}U and is to be published soon in Nuclear Science and Engrg. (Vol. 63, 430, 1977). Additional results are available on Th, U and Pb isotopes from 5 to 13.5 MeV. Evaluations have been made on Tl, Th and U, Au isotopes, Sm, Nd and C, which has been extended to 14 MeV.

GERMAN DEMOCRATIC REPUBLIC

Elastic and inelastic neutron scattering at 3.4 MeV have been completed at the Technical University in Dresden for about 50 nuclei; some results were reported at the Kiev Conference and the

remaining data will be published soon. Similar work at higher energies (6-12 MeV) has been started at the new tandem accelerator using 8 detectors at 4 to 9 meters with approximately 1 ns resolution in time-of-flight work. Studies of the p,n reactions on ^{55}Mn, ^{59}Co, ^{115}In and ^{109}Ag have also been reported recently. Measurements on the absolute fission cross sections of ^{235}U and ^{238}U in the 3-15 MeV energy range have begun; at 14 MeV the associated particle method has been used.

Evaluation on Nb data have been completed and a general comparison of various evaluated data files is being made graphically and with some interpretation of the physical reasons involved in the various evaluations. A library of neutron data has been organised at the Technical University in Dresden with some assistance from the NDS/IAEA.

Decay measurements are underway in Rossendorf and a library of nuclear structure and decay data has been established at the Center of Isotope Techniques in Leipzig.

The annual Nuclear Research Report will be issued and distributed in 1977.

INDIA

A. Measurements and Evaluation

$^{232}Th(n,\gamma)$ cross section: Our first effort at measuring the capture cross section on ^{232}Th is aimed at trying out the technique with a view to determine the limitation of the method. The measurement involves the ratio of intensities of the 459 and 620 keV gamma rays following the β-decay of ^{233}Th to the 412 keV gamma ray from ^{198}Au with a 27 c.c. Ge(Li) detector, and were carried out at neutron energies of 350, 460 and 680 keV utilizing $^{7}Li(p,n)$ reaction with our Van de Graaff. The results were consistent with an estimated absolute error of $\pm$ 15%. The improvement and modification in the technique are now underway to reduce the error to less than $\pm$ 10%.

The (p,n) reaction cross section measurements: With a view to extend this programme to higher mass numbers the cross section

measurement for ^{80}Se (93% enriched) has been carried out. These cross sections measured at subcoulomb energies as nuclides in the mass range 45 to 80 for ten nuclides, seven of which were measured at Bombay are being used to obtain one consistent set of proton optical model parameters at these energies. An attempt is made to obtain neutron optical parameters from these and to see whether they can be used to fit available neutron data. Part of this was reported at the Lowell Conference. Only ^{51}V, ^{55}Mn, ^{59}Co data were used in this work. It gave good results for the total neutron cross section.

The $^{19}F(\alpha,n)$ cross section has been analyzed in terms of the resonance parameters, strength functions and associated statistical model quantities. Work has started compilation of (α,n) reaction cross sections up to 6 MeV on nuclides up to mass 40.

Fission: Studies of fragment kinetic energy and mass correlation for thermal fission of ^{235}U have been carried out. Shape isomer excitation at 14 MeV neutron bombardment has been studied.

Evaluation: A new semi-empirical nuclear level density formula has been developed which has been used in predicting the shape isomer yield for neutron bombardment of uranium isotopes. Considerable effort has been devoted to cross section prediction and evaluation for ^{231}Pa, ^{233}Pa and ^{232}U as well as binary and ternary reaction cross section for structure material. Similarly the work reported from Reactor Research Centre Kalpakkam is all oriented towards data evaluation.

Following the TND Consultants meeting in Vienna in December, 1976, a working group has been formed to take up the data evaluation work on Th. A preliminary literature survey based mainly on CINDA is almost completed. A research contract is being requested in order to increase and stabilize this effort.

B. Facilities

The Variable Energy Cyclotron Project at Calcutta is now in its final phase. After completion of the RF power tests, beam hunting has started. The construction of the building for the 100 megawatt research reactor has started.

ITALY*

A. Measurements

Neutron transmission and capture measurements in ^{156}Gd, performed at the electron Linac of Geel have allowed estimates of energy and neutron widths of the resonances up to 3 keV with a very low Γ_n observability threshold. A method of analysis of these data has been developed which exploits the statistical properties of the level sequence to obtain reliable estimates of the level density and of the s-wave and p-wave strength functions. The significance of testing the statistical model on experimental sequences of resonances is also studied. Data analysis is in progress.

Data analysis on ^{165}Ho was completed and a paper is being written for publication. The main result is that, in the interval 0-2000 eV, the spin dependence of the neutron strength-function in ^{165}Ho + n is very weak. No convincing energy dependence of the strengths is apparent beyond statistical fluctuations.

Primary capture γ-rays have been studied for 38 neutron resonances in ^{177}Hf with energies in the range 1-165 eV. Intensities were measured for 29 transitions ending at states with an excitation energy in ^{178}Hf up to 2050 keV. The analysis was facilitated by the previous knowledge of the spin and parity of all neutron resonances and of most low-lying states. For nine final levels which had not previously been seen, information of J and π was deduced from the corresponding average intensities. A comparison of this value for the E1 strength with those reported for other nuclei with $A \geq 100$ showed that the intensities follow the A-dependence predicted by the Brink-Axel model. A non-statistical effect was observed, consisting of an enhancement of E1 transition probabilities to K = 2,3 final states as compared to K = 0,4 states.

*See INDC(ITY)-2/G.

Neutron transmission experiments have been performed at the Geel electron Linac on ^{91}Zr and ^{96}Zr enriched samples in order to obtain accurate measurements of resonance parameters below about 10 keV. The research, in parallel with a capture measurement carried on by an Euratom group with the same accelerator, is motivated both by the importance of Zr cross sections in reactor technology and by the interest of the physics of that nucleus. The experiment was carried on a 100 m flight path. Shape analysis of resonance transmission dips is in progress for ^{91}Zr, using an original computer code; the analysis is completed up to 5 keV.

Integral capture cross-section measurements of α^5, Fe, Ni, Cr and SS by using the null reactivity method in the coupled fast-thermal RB-2 reactor in Bologna were completed. In addition, reactivity worth measurements for the same structural materials plus Ti, Mn and Mo were performed. The analysis of the experimental results and the comparison with predictions based on ENDF/B-IV are underway.

B. Evaluations

Complete evaluation and compilation in ENDF/B format, in the energy range 10^{-5} eV - 15 MeV, of the following isotopes: Y-91, -92, -93, -94, -95, -96; Nb-95; Ru-100, -106, Pd-104, -106, -108, -110; In-115; La-139; Ce-140, -141, -142, -144; Pr-143; Nd-144, -146, -147, -148, -150; Eu-154, -155; Gd-156, -157; Tb-159. Each file contains resolved and mean resonance parameters, relevant cross sections (i.e. total, elastic, inelastic, n-2n, n-γ, n-p and n-α), angular and secondary energy distributions. Twenty-five group cross sections in CARNAVAL format at infinite dilution and $0^{o}K$ temperature have been generated for each evaluated isotope.

JAPAN

Facilities

A report, "Construction of 20 MV Tandem Accelerator Facility," of JAERI has been distributed. News of the Tandem Laboratory will now be published twice a year.

Three MeV Pelletron accelerator at Tokyo Institute of Technology was completed in this March. It is used for heavy-ion and neutron physics research.

A 500 MeV-100 kW electron linac is proposed to be installed in Tsukuba Site of the Electrotechnical Laboratory. It will be used for generation of high intensity secondary radiations such as π-mesons and the electron injection to a SOR (Synchrotron Orbit Radiation) ring. A broad range magnetic analyzer has been designed.

JAERI's 100 MeV Linac has been suffering from deterioration of the accelerating tubes, but improvement has almost finished and higher performance is expected.

Several reports of interest were presented at the Nuclear Data session of the April, 1977, meeting of the Atomic Energy Society of Japan:

- Statistical model calculation of the charge distribution of fission fragments,
- Evaluation of the neutron cross section of ^{6}Li,
- Calculation of the gamma-ray production cross section and gamma-ray spectra of Al, ^{40}Ca, ^{56}Fe, ^{93}Nb and ^{181}Ta by fast neutrons,
- Measurements of the activation cross sections of Zr and Mo isotopes by 14.6 MeV neutrons,
- Calculations of the (n,p) cross sections by 14 MeV neutrons taking both compound and pre-equilibrium processes into account in the mass region of about 90 to 200,
- Theoretical evaluation of the (n,p) cross sections of fusion reactor material such as V, Fe, and Ti in the energy region up to 20 MeV,

- Measurement of the fusion cross section of $^{6}Li(p,^{3}He)$ reaction in the energy region of 80 to 350 keV,
- Self-indication benchmark experiments on the resonance parameters of ^{238}U made at RPI,
- Resonance parameters of ^{238}U,
- Neutron transmission and capture measurements of ^{159}Tb,
- Neutron capture cross section measurements of ^{151}Eu and ^{153}Eu, and
- Measurements of cross section minima of Si (at 14.7 keV) and Fe (at 24.3 keV).

Benchmark tests of JENDL-1 have been made. In these tests, 21 international benchmark cores, 13 cores of the JAERI's Fast Critical Assembly, and 8 cores for doppler coefficients were chosen. The results were fairly satisfactory for K_{eff}, central reactivity worths, and doppler reactivity coefficients. But, the fission cross section of ^{239}Pu and the iron cross section need to be reexamined. Detailed analysis on Cr, Fe and Ni and their data evaluations will be reported at the Geel Meeting in December. The JENDL-1 magnetic tape will probably be released in a few months.

At the Fast Critical Assembly of JAERI, measurements of neutron spectra angular dependences from a Li assembly irradiated by 14-MeV neutrons have been made recently. Analyses with ENDF/B-IV data show discrepancies between the experiments and calculations in the energy range of 2-13 MeV. Analysis is a rather fine one using the U.S. code NJOY, and the problem seems to be in the non-elastic data in ENDF/B-IV. There is a similar discrepancy for a graphite assembly, and more generally, improvements of the non-elastic data for light elements seem to be necessary.

A Chart of the Nuclides has been published by JAERI. Some of the special features of this chart are the estimated half-lives and tables for gamma-ray intensity standards.

SWEDEN

The Neutron Physics Laboratory at Studsvik, which has belonged to AB Atomenergi, will as a result of a reorganization effective from July 1, 1977, belong to the Swedish Research Council's Laboratory. The present research program, which includes neutron physics, decay heat measurements and heavy ion bombardment of different materials for first wall CTR studies, will for the near future continue as before.

The program on fission product decay data at the on-line OSIRIS facility of the Swedish Research Council's Laboratory will also continue. Results of measurements of the total beta decay energies for some 50 nuclides are summarized in a table on page 40 of the progress report. Furthermore, a survey has been made of delayed neutron spectra of 25 precursors in fission (INDC (SWD)-9/G+P).

At the Reactor Division of AB Atomenergi, a group cross section library for the actinides has been prepared based on data from Savannah River. Along with this work there are plans to compile and compare evaluated data for about 15 actinides. This compilation work has not yet been funded.

At the newly installed 6 MeV Pelletron tandem accelerator at the Lund University, measurements are underway of capture cross sections with an improved activation technique. Measurements have been made at 14.7 MeV for ^{115}In, ^{127}I, ^{186}W and ^{197}Au and are underway concerning the energy dependence of the capture cross sections between 1-10 MeV for ^{197}Au and ^{238}U.

At the Tandem Acceleration Laboratory at Uppsala, measurements have been made of the gamma ray production cross section for oxygen between 7 and 10.5 MeV. The results indicate that the inelastic cross sections for oxygen in the ENDF/B IV file are low by about 50% in this energy region. Furthermore, a measurement is in progress of the $^{6}Li(n,\alpha)$ cross section relative to the (n,p) or (n,d) scattering cross section up to about 5 MeV by recording the outgoing tritons and α-particles. In parallel a measurement is underway of the inverse reaction $T(\alpha,^{6}Li)n$ by recording the outgoing ^{6}Li ions.

As a part of a program to study few nucleon reactions the n-d elastic scattering cross section at 180° has been measured with high precision (~1%) at 8 MeV and an angular distribution at 10 MeV. The results have been compared with recent three-body calculations.

The Ni-59 2200 m/s (n,α) and (n,p) cross section values measured by Sjöstrand et al. at the Chalmers University of Technology have been revised due to a recalibration of the ^{6}Li reference foil used in the experiment. The new values are now 11.3 ± 1.0 and 2.0 ± 0.6 barns, respectively, in good agreement with most other measurements.

U.K.

Facilities

The old linear accelerator at Harwell was closed down for neutron physics in November 76 but the schedule on the replacement machine has slipped by about six months, so that full operation is not expected much before the end of 1978. The old boron pile which was transferred to NPL over ten years ago is now being reassembled for more precise neutron source measurements.

Progress

Measurements on the fission and capture cross section of Am-241 have been made in the energy range 50 eV to 10 keV. The results are in general agreement with the old accelerator results of Bowman et al. and recent ones of Weston and in strong disagreement with bomb-shot data except over a limited range of low energies. In this connection it is interesting to note that half the neutrons from the sample, a considerable source of difficulty in the experiment, arose from α-n reaction in a 0.1% fluorine impurity.

Analysis is virtually complete of some 85 ($l > 0$) resonances of natural and isotopic nickel.

The experiment on the inelastic scattering of neutrons by U-238 is now complete and being prepared for publication. The

cross sections appear to be significantly lower than those of other workers and the departure from ENDF/B-IV is not great, except perhaps at the lower end of the neutron range.

A multigroup data library is being prepared to enable assessments of transmutation, activation and afterheat in fusion reactor structures to be carried out.

Assessment studies of nuclear incineration are continuing. As an aid to such studies, calculations have been carried out of the effective half-lives of mono-isotopic "fuel" in a thermal and a hard spectrum reactor averaged over the incineration time. All dominant higher actinides in waste burn up much more rapidly in a fast than in a thermal reactor, and faster than Pu/U fuel in a fast reactor.

Isotopic production cross section of isotopes of potential medical interest have been measured in the energy region up to 150 MeV for Bi-204, Bi-206, Rb-81 (the parent of the very short lived Kr-81) Rb-84m and Rb-85m.

The variation of fission yield from Pu-239 with incident monokinetic neutron energy has been measured in the range 100-2000 keV and accepted for publication.

Measurements of the Pu-241 half life are continuing without so far resolving any of the present discrepancies.

At the U. of Birmingham, measurements have been carried out of the neutron spectrum in a 1.25 m sphere of LiF with a 14 MeV neutron source at its centre. Close to the source the agreement with calculation is quite good, but at greater distances there appears to be some discrepancy below 200 keV.

At NPL, measurements of Fe-56(n,p), Cu-63(n,2n) and Cu-65(n,2n) have been carried out in the range between 14 and 19 MeV. The preliminary results agree well with ENDF/B-IV. The work was done in connection with the programme on neutron flux standards.

NPL has started a programme jointly with U. of Birmingham on the measurement of W for protons of 0.7 to 3 MeV in H_2, C_2H_2, C_2H_4 and tissue equivalent gas.

U.S.

Smith enumerated the important U.S. meetings and mentioned that the Proceedings and U.S. Progress Reports have been distributed or would be available. These were:

1976 International Conference on the Interactions of Neutrons with Nuclei, July 6-9, 1976, at Lowell, Mass. USA	CONF-760715 -P1 and -P2
International Specialists Symposium on Neutron Standards and Applications, March 28-31, 1977, at Washington D.C.	NBS Special Publication 493
Symposium on Neutron Cross Sections from 10-40 MeV, May 3-5, 1977, at BNL	INDC(US)-78/L
Reports to the ERDA Nuclear Data Committee 1976	INDC(US)-75/U
1977	INDC(US)-77/U
Information Meeting on Accelerator Breeding January 18-19, 1977, at BNL	CONF-770107

Smith and Motz mentioned some work of particular interest:

- ^{7}Li system, via ^{6}Li neutron scattering, at ANL with Geel
- ^{7}Li system studied via the inverse reaction T(α,Li)n at LASL
- Sc and Fe cross section minima measurements at RPI/BNL
- Charged particle emission spectra and cross sections from 14 MeV neutrons at LLL
- Decay heat measurements for ^{235}U have been completed at LASL, ORNL, LBL and IRT Corporation at San Diego. Measurements on ^{239}Pu are underway.

A number of facilities were mentioned:

- Heavy Ion Facility at ORNL under construction
- Superconducting heavy ion linear accelerator planned at ANL
- LASL Intense Neutron Source for radiation damage at 14 MeV
- ORELA, the ORNL electron linear accelerator, being upgraded
- LAMPF, the 800 MeV proton accelerator at LASL, has now operated at 300 A for some hours, and
- WNR, the pulsed neutron facility at LAMPF, has obtained an initial proton beam and neutron targets are being completed.

U.S.S.R.

