[INDC (US)-10"A"]

INDC-176

Technical Resume' of

REQUIREMENTS OF A SYSTEM FOR COMPUTERIZED SUPPLY
OF MICROSCOPIC NUCLEAR DATA

Report to Division of Research

From

The Nuclear Cross Sections Advisory Group

Table of Contents

PREFACE

The Division of Research, AEC, has asked the Nuclear Cross Sections Advisory Group (NCSAG) to consider methods for meeting the pressing and continuing national needs for a computerized system for nuclear data collection and dissemination and to make such recommendations as is felt warranted to meet these needs. A Nuclear Data Compilation Sub-committee of the NCSAG was appointed to study the problems in detail. This Sub-committee, including specialists in the pertinent fields, has considered the opinions and suggestions of a diverse spectrum of competent and responsible suppliers and users of nuclear data. Special attention was given to the requirements for a computerized system for the collection and dissemination of microscopic neutron data. A number of technical recommendations were made some of which are relevant to collaborative international efforts in the field. This resume' summarizes only these technical aspects of the parent document. It explicitly should not be construed as either a statement of U.S. policy or as a review of the original document in its entirety.

This resume' quotes liberally from the original document. In doing so, every effort was made to retain technical fidelity and to avoid quoting out of technical context. The resume' represents only the best judgments of the reviewer and should not be construed as a Group or Committee opinion.

Reviewed by: A. B. Smith
January 1967

I. Need and General Requirements

"The rapidly growing demand for microscopic nuclear data is of such importance to many aspects of the United States nuclear energy effort as to urgently require a coordinated and integrated activity in the field. The requisite nuclear data include microsopic neutron cross sections and other information pertinent to neutron induced interactions, cross sections for charged particle interactions and photon induced processes and information relating to the structure and decay properties of nuclei. These data are necessary for applied nuclear programs, for furthering the basic understanding of nuclear physics and for advancing the nuclear aspects of such diverse bordering fields as astrophysics and bio-medicine. Appropriate provision of these data requires effective initiation, implementation and coordination of measurements, analyses of experimental results, and communication of the data." *

The requisite nuclear data activities should be implemented and, particularly, coordinated "with relevant national and foreign efforts in accord with international agreements established by the responsible governmental agencies." "Initital and immediate emphasis should be given to the most important and urgently needed microscopic neutron data but the activities should be expanded as rapidly as possible within the domain of microscopic neutron data and later to the broader area of nuclear data relevant to the nuclear energy field."

---

* Throughout direct quotations from the parent document are indicated by quotation marks.

The immediate and future functions should include the following:

A. Immediate Functions

1) "Implement an efficient and expandable computerized system for storage, retrieval, and distribution of neutron cross section data. This includes the development of new and improved programs for data presentation and retrieval."

2) "Store in this system all useful neutron cross section data."

3) Implement analysis of microscopic neutron cross section data.

4) "Retrieve, using computer techniques, and distribute special and generally requested neutron cross section data in the form of magnetic tapes, plots, edits, etc."

5) "Prepare and distribute graphical displays of neutron cross section data in book format such as BNL-325."

6) Inform users as to the current status of the status of the effort.

B. Future Functions

1) "Prepare computer programs for retrieval and editing by users of information on magnetic tapes."

2) "Extend and apply the computerized system to include other nuclear data."

3) "Extend the responsibilities to the analysis of pertinent nuclear data."

The above functions should be carried out with regular and frequent consultation with a selected group of advisors inclusive of nuclear scientists with interests in all facets of the problem.

II. Computer Requirements

A. Information Output

Information should be accepted for input in the form of graphs, printed tables, and magnetic tapes. The tables and tapes should be selective on the basis of any combination of agreed retrieval parameters, the graphs on some subset only. Printed and graphical information should be clearly labeled in a standard notation. The storage and retrieval parameters for neutron data are delineated in detail in sections below.

The magnetic tape options should include unpacked BCD (80 characters per record maximum) for uses with small computers and/or packed BCD (800 characters per record minimum), and should include machine binary (one floating point number or one or two integers per machine word) for the most common machine word formats. There must also be the option of dividing the numerical data and the associated comment material between separate tape reels or provision for combining everything on the same reel.

