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**INTERNATIONAL NUCLEAR DATA COMMITTEE**

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REPORT OF THE PANEL  
ON NEUTRON DATA COMPILATION

Brookhaven National Laboratory, USA  
10 - 14 February 1969

Vienna, May 1969

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**IAEA NUCLEAR DATA UNIT, KÄRNTNER RING 11, A-1010 VIENNA**

INTERNATIONAL ATOMIC ENERGY AGENCY

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Summary

After surveying current world needs for bibliographic and compilation activities in the field of neutron data, the report of this Panel of 31 individual technical experts, considers the immediate and future role of the world's neutron data centres in this task. In Chapter V the Panel's findings are summarized in the form of recommendations directed to the centres and their associated national and international advisory committees together with all users of the centres.

TABLE OF CONTENTS

| Para.      |   | Page |
|------------|---|------|
| 1 - 7      | I. INTRODUCTION . . . . .   | 1    |
|            | II. CURRENT AND FUTURE NEEDS FOR NUCLEAR DATA COMPILATION . . . . .   | 3    |
| 8          | (A) General appraisal . . . . .   | 3    |
| 9 - 11     | (B) Bibliographic activities - CINDA . . . . .  | 3    |
| 12 - 17    | (C) Compilation of numerical data . . . . .   | 4    |
| 18 - 19    | (D) Definition and classification of neutron reactions and associated data . . . . .                        | 5    |
| 20         | (E) Characterization of experimental measurements . . . . .   | 6    |
|            | III. THE ROLE OF THE WORLD'S PRINCIPAL NEUTRON DATA CENTRES . . . . .                                       | 6    |
| 21--22     | (A) General philosophy . . . . .  | 6    |
| 23 - 29    | (B) Definition and classification of neutron reactions . . . . .  | 6    |
| 30 - 31    | (C) Characterization of experimental data . . . . .   | 8    |
| 32 - 34    | (D) Implementation of the second generation, compilation, storage and retrieval system, SCISRS-II . . . . . | 8    |
| 35 - 42    | (E) Input of experimental data . . . . .  | 9    |
| 43         | (F) Indexing of compiled data . . . . .   | 11   |
| 44         | (G) Reviews of compiled data . . . . .  | 12   |
| 45--48     | (H) Dissemination of information to users . . . . .   | 12   |
| 49 - 51    | (I) Evaluated data . . . . .  | 13   |
| 52         | (J) Integral data . . . . .   | 14   |
| 53 - 59    | (K) Publicizing the activities of the principal neutron data centres . . . . .                              | 14   |
|            | IV. DEVELOPMENT OF THE WORLD'S PRINCIPAL NEUTRON DATA CENTRES . . . . .                                     | 15   |
| 60         | (A) Estimated future data flow . . . . .  | 15   |
| 61         | (B) Future objectives in indexing . . . . .   | 15   |
| 62         | (C) Future goals in evaluation . . . . .  | 16   |
| 63 - 64    | (D) Long-range developments . . . . .   | 16   |
| 65 - 66    | V. CONCLUSIONS AND RECOMMENDATIONS . . . . .  | 16   |
| APPENDIX A | LIST OF PANEL PARTICIPANTS . . . . .  | 20   |
| APPENDIX B | LIST OF PAPERS PRESENTED TO AND DISCUSSED DURING THE PANEL MEETING . . . . .                                | 22   |
| APPENDIX C | GLOSSARY OF TERMS . . . . .   | 24   |

REPORT OF THE PANEL ON NEUTRON  
DATA COMPILATION  
Brookhaven National Laboratory  
U.S.A., 10-14 February 1969

I. INTRODUCTION

1. At its May 1968 Meeting, the International Nuclear Data Committee (INDC) agreed that a general review of world neutron data compilation activities was desirable and recommended that the International Atomic Energy Agency (IAEA) convene a panel for this purpose. In this context neutron data compilation encompasses the collection, storage, and dissemination of bibliographic information and of qualitative and quantitative numerical data on the interaction of neutrons with nuclei and atoms for all incident energies. Such information and data have important applications in low energy neutron physics and many important areas of nuclear technology.
2. As the amount of information in this field has increased, its handling has become a task for large national and international organizations. At present there are data centres at Brookhaven, USA (the National Neutron Cross Section Center - NNCSC\*), Obninsk, USSR (the Information Centre on Nuclear Data - ICND), Saclay, France (the European Nuclear Energy Agency's Neutron Data Compilation Centre - CCDN) and Vienna (the IAEA Nuclear Data Section - NDC) designated as principal data centres for world-wide neutron data compilation and exchange. Representatives of these centres have been meeting regularly to consider the technical problems of data compilation and storage and retrieval systems. The development and activities of the centres are guided by appropriate national and international committees and by the constant interaction between the centres and their users.
3. A Panel met at Brookhaven National Laboratory during 10 - 14 February 1969. Data centre representatives and data centre users jointly reviewed how the world's principal data centres could ideally meet the demands and needs of experimental and theoretical neutron physicists, evaluators, reactor physicists as well as other existing and potential users. This Panel consisted of 31 scientists drawn from 12 countries, the European Nuclear Energy Agency (ENEA) and the IAEA. (A list of names and affiliations is given at Appendix A.)

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\*It should be noted that within the United States/Canada area bibliographic work of the CINDA type - Computer Index to Neutron Data - is handled by the Department of Technical Information Extension (DTIE) Oak Ridge, USA. In other areas the centres combine bibliographic and data compilation activities.