Usachev mentioned a number of publications that have been distributed since the last meeting or are in the process of distribution. These included:

	INDC(CCP)
Nuclear Constants Volume 20,	
Part I	-86/G
Part II	-87/G
Extracts translated-	
-Fe Evaluation	-90/U
-Nu-Bar 233U, 235U, 238U and 239Pu	-91/U
Nuclear Constants Volume 21	-101/G*
Table of Contents transl.	-103/U
Supplement (Erbium)	-102/G
Nuclear Constants Volume 22	-105/G*
Supplement	-110
Nuclear Constants Volume 23	-106/G*
Nuclear Constants Volume 24	-114/G
Nuclear Constants Volume 25	-115/G
Analysis and Evaluation of Experiment Alpha for 239-Pu by Kolonov	-108
Adjustment of Evaluated Microscopic Data on the Basis of Evaluated Integral Expts	-109/U
Proceedings Third All Union Conference Kiev, USSR, 9-13 June, 1975	-99/G
Fourth All Union Conference Kiev, USSR, 18-22 April, 1977	-113/U
*Table of Content Translations	-103/U

Kulakov reviewed the recent experimental work and this has been distributed as INDC(CCP)-112/LN. The Karnov paper on evaluated decay properties of 100 nuclei should be published in 1977. A request was made for distribution of the Demidov paper on gamma rays from a number of elements irradiated by reactor neutrons. Kulakov said that he would inquire to see if such a distribution could be arranged.

VII. COORDINATING ACTIVITIES

VII.A. WRENDA 76/77 Publication

Lessler presented several options regarding the plans to publish WRENDA in the 1978-80 period. The accepted plan was to omit the publication of WRENDA 78 and to publish the next edition in the Spring of 1979. This will initiate a planned two-year cycle so that the following issue would then be expected in 1981.

The fusion and safeguards requests have been kept separate in the WRENDA issues, in part because they have not had the same review or priority considerations. It was agreed that these requests should now be included in the main body of the report along with the fission reactor requests although a tagging procedure was recommended.

The committee discussed the fact that various specialist committees often generate a timely and often independent list of requests related to the subject of the meeting. While this can be a valuable contribution, it was not felt that such lists should be accepted for inclusion in WRENDA or any supplements unless they received national committee review and endorsement. It is quite possible that such requests could be considered nationally prior to a meeting in some instances, at least if an early warning concerning the required review is made clear to the attendees.

VII.B. Condensations of WRENDA Requests

One of the pitfalls to any formal request procedure is that the natural tendency for the list to grow tends to dilute its purpose and downgrade the most important items. WRENDA is suffering from such expansion and the Chairman noted that there had been a recent NEANDC/NEACRP joint subcommittee to consider the possibility of emphasizing the priority 1 requests for fast reactors. Both Michaudon and Rowlands had taken part in a two-day, six-man European meeting held in March. Since the representatives of only France, Germany and the U.K. were present, the list was not to be made available until it had the

prior approval of NEACRP. The earliest this could be expected would be the June Meeting in Petten. Rowlands and Michaudon accepted an action to ensure that the INDC received copies of this list when it was available for further distribution.

VII.C. Targets and Samples

R. Lessler distributed an updated version of the target requests and orders, four of which are carried over from 1976 but not yet delivered, and six new items for 1977. Considerable delays are being encountered in receiving bids (about six months) and in receiving delivery (18 to 24 months). These delays complicate the budgeting and experimental scheduling, but they appear to be unavoidable. The 1977 budget is $27,000 for this program. This allotment may be reduced to $15,000 in 1978. A. Smith agreed to inquire at ORNL about the delivery problems for these NDS orders, some of which may be related to the technical difficulty of meeting the specifications required.

VII.D. Cooperation between India and Bangladesh in the Measurement of Thorium Cycle Fission Data

No progress to report.

VII.E. Coordinated Research Programs and IAEA Research Contracts

Two programs had been discussed earlier in the meeting. These were:

(i) the suggested NDS evaluation of the actinides, see Agenda Item VIII,

(ii) the coordinated program to compare evaluations (Agenda Item II.E.2)

Another coordinated research program to measure decay properties of the actinides is presented in a working paper given in the Appendix (VII.E). The priority list associated with the working paper was generated at the 1975 Karlsruhe TND meeting and

some questions were raised concerning justification for some entries and whether the accuracy needs given were current. This program will not initiate any new measurements but merely attempt to assist measurers in coordinating their efforts. The necessity of signing agreements or contracts was raised by Smith in the same sense as for (i) above (Agenda VIII). Following these questions, two minor alterations were made in the working paper document and these changes are incorporated in the Appendix version. The committee agreed to this proposed program as stated in the working paper.

VII.F. Other Coordinated Measurement Programs

Fuketa discussed the efforts made to initiate the Korea/Japan cooperative program. Inquiries were made recently but no answer has been received from the Korean Atomic Energy Research Institute. There has been no practical progress on this program to date.

VIII. PLANS FOR COOPERATION IN THE EVALUATION OF ACTINIDE NEUTRON DATA

During the 1975 Karlsruhe Meeting on the Actinides, a suggestion was made that a unified international approach to a complete evaluated nuclear data set might be advisable. A consultants' meeting on this subject was held in Vienna on December 13-14, 1976 (see INDC(NDS)-89/G+Sp). Interest in such a cooperative program has been expressed by a number of countries and a tentative list of evaluation assignments has been agreed upon and is given in INDC(NDS)-89/G+SP.

The Division of Nuclear Power and Reactors of the IAEA had a consultants' meeting in session during the same period as the INDC Meeting and several of these consultants were invited to meet with the INDC to discuss this suggested cooperative program. These were: J. Y. Barré, France, H. Küsters, Germany, C. C. Campbell, U.K. and A. F. Henry, U.S.A. P. Cate of the IAEA Division of Budget and Finance was also present.

Several aspects of the planned program involved IAEA Research Contracts and Research Agreements. Details of these various arrangements were new to many INDC Members. The contracts usually involve some monetary support which is available from the Agency's Research Contract Program, Nuclear Data Section. The agreements, on the other hand, represent an understanding of cooperation and involvement. It is important that either of these arrangements, contracts or agreements, also allows the payment of travel to signatories so that meetings may be organised concerning the associated activities. The NDS Working Paper on this subject contained the following comments:

> Nine countries are definitely interested in the evaluation of actinide neutron cross sections, i.e., France, FRG, India, Israel, Italy, Japan, Romania, UK and the USSR. For many of these countries, actinide evaluations are closely linked to their national reactor projects. For these countries the evaluation of Am, Cm and higher Pu-isotopes forms a high priority in their national reactor programme. However, in view of the complexity of the actinide evaluation task, they wish to emphasize the exchange and intercomparison of

evaluation methods and their results. They are interested in a full exchange of actinide data and desire that by about 1980 a full actinide evaluated data file be built up, for at least the important isotopes. Other countries such as Romania and India are interested in and have partially agreed to share evaluation work on Th cycle nuclides. So far these countries have not had much experience in evaluation and they are interested in a free exchange of information and data. Within the framework of the build up to their own nuclear data libraries, they are interested in learning evaluation procedures and hope to benefit from an Agency supported exchange and from intercomparison with the more developed countries.

Therefore the following cooperative scheme is suggested: The nine countries interested in actinide evaluation are asked to join in an Agency supported "Coordinated Programme on the Intercomparison of Evaluations of Actinide Neutron Nuclear Data." The goal of this programme should be to establish in about 2-3 years a first version of an evaluated actinide neutron nuclear data file. If such a programme is agreed upon it will probably be supported by the IAEA research agreements (without Agency financial support except to attend coordination meetings). Some of the developing countries will apply for IAEA research contracts (with limited Agency financial support). Starting with the ninth month, the contracting countries will be obligated to submit reports every 6 months on the progress of their work. All countries will have to ask for annual renewal of the contracts or agreements. Furthermore the Agency will convene all participants in coordination meetings as the need occurs (normally annually) which would review the results and guide the future direction of the work. It is suggested that, in addition to these meetings the evaluated results be reviewed mutually by the participants and by the last evaluators of the given evaluation.

If this suggested programme is adopted, the Agency will try to make sure that this effort produces a uniform data file with schedules and common rules for the participating groups.

Several basic aspects of the program were discussed at some length. Although NDS is attempting to avoid redundancy in isotope assignments, it was evident from the preliminary lists (see INDC(NDS)-89/G, pages 4-6) that most of the effort is nationally funded and organised and thus will not be "coordinated" in the true sense of the term. Nevertheless, the ability of NDS to potentially involve other countries and to arrange for exchange of information was regarded as valuable and desirable.

A difficult aspect of the proposal is how one can meet the final objective of obtaining a common data file in a reliable and acceptable manner. Schmidt agreed that this objective should not be attempted during the initial three-year phase planned for the program. A less demanding but important mechanism is the use of standard formats between the NDS and participants. It was accepted by all representatives that the ENDF/B format was acceptable for this purpose.

Some questions as to the necessary formality of signing agreements were raised. Schmidt pointed out the advantages of agreements: The program could not only support some travel costs but would have a much more unified and visible position if a core of committed participants existed. Smith and Motz asked if the signed agreements were a requirement or if additional persons could be involved on a non-contractual, voluntary but cooperative basis. Cate and Schmidt responded that, if the country involved desired to send individuals to meetings and be involved in other ways, it was entirely acceptable to the IAEA. In order to ensure that a reasonable possibility would exist for such participation, the committee agreed to include in its recommendation that the NDS would "inform the INDC members and regional data centers on the progress of the program, including status reports and plans for meetings." It is understood that voluntary cooperation and active participation in this program may occur without a research agreement. The complete recommendation is given in the Appendix.

The NDS summary of these INDC discussions appears in INDC(NDS)-89/G, page 18.

IX. REPORTS OF TECHNICAL AND AD-HOC SUBCOMMITTEES

A procedural question was raised during the discussion of when technical reports from the subcommittees would be distributed as G documents. The chairmen of the subcommittees agreed to send contributions to all subcommittee members, the chairman of the INDC, and to the secretariat when they were complete. The NDS will issue this material as a G document within one month of receipt. The deadline for subcommittee members was generally set as June 30, 1977. This information will also be sent to the appropriate subcommittee chairman of the NEANDC.

IX.A. Standards Subcommittee

Liskien reviewed the subcommittee report which is given in the Appendix. The deficiencies of some of the Centers' data files for standards was raised again.* Liskien and Smith agreed to transmit specific problems encountered in recent ^{10}B and fission cross section retrievals. The point was made that the Centers should take a more active and organized approach to this matter of improving the quality as well as the completeness of the standard data files. These problems will not correct themselves and it was recognized that of all areas, standards files should be the most straightforward and trusted. Generally when reviewers find problems with the files, they should let the centers have the information so that improvements can be made.

Whenever discrepant data exist, some special manner for handling such discrepancies must be accommodated during an evaluation process. The general remarks of the subcommittee regarding R-matrix fitting procedures were interpreted by Motz as indicating that the subcommittee found the procedures employed in the n + ^{6}Li reaction unacceptable. In the simplest terms, the subcommittee said that each individual reaction channel must be first separately reviewed and evaluated before the different channels are combined in an R-matrix analysis. Motz expressed

*See II.E.1, page 9.

the view that the converse was more revealing; you simultaneously enter all of the data possible from all the reactions with the best weighting you can perceive and let the physics of the analysis tell you which are the most consistent individual channel estimates. If the analysis procedure is sound, this should be the most comprehensive and thorough approach. The question remained one of fundamental difference and may be decided only in the future by an historical overview.

As noted in the report, tentative consideration will be given to the $^{27}Al(n,\alpha)^{24}Na$ and $^{237}Np(n,f_x)$ reaction cross section as standards.

IX.B Discrepancy Subcommittee

Froehner summarized the discrepancy committee report which appears in the Appendix. Vlasov had suggested that the dosimetry reactions $^{63}Cu(n\alpha)$ and $^{93}Nb(nn')$ be considered. It was agreed that a summary of these proposals would be presented later by Vlasov to the subcommittee for their consideration. A delayed neutron specialist meeting request was forwarded to the Ad-Hoc Future Meeting Subcommittee. Froehner distributed a list of individual responsibilities for discrepancies, and this is included as Appendix IX.B-2.

IX.C. Report of the Ad-Hoc Subcommittee on the Status of the Barn

The Ad-Hoc Subcommittee presented a draft document for discussion. The intent was to transmit this to the Director General of the IAEA in the expectation that the Agency would then forward it to the appropriate international committees, ISO and CIPM. There was further detailed and extensive discussion on the proper tactics, arenas, and methods for defending the barn. There was a need to be concise and speedy but also a need was expressed to give some strong arguments as to the reasons, economic or otherwise, to help justify the retention of the barn as a useful unit of cross section. These suggestions were incorporated into the statement, and the final version as transmitted to the Director General is given in the Appendix.

IX.D Report of the Ad-Hoc Subcommittee on Meetings

The committee spent considerable time discussing the detailed subcommittee recommendations and NDS plans for future meetings. This involved the following important considerations:

- the NDS budget, effort and expertise
- the need and sources of help for NDS in technical areas, mainly the INDC Subcommittees and NEANDC consultation
- the balance between technical subject priorities and needs for compilation and evaluation activities in several areas (Neutron Data, NSDD, CPND and A+M)

The INDC expressed a serious concern and strong interest in this area in particular because the present 1-1/2-year meeting cycle requires consultation and study of these matters between INDC meetings. It was recognized that the technical meeting subjects should not be entirely guided by the in-house expertise that existed at NDS alone; plans must include the best judgment of priorities by the member countries as now expressed by the INDC. In order to ensure that the priorities were recognized and reinforced as presented in the Ad-Hoc Subcommittee Report in the Appendix, the appropriate Subcommittees will be expected to assist in helping to organize many of these technical meetings.

The summary of recommended meetings through 1980 and beyond, along with the past meetings is presented in a chart included with the Subcommittee report. It was not felt by the committee that too many meetings were being requested in this projection, but it was recognized that some schedule adjustments might be necessary partly because of budget limitations. The final Subcommittee report is in the Appendix.

X. REPORTS OF THE POLICY SUBCOMMITTEES

X.A. Energy Applications Subcommittee

Rowlands presented the subcommittee report which appears in the Appendix. This covers a wide range of information types and the subcommittee had endeavored to carefully recommend possible new reactions to both the standards and discrepancies subcommittees and also meetings for consideration.

Fission product nuclear data are to be discussed in depth at the Petten meeting in September of 1977 and information received at that time will be important to the committee and aid in deciding on further recommendations. Extensive work on afterheat from fission is underway and the current status was discussed and will be further reviewed at Petten. Delayed neutron spectra are being measured in detail at several installations and it was believed that a consultants' meeting on this subject would be timely and productive.

Sensitivity calculations regarding shielding data were believed to be very important and needed further work. Results could solidify and perhaps alter current requests as given in WRENDA. Smith noted that a number of total cross section measurements (Fe, Ti and Cr) appear to have underestimated source thickness effects and thus do not give accurate cross sections. The thick sample "broomstick" experiments done at ORNL have shown that present cross sections are not sufficiently good to calculate thick sample transmission.

Alternate fuel cycles are receiving considerably more attention and it was suggested that a meeting should be considered for the near future. This was addressed in IX.D.

Dosimetry is an important technique and numerous committees and meetings include this field. Recent NDS publications are INDC(SEC)-54/L and INDC(NDS)-81/L.

Vlasov discussed benchmark neutron fields and integral cross section measurements for reactor dosimetry with the committee. Vlasov requested that consideration be given to discrepancies in the $^{54}Fe(n,p)$, $^{63}Cu(n,\alpha)$ and $^{232}Th(n,f)$ cross sections and that

some problems with the neutron spectrum from fission might still exist at low energies (< 1 MeV) and at high energies (> 8 MeV). Extensive plans were described concerning the NDS program on evaluations in this field. The subcommittee requested that it would be helpful if the user community could define their requirements more precisely in order to justify the needs for more accurate differential and integral measurements.

Fuketa reported on the status of a comprehensive survey being made on data related to safeguards. It is not yet clear what definitive measurements might be required in support of such efforts, especially since standard reference samples are often used in this work.

Nuclear data requirements for fusion are rapidly taking form from new calculations being performed in many countries. A meeting on this subject was recommended (see IX.D.).

X.B. Report of the Non-Energy Subcommittee

Rose presented a review of the draft report of the Subcommittee which included discussions on the following items:

- Biomedical data needs, which have been considered in a detailed report distributed by Cross (INDC(CAN)-17/G) and in a U.K. working paper attached to the subcommittee report in the Appendix.
- Surface analysis data requirements including a working paper by Dearnaley
- Geological investigations; see working paper by Sanders in the Appendix.

Since an international meeting on biomedical work was being held during the week of May 23, 1977, the committee agreed to postpone a consideration of a possible future IAEA meeting since the data requirements do not now clearly indicate that such a meeting is required.