B. Information Input

In addition to the data which is extracted from journals and reports, the receipt of data directly from the originator of the information should be specifically encouraged in order to insure the useful, current, and complete compilation of available data. The data must be accepted as BCD data on magnetic tape or cards in any FORTRAN format. Data in the form of printed tables should also be accepted in reasonable amounts. Data should be acceptable in any commonly used units. The storage should be such as to clearly distinguish between primary experimental data received from the contributor and data deduced from the measured values. Direct ratio measurements and other primary experimental data should be stored when available and when these data are judged to be useful.

C. Internal Computer System and Practices

"The computer library will consist of a long sequence of items together with one or more indices. Most of the items will be correlated essentially one-to-one with measured or other numerical data. There will be some items which specify such things as target, reference, or reaction for an entire group of items. An item will contain both explicit and implicit information. The explicit information is the sequence of bits (characters, numbers) making up the item. Many of these bits will be flag numbers, rather than experimental data. The implicit information will be of two kinds: 1) by virtue of the item's position in an ordered library, 2) by coded reference to explicit (possibly non-numeric information elsewhere in the library)." Any programs which are likely to be useful to other laboratories should be written in commonly accepted machine independent language. It is anticipated that the following types of programs will be needed;

1. "Programs for inserting new items. The insertion should be such as to permit recovery of the item by insertion date. A printout of the new items should be sent to the experimenters supplying the items."

2. "Programs for deletion of undesired (presumably erroneous items. These programs must include extensive safety procedures."

3. "Programs for correction or other replacement of data, including the appending of additional data to an existing item."

4. "Both 1) and 3) above need a program for the computer assignment of a unique identification to each item."

5. "Programs for creation and continual up-dating of indices and tables of content needed by the retrieval programs."

6. "Retrieval programs which collect and order the items to be put out."

7. "Output programs as needed."

III. Technical Requirements for Storage and Retrieval of Neutron Cross Section Data*

In this section, attention is focused on technical problems inherent to the computer storage and retrieval of neutron cross section data. The recommended principles can be extended later to other types of nuclear data. Three areas can be distinguished: a) the choice of data to be stored; b) choice of retrieval capability; c) choice of ordering and format for numerical data on magnetic tape, discs, punched cards, etc. The report confines itself largely to the first two areas, the details of the third being primarily an internal concern of the data center.

A computerized data library may be stored on disk, data cell, etc., but at the present level of technology, it is necessary for ease of transmission and for safety that the library also exist on magnetic tape. A data library consists of information in the form of stored sets of items or, more precisely, values assigned to program variables. Some explicit information should identify all related information either in the stored data library (for example, comments or derived data) or outside of the stored data library (for example references). Explicit or implicit information should relate to library

---

* This section is essentially a verbatim quotation from the original report.

management supplying, for example, an acquisition date, an acquisition number uniquely identifying the item set, the date of most recent retrieval, etc.

In principle it is possible to retrieve an item set by requiring that any particular subset of stored items have values in assigned ranges. A simple and opposite alternative is to retrieve the item set only by its unique acquisition number. In practice a compromise is indicated, and is recommended here, wherein item sets are classified according to suitably descriptive categories used for purposes of retrieval. With this arrangement a stored item set can be retrieved by category as well as by ranges of values of stored items. It is advisable for efficient retrieval that items sets of the same category be ordered similarly in the storage sequence. It is necessary that the ordering of the items in a set should be known by users. It is highly desirable that item sets of the same category use similar formats. This will greatly simplify the use of the data and implement the internal function of a data center. In any case the applicable format must be clearly discernible to the user. Summarizing: each stored data set is associated with a stored control data set of descriptive information identifying retrieval category, size of item set, formats and possibly ordering of stored items, related information, and library management data. In addition, a stored data set may be accompanied by an associated data set, that is, a set of data common to items in the main data set. For example, sample thickness, composition and parameters of state comprise an associated data set accompanying a stored transmission fraction data set obtained from a transmission experiment. Each stored data set should be associated with a control data set and an associated data set.