4. In spite of the difficulties caused by a heavy snowstorm which struck New York on the day before the scheduled initial session, the Panel was assembled in time to start serious work during the afternoon of February 11. Only two of the original 33 invitees were unable to reach Brookhaven while the Panel was in session. The Panel members are indebted to the Brookhaven National Laboratory who extended their hospitality to the meeting. The unfailing devotion and tireless efforts of the BNL staff concerned was of great help to Panel participants before, during and after the meeting.
5. Fourteen papers were considered during formal sessions of the Panel. A list of titles and authors is given at Appendix B. The members of the Panel separated into five working groups to consider specific aspects of data compilation and make recommendations. Their individual reports were discussed by the full Panel and, after amendment and editing at the meeting and by correspondence afterwards, constitute the substance of this final Panel report. In the limited time available it was not possible to resolve all differences of opinion between Panel members, and in some instances it has been necessary to record dissentient points of view.
6. As a consequence of the short time available as well as the diversity of interests represented, it is inevitable that the majority of the Panel's conclusions and recommendations are concerned with general policy rather than with technical details. Nevertheless, the Panel's deliberations should serve to stimulate the efforts of the principal data centres to reach agreement on the many technical questions involved in their cooperative and exchange programs and, both directly and indirectly, lead to the provision of a better service for the 'centres' users.
7. The Panel recognized that neutron data compilation had been considered in greater or lesser detail in at least seven scientific meetings held during the previous seven years. However, the Panel noted that the arrangements for compiling and evaluating neutron data were now much more formalized than at the beginning of the present decade. The following main sections of the report record the Panel's view on many of the problems and opportunities which have arisen and are likely to arise in the next few years. In the limited time available the Panel was unable to consider fully many interesting suggestions made in the written papers. The collection of individual papers presented to the Panel was issued as a report in the IAEA-series (IAEA-III). A closer study of these papers is recommended to specialists in neutron data compilation and related fields and to the principal data centres.

## II. CURRENT AND FUTURE NEEDS FOR NUCLEAR DATA COMPILATION

### (A). General appraisal

8. The need for neutron data compilation activities on an international basis has been clearly demonstrated during the past few years. The Panel recognized that the two main activities in this field - bibliographic indexing and compilation of numerical data - should continue for the foreseeable future. Suggestions are continually being made, as in some papers presented to the Panel, for both minor and extensive modifications of the existing systems, either to take into account specialized requirements of a few centre users or to exploit advances in computing and information retrieval techniques. Unfortunately, it is difficult to delineate and apply satisfactory criteria for an assessment of these many suggestions. In terms of sheer bulk of material handled, the largest users of the centres are scientists preparing sets of evaluated neutron cross sections primarily for use in reactor technology. However, nuclear physicists performing cross section measurements and testing nuclear theories are making increasing use of the centres and could eventually make the greatest number of requests for help from the centres. Occasional users can be singled out in fields such as neutron activation analysis. As will be seen in later sections the data centres currently experience difficulty in meeting their present requirements. It is a matter of judgement how much of their effort should be devoted to meet the needs of peripheral users and extend the services provided; what is right for one centre to attempt may not be right for another.

### (B) Bibliographic activities - CINDA

9. The Panel considered that the operation of CINDA had been extremely successful both in providing bibliographic information and in showing that four centres, which were widely separated geographically, could work well together. Publication of the full bibliography on an annual basis together with a semi-annual supplement was satisfactory and more frequent publication was felt to be impractical with the decentralized reader system presently operated.
10. In the future CINDA should be extended to include references to theoretical work relevant to neutron data including both general theory and calculations for specific nuclides and reactions; certain information is already included but considerable improvements could be effected.
11. The principal question to be resolved is the possibility of using a revised CINDA as an index to compiled data available from the data centres. This index might be fairly complex. An intermediate arrangement might indicate unequivocally which references contained numerical data and whether these data were available in total or in part from the centres; the remaining references would then be seen as containing qualitative information only.

C. Compilation of numerical data

12. The Panel considered that whilst scientists directly associated with reactor technology remained the dominant users of the centres the principal need was for data on neutron-induced reactions at incident energies less than 20 MeV. However, data at higher neutron energies are important in source reactions used in resonance studies made with cyclotrons and in considering the shielding of high-energy accelerators and space vehicles, for example. Reactions involving mesons were ignored, the additional effort required to compile neutron-induced cross sections also for energies above 20 MeV is small and should be made available by all four centres. This extension of the energy range to be covered by the data centres should also be reflected in CINDA, and the CINDA Readers should be notified accordingly. This recommendation might need to be reviewed if the amount of high-energy data showed a marked increase.
13. The types of data to be compiled should include:
- (a) microscopic cross sections for all neutron-induced reactions (for example,  $(n,f)$ ,  $(n,\gamma)$ ,  $(n,n)$ ,  $(n,n')$ ,  $(n,p)$ ,  $(n,\alpha)$ ,  $(n,2n)$ , etc.), together with quantities involving cross-section ratios such as  $\alpha = \sigma_{\gamma}/\sigma_f$  and  $\eta = \bar{\nu}/(1+\alpha)$ ;
  - (b) angular distribution for elastically scattered neutrons and elastic scattering polarization data (the latter can assist in the determination of optical model parameters) and angular and energy distributions for inelastically scattered neutrons;
  - (c) differential angular and energy dependent excitation data for outgoing neutrons, protons,  $\alpha$ -particles, gamma-rays, etc., or outgoing combination of these particles;
  - (d) Number, energy spectra, and angular distributions of prompt and delayed fission neutrons and the half-lives of delayed neutron precursors;
  - (e) resolved and statistical resonance parameters, Legendre polynomial coefficients of scattering angular distributions, nuclear temperatures derived from neutron inelastic scattering to the "continuum" range of residual nucleus energy levels and similar physically significant parameters derived by experimenters from their measurements;
  - (f) fission product yields.

14. "Clean" integral data having immediate application in experimental neutron physics and in evaluation should also be compiled. The principal types are average cross sections measured in well defined neutron spectra of standard forms, such as thermal reactor and neutron fission spectra, together with infinite dilution resonance integrals.
15. The interests of data users vary with time. At any given moment some classes of data will be of greater interest than others. The Panel identified the following areas of data which are likely to be of special importance in the next few years:
  - (a) data for fissile and fertile nuclides;
  - (b) data relating to cross-section standards;
  - (c) data for reactor structural and coolant materials;
  - (d) data for shielding materials; and
  - (e) data for transactinium nuclides produced during reactor operations.
16. Current experimental interests and the growing data needs in shielding work have increased the significance of differential and total gamma-ray production cross sections for neutron-induced reactions.
17. Certain neutron producing reactions induced by gamma-rays or charged particles are of interest to experimental neutron physicists or evaluators. Some of them are used in the calculation of neutron source strength and neutron source spectra or in the determination of standard cross sections. Evaluators can sometimes use the cross sections for charged particle-induced neutron producing reactions to determine - by detailed balance arguments - the cross sections of inverse reactions which are difficult to measure directly. The Panel felt that information on the more important of these reactions should be compiled; - some bibliographic information is already available in CINDA.