It was recommended that encouragement be given to local meetings of data users in the field of surface analysis in order to better identify the requirements for data compilations in this field. For example, a meeting was scheduled in the U.S. (Third

International Conference on Ion Beam Analysis, June 27-July 1 at Washington, D.C.) and it would be advisable for a member of NNDC to attend. A working group had met in Catania, Italy, in June, 1974. The compilation from this group has been difficult to obtain but it is being published by J. Mayer and E. Rimini ("Ion Beam Handbook for Material Analysis," Academic Press, 1977). A need was expressed for further compilations in this rapidly expanding and very practical field.

Nominal half life data should be available for international use in shipments and identification of commercial samples. Actions were placed on the NDS to consider the advisability of IAEA/NEA and IAEA/U.S. cooperation in this effort. Data are, of course, available and are presented in many compilations, but a properly certified and common reference set apparently does not exist.

The imbalance between the energy and non-energy committees has been apparent for some time. Although the data requirements associated with non-energy are very important, it represents a diffuse domain and an elusive target. It was agreed that a major subcommittee reorganization was advisable. This was precipitated by the recommendation that the non-energy subcommittee, as it now exists, be dissolved.

The report was accepted with modifications. The final version appears in the Appendix.

X.C Reorganization of the Standing Policy Subcommittees

Rowlands and Rose proposed that the work distribution of the two policy subcommittees be more application-oriented and that a distribution of scope be made so as to try to balance the work load of the two subcommittees. Considerable discussion of these points followed and strong general agreement was expressed that this was a very worthwhile reorganization. The two new subcommittees and Chairmen that were accepted were:

A: Nuclear Data for Fission Reactor Systems; Rowlands, Chairman

B: Nuclear Data for Environmental, Future Systems and Other Applications: Rose, Chairman

The proposed items of responsibility are listed in Appendix X.C-1. Membership of these two subcommittees was reviewed and the resulting list is given in the Appendix X.C-2.

Liskien did not expect to be able to attend the next meeting of the INDC and asked to be replaced as Chairman of the Standards Subcommittee. Smith agreed to be the new chairman. Froehner agreed to continue as chairman of the discrepancies subcommittee. The membership for the next meeting was discussed and the list is also given in Appendix X.C-2. It was agreed in principle that some shifting of specific items from one technical committee to the other would be advisable. Rowlands suggested that perhaps the fission cross sections, fission neutron spectra and nu-bar could be changed from discrepancies to standards. The two chairmen agreed to consider these suggestions and make some recommendations but time at the meeting was too short to complete this item.

In view of the long period between meetings, it was recognized that the chairmen must more carefully organize their duties and those of their subcommittee members. This should permit more work between meetings and encourage preparation of timely reports just prior to meetings. In order to emphasize and better define these aspects, Rowlands submitted a methods of work paper for Subcommittee A and proposed tentative responsibility assignments as given in Appendix X.C-4. Rose later circulated methods of work (Appendix X.C-5) and proposed tentative assignments (Appendix X.C-6). Agreement on actual reporting responsibility in the case of multiple assignments will have to be agreed upon before the next meeting.

XI. MEETINGS

XI.A. Past Meetings

The NDS Report to the INDC (INDC(NDS)-85/LNA) presents a very complete summary of past and future NDS/IAEA Meetings on pages . The report of the Ad-Hoc Subcommittee on Meetings appears in Appendix IX.D. Proceedings of some past meetings are mentioned in the Progress Reports, Agenda Item VI.

XI.B. Future Nuclear Data Conferences

Major meetings that are scheduled in the 1977-79 period are listed below.

International Conference on Nuclear Structure
September 5-10, 1977, Tokyo, Japan

IAEA Advisory Group Meeting on Fission Product Nuclear Data
September 5-9, 1977, Petten, Netherlands

ASTM-Euratom Symposium on Reactor Dosimetry
October 3-7, 1977, Palo Alto, California

NEANDC Specialist Meeting on Cross Sections for Structural Materials
December 5-8, 1977, Geel, Belgium

International Conference on Nuclear Interactions
August 28-September 1, 1978, Canberra, Australia

International Symposium on Neutron Capture Gamma-Ray Spectroscopy
September 18-22, 1978, Brookhaven, New York

Conference on Neutron Physics and Nuclear Data for Applications
September 25-29, 1978, Harwell, U.K.

IAEA Symposium on the Physics and Chemistry of Fission
1979

International Cross Section and Technology Meeting
October 22-26, 1979, Knoxville, Tennessee

XI.C. Winter Courses on Nuclear Physics and Reactors

The ICTP plans to hold courses at Trieste during the period January-March, 1978. The ad hoc subcommittee on meetings and the INDC wished to encourage ICTP in these efforts to apply its expertise in assisting the developing countries to develop an interest and improved capability in doing theoretical work related to applications. It was felt that the interest of both the ICTP and the attendees (and the national programs they represent) should be reviewed following these courses to see if further activities in this area should be pursued. These ideas are expressed in the Appendix IX.D, pages 1-2.

APPENDICES

II.C

PROPOSAL FOR THE LINKING OF INIS WITH DATA COMPILATION, ANALYSIS AND DISSEMINATION CENTRES

L.N. Usachev

General considerations

Data centres dealing with relatively narrow scientific fields in which numerical data are of importance have shown themselves to be an effective tool not only for the collection of bibliographical information, but also for the accumulation of numerical data, establishment of measurement requirements, organization of data analysis and elaboration of recommended values. In this connection we can refer to the system of four neutron nuclear data centres. The users do not receive a set of references to articles, the data in which may be mutually contradictory, but rather are given recommended data worked out by specialists in the particular field. We are all witnesses to the formation of data centres in more and more new fields of science.

If it were possible to organize such data centres for all the important branches of science and to operate them efficiently, as a tool for planning research and achieving results in the form most accessible to the broad range of users, then the problem of the "information explosion" would be largely solved.

It should be pointed out that this conception of the role of data centres is to be found at the level of the International Council of Scientific Unions (ICSU) and its Committee on Data for Science and Technology (CODATA), and has also been expressed by the latter in a report for UNESCO-UNISIST entitled "Study of Problems of the Availability and Dissemination of Data for Science and Technology" (UNESCO, SC 74/WS/16, and CODATA Bulletin No. 16 for October 1975).

The Bulletin points out the need to set up a reference system that can direct the user to the right data centre.

In the sphere of nuclear science and technology there is no need to establish a system of this kind, since its functions can be carried out by the presently-operating information system - INIS.

In other words, when receiving a query from a user on the basis of the given key words, INIS should be able to decide whether or not the user should be referred to a data centre, since he may thereby be satisfied to a far greater extent than by being given source abstracts and related references.

Specific proposal

It is proposed that, in addition to new literature sources and their key words, INIS tapes should also record information on data centres, also described by key words. In this way, during a routine search for sources from key words the user will be given information on the data centre appropriate to the problem, its sphere of competence, and ways of approaching it. Since there are relatively few data centres compared to the number of literature sources, information regarding them can be repeated on each INIS tape sent out. INIS will thereby start to play the part of a reference centre for data centres.

It is possible, of course (without repeating the recordings on each tape), to send round a periodic tape with information on the data centres, perhaps together with data on reference works and other "factographic" systems. That tape could then be checked through first, when answering a user's enquiry at local level from his key words, after which the regular tape with the recorded sources could be looked at.

Summing up the situation, we can say that the gist of the proposal is that INIS should be fed with information on data centres in the same way as it is fed with information on sources, using the same key words. Clearly, that is a very economical proposal, since the system is not altered, no additional effort is required at local level, and the effort involved in feeding the system with information on data centres, by being centralized, is minimal.

Comments on earlier proposals

The proposals made by Dr. N. Tubbs from NEA (OECD) are based on the same general considerations as our own. But in his case the user is referred to the data centre by a separate source only if the numerical data pertaining to the source are available there. We feel that the proposal we are making here achieves the goal set by Dr. Tubbs - converting INIS into a reference system for data centres - more effectively.

The proposals made by Dr. H. Lemmel from the Agency's Nuclear Data Section (NDS) on altering the headings and systems of key words so as to define more accurately the spheres of responsibility of the existing nuclear data centres are useful in terms of more effective use of INIS services by data centres in searching for sources in journals for which the range of subjects of interest to the data centre is not a main one. A change of this type in the system of key words would also make it possible to handle more effectively the search for the right centre from the key words in accordance with our proposal.

General comments

An information system covering a broad range of subjects of the INIS type is unrivalled when it comes to information on new facts and ideas, but in the narrower spheres of competence of the data centres, it cannot compete with the latter in terms of the quality of service to users. It should be pointed out, however, that although data centres are being set up in more and more branches of science, coverage of the full range of INIS subjects by the data centres is hardly likely within the next few decades. Hence improvement in the submission of numerical data to INIS, which is being discussed in the light of experience gained by the existing data centres, is of great importance, especially for branches of science not covered by the data centres. If INIS can become a system for reference to data centres, the structure of the information in the area of nuclear science and technology will reach logical fulfilment.

II.E-2

INDC RECOMMENDATION

COMPARISON OF EVALUATIONS

Different evaluated nuclear data files and other nuclear data evaluations are becoming widely available and comparative analyses are of growing importance.

The INDC believes that it would be valuable to intercompare important evaluations so as to show up any differences, analyze their sources and so contribute to the improvement of evaluated data files.

The INDC therefore invites the IAEA/NDS, in cooperation with the other centers, to consider how such comparative analyses for specific important data can best be achieved for the benefit of all users.

In particular, the IAEA is asked to consider whether such work can be done under research contracts or technical assistance.

Yiftah, Lessler, Rowlands and Froehner

Current Status of Agreement to Share in the Evaluation of Mass Chain Nuclear Data

Centre/Group	Head/Address	Mass Chain Commitments	Status/Comments
US/BNL	S. Pearlstein National Neutron Cross Section Center Brookhaven National Laboratory Upton, New York 11973, USA	136–145	Mass 141 started
US/NDP	W.B. Ewbank Nuclear Data Project Oak Ridge National Laboratory Oak Ridge, Tennessee, 37830, USA	All other mass chains	Many evaluations
US/LBL	M. Lederer Lawrence Berkeley Laboratory University of California Berkeley, Calif. 94720, USA	146–152, 163–192	Will begin in June 1977 after Table of Isotopes Publication
US/INEL	R.L. Heath Idaho National Engineering Lab. 550 Second Street Idaho Falls, Idaho, 83401, USA	153–162	Mass 157 started
US/UP	F. Ajzenberg-Selove University of Pennsylvania Philadelphia, Penns. 19174, USA	5–20	Masses 18–20 being evaluated
USSR/CAJAD	F.E. Chukreev Institut Atomnoi Energii I.V. Kurchatova 46 Ulitsa Kurchatova Moscow, D–182, USSR	1–4, 130–135, 238, 240, 242, 244	Masses 3, 134 and 239 have been started
NED/UTRECHT	C. Van der Leun Fysisch Laboratorium Sorbonnelaan 4 Utrecht, The Netherlands	21–44	New evaluation started in the fall of 1976

Centre/Group	Head/Address	Mass Chain Commitments	Status/Comments
UK/DARESBURY	P. Twin Oliver Lodge Laboratory University of Liverpool Liverpool L69 3BX, UK	65–74	Attended ORNL Training Session in March 1977
FRG/ZAED	H. Behrens Zentralstelle f. Atomkernenergie-Dokumentation Kernforschungszentrum D-7514 Eggenstein-Leopoldshafen	81–100	Attended ORNL Training Session in March 1977
JAP/JAERI	T. Tamura Japan Atomic Energy Research Institute Division of Physics Tokai-Mura, Naka-Gun Ibaraki-Ken, 319-11, Japan	118–129	Funding began in April 1977
SWD/LUND	L. Carlen University of Lund Solvegatan 14 S-223 62 Lund, Sweden	113–117	Will probably start with mass 113
KUW/KISR	A. Shihab-Eldin Kuwait Institute for Scientific Research Shuwaik, Kuwait	75–80	Attended ORNL Training Session in March 1977

V.C-1

SECOND MEETING

of the

JOINT IFRC/INDC SUBCOMMITTEE
ON
ATOMIC AND MOLECULAR DATA FOR FUSION

Vienna, 14 May 1977

Participants

C. M. Braams	IFRC	Chairman	FOM - Instituut voor Plasmfysica Jutphaas, Netherlands
J. Decker	IFRC[a]	Member	DMFE, ERDA, Washington, D.C.
H. W. Drawin	IFRC	Member	Dept. of Plasma Physics & CTR, CEA, Fontenay-aux-Roses, France
Yu. V. Martynenko	IFRC	Member	Atomnoi Energii I.V. Kurchatova, Moscow, USSR
T. Fuketa	INDC	Member	Nuclear Data Center, JAERI, Japan
M. K. Mehta	INDC	Member	Bhabha Atomic Research Center, Trombay, India
G. B. Yankov	INDC[b]	Member	Atomnoi Energii I.V. Kurchatova, Moscow, USSR
J. J. Schmidt	NDS	Member	
E. C. Beaty	NDS	Observer	
W. G. Cross	INDC	Observer	
H. T. Motz	INDC	Observer	
R. E. Seamon	NDS	Observer	
H. Suzuki		Observer/JAP/Nagoya	
A. Lorenz	NDS	Scientific Secretary	

[a] Decker is also advisor to the U.S. delegation to INDC.

[b] Yankov is no longer on INDC, but Usachev, USSR member, requested that he remain on this Joint Subcommittee.

V.C-2

14 May 1977

Preliminary Version

Conclusions and Recommendations of the Second Meeting of the Joint IFRC/INDC Subcommittee on A+M Data for Fusion

1. Plans and schedule for publication of the Bulletin as outlined were considered acceptable. It was agreed to allow the publication of data in the Bulletin, and to allow requests and statements about data requirements for fusion to be included. Emphasis was placed on the need to be selective in the papers and topics chosen from the whole range of atomic physics. The best service to the NDS/A+M Unit as a whole will be provided if the Unit can demonstrate the ability to be selective, thereby making the product clearly related to fusion. Admittedly, there is not a unified view of what is really needed, but it was felt that the papers presented at the Culham meeting could be of guidance in reaching decisions.

2. Concerning the Index to atomic collision data, the A+M Unit is requested to work out a schedule leading, if possible, to publication by the end of 1978. It was agreed that there should be no truncation in time (i.e. papers from the 1950's are acceptable); that data for all atoms should be included unless specifically excluded, while data for molecules are excluded unless specifically included; that as a compromise solution, full bibliographic citations including titles will be included in the data file but omitted from the first issue of the Index; that the scope will be limited by considering the needs of magnetically confined fusion systems.

INDC/P(77)-26

Footnote: Official version issued August, 1977, INDC(SEC)-63/GA.

3. Concerning the needs within the fusion community, the priority given to magnetic confinement devices was accepted at this time because of the restricted manpower in the A+M Unit. It was emphasized that it is not right to exclude inertial confinement devices, and that associated needs - even if not well defined at this time - must be taken into account as the program matures.

4. In spite of the work load confronting the NDS/A+M Unit, it was felt that a detailed proposal and work-load justification was needed before the Subcommittee could recommend the hiring of two additional temporary staff members (a P-2 physicist and a G-6 data analyst). The NDS was instructed to keep the budget open to allow for possible staff augmentation during 1978.

5. It was agreed that during the trial period the NDS/A+M Unit would not become involved in the issuance of research grants for data evaluation or measurements.

6. It was recognized that data on plasma-surface interactions is definitely a part of A+M data, although it will not be included in the Index at this time. The Subcommittee notes the ZAED (Karlsruhe) work in this area.

7. It was agreed to drop all efforts on the compilation of atomic wave-functions during the trial period.

8. The need to clarify the relation between this Subcommittee and the parent IFRC and INDC Committees was recognized. It was agreed that before an official approach to an outside organization or IAEA is made, and that before any commitments of the NDS are made, the intended actions should be approved by the chairmen of both the IFRC and the INDC.

9. The next regular meeting of this Subcommittee will be held in May, 1978. There exists the possibility of another gathering October, 1977 for program review, in particular to address the question of staff.

10. J. Schmidt was asked to summarize this meeting at the Ninth INDC meeting.

11. The following statement was agreed upon:

Since the initial decision to embark on an A+M data program was made, it has become even more apparent to the fusion community that the need exists for an efficient data collection and dissemination system. The trial period is going according to the best expectations of the Joint IFRC/INDC Subcommittee on A+M Data for Fusion; there has been considerable work accomplished, and there is good evidence that this program should be continued after the trial period. The Joint Subcommittee will continue to review progress and will make a more definitive assessment at a later stage during the trial period.

Note: Underlined words represent changes made during the INDC discussions. H.M.

INDC Conclusions Regarding the IAEA A+M Data for Fusion Programme

The INDC endorses on the whole the conclusions and recommendations of the Second Meeting of the Joint INDC/IFRC Subcommittee on Atomic and Molecular Data for Fusion[Ref. 1] except for the following points on which the INDC wishes to make more specific recommendations:

#4 The need for additional staff (a P-2 assistant physicist and a G-6 assistant programmer) for the NDS to carry out the programme committed during the trial period was discussed. The committee recognized the possibility for such a need but recommended that a specific justification describing the work load and its distribution be prepared by NDS by the end of July and circulated to the Joint Subcommittee members as well as to the chairmen of the parent committees. The Subcommittee then through its chairman can make the recommendation which then may be approved by the parent committees according to the procedure outlined in #8 below. This recommendation, by which the budget provision already requested by NDS will be supported or not, should reach the IAEA well in advance of the deadline (about October 1977) for submission of the final budget estimates for 1978.