For safety and ease of handling it is desirable that data cards, when used, be uniquely identified. The cards of a data set are sometimes identified by a set of retrieval category data unique to the data set, in which case there is a motivation for use of compact category data so that the card identifiers will occupy as little as possible of the limited card space. However, this compactness is restrictive and unnecessary because each card can be uniquely identified by the acquisition number which was chosen for the stored data set and by a card sequence number within the data set. For this reason and other reasons it is recommended that the choice and identification of retrieval categories be extensive rather than compact. Ample provision should be made for extension of the category set to include retrieval properties not yet defined. When a data set is received and prepared for storage, it should be categorized by physicists--a time-consuming task which sets an upper limit on the extensiveness of categorization. This categorization should be done promptly. However, under pressure, data should be stored with blank category entries interpreted as signifying "not yet categorized". Such uncategorized data could still be retrieved on an interim basis by acquisition number or by specified range of values of stored items. Temporary, uncategorized, storage should be most prevalent in the initial phases of the effort.

In order to reduce the overall compilation effort, reduce redundancy and promote cooperation, it is recommended that, insofar as possible, the categories chosen to be compatible and/or identical with those of other information storage systems.

It is recommended that retrieval categories for nuclear reaction data include: a) reaction properties such as target material, reaction type, range of incident and exit particle energy and state; b) library management information such as acquisition number, acquisition date and date of most recent retrieval; c) origin information such as reference, person providing data, method, laboratory, and date of the study from which the data are obtained. It is recommended that a capability be provided for retrieval of an item set containing specified items with values in defined ranges. There should be a capability for retrieval of item sets which are related to other item sets.

It should be noted that descriptive data should be edited in full using easily understood notation, although it is not necessarily stored internally in this notation.

The following discussion outlines a desirable set of logical categories devised according to a rational approach for measured and analyzed data and cross sections. These data should be characterized by target material in the suggested form of Z identifier, A identifier, and in some cases an identifier for isomeric state of the target. The energy of an isomeric state above the ground state, and such other information as is necessary to unambiguously identify the state, should be stored as associated data. A naturally occurring elemental target is usefully categorized by Z and zero A, and isomeric state identifiers. Care must be taken to insure proper isotopic identification because small, and sometimes ignored, isotopic contamination may have a significant effect on measured data. A target with a well-known and frequently encountered molecular, crystalline, alloy or other composition can be assigned a unique identifier. These choices permit correspondence with target categorization methods used in other information storage systems. When a target is composed of more than one nuclide, element or other substance in known but unusual proportions, more than one identifier should be entered (one identifier for each important target substance). The use of multiple identifiers for target category is in keeping with the present general recommendation for extensive categorization. Numerical descriptions of target composition and parameters of state should be stored as associated data, only the target category identifiers being used for primary retrieval. In some experiments two or more targets are involved, and each should be assigned target category identifiers. When two or more reaction types are involved, each should be categorized. In all cases, a single most important target category identifier should be chosen for initial entry, this entry being emphasized to permit correspondence with other data storage systems, all of which use only a single target category identifier.

A very large number of categories can be defined for classification of nuclear data. It is convenient, therefore, to introduce a hierarchy of categories, viz, general categories identified by a G-number and particular categories identified by a P-number. A general or G-category should include data measured in a certain manner or data for a certain reaction type. A particular or P-category includes data expressed in a particular form for a certain reaction property. A suggested listing of general G-categories is given in the left-hand columns of Tables 1 and 2 of Appendix 1. The particular assignments of G-numbers and extensions and/or modifications of these categories should be determined in concert with the advisory group of users. The assignment of data to G-categories is often a subtle matter demanding the attention of competent physicists to make use of physical properties in achieving a useful categorization of the incoming information. Cognizance must be taken of spin, parity, analogue states, reciprocal processes, etc., if the most value is to be obtained from the available information. Initial operations should employ a limited and very specific set of G-categories, those which are of most urgent need, with expansion in scope as need and competence indicates. Such definition and selection must be assayed on a continuing basis commensurate with user requirements. For comparison and in order to illustrate compatibility, Tables 1 and 2 of Appendix 1 show analogous categories used by systems other than that suggested. Ambiguous cases are indicated by parentheses enclosing identifiers.