D. Definition and classification of neutron reactions and associated data.

18. The papers by Goldberg and Goldstein (see Appendix B) indicated that the definition and classification of neutron reactions and associated data is insufficiently refined to meet current bibliographic and data compilation needs. Fundamentally, the problems encountered arise from the limitations and variety of the experimental techniques used in neutron cross-section measurements.
19. The Panel considered that it was vital to establish a fine-meshed classification system for use in data compilation. This should be compatible with the coarse-meshed quantity scheme of the CINDA reference index, which must be refined concurrently. In chapter III detailed recommendations are made on the essential tasks which should be carried out to achieve this objective in which the principal data centres would have a key role.



### E. Characterization of experimental measurements

20. The papers by Goldberg and Schmidt (see Appendix B) presented arguments for associating with each set of compiled numerical data a detailed statement of the main characteristics of the experiment(s) from which the data had been obtained. The Panel accepted that these arguments were generally sound and Chapter III recommends action designed to achieve this objective.

## III. THE ROLE OF THE WORLD'S PRINCIPAL NEUTRON DATA CENTRES

### A. General philosophy

21. The world's principal neutron data centres exist to meet the requirements of scientists, engineers, and technologists in clearly defined areas. The individual user is generally uninterested in the niceties of four-centre meetings and cooperation; his primary concern is the efficiency with which his centre meets his needs. It follows that four-centre\* activities should be conducted with speed and dispatch. In discussing the role of the world's principal neutron data centres in meeting the needs set out in Chapter II the Panel was very conscious of the need to make recommendations designed to put four-centre cooperation on a much simpler routine basis. The Panel believed that the advisory committees and heads of the centres would welcome progress in this direction. Implicit and explicit in the Panel's discussion was the view of some of the users that far too much time was being spent on reaching agreement on such questions as cross section definitions and the second generation of storage and retrieval system for compiled data.
22. The following paragraphs describe the Panel's views on the problems which deserve attention in the short term if the data centres are to fulfil their task successfully. Chapter IV contains a brief discussion of the longer term future.

### B. Definition and classification of neutron reactions

23. The Panel stressed that the compilation and bibliographic centres (the four principal data centres and DTIE, Oak Ridge, USA) will carry the main burden of implementing and using the new classification scheme proposed in paragraph 19. They should take the final decisions on the scheme after receiving comments from the user community.

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\* Here and elsewhere the use of the term "four-centre" should be understood to encompass both bibliographic and compilation activities as far as United States/Canada is concerned.

24. The centres should establish a classification scheme covering neutron-induced reactions for the energy range up to about 20 MeV. Many of the quantities and conventions would be directly applicable to the handling of higher energy data but a detailed consideration of the problems raised by such data was not presently required. The classifications and definitions should conform to the natural order and structure of the physics of the situation as far as is feasible but any practical system will include many specific conventions derived by pragmatic decisions. An example is provided by the area of light nuclide reactions. The compilation and indexing centres should not hesitate to establish such conventions, on the basis of the experience they have acquired, where this is necessary for the smooth operation of the classification procedure.
25. Discussion between the centres on a classification scheme has already taken place. An initial specification should be prepared and agreed by the centres for issue in a report form by the end of May 1969. This should include not only the gross structure but also the specific vocabularies which will be used, and their associated definitions. Any fringe area problems should be expounded comprehensively and any necessary conventions should be spelt out in detail. (The subsequent working meeting held at Columbia University on 24 February provided the opportunity to make an early start; representatives of several centres were present. Further personal contacts between centre staff during March, April and May would also be of assistance.)
26. The report containing the initial specification for the classification scheme should be distributed to interested experimenters, evaluators and other centre users selected by the centres in consultation with members of their advisory committees.
27. A period of about two months (and not more than three) should be allowed for the receipt of constructive comments after which the scheme should be revised by the centres, for finalization at or before the four-centre-meeting planned for the autumn of 1969 and implementation immediately thereafter.
28. The Panel recognized that it is impossible to construct an immutable, comprehensive scheme and recommended that the centres establish a procedure for agreeing on modifications and extensions without undue delay. Equally the scheme to be agreed during 1969 will not be completely satisfactory to all concerned and the centres should endeavour to provide reasoned arguments against any suggestions they may decide to reject.
29. The Panel urged that all concerned should cooperate in using a neutron reaction definition and classification scheme drawn up as outlined in the preceding paragraphs.

C. Characterization of experimental data

30. The Panel recommended that the work initiated by the principal neutron data centres along the lines of the proposals of Goldberg and Schmidt should be continued. The physics characteristics list proposed by the centres should be distributed to interested experimenters, evaluators and other centre users selected by the centres in consultation with members of their advisory committees. Comments should be invited within a strict time limit so that a final scheme can be adopted not later than the end of 1969. Indeed, the exercise could proceed concurrently with that on the definition and classification of neutron reactions detailed in paragraphs 23-29.
31. The finally agreed scheme should be introduced as a part of SCISRS-II. (For definitions of SCISRS I and II see paragraph 33.) There will be a backlog of information to be associated with data which have already been entered directly into the SCISRS-II storage system or which have been transferred from its predecessor, SCISRS-I. The Panel recommended that priority should be given to cross sections of fissile and fertile materials and to standard cross sections and that the more recent data sets should be looked at first. The cooperation of the experimental physicists concerned and of evaluators would be necessary if rapid progress were to be made with this work without detracting from the effect involved in handling the numerical data themselves.