#8 The committee suggests that this point be rewritten to read as follows:

Before any official approach is made by the Joint Subcommittee to IAEA or to an outside organization, and before any commitments of the NDS are made, the intended action should be approved by the chairmen of both INDC and IFRC.

The chairman of INDC will decide for each individual item whether to submit it to all INDC members for approval or not.

#11 The INDC noted that the trial programme has started well and is showing the expected progress, indicating that it may well be justified to continue the programme on a permanent basis. The Agency should undertake the appropriate steps to be ready to continue the A+M data programme on a permanent basis upon completion of the trial period, with the understanding that a final recommendation on the future of this programme will be made in the latter part of 1978.

The INDC recognizes that the primary recommendation on the needs and value of the A+M data programme will come from the IFRC. The INDC will continue to provide advice to NDS and the DG during the trial period on those aspects of the A+M data programme where INDC has appropriate technical experience, e.g. data handling, data centres operation, etc.

In addition, the INDC suggests that the joint subcommittee and IFRC consider the possibility of reaching their decisions on the recommendations for continuation by July 1978 since this would aid the NDS in its future staffing and budget plans.

Reference 1: Conclusions and Recommendations of the Second Meeting of the Joint IFRC/INDC Subcommittee on A+M Data for Fusion, Dated 14 May 1977 (Preliminary Version). Ref: INDC/P(77)-26.

VI.A

REVIEW OF EXPERIMENTAL WORK BY SOVIET SCIENTISTS IN THE FIELD OF NUCLEAR DATA ACQUISITION

V.M. Kulakov

I. Neutron data

A cascade accelerator has been used as a basis on which to construct a correlation spectrometer designed for time-of-flight measurement of spectra and angular distributions of inelastically-scattered neutrons with 14 MeV energy [1]. Together with klystron bunching, the spectrometer makes use of the modulation of an ion beam by a pseudorandom signal. The resolving power of the spectrometer is determined by the width of the bunched pulses, while modulation by the pseudorandom signal makes it possible to reduce the effect of the non-coherent background on the statistical accuracy. The duration of the neutron pulse from the target is 2.5 nsec, and the length of the pseudorandom pulse code is 15.

The correlation spectrometer has been used to measure secondary neutron spectra in plutonium-239 at an initial neutron energy of 14.3 MeV [2]. To obtain the neutrons use was made of the reaction $T(d,n)^4He$. Resolution of the spectrometer over the elastically-scattered neutron peak width is 4.5 nsec for a path length of 3 m. The sum spectra for neutrons from the reactions (n,f), (n,n'), (n,2n) and (n,3n) have been measured over the energy range 100 keV-14 MeV at angles of 30, 60, 90, 120 and 150°. A set of algorithm-based programs has been worked out for processing data obtained with the correlation spectrometer.

Experiments have been carried out with an evacuated model of a pulsed neutron generator with a laser deuteron source [3]. As the laser targets use was made of LiD and TiD, i.e. the reaction $D(d,n)^3He$ was used to obtain the neutrons. The neutrons were recorded by being slowed down to thermal velocities, followed by counting with a boron counter. A yield of $\sim 10^6$ n/pulse was obtained at an accelerating voltage of 150 keV. Evaluations of the neutron yield under various generator conditions and for different life times of the laser target have been made.

A multiseries macroscopic fast-neutron spectrometer has been constructed for the study of fission neutron spectra [4]. It consists of a rectangular block made of eight polyethylene slabs 5 cm thick, with channels drilled through them for BF_3 or ^3He counters. Each series of counters is connected to a single recording channel. This spectrometer has been used to measure [5] the intermediate energy ratios for neutrons emitted during the fission of uranium-233, uranium-235 and plutonium-239, and during spontaneous fission of califronium-252 $(0.967 \pm 0.003):(0.946 \pm 0.003):(0.983 \pm 0.002):1$.

The time-of-flight method has been used to measure prompt neutron spectra for the fission of uranium-233, uranium-235 and plutonium-239 by thermal neutrons over the range 0.01-4 MeV, and for spontaneous fission of californium-252 over the range 0.01-10 MeV [6]. The measurements were made with a thermal neutron beam in the SM-2 reactor, using non-threshold neutron detectors with a uranium-235 base.

Cross-sections for fast-neutron fission of uranium-233, uranium-238, plutonium-239, plutonium-240, plutonium-241 and plutonium-242 with respect to the fission cross-section for uranium-235 have been measured over a wide range of neutron energies [7]. The work was carried out in electrostatic accelerators, using the reactions Li(p,n), T(p,n) and D(d,n) as the neutron sources. A back-to-back ionization chamber served as the fission fragment detector.

The spectra for secondary neutrons produced by the bombardment of uranium-238 by 9.1 ± 0.2 MeV neutrons have been measured at angles of 30, 60, 90, 120 and 150° by the time-of-flight method in the 150-cm FEI cyclotron [8]. There have been determinations of double differential interaction cross-sections for neutrons and uranium-238 nuclei. The integrated neutron spectrum for the reactions (n,n) and (n,2n) has been analysed within the framework of the pre-equilibrium model.

Neutron spectra at 5 angles for the reaction $^{27}Al(p,n)^{27}Si$, at a 10.3 ± 0.1 MeV proton energy, have been measured by the time-of-flight method in the FEI cyclotron (150 cm) [9]. The resolving power of the spectrometer was 1.4 nsec/m. The stability with which the spectrometer

operated was checked by multiple measurement of the neutron spectrum of californium-252 spontaneous fission. The discrete neutron groups observed in the spectra tally well with the energy level diagram for ^{27}Si. The angular distribution of the neutron group corresponding to the ground state is 90° symmetric.

Neutron spectra and angular distributions for the reactions $^{181}Ta(n,n')^{181}Ta$ at an initial neutron energy of 9.1 ± 0.2 MeV, and $^{181}Ta(p,n)^{181}W$ at Ep = 10.2 ± 0.2 MeV have been measured by the time-of-flight method in the FEI cyclotron at angles of 30, 60, 90, 120 and 150° [10]. The initial proton and neutron energies were selected so as to attain the same excitation energy interval. It turned out that for the same excitation energy the integrated inelastically-scattered neutron spectrum has a more rigid shape than the neutron spectrum for the reaction (p,n), while the angular distribution of the inelastically-scattered neutrons indicates the presence of an asymmetric component, more especially in the higher energy bands.

Neutron spectra and angular distributions for the reaction $^{115}In(p,n)^{115}Sn$ have been measured by the time-of-flight method for 5.6 and 7 MeV proton energies [11]. The spectrometer's time resolutions was 1.5 nsec/m, and the path length 2 m. For all the energy regions the angular distributions proved for practical purposes isotropic or symmetric with respect to the neutron emission angle $\vartheta = 90°$, which indicates that the reaction proceeds mainly through the compound nucleus. For all the measured spectra the high energy neutron yield proved less than was predicted by the Maxwell distribution.

Functions for passage through uranium-235 samples were measured in energy groups ranging between 2 eV and 20 keV [12]. Proportional ^{3}He counters and fast-response fission chambers with uranium-235 layers were used as the detectors. The measurements were made with the aid of a neutron time-of-flight spectrometer in the fast pulsed reactor (IBR) at the Joint Nuclear Research Institute (OIYAI). Data analysis provided evaluations of the factors for resonance blocking of the uranium-235 fission cross-section. Similar measurements are planned for 1977 with plutonium-239.

VI.A

A device has been constructed for obtaining ion current pulses over the nanosecond and microsecond ranges with a broad pulse recurrence frequency band, using the EG-1 FEI electrostatic generator and applying the chopping and bunching method [13]. The device permits neutron spectrometry in the fast and resonance neutron regions and, more especially, enables the saturated resonance method to be used for an absolute measurement of the neutron radiative capture cross-sections.

A neutron time-of-flight spectrometer with a resolution of ~0.3 nsec/m has been constructed [14] on the basis of the pulsed electrostatic accelerator belonging to the Atomic Energy Institute (beam parameters: current pulse length 1.5 nsec; amplitude up to 3 mA and mean target current 8 μA, for a recurrence frequency of 2 MHz). The accelerator makes it possible to obtain the same data as when using underground nuclear explosions as the neutron source, but under more stable and controllable conditions, with considerably less expense, and with much smaller amounts of fissile material (reduction by a factor of 10^4–10^6).

The time-of-flight method has been used in the accelerator to measure differential elastic scattering cross-sections at 90°, and partial inelastic scattering for the 2^+, 4^+, 1^- and 3^- states of the uranium-238 nucleus [15]. The efficiency of the detector (stilbene crystal and FEU-30 photomultiplier) was determined from the neutron spectrum for spontaneous fission of californium-252. A uranium sample in the form of a hollow cylinder 32 mm high, 36 mm in diameter and 4 mm in wall thickness served as the scatterer. The total energy resolution was ~40 keV for 1 MeV neutrons.

En (keV)	$\frac{d\sigma_{el}}{d\vartheta_{90°}}$ (barn/steradian)	σ_{ind} (barn) 45 keV	148 keV	680 keV	730 keV
1200	0.169 ± 0.010	0.84 ± 0.14	0.51 ± 0.04	0.30 ± 0.06	
1350	0.161 ± 0.014	0.62 ± 0.21	0.48 ± 0.04	0.24 ± 0.03	0.17 ± 0.03
1400	0.161 ± 0.014	0.58 ± 0.35	0.43 ± 0.03	0.19 ± 0.02	0.17 ± 0.03

A facility has been constructed, following a feasibility study, for the measurement of the spectrum for the multiplicity of neutrons and gamma quanta emitted by excited nuclei, and for simultaneous spectrometry of neutrons exciting the nucleus [16]. The facility includes a 12-section 4π NaI(Tl) detector with ~90% efficiency in recording the capture event; an (n,γ) converter, electronic instruments for shaping the detector pulses, a multi-input time interval measuring device, and a minicomputer. Two detectors with crystal volumes of 17 and 26 litres were used for the work. The spontaneous fission multiplicities for californium-252 and $^{133}Cd + n$ have been measured, and neutron resonance spins have been determined for cadmium-133. The capture cross-section (σ_γ) for uranium-238 in the neutron energy range $0.1 \leqslant En \leqslant 30$ keV has been measured. The statistical error in $<\sigma_\gamma>$ is less than 2% [17]. Over the same neutron energy region there have been measurements of the absolute value of α, the fission cross-section and capture cross-section for uranium-235 [18]. The statistical error in $<\alpha>$ is less than 2%, and the error in $<\sigma_f>$ not more than 2-3% (disregarding the calibration error).

The SM-2 reactor (NIIAR Institute, Dimitrovgrad) has been used to measure cross-sections for fission of uranium-233 by 0.0253 eV, 2, 24, 55 and 144 keV neutrons [19]. A double fission chamber was used. The fission cross-section of uranium-235 measured earlier with an accuracy of 2% was used as the standard. For the given neutron energies the following fission cross-sections have been obtained: 528.6 ± 8.0; 8.93 ± 0.22; 2.94 ± 0.08; 2.45 ± 0.06 and 2.16 ± 0.05 barn.

Absolute measurements of the fission cross-sections for uranium-233, neptunium-237 and plutonium-239 have been made with 14.8 MeV energy neutrons [20]. The neutron source was a neutron generator based on the reaction $^{3}H(d,n)^{4}He$. The method used was to record the coincidence of fission in the target with particles accompanying the neutrons. Measurement accuracy was better than 2%.

Fission cross-sections

	σ_f (barn)
^{233}U	2.350 ± 0.042
^{237}Np	2.430 ± 0.047
^{239}Pu	2.620 ± 0.046

For the same isotopes there have been measurements of the neutron fission cross-sections for the fission spectrum of californium-252 [21]. The error in measurement is 1.6%.

	σ_f (millibarn)
^{233}U	1947 ± 31
^{237}Np	1442 ± 23
^{239}Pu	1861 ± 30

The work was carried out with the support of the IAEA (Research Contract No. 1718/RB).

A study has been made of the fission of actinium-227 by neutrons and gamma rays [22]. The dependence of the photofission yield on the boundary bremsspectrum energy over the range 7.5-12.75 MeV has been measured. Neutron cross-sections have been used to determine fission barriers for $B_f(^{228}Ac)$ = 7.2 ± 0.2 MeV, and $B_f(^{227}Ac)$ = 7.0 ± 0.5 MeV, and they have also been determined from the photofission yields for $B_f(^{227}Ac)$ = 7.8 ± 0.5 MeV.

The time-of-flight method has been used in the SM-2 reactor to measure total neutron cross-sections for the isotopes curium-244, curium-245, curium-246 and curium-248 [23]. The time resolution was 70 nsec/m, and the statistical accuracy 0.5-1.5%. The resonance parameters were computed by the shape and area method on the basis of the Breit-Wigner single-level formula.

The neutron fission spectrum for californium-252 has been measured by the time-of-flight method over the energy range 0.01-10 MeV [24]. As neutron detector use was made of an ionization chamber with 12 uranium-235 oxide layers 10 cm in diameter, the total amount of material being 1.5 g. The efficiency attained in recording californium-252 fission fragments was 99%. A search has been made for the fine structure in the neutron spectrum for spontaneous fission of californium-252 in the 1-5 MeV range [25]. Irregularity in the spectrum within the bounds of the experimental errors (1.5-2.5%) was not observed.

At the Joint Institute for Nuclear Research (Dubna) a pulsed periodic reactor (IBR-2) is approaching completion [26]. The reactor will generate slow neutron pulses lasting 100 μsec and with a peak thermal neutron flux density of 10^{16}-10^{17} n/cm^{2}sec. The reactor is being fitted with experimental facilities for physical studies based on neutron time-of-flight spectroscopy.

II. Non-neutron data

The twenty-seventh conference on nuclear spectroscopy and structure of the atomic nucleus was held in Tashkent from 22 to 25 March. More than 700 papers were presented at the meeting. The collection of abstracts contains a wealth of reference material on nuclear data obtained by Soviet scientists in 1976. Suffice it to say that the energy level diagrams have been made more accurate or plotted afresh for more than 150 isotopes, and the discovery of 9 new isotopes (barium-177, lanthanum-123, lanthanum-124, lanthanum-125, cerium-124, cerium-125, cerium-126, cerium-127 and rhenium-173) was reported. The half-lives of a number of isotopes have been calculated more accurately or measured for the first time.

Let us take a brief look at some of the papers presented at the conference.

An analysis of experimental data obtained since 1945 has been made for 100 nuclides used in the national economy [27]. Evaluated data for all the nuclear-physical characteristics of the nuclides have been reported and the table covers the following nuclei:

^{3}H, ^{7}Be, ^{14}C, ^{22}Na, ^{24}Na, ^{32}P, ^{33}P, ^{35}S, ^{36}Cl, ^{37}Ar, ^{45}Ca, ^{51}Cr, ^{54}Mn, ^{55}Fe, ^{59}Fe, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{63}Ni, ^{65}Zn, ^{68}Ga, ^{68}Ge, ^{71}Ge, ^{74}As, ^{85}Kr, ^{85}Sr, ^{90}Sr, ^{88}Y, ^{90}Y, ^{91}Y, ^{95}Zr, ^{95}Nb, ^{93}Mo, ^{99}Tc, ^{103}Ru, ^{106}Ru, ^{103m}Rh, ^{106}Rh, ^{105}Ag, ^{110}Ba, ^{109}Cd, ^{113m}In, ^{114m}In, ^{113}Sn, ^{122}Sb, ^{124}Sb, ^{125}Sb, ^{125m}Te, ^{125}I, ^{129}I, ^{131}I, ^{131m}Xe, ^{131}Cs, ^{134}Cs, ^{137}Cs, ^{133}Ba, ^{140}La, ^{139}Ce, ^{141}Ce, ^{144}Ce, ^{147}Pr, ^{146}Pm, ^{147}Pm, ^{155}Eu, ^{153}Gd, ^{160}Tb, ^{169}Er, ^{170}Tm, ^{171}Tm, ^{169}Yb, ^{181}Hf, ^{181}W, ^{185}W, ^{185}Os, ^{192}Ir, ^{195}Au, ^{193}Au, ^{203}Hg, ^{204}Tl, ^{207}Bi, ^{210}Po, ^{234}U, ^{233}U, ^{234}Np, ^{239}Np, ^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242}Am, ^{242m}Am, ^{243}Am, ^{242}Cm, ^{244}Cm, ^{249}Cf, ^{252}Cf

A machine-based data bank on the properties of even-even nuclei with $150 \leqslant A \leqslant 196$ and $A \geqslant 220$ has been established [28].

At the Joint Nuclear Research Institute (Dubna) a procedure has been developed for high-precision gamma spectroscopy based on the use of semiconductor detectors [29]. A complete set of standards for energies and relative gamma ray intensities of radioactive nuclei has been put together. The summary data in the tables are the result of processing more than 3000 instrumental spectra.