The categorization of nuclear data suggested in Appendix 1 proceeds as follows: Data measured in an experiment where only particles of Type b) are independently detected emerging from processes initiated by particles of Type a) are categorized together and so designated as (a, b Detection) in Table 1 of Appendix 1. Product gamma rays should be indicated collectively with de-excitation prescribed in subsequent detail. The detected particles may emerge from reactions of various types as, for example, neutrons detected in an experiment may have emerged from elastic scattering, inelastic scattering, and fission reactions. From these measured quantities and from the logical physical interpretation of measured inverse or associated nuclear processes the experimenter may have derived cross sectional or other conventional categorizable nuclear data of the type noted in Table 2 of Appendix 1. Such deduced data are subject to storage and retrieval and are distinct from data determined from the composite of several adjustments to obtain internal consistency, or the judgment of "best" or "most credible quantities". It is possible, but not requisite, that data will appear as detected quantities and as deduced values (transmission and total cross section for example). When this is true, the correlation between the two forms of expression must be clearly noted together with any assumptions such as standards used in obtaining the derived information. When ambiguities arise, the most appropriate category should be chosen. It is realized that derived experimental information is not unambiguous and the resolution and quality of detection will frequently enter decisions as to categorization. These decisions will demand a high degree of judgment. Such judgment will be greatly aided by the clear definition of the respective categories and logical reference to the meaning of basic physical concepts such as coordinate transformations, units, and differentials (multiple as well as single) of angle and of energy.

Data measured in an experiment where associated* particles b, c, and d (including identified recoil nuclei) are detected emerging from reactions initiated by particles of Type a form a category designated (a, b, c, d, Detection) in Table 1, Appendix 1. This does not imply that products b, c, and d were emitted successively in that order. In some of these cases, the reaction cross section can be inferred from the physical situation and, indeed, the properties of unmeasured products may well be determined from the measured quantities. It is not necessary that the products be coincident in time, but only that they be deduced as related to the process in question. Neither is it requisite that a correlation be established in all dimensions (inclusive of time) but only sufficient to define the respective stated cross sections or other properties which may be an integral over one or more dimensions. Particularly in initial functions, it would be well to execute storage and retrieval functions on the most explicit forms of categorization leaving the more subtle and complex data for subsequent categorization. Such detailed information should, however, be retained in an uncategorized form for future classification. Explicit definition of the most important categories are the immediate concern.

---

* Associated product particles are those produced in the same interaction insofar as can be ascertained from the measurement. Unassociated product particles are those without any reference to other particles emitted or other characteristics of the process.

It is necessary to make more precise the role of de-excitation products in the choice of G-category. In a broad sense all reaction products serve to de-excite an aggregation of nucleons. In a more restrictive sense, a nucleus is de-excited by photon emission to a lower energy state of the same nucleus or the nucleus undergoes transition to another nucleus consequent to particle emission. If the de-excitation or transition occurs very shortly after reaction then classification according to the proposed categories is no problem (see left-hand columns of Table 1, Appendix 1). Thus observations of two correlated cascade gammas de-exciting nuclei formed in (n;γ) or (n;n') reactions would be categorized as (n;γ,γ' Detection). However, when the de-excitation or transition is delayed an ambiguity arises because of the decaying nuclide or isomeric state can be identified, then this isomer might itself be entered as a reaction product. While no completely general course is recommended, it is advised that activation and similar processes be stored and categorized by the deduced cross section when possible. When this is not possible, measurements should be categorized as (a; Decaying Nucleus Detection). For example, activation measurements of the Nb^{93} (n;γ) 6.3m Nb^{94m} and Nb^{93} (n;γ) 2 x 10^{4}yNb^{94} cross sections should be categorized as (n;Nb^{94m} Detection) and (n;Nb^{94} Detection). There exist experiments which yield data which are best categorized simply as multiple product data. For example, a fission neutron multiplicity experiment might yield data of all or only some of the categories (n; Fission Fragment, n Detection), (n; Fission Fragment, n Detection), (n; Fission Fragment, n,n' Detection), etc.

Particular categories, i.e., those identified by P-numbers, are not explicitly defined here. An example which illustrates the definition of P-category given earlier is the case of the general category (n; p Detection). For this case three P-categories might be assigned, one denoting the measured and stored distribution in proton energy and angle, one denoting the distribution in proton energy as integrated over angle, and one denoting the distribution in angle as integrated over energy. The ordering of stored data should be well defined and communicated for each P-category. When data are stored in alternative forms these should be distinguishable by stored information, for example, by distinct P-categories. In the example just cited, the angular distribution or emitted protons might be described by a differential cross section or reaction rate stored as a function of direction of emission, or the differential quantity might be represented by some polynomial expansion with stored coefficients. Again, some or all of the data may be defined in a special coordinate system, e.g., the center of momentum system. Only when a discrete momentum-energy relation applies can an unambiguous coordinate transformation be carried out. Each alternative representation should be distinguished by a P-category. When binding of the target nucleus in a molecule, crystal or other aggregate is important, the cross section or reaction rate data are stored as defined per nucleus, molecule or other aggregate. This and other relevant information should be stored, if not by P-category, at least by comment. For example, data obtained by scattering neutrons from H_2O may be reported per molecule, or they may be reported per hydrogen nucleus, after removal of some nominal, stored contribution from the oxygen nucleus.