D. Implementation of the second generation compilation, storage and retrieval system, SCISRS-II

32. The Panel was unanimous that the immediate primary tasks of the principal data centres are:
  - (i) to complete the compilation of existing numerical data, whilst keeping abreast of the output of new data, and
  - (ii) to agree and implement an improved compilation, storage and retrieval system.
33. The initial computerized system SCISRS-I (Sigma Center Information Storage and Retrieval System) is now generally agreed to be deficient in certain respects and the centres are currently seeking agreement on the specification of a new system - A Cross Section Information, Storage and Retrieval System - CSISRS, but now conveniently referred to as SCISRS-II - has been specified by the National Neutron Cross Section Center at BNL and its implementation by the principal data centres is under discussion.
34. The Panel agreed that these two primary tasks are likely to tax the present compilation effort of the centres for several years. Having in mind the success of the de-centralized CINDA reader system, the Panel recommended that individual scientists outside the centres, and particularly at the major research centres, should be encouraged to participate in compilation work. These individuals would be made responsible for the provision of information from their local area and institution. They would prepare and submit this information to

the appropriate regional centre in a standard format agreed between the individual and the centre; hopefully the number of different formats would be very small. Apart from easing the work of the centres this scheme would provide another link between the centres and the experimental community. The centres would continue to be responsible for the timeliness and quality of the compiled data and for its relationships with the measuring community. The general relation between the centres and experimenters is discussed in paragraphs 35-42.

#### E. Input of experimental data

35. The Panel reviewed the problems involved in transmitting experimental data to the centres. As a broad generalization it can be said that whilst the centres are crucially dependent on the cooperation of experimenters, the latter are still seldom amongst the centres current major users. The Panel was particularly conscious of the need to examine ways in which the centres could assist experimenters, particularly at a time when the latter were likely to be called upon for additional help (see paragraph 34).
36. The first requirement is to establish good personal relationships between staff of the centres and experimenters. This can and is being done by centre staff visiting data-producing laboratories in the appropriate geographical areas; centre personnel should spend time at experimental installations. Contacts can also be made if center staff attend scientific meetings and in this case the centres usually receive useful publicity. If experimenters can be persuaded to spend short periods at the centres this will be of mutual benefit to experimenters and compilers.
37. The second requirement is to be able to provide the experimenter with all information relevant to the planning of his experiment. He will wish to have available bibliographic and experimental information relating to previous measurements (if any) in the area of interest and the centres should be able to make this available in both tabular and graphical forms indicating quoted errors and any other relevant quantitative and qualitative information. In the past, hard copy publications such as BNL 325 and BNL 400 have done much to meet this need but direct interrogation of the centres' files may eventually be capable of producing a better service.
38. The third requirement is to assist the experimenter in the derivation and interpretation of his results. The centres should make available the current best evaluated values of the common cross-section standards (the means by which these are to be made are discussed in paragraph 51). On request, they should provide experimenters with plots of their results together with the results of previous measurements; this service will be expedited if experimenters submit their results in a standard format. In certain instances the centres may be able to participate directly in the experimental analysis in order to expedite the provision of information; this could help where the experimenter was understandably reluctant to release preliminary data but was unable to find the effort for its complete analysis, or where the experimenter's

primary interests did not require him to extract all the data which his experiment could yield. Centres may be able, either directly or through the established computer code centres, to provide tested computer programmes for analysis and interpretation such as resonance fitting and optical model calculation.

39. The fourth requirement is to convince the experimenter that data sent to the centres will be treated with consideration. Careful checking procedures are needed including the sending back of a numeric and/or graphic proof copy to the experimenter before the data are made generally available through the centres' files. In this way he will be able to check any physical description of his data made by the centre and to check general errors in the transcription of his data from the original transmission medium to the standard computer storage format of the centre. This mutual consideration of data by experimenter and compiler can only be beneficial to both.
40. The handling and documenting of data which are either preliminary or are not fully detailed in the conventional literature, generally from considerations of space, require special care. To an evaluator, preliminary data are sometimes better than no data at all, and the centres should negotiate for their release to meet urgent requests in the period before the data become "final" and freely available. Efforts should be made to have data available at the centres as soon as they are useable; thus cross-section data can be useful before a full resonance parameter analysis has been completed. If such efforts are to succeed it is essential that preliminary data be revised and/or removed at the request of the experimenter and that he be kept cognizant of the centre's interpretation of revisions.
41. A question which generated heated discussion at the Panel was re-normalization of data sets by the experimenter, the centres and the users. It was agreed that all centres should hold the latest version of the data set provided by the experimenter, even though the normalization was outdated. The associated descriptive information should state clearly the normalization employed, including all the numerical values actually used. Data should be supplied in this form to all requesters. Any user, including centre users preparing publications such as BNL 325, would be free to renormalize the data in the course of evaluation work or other applications.

Some Panel members felt that the centre should be explicitly forbidden renormalization without concurrence of the experimenter, but the majority felt that this was unduly restrictive; there should be no difficulty if documentation was adequate. Should the experimenter provide revised data - re-normalized or altered in some other way - all centres should forthwith include the revised data in their master files and indicate this change to users through the published index or by other means. Experimenters' requests to remove data no longer considered valid should be handled in a similar way - with adequate recording.

42. The fifth requirement is to secure general acceptance of the concept that no relevant experiment in neutron physics should be considered as completed until the data have been sent to the appropriate centre. Authors and editors should be encouraged to include a note that this has been done in any final report on the work. The Panel noted that such action can save the experimenter much time formerly consumed in correspondence with potential users of his data; this task would then fall to the centres; the pressure on journal space might also be slightly reduced. This question is touched on again in paragraph 58 in connection with publicizing the activities of the centres.

#### F. Indexing of compiled data

3. Most of the Panel felt that some form of index was needed in order to describe and advertise the data which the centres have compiled in their files.\* There was general agreement that CINDA should give at least a general indication of what numerical data were held by the centres and possibly the number of points in each data set, but whether it can be adapted as a data index to meet all the needs of the centres and their users is not clear (see also paragraph 11). Other possibilities include an extension of CINDU (Catalogue of the IAEA Nuclear Data Unit), a replacement of the CCDN Newsletter No. 4 or some new edit of SCISRS-II. In the opinion of experimenter members of the Panel the available experimental data do not change sufficiently frequently to make frequent publication of such an index desirable; six-monthly intervals should be acceptable and the index could well be organized on the basis of an annual cumulative edition and an intermediate supplement. Intermediate needs could be met by means of "user profile" techniques as described in paragraph 48. The current position is that several centres are carrying out experiments aimed at meeting needs for communication within centres, between centres, and between centres and users. The Panel expressed concern at the amount of effort being consumed but, in the time available, was unable to make a general technical assessment of the competing and complementary alternatives, except in respect of CINDA (see above and also paragraph 11).