A pair spectrometer for hard gamma radiation has been constructed with a view to studying (p,γ) reactions at low and medium proton energies [30]. The spectrometer is constructed on the basis of a germanium detector (DGDK-70A) and four NaI(Tl) crystals of diameter 120 x 120 mm. Its energy resolution for $E_\gamma \approx 10$ MeV is 35 keV, its efficiency compared with the single-crystal model is ~10%, and the Compton background attenuation is by a factor of 40.

A combined gamma-spectral absorption method has been developed for determining uranium, transuranic isotopes and fission products in solutions from the reprocessing of irradiated fuel elements [31]. A program for computer processing of the spectrometric data obtained has been written.

In 1976 the Atomic and Nuclear Data Centre operated by the State Committee on the Utilization of Atomic Energy was working on the software required for exchanges with foreign countries. At the present time the tapes prepared by the Centre are being read in all the centres to which they are dispatched.

An evaluation has been made of the radiation characteristics occurring during decay of nuclides with A = 95, and there has been re-evaluation of the half-life of tritium with allowance for the dependence of its half-life on the electron environment of the nucleus in the material.

Centres working with the above-mentioned Atomic and Nuclear Data Centre have been furnished with bibliographic material on Soviet nuclear-physical research and have received their first tape with numerical data from Soviet studies on cross-sections and radioisotope yields.

Over the last few years there has been a successful new development - the study of gamma spectra during inelastic scattering of fast reactor neutrons. Scientists at the Atomic Energy Institute, together with Iraqi physicists (Baghdad), have obtained a wealth of experimental material so far; some of it has been incorporated into the "Atlas of Gamma-Ray Spectra from Inelastic Scattering of Fast Reactor Neutrons; $Z \leqslant 42$" (the authors of which are A.M. Demidov, M.R. Akhmed, L.I. Govor et al.), which is ready for press.

References

1-26 References to papers presented at the IVth All-Union Conference on Neutron Physics held in Kiev, 18-22 April 1977.

27, 28 and 30, 31 References to papers in the proceedings of the XXVIIth Conference on Nuclear Spectroscopy and on the Structure of the Atomic Nucleus, held at Tashkent, 22-25 March 1977. Published by "Nanka", Leningrad 1977. (Ref. 27 - page 529, Ref. 28 - page 523, Ref. 30 - page 128, Ref. 31 - page 563)

29 Ts. Vylov. JINR (Dubna) preprint P6-10417, 1977.

This report was issued as INDC(CCP)-112/LN in September, 1977.

VII.E

Proposed Coordinated Research Programme for the Measurement of Actinide Nuclear Decay Data

Background: The IAEA Advisory Group Meeting on Transactinium Isotope Nuclear Data (TND), November 1975, recommended the development of an international cooperative research programme to measure and evaluate needed decay data of transactinium nuclides which would be coordinated by the IAEA Nuclear Data Section (see INDC(NDS)-74/L+, March 1976).

Justification: The presently available accuracies of half-lives, and alpha and gamma-ray intensities of a number of transactinium nuclides are not adequate for the requirements set for fuel analysis, safeguards applications, mass determination and the preparation of standards.

Requirements: The data accuracies required for the isotopes in question, and their specific applications are listed in the attached Appendix.

Objective of the programme: to arrive at a world-wide consistent set of required decay data which satisfy the required accuracies.

Participants of proposed programme: The following individuals have been approached by letter dated 18 April 1977 to participate in this project:

Dr. H. Liskien of the Bureau Central de Mesures Nucleaires, Geel,
Dr. Y. Le Gallic of the Centre d'Etudes Nucleaires de Saclay
Dr. M.K. Mehta of the Bhabha Atomic Research Centre, Bombay
Dr. T. Fuketa of the Japan Atomic Energy Research Institute, Ibaraki-Ken
Dr. J.G. Cuninghame of the Atomic Energy Research Establishm., Harwell
Dr. G. Rogosa of the Energy Res. & Developm. Admin., Washington
Dr. A. Zelenkov of the Institut Atomnoi Energii, Moscow

Nature of programme: The programme should consist of coordination and intercomparison of measurements between laboratories concerned, and exchange of samples and techniques.

In context of the Coordinated Research Programme (still to be approved) the IAEA would conclude either Research Agreements (no remuneration) or Research Contracts (modest remuneration) with the pertinent laboratories or institutes as warranted.

Conditions of Agreements and Contracts: The participating institutes would agree to provide reports on the progress of its contributing effort. These agreements or contracts would cover a period of one year, and would be subject to renewal. With respect to the reports to be provided, under research agreements it would of course be understood that the author(s) would be given full credit, that the information provided could be made freely available throughout the world, and that the report may be in the form of a re-print, pre-print, or of a report prepared for other purposes. Reports would be required on a semi annual basis in the case of research contracts and would cover the progress of the project during each 6 months period.

In return, each institute would participate in all exchanges of information between the participants in the programme, and the chief scientific investigator from each participating group is normally invited at Agency expense, to attend one or more group meetings which would be planned to take place at appropriate intervals.

Budget: $ 10,000,- for 1977 (same amount requested for 1978).

Responsible Officer: A. Lorenz, Nuclear Data Section.

VII.E

Summary of most needed nuclear decay data for actinides

(Excerpted from Proceedings of Karlsruhe 1975 TND Meeting, IAEA-186)

Nuclide	Data type	Required Accuracy	Needs for
U 234	I_α	1%	mass determination, fuel assay
	I_γ	5%	
U 235	α $T_{\frac{1}{2}}$	1%	mass determination, fuel assay
	I_α	1%	
	I_γ	1%	
U 236	α $T_{\frac{1}{2}}$	1%	mass determination
U238	I_α	1%	mass determination
Np 237	I_α	1%	mass determination
Pu 238	α $T_{\frac{1}{2}}$	0.5%	thermal and fast reactors, destructive fuel assay, calorimetry
		0.02 %	high-precision mass standard
	I_α	0.1%	mass determination
	I_γ	1%	non-destructive fuel assay
Pu 239	α $T_{\frac{1}{2}}$	0.5%	thermal reactor application, fast reactor fuel analysis
		0.2%	destructive fuel assay, mass determination
	I_α	1%	mass determination
	I_γ	1%	non-destructive fuel assay
Pu 240	α $T_{\frac{1}{2}}$	1%	fast reactor fuel analysis
		0.2%	mass determination, calorimetry
	I_γ	1%	non-destructive fuel assay
	I_α	0.2%	mass determination
Pu 241	α $T_{\frac{1}{2}}$	1%	thermal and fast reactor applications, destructive fuel assay
	I_γ	1%	non-destructive fuel assay
Pu 242	α $T_{\frac{1}{2}}$	1%	mass determination
	I_α	4%	mass determination
Am 241	α $T_{\frac{1}{2}}$	1%	fast reactor application
	I_γ	1%	intensity standard
Cm 242	α $T_{\frac{1}{2}}$	0.1%	destructive fuel assay (decay correction)
	SF $T_{\frac{1}{2}}$	3%	fast reactor fuel handling
Cm 244	SF $T_{\frac{1}{2}}$	3%	fast reactor fuel handling
Cf 252	α $T_{\frac{1}{2}}$	0.2%	destructive fuel assay (decay correction)

VIII.

INDC RECOMMENDATION

INDC agreed on the usefulness of a "Coordinated Program on the Intercomparison of evaluations of actinide Neutron Nuclear Data: and recommended that for such a program to be successful, the IAEA should:

1. Conclude research contracts or agreements with the participants in the program;

2. Sponsor research coordination meetings between the program participants at appropriate intervals;

3. In cooperation with other data centers, provide to the participants in the program both experimental and evaluated data in the format in which they were received; agreement to standardize the data in the ENDF/B format is desirable;

4. Correlate and distribute the results of evaluations performed as part of the coordinated program; and

5. Inform the INDC Members and Regional Data Centers on the progress of the program, including status reports and plans for meetings.

IX.A

REPORT OF THE SUBCOMMITTEE ON STANDARD REFERENCE DATA

Following the last INDC meeting, again entries were made to the joint standard file from both (INDC, NEANDC) subcommittees. It is believed that one of the main reason for the existence of such a status file is its impact on the improvements of the ENDF/B standard file. In this sense INDC-24/L is duly timed and sucessive corresponding publications should be time-correlated with the issue of new ENDF/B versions.

However, it is expected that in future the exploitation of the joint standard file is done in cooperation of both subcommittees and that all reviewers which contributed to it are involved.

On a tentative base we included cross sections for the $^{27}Al(n,\alpha)^{24}Na$ and $^{237}Np(n,f)$ reaction in the future list of standards, both reactions are widely used as measuring standards in reactor dosimetry. For ^{237}Np one has not in mind the total fission cross section (as used with fission chambers) but the production cross section for a specific, not yet defined fission product.

Although the recent Washington Standard Symposium has documented extensively the status in this field, it was decided to ask also this time entries from the relevant reviewers. But we will not insist on a new report if the reviewer confirms the finding of the symposium contributions. A deadline has been set at June 30. Membership in the subcommittee has changed, assignment of responsibilities for member countries is unchanged with the exception that an entry for X-ray intensity standards will be prepared by Hungary (Dr. Berenyi) and that IAEA (Dr. Vlasov) has accepted for the time being to care for the entries concerned with the two dosimetry cross section standards.

IX.A

ENDF/B-standard file version V is expected to be released in January 1978, n-p-scattering will remain unchanged. There will be no reaction which is already equipped with a formal error file. It has been confirmed that the standard file will be separately documented similarly like INDC(US)-73/L for the ENDF/B-IV standard subfile.

The task of the ad-hoc group on neutron energy standards under Dr. James (other members being Drs. Boldeman, Corvi, Harvey, Lachkar, A.B. Smith, Voss) were twofold:

(a) setting up an agreed list of sharp resonances suited as neutron energy standards covering the 7 decades from ~1 eV to ~10 MeV;

(b) promoting experiments and evaluations to derive a consistent set of peak energies for the chosen resonances with sufficient accuracy .

The part (a) now has been finished and it has been suggested that Dr. James should be encouraged to publish the agreed list as short notice in a relevant journal (NSE ?).

Proposals for IAEA sponsored meetings relevant to standards were discussed and forwarded to the ad-hoc committee on future meetings.

The subcommittee was concerned with the fact that in the standard field R-matrix fits are employed which use as input data selected experimental data sets instead of results from classical evaluations. It would also like to see much more sensitivity calculations in R-matrix fits to get a feeling for the influence of used theoretical parameters. New phase shift calculations for the n-p scattering should aim also at proper uncertainty propogation from basic observables via phase shifts to differential scattering cross sections.

IX.A

The experimental data files relative to standards at the four nuclear data centres are not in such a shape that they could be used as starting point for evaluation work. This became obvious from retrievals made at the occasion of the NEANDC-NEACRP specialists meeting on fast neutron fission cross sections for $^{235}U(n,f)$ and at the occasion of the recent standard symposium also for other standard reactions. Since then ANL keeps a cleaned and updated experimental data file for $^{235}U(n,f)$.

Typical deficiencies in the retrievals will be sent to NNDC-Brookhaven (U-235; A.B. Smith) and to NDCC-Saclay (B-10; Liskien) and to others interested.

The status of the adopted standards have not been discussed. The time available and the small number of members at present in this subcommittee does not expect that such a discussion could yield valuable findings. However, a more or less complete set of preprints from the NBS (IAEA-sponsored) standard symposium is available. Every-body interested may look at them and approach the authors to receive copies.

Report of the Discrepancy Subcommittee

1. Review of existing entries

Existing entries were reviewed in the light of new information. An attempt was made to identify entries which could be deleted from the list.

Some of the data under consideration are now apparently known to an accuracy approaching requested accuracies. Examples are

- σ_f of ^{235}U (accuracy of ± 2% above ~100 keV seems to be achievable with work already in progress; WRENDA target accuracy : ±1%);

- thermal parameters for fissile nuclei (only remaining real discrepancy: ~1.5% difference between σ_f measured directly and σ_f deduced from Maxwellian averages via Westcott factors for ^{235}U);

- σ_γ for natural iron (largely improved data on ^{56}Fe and ^{54}Fe up to 800 keV thanks to ORELA results now available);

- the fission neutron spectrum of ^{235}U.

For other data large discrepancies exist, but no new measurements have been undertaken since quite a number of years which raises questions as to their importance. An example is the radiation width of the Na resonance at 2.85 keV.

The subcommittee agreed, however, that none of the items could be completely deleted from the list at the present time.

2. Proposed new entries and reviewers

The following new entries were proposed for inclusion in the discrepancy list:

- The ^{232}Thorium fission and capture cross section below 10 MeV (for the Th-U-cycle).
  Reviewer: M. K. Mehta

- The ^{93}Nb(n,n')^{93m}Nb cross section below 15 MeV and the related half life (for dosimetry applications)
  Reviewer: M. F. Vlasov

- The ^{63}Cu(n,α) cross section below 15 MeV (for dosimetry applications)
  Reviewer: M. F. Vlasov

3. Proposal for a Specialist Meeting

The subcommittee was informed that a large body of new information on delayed neutron emission following fission was becoming available and considered this as a suitable topic for a specialist meeting in 1978. A corresponding proposal should be forwarded to the ad-hoc Subcommittee on Future Meetings.

F. Froehner

May 20, 1977

INDC DISCREPANCIES LIST

Person	Responsibilities
Usachev	Alpha values for ^{235}U and ^{239}Pu above about 100 eV
Michaudon	Resonance parameter data of ^{235}U, ^{238}U and ^{239}Pu
Motz	Inelastic scattering data of ^{238}U
Froehner	Capture cross sections of Cr, Fe and Ni above ~ 100 eV
Rowlands	Parameters of the 2.85 keV resonance of sodium
Lemmel	Thermal parameters for ^{233}U and ^{235}U
Froehner	$^{59}Ni(n,\alpha)$ cross sections
Michaudon	$^{241}Am(n,f)$ cross sections
Mehta	Capture and fission cross sections of ^{232}Th below 15 MeV
Vlasov	$^{93}Nb(n,n')^{93m}Nb$ and $^{63}Cu(n,\alpha)$ threshold cross sections
Cierjacks*	Capture cross section of ^{238}U above about 100 eV
Rudstam*	Delayed neutron emitters

*To be confirmed

F. Froehner
May 20, 1977

RECOMMENDATIONS ON THE STATUS OF THE BARN

The Conférence Générale des Poids et Mesures (CGPM) has decided[1], as part of the general adoption of the International System of Units (SI) that the "barn" may be used as a unit of nuclear cross section for an unspecified time but that it should eventually be replaced by the m^2 or by one of the preferred submultiples of the m^2. This decision was originally made in 1969, without consultation with representatives of the nuclear physics and nuclear energy communities most concerned with the use of nuclear cross sections, who became aware of this decision only a few months ago.

The INDC has carefully considered the consequences of the replacement of the barn suggested above. The committee emphasizes that a nuclear cross section - the number of nuclear interactions of a specified type per unit fluence and per target nucleus - is a critical nuclear quantity requiring a special unit. Although a nuclear cross section has the dimensions of area it is not an area.

The barn is a metric unit. The CGPM recogizes the need of special metric units for use along with the SI. A special unit of nuclear cross section would permit use of SI prefixes differing by factors of 10^3, whereas the preferred sub-multiples of the m^2 (except for the cm^2) differ by factors of 10^6. The INDC considers that the barn, which for many years has been used universally as the unit of nuclear cross section, would be the most appropriate unit. The disadvantage that it does not conform to the preferred set of SI sub-multiples is strongly outweighed by its convenience, by the possible consequences of the errors in nuclear reactor calculations that would inevitably result from its replacement and by the considerable economic penalties which would result from the conversion of reactor computer programmes and data files.

Similar conclusions have recently been reached by the Nuclear Energy Agency Nuclear Data Committee, by the Kiev meeting of the Nuclear Reaction Data Centres, by nuclear data committees in the USA and United Kingdom and by other representative bodies.

The INDC recommends that the IAEA support the continued use of the barn ($10^{-28}m^2$) as a special unit of nuclear cross section and inform the appropriate international organizations - particularly the Comité International des Poids et Mesures (CIPM) and the International Standards Organization - of this position.

Submitted by: Cross, Cuculeanu, Kulakov, Legrand, Lemmell, Seeliger, and Smith.

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(1) LeSystème International d'Unités (SI), Bureau International des Poids et Mesures, Sèvres, France, 1977.

NOTE: This is the final version as transmitted to Dr. S. Eklund by the Chairman on June 29, 1977.