Polarization data are not explicitly categorized here but are important for some types of usage particularly that associated with light nuclei. Therefore, polarization data should be stored and retrieved in a simple and explicit format using the Basel convention.

Deduced cross sections should be of two types; a) those deduced from a set of experimental values by the experimenter, and b) interpretations or analysis of microscopic data done by persons other than the experimenter. The latter include model oriented analysis of measured information and derivations of "best" or "credible" values from various reported experimental quantities. In both storage and retrieval the above two types of deduced data must be clearly delineated. The categories and notation for both types of deduced data should follow conventional usage; for example, that given in the left-hand column of Table 2 of Appendix 1. In principle, deduced cross section data should be expressed and categorized according to a formal theory of nuclear reactions. In practice, this ideal is not usually attained. For example, a fission cross section deduced from measurements of fission fragment pulse rate includes partial cross sections for processes occurring in various fission channels as well as processes where fission took place subsequent to photon or particle emission. Cross sections deduced for such detailed processes are not generally categorized in Table 2, Appendix 1 and it is recommended that when necessary they be categorized by P-number. An important application of this recommendation arises when a reaction (a,b) is induced by particle a) and only one particle a) is emitted in addition to a recoil nucleus. The recoil nucleus may be excited or in its ground state, these being distinguished by the reaction Q value. Particular or P-categories should distinguish between cross sections for a particular Q value or for a number of Q values. The numerical value of a particular Q should be stored as an associated datum. Care must be taken to properly interpret and differentiate between those processes clearly observed as discrete reactions and reactions where all or part of the products are observed as a continuum distribution.

It is recalled again that the data set can be retrieved by searching for a particular item, in this case Q, with values in a specified range. When cross section data are fitted by theoretical or other formulae, values of the parameters required for these formulae should be stored. Typical categories of such parameters are given in Table 2 of Appendix 1. These parameters may be either those directly provided by the experimenter or may be the "recommended" or "best" or "credibly deviant" values derived from analysis. Whichever the case they must be so designated and a detailed reference to the theoretical method or formulae employed should be available at least as associated information. The storage and retrieval capability for parameters does not render unnecessary the storage of basic datum points employed in obtaining the parameters. These are a primary concern and can be stored at the discretion of the Institute.

The published reports describing data storage, retrieval, and manipulation programs should be coauthored by the physicists specifying the program and by the programmers. Included in the reports should be complete descriptions or references to definitions, categorization, and ordering of stored data. Consultants, the advisory group and others should assist in this effort.

IV. Experimental Neutron Cross Section Data to be Stored*

The principles of categorization and storage of neutron data have been outlined in the previous section III. The incident energy range of primary interest extends to about 30 MeV. Processes at higher incident energies

---

* As for Section III, above, this Section is essentially a direct quotation from the primary report.

should be stored where they have a direct relevance to neutron reactions at lower energies or where there is an explicit applied need for higher energy information. Data for reciprocal reactions pertinent to neutron cross sections should be stored with categories chosen in anticipation of later storage of charged particle and other cross sections. Also to be stored are experimental statistical information, incident beam spread information including target thickness, detector resolution information, and, in general, any numerical information describing experimental uncertainties. It would be very useful to distinguish by stored information the various possible types of errors which might be quoted, e.g., standard deviation, 95% confidence limits, counting statistics, and calibration. Whenever feasible, the errors should be given in the units of the respective value with both plus and minus errors stored. In cases of ratio or other dimensionless measurements the errors are, of course, dimensionless. Such a procedure will lead to ease in the mechanics of retrieval and graphical output. Similarly useful, is information concerning shapes of resolution functions, beam spread, etc. Nevertheless, it is noted that eliciting such information from experimentalists is notoriously difficult. Only such material as the experimentalist will provide and which is judged should be stored. Experimental methods of producing the incident particle or photon, or maintaining the target state, and detecting various product particles or radiation should be stored and identified by category assignments. Examples of such retrieval information are time-of-flight, sphere transmission, "monoenergetic" Van de Graaff beam, etc.