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\* Two members of the Panel dissented from this view. They argued that there should no longer be any need for an index of compiled data, except perhaps for internal use at the centres. For the user a published index might prove a deterrent; if the data he wanted were not listed he probably would not trouble to send his request to the centres. The user ought to be able to assume that all data are available from the centres on request, and that the centres would be eager to try and obtain quickly any requested data which are not yet available in their data files. The exponents of this argument felt that it would lead more speedily to the fulfilment of the primary tasks defined in paragraph 32. Their proposal would enhance the role of the "user profile".

### G. Reviews of compiled data

44. The Panel accepted that the data centres should continue to issue review publications which they believed would serve the user community. The compilation volumes BNL 325 and BNL 400 are the best known examples of such reviews and had been well received by users. Many of those present believed that this type of graphical review will remain very useful to experimenters by fulfilling a need which cannot be met by explicit requests to centres. Future publications might include the results of systematic well-documented evaluations to the mutual advantage of experimenters, centres and evaluators, and discrepancies between experimental and evaluated data would be highlighted. The volume of material now available was very large and new thinking was needed on the form that future review publications should take. Such publications were unlikely to be produced as frequently as indexes of compiled data (see paragraph 43).

### H. Dissemination of information to users

45. The Panel recognized that many different methods were theoretically available for the dissemination of information to the centre's users. Formal methods such as the published cumulations of CINDA (paragraphs 9 - 11), indexes of compiled data (paragraph 43) and reviews of compiled data (paragraph 44) have already been mentioned.
46. Many different output media for data could be made available with formats tailored to the individual tastes of the users but the widespread adoption of a few standard forms should enable the centres to provide a better service for all users. The following outputs merit particular attention - well-arranged printed listings, punched cards, paper tape, magnetic tape and hard copy graphs with appropriate scales. It is desirable that centre-to-centre and centre-to-user communication in computer oriented media should be in a language which is machine-independent and consistent with regional scientific computer usage where practical. The Panel recognized that this objective was a good way from completion but urged the centres to continue efforts in this direction.
47. The Panel accepted that the centres, through their newsletters and other publications, should specify the types of retrieval available and should overtly offer guidance in the choice of transmission formats, making recommendations that will encourage standardization and enable users to specify the particular retrieval best suited to their needs. In this process there will need to be continuous consultation with users, particularly with those wishing to have large blocks of data on magnetic tape for use in computerized aids to evaluation such as the computer-graphics code, SCORE. On the other hand, the centres might carry out simple arithmetical transformation of the compiled data for users having limited access to computers. This service would only be provided on special request and might involve, for example, fitting Legendre coefficients to angular distributions, or changing coordinate systems, but any such transformation should not alter the physical content of the compiled files.

48. Whilst many users will be content to request data from centres by referring to the latest available index, there may be cases where immediate access is required to the latest data. The Panel commended the suggestion that the centres investigate the possibility of building up profiles of individual user needs and contacts between the centres and their customers would be strengthened. The profiles could be automatically and routinely compared with incoming bibliographic and numerical data so that any relevant material would be retrieved in a form suitable for immediate transmission to the requester. In this way any residual problems arising from the periodic publication of CINDA and data indexes could be minimized.

#### I. Evaluated data

49. Although much of the centres' efforts stem from the need for better evaluations of neutron cross sections, the direct involvement in evaluation work varies from centre to centre. The Panel recommended that all centres should continue to hold and disseminate evaluated data on request to users within their respective service areas in accordance with the policy worked out by the appropriate advisory and executive bodies. The Panel saw a need for more effort to be devoted to evaluation work but appreciated that the amount, if any, of money and manpower which each centre should make available for this work is a matter which only the appropriate advisory committees and executive authorities can decide. The Panel considered that the IAEA had a role to play in organizing discussions on data evaluation methods and bringing together those groups in the world engaged in neutron data evaluation. Its conferences on nuclear data contributed towards achievement of these aims. The Agency's Nuclear Data Section could also play a role in the preparation of review articles (see also paragraph 44).
50. In discussion it was pointed out that full evaluation of data for a particular nuclide provided the best opportunity for making a detailed check on the accuracy and completeness of the centres' bibliographic and numerical data for that nuclide so that the centres should maintain close contact with the community of evaluators.
51. The Panel noted the recommendation of the Panel on Nuclear Standards needed for Cross-Section Measurements (Brussels, May 1967) that the Agency continue or extend its support for the evaluation of standard cross sections. The centres might have an important role in this work. They may themselves undertake evaluations of such quantities or, more likely, coordinate such activities. The centres' files should be made available to the appropriate specialists who might be encouraged to visit the centres when engaged in evaluating standard cross sections. The centres should publicize evaluations of standard cross sections and encourage their wide availability (see also paragraph 38). The Panel urged that the Agency through the International Nuclear Data Committee (INDC) should now initiate permanent arrangements for undertaking regular evaluations of standard cross sections.



J. Integral data

52. Many reactor physicists wish to make calculations involving both evaluated differential neutron data and so-called "dirty" integral data derived from measurements on assemblies of fissile, fertile, and other materials. Whilst the compilation of such quantities as effective resonance integrals, Doppler coefficients, critical sizes, and spectral indices is not within the data centre's field of work, it could be useful for the centres to store such data and make them available to reactor physicists on request, as is done with evaluated cross-section data. This presupposes that arrangements are made for the compilation and possible evaluation of those data. Reactor physicists present at the Panel considered that this possibility should be raised with the International Working Group on Fast Reactors (IWGFR) of the IAEA and the European-American Committee on Reactor Physics (EACRP). Due account should be taken of a computerized bibliographic and data system for such material which had been inaugurated at the Lawrence Radiation Laboratory, Livermore, USA.