REPORT OF THE AD-HOC SUBCOMMITTEE OF THE INDC ON THE SCOPE, PLANNING AND SCHEDULING OF IAEA-NDS MEETINGS

I. Charge to the Subcommittee and Introductory Remarks

The Subcommittee was charged to provide advisory guidance to the IAEA-NDS via the parent Committee (INDC) as to the scope, planning and scheduling of IAEA-NDS meetings. The reference period was a minimum of three years; i.e. extending through at least 1980. Major emphasis was placed upon the policy and technical areas at or approaching a decision point, and on developing-nation interests. The implementation of the resulting advisory recommendations is an executive judgement of the IAEA-NDS constrained by available resources and adapting to needs that will change over the extended three year period. The INDC standing subcommittees provide a sound basis for continuing guidance and planning of such meetings. Subsequent portions of this report deal with: II. general meeting concepts, and III. specific definition of the meetings. The suggested schedule of meetings is outlined on the attached calendar and reference is made thereto throughout.

II. General Concepts, Policies and Practices

The 3-yr cycle of major regional cross section and technology conferences is formulated through the early 1980's. During this period IAEA-NDS should continue to stimulate participation by developing-country personnel within and beyond the particular regional areas. This cyclic major-conference concept should be periodically reassessed particularly at the end of the presently planned cycle (i.e., beyond 1980).

The subcommittee noted the continuing impact of basic understanding of the fission process on a wide range of nuclear applications. Therefore, the past sequence of basic, IAEA sponsored, fission conferences remains of great value and should be continued on an approximately five-year cycle. This indicates a meeting in this sequence on or about 1979. The subcommittee understands that the IAEA (Physics Branch) has initiated planning of a conference on the Physics and Chemistry of Fission for 1979. The Subcommittee recommends the NDS encourage this conference. In doing so, the NDS should point out the importance of many basic aspects of the fission process to nuclear energy programs generally and its own program, specifically.

A major standards conference has just been concluded (NBS, 3/'77). The value of this conference and its predecessors under IAEA-NDS auspices was recognized by the Ad-hoc Subcommittee and the Standards Subcommittee. It was recommended that such nuclear-standards conferences be pursued by the IAEA-NDS on approximately a five year cycle. This implies the scheduling of such a meeting in 1980.+

A two part course on Nuclear Physics and Reactors is scheduled for January 1978 at Trieste. The subcommittee felt that a periodic continuity

of these courses might well be desirable, particularly if associated with such IAEA-NDS endorsed activities as cooperative trans-uranium evaluations where theory will have a strong impact. However, such continuity strongly depends upon the willingness of the Trieste Center to engage in applied work such as cross section calculation. The future of these courses also depends upon the interests of the developing countries for which they are given and on the benefits they derive therefrom. In view of these uncertainties, the Subcommittee felt that the value of the forthcoming meeting should be carefully assessed before making a commitment to subsequent such courses. Such considerations may well indicate that working groups focusing on better defined and more limited topics are a more viable alternative.

The Subcommittee recognizes the continuing importance of NDS data compilation and evaluation activities. A major portion of this work deals with neutron and charged-particle data and the established sequence of 4C+CPND meetings is recommended on a continuing annual basis. NSDD data is a new area now in a rapid and promising growth period. The NSDD world-wide effort should be nurtured through by alternate advisory group and center meetings on an annual basis during the coming three years. The A+M data effort clearly requires detailed attention during the coming two-year test period. An A+M oriented meeting is recommended on an annual basis, alternating between center-function and advisory-group meetings. In addition, supervision will be exercised by the joint IFRC/INDC A+M Subcommittee and appropriate meetings of this advisory group are recommended. The above is a heavy commitment of meetings to center-oriented problems. The Subcommittee feels that in areas where the compilation and evaluation activities are stable and routine the associated meetings should be reduced by extending the intervals between meetings and/or combining meetings so that more of the available NDS meeting resources can be devoted to new areas. This is only a logical outcome of a well established and smoothly working center system. For example, some Subcommittee members found it difficult to justify the proposed EXFOR training meeting in 1979-1980 when that system is said to be working effectively now. There are also uncertainties as to the long term outlook of the A+M data program as discussed at length in the plenary sessions. These make it impossible to project A+M meetings beyond the next two year trial period.

The NDS has given consideration to non-energy oriented specialists meetings; specifically, Isotope Data Requirements for Science and Technology (see INDC(NDS)-85). Such application needs were extensively reviewed by the Non-energy Subcommittee of the INDC and no large requirements could be identified. Therefore, a meeting of this type cannot be justified at the present time. This judgement is subject to periodic reassessment and at a future date a topical area of importance warranting a meeting of this nature may emerge.

The Subcommittee endorses the planned shielding meeting ('78) as of technical value and of NDS relevance. It is largely implemented under non-NDS auspices.

III. Specific Meetings

The subsequent remarks are addressed to specific topical meetings of a technical nature that are well defined in the near term or more broadly outlined in a longer term. Each is related to the technical area of one

of the standing INDC subcommittees and/or a major NDS program. As such detailed definition and planning can be a correlated function of the NDS and the appropriate INDC subcommittee and such is recommended. Each meeting addresses a well defined technical area warranting timely and detailed study with a potential for resolving major issues and/or for stimulating technical initiatives of direct relevance to member states and IAEA-NDS programs.

1. Delayed Neutron Properties

Consultants Meeting, '78

Uncertainties in delayed neutron yields, periods and spectra have been a long term concern in the development of fission-energy systems. This has been recognized with a number of measurement programs that have recently provided a wealth of new information (e.g. Sweden, Germany, Israel, U.S., etc.). It is now an opportune time to assemble a specialists group to assess these new results with the potential of resolving the long standing discrepancies in delayed neutron data. Such a specialists group would probably consist of 5-10 people and their detailed deliberations are not consistent with a session at a larger forum. It is suggested that such a meeting be held in the coming 12-18 months. The forthcoming FPND meeting (Petten, 9/77) offers the opportunity to assemble a suitable planning group including members of the INDC Discrepancy Subcommittee.

2. Nuclear Data for Fusion Technology

Advisory Group Meeting, '78 (November)

At its previous meeting (8th) the INDC suggested that this field would warrant discussion several years hence (i.e. in 1978). For a number of years WRENDA has reflected world-wide interest in this data area and there are several active working groups in member states (e.g. U.S. and Japan). The scope of the problems includes data for: neutronic design, radiation damage and dosimetry, transmutation, and residual activity. Energy Subcommittee-B reviewed the interest in this data area and recommended such a meeting with modest priority for 1978 or shortly thereafter. The Subcommittee recommends that planning for such a meeting be implemented via the NDS and the Energy Subcommittee-B.

3. Special Technical Workshops

The Subcommittee felt that there were a number of technical problems of high priority which, from time to time, reach a decision point where a specialized consultants workshop would have great impact in resolving critical discrepancies. These problems are often in the areas of standards or discrepancies and are often consistent with major accomplishment on the part of developing nations. The stimulation of technical effort and the resolution of outstanding problems are proper functions of the NDS, contributes to the technical stature of the Section, and is in the proper context of the IAEA-NDS role of international coordination. Therefore, the Subcommittee recommends an annual consultants workshop devoted to selected technical issues to be held on a continuing basis. Guidance as to planning and implementation should be provided by the standing INDC technical subcommittees; i.e. Standards and Discrepancies. Several standard problems

were identified as suitable for near-term meetings and several discrepancy issues were suggested for meetings several years hence as follows:

A. Neutron Sources for Standard Studies

Consultants Workshop, '78/'79

Standard measurements often require precise knowledge of neutron-source properties and the proper choice of source characteristics. Such sources include: mono-energetic reactions, white-source spectra, spontaneous-fission-neutron spectra, gamma-neutron and alpha-neutron sources, filtered beams, and thermal and epi-thermal pile beams. Some of these sources are particularly adapted to use at modest facilities. A workshop should assay the status of these source reactions and provide recommendations as to their use including spectral and angular distributions, half-lives, intensities, etc. A definitive review would improve the precision of a wide range of standard measurements. The Standards Subcommittee can assist in the guidance and planning of such a meeting.

B. Fast Fission Cross Sections of U-235 (0.01-10.0 MeV)

Consultants Workshop, '79/'78

The status of this problem was extensively reviewed in 1976 (ANL-76-90) and guidelines for subsequent measurements set forth. These measurements are now nearing completion (e.g. see the NBS Standards Meeting) and it is reasonable to expect this specialists meeting to draw definitive conclusions as to the status of this key standard. These conclusions may well result in a definitive evaluated file to accuracies of 2-3% and that would be a very significant accomplishment. The Standards Subcommittee could assist in the guidance and implementation of such a workshop.

C. Capture Cross Sections of U and Pu Isotopes

Consultants Workshop '78/'79

The Discrepancy Subcommittee suggests that the status of U-235 and Pu-239 alpha and U-238 and Pu-240 capture cross sections be critically reviewed by selective specialists working in the area. Definitive new results should be available within the coming 1 1/2-2 years. The objective is a definitive statement of status and recommendations as to any future work requisite to resolving remaining discrepancies. The energy range of interest extends from the low eV to MeV regions. Guidance in planning and implementation can be obtained from the Discrepancy Subcommittee.

D. Resonance Parameters of U and Pu Isotopes

Consultants Workshop, '79/'78

The status of resonance parameter data for both the resolved and unresolved resonance regions of U-235, U-238, Pu-239 and Pu-240 should be reviewed with recommendations as to current status and future work. A meeting limited to U-238 was held in 1975 (U.S., BNL-NCS-50451). By 1979 a significant amount of new data is expected to become available and a critical

assessment of the data for all four isotopes will be warranted. The Discrepancy Subcommittee can give guidance as to planning and implementation.

4. Reactor Dosimetry Data and Standard Fields

Consultants Meeting, '79

The Subcommittee supports this meeting as a proper function of the strong and successful IAEA-NDS program in this area. By its very success, this program is mature and there is hope that this meeting will summarize the status of the field in a definitive manner. The initial proposal (INDC(NDS)-85) was a scheduled 1978 date. This was felt to be too soon in view of the status of the field, the hoped for summary nature of the meeting and the fact that a major regional meeting on the subject will be held in late 1977 (US-EPRI). The latter will be widely attended by many of the same people who would attend the above consultants meeting. The INDC standing Subcommittees Energy-A and Discrepancies are appropriate advisory bodies for this meeting.

5. Trans-actinium Nuclear Data

Advisory Group Meeting, '79

This tentatively proposed meeting (see INDC(NDS)-85) is a logical continuation of meetings of this nature (e.g. 4 years since the past meeting) held over the past few years and consistent with NDS programatic interest in the topic. However, the character and scheduling is not clear at this time. It is possible that the new initiative in cooperative evaluation of the actinides will have reached substantive goals by 1978 and, as a result, this meeting could focus on that evaluation effort rather than following the more general scope of past meetings of this type. Moreover, there is some uncertainty as to redundancy of the general topic as it seems possible that the NEANDC will sponsor a meeting on cross sections of relevance to actinide burn-up in late 1978. The exact character of the NDS meeting and its scheduling should await the resolution of these uncertainties. The meeting content may be relevant to Energy Subcommittees A and B and timely guidance can be obtained therefrom.

6. Alternate Fuel Concepts

Advisory Group Meetings, '79/'80/'81

An outstanding characteristic of the 9th INDC meeting was the interest in a variety of alternate nuclear-fuel concepts. This interest is reflected in the restructuring of the standing subcommittees, particularly the formation of the Energy-B Subcommittee. Many of these concepts are of considerable contemporary importance to member states (e.g. the thorium cycle in India). Clearly, there is a strong motivation to examine the data requirements of these new approaches to nuclear energy. Thus the Subcommittee recommends that Advisory Group meetings be scheduled several years hence addressing the data needs of these new areas. Such scheduling should commence in 1979 and extend through 1981 with 2-3 meetings. The intervening two years will allow time to better define the more promising concepts and their data needs. These matters are a primary interest of the Energy-B Subcommittee of the INDC. It is premature at this time to specify specific meeting topics. However, illustrative of the current trends are the thorium cycle and electro-

nuclear breeding. Both are the subject of intensive study in member states and both are known to have large and largely unfulfilled nuclear data needs. During the coming 18 months, either of these topics may become firm or alternate choices may become more desirable. However, it is only prudent at this time to schedule Advisory-Group meetings in this general area of alternate or advanced concepts knowing that, in all likelihood, they will become of very great interest in the years 1979 and beyond.

This report was drafted by the Subcommittee Chairman and is believed to be a consensus of the opinions expressed by the Subcommittee and in the subsequent discussions in the full Committee (INDC). It is submitted to the INDC for review.

Argonne, 1 June 1977

Subcommittee membership:

W. Cross
F. Froehner
H. Liskien
A. Michaudon
B. Rose
J. Rowlands
J. Schmidt (alternate, A. Lorenz)
A. Smith, Chr.
L. Usachev
S. Yiftah

SUGGESTED SCHEDULE OF NDS MEETINGS*, 1977-1980

Type	1975	1976	1977	1978	1979	1980	1980+
Major Conf.	Washington* (NBS-425)	Lowell* (CONF-760715)	Kiev* (4/77)	AERE-Harwell* (9/78)	Knoxville (US)* (9/79)	Kiev*	Western Europe*
Symposia	----------	----------	Standards* (3/77-NBS)	----------	Phy. + Chem. of Fission* (IAEA - Phy. Branch)		Standards (5 yr. interval)
Seminar	CINDA-Readers (11/75)	----------	----------	Theory + Eval. (Trieste 1/78)	----------	EXFOR Training (not recommended)	Theory + Eval. Trieste ?
Tech. Committees	INDC (10/75) Vienna	INIS (4/76) Shielding*-Vienna (10/76)	INDC (5/77) Vienna	INDC (Late/78) Shielding* (6/78)	----------	INDC (early/80)	INDC
Advisory Group	TND KFK-Cermany	NSDD Vienna (5/76)	FPND Petten (9/77) NSDD ORNL (8/77)	A+M Adv. Group Nucl. Data for Fusion	NSDD Vienna TND (?)	FPND A+M Adv. Group	
					← Alternate Fuel Concepts → (2-3 Meetings over 3 yr. period)		
Consultants Meeting	4C+CPND Vienna Theory + Eval. Trieste (12/75)	4C+CPND Vienna (4/76) IFRC/INDC Sub. C Culham (11/76) DOSIMETRY Vienna (11/76) ACTINIDE EVAL. Vienna (12/76) NUCL. + REACTOR THEORY Vienna (12/76)	4C+CPND Kiev (4/77) A+M Centers Vienna (5/77) IFRC/INDC Sub. C Vienna (5/77)	4C+CPND CCDN NSDD Centers IFRC/INDC Sub. C (9/78) DELAYED NEUTRONS	4C+CPND BNL A+M Centers STD. INTEGRAL FIELDS	4C+CPND NSDD Centers	4C+CPND NSDD Centers
				Special Technical Working Groups--lead via Std. and Disc. Sub. Com. of INDC One per year			
				Alternatives U-235 Fission ↔ Neut. Sources		Illustrative Capture in U + Pu ↔ Res. Par. U + Pu	

X.A

REPORT OF THE ENERGY APPLICATIONS SUBCOMMITTEE

1. FISSION PRODUCT NUCLEAR DATA

Following the highly successful IAEA FPND Panel Meeting held at Bologna in November 1973, the NDS has issued newsletters reporting international progress in FPND. The third progress report newsletter is currently in production and should be distributed shortly. It is proposed to issue these reports annually.

Newsletter

Mrs. Lammer described the objectives of the newsletter. Contributions were made by individual workers and compiled according to country and laboratory and measurements and evaluations are given separately. The index lists measurements and evaluations by primary nuclide. Mrs. Lammer asked if members of the subcommittee considered the newsletter to be complete and the indexing satisfactory and they agreed that they were.

Petten meeting

Mrs. Lammer outlined the programme for the Petten meeting. The Agenda was included in the NDS progress report and had been sent to contributors to the newsletter.

Decay heat measurements

Dr. Motz described measurement programmes sponsored by NRC and EPRI. At Los Alamos 52 kg of copper, cooled to liquid helium temperatures, is being used to measure the heat output from the irradiated sample (A paper by Yarnell and Bendt is in draft). The time response is (2/10)sec. The number of fissions in the sample can be determined to $\pm$ 1% and the accuracy of the total heat was $\pm$ 2% for times from 10 to $\sim 10^4$-10^5 secs.

For a 6 hour irradiation of U235 in a thermal spectrum the decay heat is equal to the ANS standard at long times but smaller at short times. The ANS standard had an uncertainty of ± 10% and it was customary to take a decay heat output of 1.2 times the ANS standard in design studies (2 standard deviations higher). This "upper estimate" could now be reduced and this was important for the nuclear industry. Calculations using ENDFB4 data agree with the measurements to within ± 2%, although the discrepancies at times shorter than 10 secs are larger. The Oak Ridge measurements (by J.L. Dickens et al) of the separate β and γ energies have larger uncertainties but the total energy agrees with the ENDFB data to within about 5% to 7% accuracy. (A report is in draft) Measurements at times shorter than 10 secs would be valuable to extend the range of accurate data. Measurements for Pu 239 were now proposed.

Dr. Condé described measurements made at Studsvik of the γ component of decay energy. Measurements had been made of the decay energy for U235 thermal fission for decay times of 10 to 10^4 secs and had an accuracy of ± 7%. There were some differences between these measurements and the US data at long times.