As described above, deduced data provided by the experimenter or obtained in other manners should be stored. Such deduced information must be clearly noted as deduced and in what manner and does not take precedence over or substitute for the primary datum sets. The latter are the basic information and take precedence over all else. Any other information, reported or not, when it is judged useful can be stored. It is recommended that comments, judgments, and similar information (exemplified by CINDA comments) be stored, possibly on a separate "comments tape", but this information should not be used for retrieval nor should it hinder the storage retrieval of numerical data.

Units should be standardized for all data entries. Basic recommended units are electron volts for particle or photon energies, ergs for calorimetric data, degrees Kelvin for temperatures, radians for explicit angles (although cosines can be used), steradians for solid angles, barns for cross sections, centimeters for lengths, seconds for time, and grams for mass except for use of AMU in the normal convention of C^{12} standard physical masses for particles. Data should be accepted in any reasonable units, then should be converted to the standard units before actual storage.

It is wise to close this presentation with the caution that not all measured and/or derived data are either precise or useful and much such information does not warrant storage. It is suggested that judgment be exercised as to quality and type of data received before storage is initiated. Further, the data should be compacted for storage wherever possible. There appears, for example, little merit in retaining redundant and essentially identical basic data from which a given experimenter has deduced a quantity with specified error. One set or a composite provided by the experimenter will suffice. These are not idle cautions as even a large computerized system can be inundated by highly automated experimental facilities. Much of the value of the system will be lost if it becomes difficult to detect the "signal" amid the "noise".

Appendix 1 Categorization

Conta... in this appendix are two tables. These outline a suggested logical and rational framework for the categorization of measured and derived neutron data. They are a point of departure for the construction of general (G) and particular (P) categories for the storage and retrieval of the information. The detailed specification of these categories must be pursued in concert with users, other groups dealing with data categorization, and consultants. Such specifications must provide detailed and unambiguous definition of the stored physical quantities. For comparison purposes both of the tables presented here contain comparable category identities as now employed by related systems.

Table 1 is confined to categories of primary experimental data. Table 2 categorizes derived data in both senses of the primary document; 1) microscopic data derived from the measurements by the experimenter; and 2) microscopic data derived from a number of measurements at the Institute or elsewhere inclusive of "best", "recommended", and "consistent" values.

Table 1. CATEGORIES FOR MEASURED DATA

Unassociated Interaction Product Detection Data**	CATEGORY IDENTIFIERS*							
		REFERENCE SYSTEMS		EXPERIMENTAL and DERIVED DATA SYSTEMS		EVALUATED DATA SYSTEMS		
	General Category G-Number	CINDA MK2	NUCLEAR ABSTRACTS	SCISRS-1 TYPE	SCISRS-2 C-No.	AWRE C-No.	ROC T-No.	ENDF-A NREAC
Reference	To be chosen by Institute	2	3	4	5	6	7	8
(n; γ Detection)		(NEG3)		64	(23)			
(n; e Detection)								
⋮								
(n; n Detection)		NEM9		65,111, 112,135, 136	(21,24, 28,25, 37,43)			
(n; p Detection)				144	(31,32)			
(n; d Detection)					(31)			
(n; t Detection)					(31)			
(n; He^3 Detection)					(31)			
(n; α Detection)					(31,44)			
⋮								
(n; Detected Nuclide as in Activation, Spallation, Fission, e.g., Mn^{56}, O^{16}, Xe^{135})								
⋮								
(n; Fission Fragment Detection)				66				
⋮								

* Category identifiers are enclosed in parentheses when interpretation is ambiguous.