K. Publicizing the activities of the principal neutron data centres

53. The Panel recognized that, once the necessary resources of manpower, money and materials had been made available to enable the centres to satisfy the needs of their principal customers, they should also seek to serve the many potential small users whose requirements could probably be met with little or no extra effort.
54. The best form of publicity is the customer whose bibliographic and data needs have been rapidly and efficiently met by the centre concerned. Periodic publication of newsletters and other widely distributed material setting out the centres' services and activities is important but must be backed by real service. All centre publications should contain information on centre services.
55. The Panel recommended that the centres appoint specialists on a regional or institutional basis to act as local contacts for the centres and users. This would parallel the arrangements made by several computer code centres.
56. The importance of centre staff participating in scientific meetings attended by users is referred to in paragraph 36. Participation will tend to enhance the professional status of centres and their services.
57. The Panel noted that publication of its proceedings could give valuable publicity to the centres' activities and asked that the IAEA take this into consideration when considering the distribution to be made over and above that to participants, the INDC and the steering committees of the centres. Summaries of the Panel meeting should be submitted to Nature, Nuclear Engineering International, Nuclear News, Physics Today and similar journals.
58. The Panel recommended that résumés of centre activities should be

sent to editors of the journals commonly used to publish experimental results, together with a suggestion that authors of papers should be encouraged to send their results to the appropriate centre. Possibly the journals' "notes for authors" could be amended to include an appropriate recommendation.

59. The Panel recommended that universities and national and private laboratories should all be encouraged to include references to data centres and their services in appropriate educational programs, whether provided by physicists, librarians or information scientists. This point should be stressed in any articles submitted to the broad based journals such as Nature and Physics Today.

#### IV. DEVELOPMENT OF THE WORLD'S PRINCIPAL NEUTRON DATA CENTRES

##### A. Estimated future data flow

60. The future development of the world's principal neutron data centres is clearly related to the likely rate of production of new data. The Panel were given estimates obtained by analysing annual entries to CINDA which suggested that, at present, ~ 3000 entries per year contain compilable experimental neutron data, although several CINDA entries may refer to the same experiment. The figure of "3000" gives the order of magnitude. The figure depends strongly on the scope of data to be compiled and on how the term "entry" is defined, e.g. as an "experiment" or as one "data set" out of several sets resulting from the same experiment.

It also appears that the level of publication is tending to stabilize at this figure. However, the volume of data per experiment is increasing as a result of automatic data processing so that the rate of addition of data to the centres' files may well increase. Differing views were expressed as to the likely level of neutron data measurement activities in the future and some Panel members expected a decrease, particularly within their own geographical area.\*

##### B. Future objectives in indexing

61. As discussed in paragraph 43, the Panel expects to see steady progress towards coordination and completeness of indexing so as to provide a complete guide to the world's available compiled neutron data.

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\* Since the Panel Meeting the National Neutron Cross Section Center at Brookhaven National Laboratory have examined their records which suggest that in 1967 only about 1100 entries were made into their bibliographic system, which is similar to CINDA, containing compilable neutron data. The figure for 1968 is likely to be lower.

### C. Future goals in evaluation

62. The views of the Panel set out in paragraphs 49 - 51 suggest that the IAEA and the centres may slowly become more concerned with evaluated data.

### D. Long-range developments

63. The Panel believed that centres should keep themselves informed of conceptual and hardware advances in information science and computer technology. Graphical and display schemes can be expected to become of increasing importance for the maintenance, correction and review of compiled data files and as aids to evaluation. In the long term large on-line direct access data files may become important. It was too early to decide whether such equipment would be sufficiently cheap to be installed for neutron data compilation work alone but developments, including the use of such equipment in other scientific information work, should be closely followed.
64. The Panel wished to see closer links established between the neutron data centres and other centres working in related fields with a view to exchanging experience on methodology. Much might be learned from information retrieval work in medicine and meteorology, for example, particularly as regards speed of access to data by users. Conversely technological advances made in the neutron data compilation field should be made available to other information scientists.

### V. CONCLUSION AND RECOMMENDATIONS

5. This report contains the Panel's assessment of world requirements for bibliographic and compilation work in the field of neutron data, together with suggestions as to how the bibliographic and compilation centres can meet the needs which have been identified. These suggestions, which are summarized as recommendations in paragraph 66, should be seen as goals towards which the centres should strive. The Panel recognized that many of these goals cannot be attained very quickly and that questions of priority will arise. The order of the recommendations should not be taken as an order of priority. If Panel members had attempted to assign priorities, which they did not, it is likely that a diversity of views would have emerged.

It should be emphasized that Panel members were present as individual technical experts. The implementation of any recommendations involving international or national organizations or the bibliographic and compilation centres is a matter for the appropriate executive bodies. The Panel concluded their deliberations in the hope that they had provided helpful guidelines for the deliberations of those bodies and in the confidence that their recommendations will receive careful consideration by all concerned and lead to closer inter-centre cooperation.

66. The Panel's recommendations can be summarized as follows:

- a) The need for bibliographic indexing and numerical compilation of neutron data on an international basis has been clearly demonstrated and should continue for the foreseeable future (paragraph 8).
- b) The operation of CINDA has been extremely satisfactory.
  - (i) Publication of the full bibliography should be on an annual basis together with a supplement at each half year (paragraph 9).
  - (ii) CINDA should be extended to include more information in theoretical work relevant to neutron data and to include data at all energies (paragraphs 10 and 12).
  - (iii) CINDA should contain a rudimentary index to compiled data and should possibly contain an extended index (paragraphs 11 and 43).
- c) Neutron data should be compiled at all energies by all centres subject to any mutually agreed exceptions and priorities (paragraph 12).
  - (i) Classes of data to be compiled are set out in paragraph 13.
  - (ii) The areas of data likely to be of most importance over the next few years are set out in paragraph 15.
  - (iii) Clean integral data should be compiled (paragraph 14).
  - (iv) Differential and total gamma-ray production cross sections for neutron-induced reactions are now of considerable interest to users (paragraph 16).
  - (v) Data on certain photoneutron and charged particle neutron producing should be compiled (paragraph 17).
- d) A fine-meshed classification scheme for neutron reactions should be formulated and put into use before the end of 1969 in accordance with the timetable set out in paragraphs 23 - 29 (paragraph 19).
- e) A scheme for associating a detailed statement of the main characteristic of each experiment with compilations of the resulting data should be formulated and put into preliminary operation before the end of 1969 in accordance with the timetable set out in paragraphs 30 - 31 (paragraph 20).