Dr. Fuketa reported that decay heat measurements were in progress at JAERI and had been described at the NEANDC meeting.

Delayed neutron spectra

Dr. Condé summarised the delayed neutron spectrum measurements reported in INDC(SWD)-9/G+P by Dr. Rudstam. Data were given for 25 precursors.

Fission product cross sections

Dr. Benzi and Dr. Michaudon described the joint Cadarache - CNEN evaluation for 60 nuclei. The data had been used to analyse integral measurements in fast reactor spectra and would be reported to the Petten meeting.

Dr. Fuketa reported that fission product cross sections were being evaluated at JAERI. Evaluations for 27 fission products had been published in the March issue of JNS and T and were available at CCDN. Evaluations for a further 70 fission products were in progress, and some were now available.

Standards and Discrepancies

Mrs. Lammer pointed out that there were discrepancies between different data for the yield of Nd 148 in thermal fission of U235 and Pu239. This was a standard yield for the measurement of burnup. The subcommittee agreed that this discrepancy should be kept under review but that the conclusions of the Petten meeting should be considered before deciding whether to refer it to the Standards Subcommittee.

2. TRANSACTINIDE NUCLEAR DATA

The proposed NDS cooperative programmes for evaluating actinide cross sections and measuring decay data had been discussed and agreed by the main committee and were not discussed further.

Cross sections

Dr. Michaudon reported that integral measurements made in Phenix had resulted in large adjustments to the cross sections of ^{238}Pu and ^{241}Am. In particular, the ^{241}Am fission cross section had been reduced by 40% to 50%. Mr. Rowlands said that as a result of integral measurements of the fission and capture cross sections of ^{241}Am. Lynn had selected the low fission cross section in the "sub-threshold" region and high capture cross section in his evaluation. Dr. Fuketa said that in the recent JAERI evaluation the low fission cross section had been taken. It was observed that this corresponded to the choice of the Russian measurements rather than the "bomb shot" data.

Discrepancies

It was agreed that the ^{241}Am fission and capture cross sections were important and should be considered by the Discrepancies Subcommittee. Dr. Lemmel reported that the half life of Pu239 was now considered to have an accuracy of ± 1/2% and was not a major source of uncertainty.

The uncertainty in the half-life of Pu241 was large, ± 5%, but its improvement was not considered to be a high priority requirement. Dr. Froehner agreed to look into it.

3. SHIELDING

Meetings have been held on nuclear data requirements for shielding, sensitivity studies and the analysis of benchmark experiments. Further sensitivity studies and analysis of benchmark experiments are proposed before a meeting is held to discuss the nuclear data requirements (possibly in the autumn of 1978). The sensitivity studies already reported emphasize the importance of correlations in the cross section uncertainties. It was pointed out that many of the requests at present in WRENDA might be changed significantly following these studies.

Meetings

A meeting on the nuclear data requirements for shielding in the autumn of 1978 has been proposed and the subcommittee considered this time to be appropriate.

4. ALTERNATIVE FUEL CYCLES

Meetings

Members of the subcommittee considered that there were new nuclear data requirements being identified in studies of alternative fuel cycles and

that it would be appropriate to hold a meeting on this subject in 1978. Particular topics mentioned were:

(a) The thorium cycle
(b) The tandem cycle (which uses reject fuel from one reactor in another reactor)
(c) Core processing of fuel (Incineration might be included in this topic)
(d) Problems associated with indefinite storage of fuel
(e) Electronuclear breeding

INDC members were asked to send proposed topics and possible authors to Dr. Schmidt.

Discrepancies

Large discrepancies in both the fission and capture cross sections of Th232 and U233 and the absence of recent measurements of U233 alpha were described.

5. ENVIRONMENTAL PROBLEMS

This topic had been considered at the FPND and TND meetings and would be considered at the Petten meeting. Mrs. Lammer mentioned that one of the requirements described at the FPND meeting was for more accurate data on the yield of tritium in fission.

6. DATA NEEDS FOR NON-PROLIFERATION

Dr. Motz agreed to circulate to members of the INDC a paper on the data needs for non-proliferation.

7. DOSIMETRY

Dr. Vlasov described the NDS programme of work on the assessment of the status of dosimetry cross sections and the evaluation of cross sections. Integral measurements in benchmark neutron fields play an important part in the validation of dosimetry cross sections.

INDC(SEC)-54/L+Dos describes the IAEA Programme on Benchmark Neutron Fields Applications for Reactor Dosimetry and the preliminary agenda of an IAEA Consultants Meeting on Integral Cross Section Measurements in Standard Neutron Fields for Reactor Dosimetry. A summary report, giving the conclusions and recommendations of the meeting is given in INDC(NDS)-81/L+M. The meeting identified three standard neutron fields (thermal, 1/E and ^{252}Cf spontaneous fission prompt neutron spectrum) and a list of category 1 dosimetry reactions. Dr. Vlasov described other benchmark neutron fields which are being used for dosimetry.

The status of Neutron Cross Sections for Reactor Dosimetry is described in a paper presented to the Lowell Conference in July 1976 by M.F. Vlasov, A. Fabry and W.N. McElroy. (INDC(NDS)-84/L+M). The frequency of use of the different dosimetry reactions can be seen from the figures in Appendix.

Dr. Vlasov drew particular attention to the discrepancies for ^{54}Fe (n,p), ^{63}Cu (n,α) and ^{232}Th (n,f). He also drew attention to the importance of the ^{93}Nb (n,n') isomeric state reaction cross section. This reaction is similar in energy dependence to that of the atomic displacement cross section but there were large uncertainties both in the cross section and in the

half-life of the isomeric state. Further improvements were also required to the ^{235}U thermal neutron fission spectrum and to the ^{252}Cf spontaneous fission spectrum (particularly the high and low energy components, that is, above 8 MeV and below 1 MeV).

Dr. Vlasov described the future programme on dosimetry cross sections. It is proposed to adopt ENDF/B V evaluations as reference data and a co-operative programme of evaluations for reactions used in other countries has been arranged.

The additional reactions are:

(a) Inelastic scattering to an isomeric state:
^{93}Nb, ^{103}Rh, ^{199}Hg

(b) Fission:
^{241}Am

(c) (n,p) reactions
^{14}N, ^{24}Mg, ^{31}P, ^{59}Co, ^{64}Zn

(d) (n,α) reactions
^{54}Fe

(e) (n,2n) reactions:
^{19}F, ^{23}Na, ^{45}Sc, ^{63}Cu, ^{90}Zr, ^{93}Nb, ^{197}Au

(f) ^{197}Au (n,3n), ^{197}Au(n,4n)

In addition, Dr. Vlasov considered the following (n,γ) reactions to be important for dosimetry:
^{40}A, ^{50}Cr, ^{109}Ag, ^{181}Ta, ^{13}C, ^{55}Mn, ^{164}Dy and ^{176}Lu.

The community of experts on nuclear data for dosimetry have clearly defined objectives and the NDS is making a most valuable contribution to this work. However, some members said that they would like to see the user community defining their requirements more precisely and the needs for more accurate differential data and integral measurements in meeting these requirements. Dr. Vlasov described the IAEA programme on the standardisation of reactor radiation measurements (with particular reference to the multiple foil technique). This work is carried out at the Agency's Seibersdorf Laboratory with support from the computer and Nuclear Data Section of the Agency.

Standards and discrepancies

It was agreed to refer the cross section of $^{63}Cu(n,\alpha)$ and the cross section and half-life for the reaction $^{93}Nb(n,n')$ to the isomeric state to the Discrepancies Subcommittee.

Dr. Vlasov said that the reaction $^{27}Al(n,\alpha)$ was used as a standard for the measurement of other dosimetry reactions and he proposed that it should be considered by the Standards Subcommittee as a possible dosimetry cross section standard. Other possible standards are $^{237}Np(n,f)$ F.P. and $^{238}U(n,f)$ F.P.

Dr. Vlasov was asked to prepare a status report on these reactions including a statement on the accuracy requirements.

X.A

8. SAFEGUARDS DATA

Nuclear data requirements for safeguards and accountability are included in WRENDA. Six countries have contributed to this (CCP, DDR, GER, JAP, SWD, USA). Dr. Fuketa has sent out a questionnaire to groups involved in the field of safeguards and accountability asking for their nuclear data requirements and this could result in a wider contribution to the request list. Dr. Fuketa has produced a summary report "On a report in preparation".

Dr. Fuketa's Questionnaire

Some of the replies to the questionnaire commented that, currently, the accuracies of safeguards measurement techniques were not limited by uncertainties in nuclear data and that improvement of the nuclear data was not a high priority requirement. Other replies asked for improved nuclear data.

The NDS has had discussions with the IAEA Safeguards experts. Although these experts say that they do not require more accurate nuclear data at the present stage of development of techniques it is clear to the NDS that extensive use is made of nuclear data. The subcommittee asked if the NDS would hold further discussions with the Agency safeguards experts and summarize the data requirements for inclusion in Dr. Fuketa's report.

Meetings

The subcommittee took the view that discussion of the question of further international meetings on nuclear data for safeguards should be postponed until after Dr. Fuketa's report has been issued and discussed. (A meeting on safeguards techniques need not await this report but this question is not a responsibility of the subcommittee).

9. FUSION

The nuclear data requirements for fusion form part of WRENDA. There are programmes of work to measure and evaluate the cross sections required and benchmark integral experiments are also being made in several countries.

Meetings

The subcommittee supported the NDS proposal to hold an Advisory Group Meeting on Nuclear Data for Fusion but several members argued that they considered this subject to be less urgent than nuclear data for alternative fuel cycles. If a choice had to be made they would support a meeting on this subject in preference to nuclear data for fusion.

Non-Energy Subcommittee

Biomedical data needs

Following the presentation of the Canadian report (INDC(CAN)-17/G), the NDS report (Working paper by Okamoto and Yaghubian), the UK report (Working paper by G. Dearnaley, and the US report (oral report by A. Smith) discussions centered on nuclear data requirements in the biomedical field.

US Report

- Reference was made to the 1977 Brookhaven (US) Symposium in May 1977 on neutron data (for energies 10-50 MeV) which was called primarily for the biomedical and fusion reactor communities - with interest reflected primarily by the fusion community.

- The 1977 Standards NBS Symposium (Gaithersburg) identified needs for biomedical data with 5% to 8% accuracy.

- There appears to be an interest for dosimetry cross section data in the 20-50 MeV range for neutron therapy.

USSR Report

Report was made on the evaluation of ~ 100 isotopes for practical applications (ranging from tritium to Cf) including nuclear structure and selected atomic data, which was performed in the Soviet Union and presented at the 1977 Metrology Symposium in Tashkent. The list of isotopes is included in Dr. Kulakov's paper to the INDC (INDC/P(77)-10 and 10T; see Appendix VII-A).

1. There were different views expressed on the number of radioisotopes which will be used in the future for medical purposes. One school of thought asserted that the number will be rather restricted, say 10-15, while the others expected a much wider range to be used. There appears

to be no consistent list of isotope production cross sections, but neither does there appear to be pressing demands for such data which would need an international effort to satisfy. In general, such data are generated in the institutes which have the facilities for production of the isotope.

2. There appears to be a need for a compilation of structure and decay data suitable for biomedical purposes. The so-called Dillman tables have been expanded and issued by the MIRD Committee* (USA).

   In addition, W. S. Snyder# (ORNL) is compiling data for ICRP on all decay schemes with half lives greater than 10 minutes, and a survey is being carried out for ICRM by NPL-Teddington to ascertain data needs in this field. The priorities should therefore be reviewed in about a year's time.

3. Neutron Data

   The requirements on radiotherapy - neutron scattering and charged particle production - are most comprehensively summarized in Cross's paper (INDC(CAN)-17/G) and relate both to present practice up to treatment with 14 MeV neutron and possible future treatment with energies up to 100 MeV. In addition needs for gamma ray production cross sections for in-vivo activation analysis by fast neutrons were identified by the Biomedical Subcommittee of UKNDC.

   It is clear that a considerable amount of the data for dose calculation is identical to that required for shielding and radiation damage purposes, though the accuracies may not be the same. Similarly the study of source reactions for the production of neutron beams of energies greater than 14 MeV are very similar to those needed for radiation damage studies if, for example, powerful d-Li or similar neutron sources are to be built. The data below 14 MeV are probably in fairly good shape.

*Medical Internal Radiation Dosimetry

#Now deceased.

There exists no major requirements for neutron activation analysis data in the biomedical field, with the exception of $^{46}Ca(n,\gamma)$ and $^{48}Ca(n,\gamma)$, the former for environmental analysis, the latter for the determination of calcium in bone where an improved accuracy from 20% to 5% is required.

4. Electron and Photon Data
A need was expressed (see UKNDC list) for information on scattering, energy loss and penetration of low energy electrons, variously over the range 0.1 keV to 3 MeV together with photon attenuation coefficients in the energy range 0.1 to 200 keV. We are not able to comment on whether the needs are met by available information.

5. Pions, protons and heavy charged particles
A paper by E. Knapp, which was primarily concerned with therapy by pions and heavy ions, was circulated but not discussed. An initial reaction was that this sort of data is appropriate only to a very few centres which have the facilities for such treatment and therefore the facilities for making such measurement, and a major international effort hardly seems justified.

6. There is some interest in non-nuclear (e.g. atomic) data requirements such as W-values, electron stopping powers and ranges and photon attenuation, but it was felt that INDC should not get involved. The committee should note the requirement for these data and encourage the appropriate groups and committees to do the necessary work. (Note added by Chairman: NPL and the U. of Birmingham have begun a joint programme of work on W for protons of energy 0.7 - 3 MeV in various gases.)

Specialists' Meeting on Nuclear Data for Biomedical Needs

The question was raised whether the INDC should recommend holding a meeting of specialists addressed to the question of nuclear data requirements for

biomedical needs. However, because of the wide variety of data types that are of interest, it was felt that only the case of neutron therapy offered any such possibility.

No specific recommendation to hold such a meeting was made; however, W. G. Cross was going to find out from the general feeling at the forthcoming meeting of neutron therapists, to be held in Munich in the week of 23 May 77, whether there is a need for a meeting on neutron therapy nuclear data.

Mehta agreed to draw the attention of the organizers of the 1978 Trieste Course on Nuclear Theory for Applications to the importance both of certain aspects of nuclear reaction theory and neutron transport to biomedical needs.

Summary of nuclear data needs for the analysis of the surfaces of materials by charged particle beams

Reference was made to the UK paper by Dearnaley which was presented to the subcommittee. The type of data needed are elastic scattering cross sections and various reaction cross sections.

- It was confirmed that there exists no comprehensive review of these data but that a great deal of information exists in the literature though not in a compiled or codified form.

- A. Smith suggested that perhaps the Charged Particle Data Centers should explore the possibility of identifying subsets of existing data files which could be of use for material analysis, and that data centres should stimulate local meetings of data users in this field in order to identify the requirements for compilations in this field. With this end in view, the Brookhaven Center would be invited to take an interest in the Third International Conference on Ion Beam Analysis on June 27 - July 1, 1977 at NRL.

Summary of nuclear data for geological purposes

Reference was made to the UK paper on "Nuclear Data for Analysis of Geological Formations by Neutron Interrogation," by L. G. Sanders, which was presented to the subcommittee.

- The nuclear data are required to perform neutron and gamma transport calculations in the context of borehole analysis, and include inelastic neutron scattering data, γ-production, cross section data and capture gamma data in major and minor rock-forming elements.

- Data needed for this field of application appear to be well enough documented for the present exploratory phase of the work.

- In the context of the data needs for fast neutron interrogation (item 6 in the paper), it was pointed out that Demidov's Atlas of gamma spectra from the inelastic scattering of fast pile spectrum neutrons by all materials of $Z < 42$, soon to be published in the USSR, contained data of direct pertinence to the needs identified in Sanders' paper. Kulakov had already promised that copies of this work would be distributed to committee members as soon as it appeared.

- It was also pointed out that there were a few papers on this topic in the conference proceedings of the 3rd Kiev Conference (1973).

Half-life data

The question was raised about the need for an accepted world-wide set of nominal half-life values which could be used by convention, e.g. particularly in the context of documentation relating to the transfer of material through customs, or for other purposes; it was confirmed that no such comprehensive standard set exists but that there are reports, such as the to-be-published NRC report and ENDF-243, which could be referenced for such purposes.

It was not clear from the discussion whether this was anything other than an administrative matter (i.e. it was necessary that the papers accompanying packages should tally with other documents describing them) which could be solved very simply by those concerned with such shipments. However, if a real need were to be established it would be appropriate for IAEA to draw up such a list. NDS was invited to discuss the matter with an appropriate department of IAEA.

Recommendation for future action

The question was raised whether this subcommittee should continue to exist.

As the quantities of data required by individual non-energy users were small compared with that normal in the neutron field (with the possible exception of neutron therapy), it was felt that these users could compile the required information themselves without special assistance from an INDC subcommittee or large data centre efforts.