- f) The immediate primary tasks of the principal data centres are to complete the compilation of existing numerical data, whilst keeping abreast of new data, and to agree and implement an improved compilation, storage and retrieval system (paragraph 32).
- g) Input of experimental data can be facilitated by:
- (i) establishing good personal relationships between centre staff and experimenters (paragraph 36).
  - (ii) encouraging individual scientists outside the centres to participate in compilation work (paragraph 33).
  - (iii) centre aid in the planning of experiments (paragraph 37).
  - (iv) centre aid in the derivation and interpretation of results from raw data (paragraph 38).
  - (v) considerate treatment of experimental data after they are sent to the centre (paragraphs 39 - 41).
  - (vi) general recognition that no neutron cross section experiment should be considered complete until the data have been deposited at the appropriate centre (paragraph 42).
- h) Centres should publish review publications which they believe will serve the user community (paragraph 44).
- i) The centres should provide data to users in a variety of media: printed listings, graphs, paper tape, punched cards and magnetic tape - but should encourage standardization within each medium so as to free effort to meet special requirements of users having limited computer facilities (paragraphs 46 - 47). In particular:
- (i) Some form of index is needed to describe and advertise the data which the centres have compiled in their files. The centres should attempt to coordinate their activities in this field (paragraphs 43 and 61).
  - (ii) The centres should investigate the possibility of building up profiles of the data requirements of individual users, so that they may be quickly supplied with any relevant new information from routine retrievals between publications of indexes (paragraph 48).
  - (iii) The centres should continue to seek agreement on centre-to-centre and centre-to-user computer oriented communication systems in high level languages consistent with regional computer usage (paragraph 46).

- j) Centres should hold and disseminate evaluated data on request to users within their respective service areas (paragraph 49).
- k) In order to increase the effectiveness of world evaluation work:
  - (i) The IAEA should organise discussions on evaluation methods and bring together groups engaged in evaluation. (Paragraph 49.)
  - (ii) The Agency's Nuclear Data Section could play a role in the preparation of review articles on evaluation (paragraph 49).
  - (iii) The IAEA should institute permanent arrangements for the regular evaluation of standard cross sections (paragraph 51).
- l) The compilation of integral data should be considered by IWGFR and EACRP. The centres may have a role to play in the dissemination of compiled integral data (paragraph 52).
- m) The centres' activities should be publicised in such a way as to increase their usefulness per unit cost (paragraph 53).  
Specifically:
  - (i) All centre publications should contain information on centre services (paragraph 54).
  - (ii) Centres should appoint specialists on a regional or institutional basis to act as focal points of contact (paragraph 55).
  - (iii) Centre staff should participate in relevant scientific meetings (paragraph 56).
  - (iv) This Panel report should be given a wide circulation and summarised in general scientific journals (paragraph 57).
  - (v) Journals should announce and encourage the transmission of numerical data to the centres (paragraph 58).
  - (vi) The education of physicists should include information on data centres (paragraph 59).
- n) The centres should keep abreast of general developments in computer technology and information science and seek closer links with other centres working in related fields (paragraphs 63 - 64).
- o) The need and right of individual centres and their associated committees to give different priorities to the implementation of these recommendations should be recognized but several centres should work for ever-increasing cooperation (paragraph 65).

No attempt has been made to classify these recommendations as directed specifically to the IAEA, INDC, Centres etc. The Panel believes they should be studied by all appropriate corporate bodies and individuals (experimenters, evaluators, etc.).

APPENDIX A

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APPENDIX B

LIST OF PAPERS PRESENTED TO AND DISCUSSED  
DURING THE PANEL MEETING

| <u>Authors</u>   | <u>Title of report</u>   |
|--|--|
| 1. V. Bell   | CCDN - A European contribution to the world-wide collection and dissemination of neutron data information. |
| 2. M.D. Goldberg   | The specification and characterization of neutron data.  |
| 3. H. Goldstein  | On the role of cross section classification schemes in neutron data compilation and indexing.              |
| 4. W.M. Good, P.M. Attree,<br>T.A. Byer, L. Hjaerne,<br>V.A. Konshin, H.D.Lemmel,<br>and A. Lorenz<br>(presented by L.Hjaerne) | The role of the IAEA in the world-wide compilation of neutron data.  |
| 5. R.J. Howerton   | Progress report on the conversion of SCISRS I data to ECSIL.   |
| 6. M.N. Nikolaev<br>(presented by V.G.Zolotukhin)  | The evaluation of nuclear data in the Soviet Union.  |
| 7. K. Parker   | Neutron data compilation - progress in the sixties and questions for the seventies.                        |
| 8. M. Ribon  | Services expected of data compilation centres.   |
| 9. J.J. Schmidt  | Basic requirements of advanced neutron data storage and retrieval systems (CSISRS).                        |
| 10. A.B. Smith   | Neutron data compilation - an experimentalist takes a critical look.                                       |
| 11. S.I. Sukhoruchkin  | Need to extend and accelerate the exchange of data obtained from neutron experiments.                      |
| 12. L. Wallin  | Data centres: who wants what and why?  |

- |   |  |
|---|--|
| 13. V.G. Zolotukhin                                       | Activities of the Nuclear Data Information Centre, Obninsk           |
| 14. The Four Data Centres<br>(presented by M.D. Goldberg) | Joint 4-centre paper to Panel on Compilation, 10 - 14 February 1969. |

The non-specialized reader may find that a reading of these papers is assisted by reference to the Glossary of Terms made available to Panel members and reproduced as Appendix C.

APPENDIX C  
GLOSSARY OF TERMS

**BIB**

is a master file in the SCISRS-II system for all bibliographic information.

**CCDN = NDCC**

Centre de Compilation de Datas Neutroniques of the ENEA (Neutron Data Compilation Centre) at Saclay, France, services OECD countries in Western Europe and Japan.

**CINDA**

an international Computer Index of Neutron Data is an index to the literature, made in world-wide cooperation involving four information centres: DTIE, CCDN, NDU, ICND.

CINDA allows its users to find the references to specific types of cross section information or other microscopic data from neutron induced reactions, for any given target nucleus.

**CINDARELLA**

is a unified data-bibliography index which had been proposed by the NDU and the CCDN, which could be created by merging CINDU and the CCDN data index into one file. The proposed joint index aims at combining the SCISRS quantities with those of CINDA, so that the CINDA quantity is supplemented by a modifier. The CINDARELLA quantities are composed of a main quantity plus sub-quantities described by a modifier attached to the main quantity.