However, as there exists a well defined user community, it was agreed that INDC should retain this area of work as a separately identifiable topic at its subsequent meetings, but that we recommend that Subcommittees on Non-Energy Applications be disbanded.

B. Rose
Chairman

Revised 25 August 1977

X.B

U.K.N.D.C. Bio-Medical Sub-committee

Request List

1. Excitation functions for the production of isotopes of C, N, O, Na, Mg, P, S. Cl, K, Ca and I and also Fe^{52}, Pb and Tl^{201} by bombardment of suitable targets with protons, deuterons, helium-3 and helium-4 ions of energies up to 500 MeV.

   Application is the economic production of isotopes for use in medical diagnostic techniques. Suitable isotopes should have half-lives in the range from a few minutes to a few days and emit photon radiation in the energy region 100 to 500 keV.

2. Differential cross-sections for the production of prompt gamma rays by neutron interactions with C^{12}, N^{14}, O^{16}, P^{31} and Ca^{40}. Cross-sections for the neutron energy range 5 to 50 MeV are required, to an accuracy of ±10%, with the range 8 to 15 MeV of particular importance.

   Application is in medical diagnostic techniques using in-vivo activation analysis by neutron radiation.

3. Energy and angular distribution of charged particles produced by non-elastic neutron reactions with C^{12}, N^{14}, O^{16}, P^{31} and Ca^{40}. The neutron energy range required is 5 to 50 MeV with emphasis on range 8 to 15 MeV. Accuracies of differential cross-sections of ±10% would be adequate.

   Applications are to the dosimetry of neutron radiations used for cancer therapy and radiobiology, and fundamental investigations of the physical bases of radiation action on living tissues.

4. Stopping powers of protons in the energy range 0.01-10 MeV, alpha particles in the range 0.01-8 MeV and C, N and O ions in the range 0.01-2 MeV, in gases containing H, C, N and O and solids containing these elements together with Ca and P. Measurements for different phases of the same stopping

material are important. Of first importance are stopping powers for protons and helium ions to accuracies of ±3%.

Applications are to the dosimetry of neutron radiation using ionization methods in cancer therapy and radiobiology, the internal dosimetry of actinide elements in radiological protection, and for fundamental investigations of the physical bases of radiation action in living tissues.

5. Values of the average energy, W, required to produce an ion pair by protons in the energy range 0.01-15 MeV, alpha particles in the range 0.01-8 MeV, and C, N and O ions in the range 0.01-2 MeV in CH_4, C_2H_4, C_2H_2, CO_2, Ar and tissue-equivalent gas (64.4% CH_4, 32.4% CO_2 and 3.2% N_2 by volume). The accuracy of measurement should be better than ±3%.

   Application is to the dosimetry of neutron radiation by ionization methods in cancer therapy and in fundamental radiobiological studies.

6. Measurements of the angular- and energy- distributions of electrons as a function of distance from a monoenergetic point source (10 keV to 3 MeV) in homogeneous media containing H, C, N, O, Ca and P. Also measurements of the changes in the distributions at interfaces. Accuracies of ±5% are required.

   Application is to the confirmation of computer calculations of these distributions, which are used for the internal dosimetry of beta emitters in cancer therapy and radiological protection.

7. Experimental values of stopping powers, penetration and range of electrons with energies in the range 0.1 to 10 keV in tissue like material. Accuracies of ±10% are required.

   Applications are to the calculations of dose distributions about internal beta emitters, and the calculations of track structure about ions in studies of the physical bases of radiation action in living tissues.

8. Experimental values of photon attenuation coefficients for photons in the energy range 0.1 keV to 10 keV in tissue like materials including bone to an accuracy of ±5%, and in the energy range 10 keV to 200 keV to an accuracy of ±2%.

   Applications are in diagnostic radiography, in the detection of internal isotopes in radiological protection, and for the dosimetry of fundamental studies in radiobiology.

NOTE

This request list has not referred to isotope decay schemes although these are an important item of data for biomedical work. The reason is that W. S. Snyder of Oak Ridge National Laboratory is compiling data on all decay schemes with half-lives greater than 10 minutes for the International Commission on Radiological Protection, and this compilation is expected to be published during the next 12 months; also the National Physical Laboratory (on behalf of the International Committee on Radionuclide Metrology) is conducting a survey, using questionnaires, to ascertain the data needs in this field. It did not seem worthwhile assembling a request list of decay schemes until the Sub-committee has had an opportunity of studying these two pieces of work.

7 February 1977

X.B

A Note for the INDC Meeting of 18 May 1977

Sub-Committee on Non-Energy Applications

As was reported at an earlier meeting of this Committee, there is a need for an effective compilation of charged-particle nuclear cross-section data for a growing number of applications in the analysis of material surfaces.

The techniques involved are charged-particle induced nuclear reactions or elastic backscattering at energies from a few hundred keV to 5 MeV, or occasionally even higher energies. From the energy spectra of detected particles, or alternatively the variation in yield with bombarding energy, the depth distribution of certain target constituents can be determined quantitatively. The power of the technique has been extended considerably by the development of focused MeV ion beams. In the U.K., such ion microprobes were installed first at Harwell and more recently at the Universities of Manchester and Surrey.

It was our intention two years ago to embark on the compilation of a comprehensive set of nuclear data for the benefit of the users of these techniques, many of whom are materials scientists with a limited acquaintance with the widespread literature of nuclear physics but we were not able to secure financial support.

At the present time, therefore, the only compilation available is that contained in the data sheets of the U.S. - Italian (Catania) Working Party, edited by Prof. E. Rimini and Prof. J.W. Mayer (University of Catania, Italy, June 1974). This is limited to a restricted set of ions and target species, and to incident energies below 2 MeV, which constraint was set by the low energy Van de Graaff accelerators possessed by the participants.

Although a survey of the current work being carried out at centres in the U.K. other than Harwell (including the universities of Manchester, Salford, Surrey, Sussex, Leeds, London and Birmingham, the Royal Military College of Science and the Post Office Research Laboratory) has shown that each laboratory makes use of only a few reactions for specific purposes, the Harwell experimental programme has continually been extended to a wide variety of ion species and reactions. It appears, however, that once a nuclear probe technique has been demonstrated, other laboratories begin to exploit it, perhaps for some specific purpose.

This situation is exemplified by the present development of microprobe techniques for the hydrogen isotopes, based upon the $^{2}D(^{3}He,p)$ and $^{1}H(^{7}Li,\gamma)$ reactions. Several laboratories are now making use of the Harwell facilities for the first of these, and it seems likely that the second will prove even more attractive. During the course of our work, however, we have been able to show that the published cross-section data for the $^{2}D(^{3}He,p)$ reaction is incorrect, the resonance induced at around 700 keV being much broader than had been suspected. This raises the optimum energy for detection of deuterium to around 1.7 MeV.

We are therefore convinced of the long-term value of data compilation and evaluation, in a manner which is directly related to user needs, and which may result in a convenient laboratory handbook. With this in mind, an approach was made (June 1976) to the Science Research Council for funding to support a university based activity coordinated with the Harwell programme. We have recently (February 1977) been informed by the secretary of SRC's Data Compilation Committee that a proposal for support of a post-doctoral fellow will be considered. It is hoped to submit such a proposal with a view to commencing the work before the end of 1977.

G. Dearnaley.

Nuclear Physics Division,
AERE, Harwell.
4th May, 1977.

Working Paper - Non Energy Subcommittee

X.B

NUCLEAR DATA FOR ANALYSIS OF GEOLOGICAL FORMATIONS BY NEUTRON INTERROGATION

Status at May 1977

1) The elements of interest are listed in Table 1. Comments on the availability of data reflect the relative importance of the nuclides and the type of calculations at present being used. The comments also take into account the requirements for neutron field calculations and the assessment of minerals concentrations.

2) Neutron field calculations. For analytical approach or Monte Carlo adequate data are available on

   a) cross-sections in the slowing down region, in particular σ_{sf} (free atom scattering) and I_o (infinite dilution resonance integral);

   b) cross-sections in the thermal region, in particular $\bar{\sigma}_a$ (or σ_a^{2200} and g-factor). H scattering is a special case and may be derived from measured values of diffusion length.

3) Thermal neutron interrogation (prompt gammas). Tables are available for (a) $\bar{\sigma}_a$ for the natural elements;
   (b) I_γ^p (number of gammas of each gamma energy per neutron absorbed).

4) Thermal neutron interrogation (activation gammas). Tables are available for (a) $\bar{\sigma}_a$ for isotopes of the elements of interest;
   (b) I_γ^a (number of gammas of each gamma energy per disintegration);
   (c) $T_{1/2}$

5) Fast neutron interrogation (activation gammas). Monographs are available on this subject giving details of particle reactions up to 14 MeV and

data on the resultant radioactive nuclides. This topic has not been exhaustively examined in Ind. Phys. Group.

6) Fast neutron interrogation (inelastic scatter gammas). Cross sections for gamma ray production are graphed and tabulated ($0.3 < E_\gamma < 10.5$ MeV; $0.1 < E_n < 20.0$ MeV) in ORNL reports for those elements ticked in Table 1. Sufficient information for our present purposes is available on the other less important elements. The ORNL reports are summarised in Nucl. Sci.Eng. March 1977 (see two attached sheets). Cross-section data are tabulated as doubly differential cross-sections (b/sr.MeV) and also, when strong individual gamma rays are identified, as excitation functions (b/sr for a given gamma ray). In particular the latter form appears for C since only one gamma ray (4.43 MeV) is observed.

Table 1

Major rock-forming elements	Mining Group List 1
O	F
Si	
	Ni
Al	Cu
Fe	Zn
Ca	
	Mo
Na	Ag
K	Sn
Mg	
	W
Ti	Pt
H	Au
P	Pb
Mn	
C	

L. G. Sanders

DATA NEEDED FOR DOSIMETRY OF PIONS, PROTONS, AND HEAVY, CHARGED PARTICLES

1. Differential cross sections for the production of neutrons and charged particles as a function of angle and energy for pions, protons, and heavy charged particles incident on hydrogen, oxygen, carbon, and nitrogen.

   Data for other elements found in tissue and for elements found in common materials used in fabrication and production, such as copper, iron, and lead, would be useful.

   Generally, an accuracy of ±5% is adequate, although specific applications will sometimes require better accuracy. Data are needed for incident energies of a few hundred MeV/amu down to the coulomb barrier, except in the case of pions.

2. Because negative pions of zero energy capture on atoms and interact with the nucleus to cause spallation (stars), data are needed not only for in-flight reactions but, perhaps more importantly, for particles produced from pion stars. An accuracy of ±5% is desirable although data of any reasonable accuracy would be useful at this time.

3. Neutrons are produced in many charged particle reactions and can contribute to a large fraction of the total absorbed dose. Therefore neutron cross sections from zero to 100 MeV are needed with accuracies of about ±10%.

4. Stopping powers and ranges to about ±1% are needed for all particles, including electrons and muons. Data of almost any reasonable accuracy would be useful at very low energies.

5. Cross sections for processes which lead to gamma rays and long-lived isotopes will be useful for ancillary problems.

6. Total reaction cross sections for nuclear interactions to an accuracy of about ±10%.

X.C-1

Future Subcommittee Responsibilities

The Non-Energy Subcommittee (N-ESC) has decided that there is not sufficient work in this field to justify the existence of a standing subcommittee to oversee it. However, there clearly remains a continuing need for continued attention to "topic" areas as covered by the existing Energy Subcommittee (ESC).

The ESC would, however, become much too large if all members of the old N-ESC were to join it and the INDC may care to consider instead the abolition of the ESC also and the creation of two new subcommittees which will share the existing responsibilities in the energy field, plus the small residual responsibility from the non-energy field.

A suggested division of responsibilities is given below.

Topic Subcommittee A	Topic Subcommittee B
Core Performance	Waste Management
Safety	Environment
Shielding	Safeguards
Dosimetry	Fusion
Handling and Reprocessing	(a) Radiation Damage
(a) Neutron arisings from αn, spontaneous fission	(b) Activation
(c) Tritium, etc.	(c) Breeding
Thorium Cycle	Other Alternative Fuel Cycles and Nonproliferation
	(a) Nuclear incineration
	(b) Electronuclear breeding
	Non-Energy Applications
	Biomedical, Material Analysis, etc.

The subheads noted under Handling and Reprocessing Fusion and Other Alternative Fuel Cycle are, of course, illustrative only.

B. Rose and J. Rowlands
May 20, 1977

X.C-2

MEMBERSHIPS OF STANDING SUBCOMMITTEES

TOPIC A	TOPIC B
Rowlands (Chairman)	Rose (Chairman)
Smith	Motz
Yiftah	Cross
Froehner	Fuketa
Michaudon	Mehta
Cuculeanu	Condé
Benzi	Decker
Usachev	Berenyi
Gemmell	Legrand
Rapeanu	Kulakov
Schmidt	Seeliger
Lammer*	Lorenz*
Vlasov*	Okamoto*
Lemmel*	Yaghubian*
	Lessler*

STANDARDS	DISCREPANCIES
A. Smith (Chairman)	Froehner (Chairman)
Berenyi	Jackson#
Jackson#	Benzi
Legrand	Michaudon
Kulakov	Seeliger
Rapeanu	Yiftah
Fuketa	Motz
Condé	Usachev
(Future UK rep.)[a]	Rowlands
(CEC Observer)[a]	Mehta
Lemmel*	Schmidt
Vlasov*	Schwerer*

\# NEANDC corresponding member

* Ex-officio, NDS

[a] To be designated

9th INDC

May 20, 1977

X.C-3

SUBCOMMITTEE ON NUCLEAR DATA FOR CONVENTIONAL FISSION REACTOR SYSTEMS

Proposed methods of work:

It is suggested that members should try to keep their topics under continuous review.

If possible, and appropriate, they should comment to the organisers of meetings on the proposed agendas.

The NDS is asked to keep subcommittee members informed about proposed meetings.

Important developments in nuclear data (both the assessment of requirements and the important measurements and evaluations) for the topic under review should be communicated to subcommittee members by the responsible reviewer. (These developments might be the conclusions and recommendations of meetings.)

Before each INDC meeting the responsible member should review his topic and list the questions which the subcommittee should consider. In particular the review should consider proposals for meetings and other actions to be taken by the Agency and possible ways in which the Agency service to users of nuclear data could be improved.

Members should encourage the consideration of the nuclear data requirements for different aspects of the fission reactor programme in their countries (advising them about developments in other countries) and inform the subcommittee about developments.

X.C-4

MEMBERS AND RESPONSIBILITIES OF THE AD HOC SUBCOMMITTEE ON NUCLEAR DATA FOR CONVENTIONAL FISSION REACTOR SYSTEMS

Member	Responsibilities
Benzi	Thorium cycle; shielding
Cuculeanu	Core performance; shielding
Froehner	Safety; fuel handling and reprocessing
Gemmell, Lammer	Fission product nuclear data
Michaudon, Schmidt	Shielding
Smith	Dosimetry; thorium cycle
Usachev	Fuel handling and reprocessing; core performance
Vlasov	Dosimetry techniques and data requirements
Yiftah	Thorium cycle; core performance
Rowlands	Safety; dosimetry

Core performance includes:

Core design and operation, fuel cycles, failed fuel detection, burnup determination, reactor decommissioning.

Fuel handling and reprocessing includes:

Storage and transport, decay heating and activity of reactor components, actinide separation and refabrication, burnup determination and fuel compositions measured by destructive and non-destructive methods.

J. Rowlands
May 20, 1977

Methods of Work

Members should aim to keep their topics under continuous review.

The NDS ex-officio members should inform all members of proposed meetings on the topics for which this Sub-Committee has responsibility.

Members should, wherever appropriate, comment to organizers of meetings on their topics on the nuclear data implications, copied to all members.

Important developments in nuclear data (both in the assessment of requirements and in measurement and evaluation) for the topic under review should be communicated to members (e.g. conclusions and recommendations of meetings).

Before each INDC meeting, the responsible member should review his topic and list the questions which the Sub-Committee should consider. In particular, he should consider proposals for meetings and other actions to be taken by the Agency to improve the service to users of data.

Members should encourage the consideration within their own countries of the nuclear data requirements for the various topics covered by the Sub-Committee, and inform other members about developments.

DRAFT

X.C-6

Sub-Committee on Nuclear Data for Environmental, Future Systems and Other Applications (Sub-Committee B)

In this paper 'member' means 'member of Sub-Committee B' except where otherwise stated.

Responsibilities

Topic	Member responsible
Waste Management	Kulakov, Conde´
Environment	Mehta (Yaghubian)
Safeguards	Fuketa (Lessler)
Fusion	
(a) Radiation Damage	Decker, Berenyi
(b) Activation	Seeliger
(c) Breeding	Motz
Other Alternative Fuel Cycles	
(a) Nuclear Incineration	UK member
(b) Electro breeding	Motz
(c) "Non-proliferation"	(US ?)
Non-energy	
(a) Biomedical	Cross, Kulakov
(b) Material Analysis	UK member (Lorenz)
(c) Geological applications	UK member (Okamoto)

The members names in brackets are the ex-officio NDS staff.