**CINDU**

Catalogue of numerical neutron data available from the IAEA Nuclear Data Unit (now the IAEA Nuclear Data Section) which serves both as a catalogue and bibliography of the data which have been entered in the DASTAR-system.

**COMPILATION**

means the collection and storage of all experimental measurements of particular cross sections for particular materials. The general objectives of neutron data compilation are:

to make available in a most efficient manner, with the least possible delay, all of the world's numerically measured data in the field of neutron physics, to the world's scientific community;

to provide a new computerized medium of publicizing for the increasing amount of scientific results which can no longer be published by the conventional methods;

to offer optimum services to all kind of customers, in order to avoid duplication of efforts by local activities;

to review the growing data files critically and currently in order to derive maximum profit from them.

COSA NOSTRA - the older version of parts of ECSIL.

#### CSEC

the Cross-Section Evaluation Center, Brookhaven National Laboratory, deals with systematic evaluation of neutron cross-section data. It developed the punched card/magnetic tape system called the ENDF or Evaluated Nuclear Data File, which had been split into two systems ENDF/A and ENDF/B. Version A contains evaluated point data and is intended for use by individuals actively engaged in evaluation work. Version B is intended as direct input into multigroup and Monte Carlo codes.

#### DASTAR

the computerized Data Storage And Retrieval System of the IAEA Nuclear Data Section. At this date approximately 170.000 numerical data points have been entered, indexed and referenced in the DASTAR-system.

#### DAT

is a master file in SCISRS-II for numerical data, which contains data tables in a flexible form. In the March 1968 revision of the November 1967 proposal, this file was changed from an archival to a retrieval oriented file.

#### DATA INDEX

the data centres issue a catalogue of their compiled numerical experimental data. The NNCSC has issued in June 1967 a SCISRS-Newsletter, part A contains a reference listing and bibliography, part B - isotope listing. Data index of the CCDN has been issued as the CCDN Newsletter - CCDN/NW-4, December 1966. Catalogue of numerical experimental data and bibliography of the NDU is CINDU, periodically published (the last issue is No. 9, January 1969).

#### DICTIONARY

Much of the information entered into the compilation systems is coded into symbols of one to three characters. Internationally adopted dictionaries are so far the laboratory codes and the reference codes as used in CINDA.

#### DTIE

the US Atomic Energy Commission's Division of Technical Information Extension at Oak Ridge, Tennessee, has the CINDA responsibility for the North American service area.

#### ECSIL

the Experimental Cross Section Information Library, a system for the storage, retrieval, and tabular or graphical display of experimental constants associated with neutron-induced nuclear reactions. The system has been developed by the Lawrence Radiation Laboratory, Livermore, USA.

#### EVALUATION

Though the word "evaluation" is being used in a variety of meanings, the following definition should be used here:  
evaluation is the logical derivation of preferred (best) values for neutron data, taking into account all available experimental data.

#### ICND

Informazionnyj Zentr po Yadernym Dannym (the Information Centre on Nuclear Data) in Obninsk, USSR, services the USSR.

#### INDC

the International Nuclear Data Committee of the IAEA is a continuously acting working group which has "the dual purpose of serving as a means of promoting international cooperation in all phases of nuclear data activity, and of advising the Director General of the IAEA in this field" (Terms-of-Reference for the INDC). Through explicit actions of the INDC international collaboration has been influenced in the following areas:

- a) compilation and exchange of neutron data;
- b) standards for neutron cross section measurements;
- c) international meetings.

#### INTERNATIONAL DATA INDEX

future index planned by the IAEA Nuclear Data Unit in cooperation with the other centres, proposed as a periodic publication along the lines of CINDA-CINDU to incorporate the functions of indexes to all international data files and of CINDA.

#### NDU=NDS

the IAEA Nuclear Data Unit (now the IAEA Nuclear Data Section) in Vienna, Austria, services all other countries in Eastern Europe, Asia, Africa, South and Central America, Australia and New Zealand.

#### NEUDADA

NEUtron DAtDA Direct Access, - neutron data storage and retrieval system in operation at CCDN.

#### NEUTRON DATA

is defined as measured or deduced microscopic neutron cross sections, related fission, capture and scattering parameters, resonance and reaction parameters as well as other quantities pertinent to neutron physics in the full energy range up to 20 MeV. Such data forms a subset of the totality of nuclear data.

#### NNCSC

National Neutron Cross Section Center at Brookhaven National Laboratory, USA, services the United States and Canada. The centre was formed from the two groups Sigma Center dealing with experimental and CSEC with evaluated data.

#### PRINCIPAL DATA CENTRES

the four major data centres - NNCSC, CCDN, ICND, NDU - which are coordinated into an international network for neutron data compilation.

#### QUANTITY

Different types of cross-sections, resonance parameters, spectra of neutrons and gamma-rays and other neutron data, which are compiled by the data centres. Definition of quantities compiled in CINDA is that of H. Goldstein. At present, the four centres are using two sets of quantity codes in parallel: the CINDA set, used also in CINDU, DASTAR, and the SCISRS-I set, used also in the Obninsk system. The SCISRS-I set is more detailed than the CINDA-set.

#### RED

the REtrievable DAta file in SCISRS-II was a retrievable data file in the November 1967 proposal, but in the March 1968 revision it was changed into a retrieval index containing no data.

**REF**

the retrievable REFerence file in the SCISRS-II system made directly and automatically from BIB. RED and REF are short files designed for internal use by the system and contain only those criteria that are most frequently requested.

**SCISRS I - SCISRS**

Sigma Center Information Storage and Retrieval System, developed for experimental neutron data compilation at the Brookhaven National Laboratory Sigma Center.

CSISRS is now generally replaced by SCISRS-II for phonetic reasons.

**SCISRS II**

Cross Section Information and Storage Retrieval System, a new computerized storage and retrieval system, being developed by the NNCSC, BNL, for experimental neutron data compilation. The library is divided into two major subdivisions: the first contains all of the data or numeric information associated with the system (DAT and RED), and the second contains all of the bibliographic or alphanumeric information (BIB and REF). The files are linked together by a system of accession numbers.

**UKAEA NUCLEAR DATA LIBRARY**

contains evaluated values of neutron cross sections for particular elements or isotopes. (New version released February 1968).