** The detected particles may have emerged from a variety of types of reactions.

Table 1. CATEGORIES FOR MEASURED DATA (Continued)

Associated Interaction Product Detection Data**	CATEGORY IDENTIFIERS*							
	General Category G-Number	REFERENCE SYSTEMS		EXPERIMENTAL and DERIVED DATA SYSTEMS		EVALUATED DATA SYSTEMS		
		CINDA MK2	NUCLEAR ABSTRACTS	SCISRS-1 TYPE	SCISRS-2 C-No.	AWRE C-No.	ROC T-No.	ENDF-A NREAC
(n; γ, γ' Detection)	To be chosen by Institute			1				
(n; γ, e Detection)								
(n; γ, n Detection)				2				
⋮								
(n; n', n" Detection)								
(n; n', p Detection)				3				
⋮								
(n; p, γ Detection)				4				
(n; p, p' Detection)								
⋮								
(n; α, γ Detection)								
⋮								
(n; Fission Fragment, γ Detection)								
(n; Fission Fragment, n Detection)				91-95				
(n; Fission Fragment, p Detection)				67				
(n; Fission Fragment, d Detection)				67				
(n; Fission Fragment, t Detection)				67				
(n; Fission Fragment, He^3 Detection)				67				
(n; Fission Fragment, α Detection)				67				
⋮								
(n; Fission Fragment, Fission Fragment Detection)								
⋮								

Table 1. CATEGORIES FOR MEASURED DATA (Continued)

	CATEGORY IDENTIFIERS*							
		REFERENCE SYSTEMS		EXPERIMENTAL and DERIVED DATA SYSTEMS		EVALUATED DATA SYSTEMS		
	General Category G-Number	CINDA MK2	NUCLEAR ABSTRACTS	SCISRS-1 TYPE	SCISRS-2 C-No.	AWRE C-No.	ROC T-No.	ENDF-A NREAC
Other Associated Interaction Product Detection Data	To be chosen by Institute							
Multiple Product Associated Data								
Transmission Data								
Transmission Fraction				53				
Self-Indication Data								
Mutual-Indication Data								

Table 2. CATEGORIES DERIVED CROSS SECTION DATA

Derived Cross Section Data for Emission of One Lighter Particle and/or Residual Nucleus, Possibly Deexciting	General Category G-Number	REFERENCE SYSTEMS: CINDA MK2	REFERENCE SYSTEMS: NUCLEAR ABSTRACTS	EXPERIMENTAL and DERIVED DATA SYSTEMS: SCISRS-1 TYPE	EXPERIMENTAL and DERIVED DATA SYSTEMS: SCISRS-2 C-No.	EVALUATED DATA SYSTEMS: AWRE C-No.	EVALUATED DATA SYSTEMS: ROC T-No.	EVALUATED DATA SYSTEMS: ENDF-A NREAC
(n;γ)	To be chosen by Institute	NG9 SEL5		70,117	8	1102 1002	9	102
(n;n)		DEL6		109,133	2	7002	1	2
(n;n',γ),(n;n',e⁺,e⁻), etc.		DIN5 DNG6 SIN4		82,110, 134,137, 140	4	1004 -1015	31, 32	4
(n;p),(n;p,γ),etc.		NP3		74,75, 76,131	9	1103	5	103
(n;d),(n;d,γ),etc.		ND4		61,62, 63,129	10	1104	7	104
(n;t),(n;t,γ),etc.		NT5		77,78, 79,132	11	1105	8	105
(n;He^3),(n;He^3,γ), etc.		NH8		71,72, 73,130	12	1106		106
(n;α),(n;α,γ),etc.		NA6		58,59, 60,128	13	1107	6	107
⋮								
Derived Cross Section Data for Emission of Two Lighter Particles and Residual Nucleus (Deexcitation not made explicit)								
(n;n',n")		N2N7		87,146	5	1016	35	
(n;n',p)		NNP7		84,142	(17,25)	1028		28
(n;n',d)		NND8		81,139	16(20)			
(n;n',t)		NNT9		85,143	19			

CATEGORY IDENTIFIERS*

Table 2. CATEGORIES DERIVED CROSS SECTION DATA (Continued)

Derived Cross Section Data for Emission of Two Lighter Particles and Residual Nucleus (Deexcitation not made explicit)	CATEGORY IDENTIFIERS*							
	General Category C-Number	REFERENCE SYSTEMS		EXPERIMENTAL and DERIVED DATA SYSTEMS		EVALUATED DATA SYSTEMS		
		CINDA MK2	NUCLEAR ABSTRACTS	SCISRS-1 TYPE	SCISRS-2 C-No.	AWRE C-No.	ROC T-No.	ENDF-A NREAC
$(n;n',He^3)$	To be chosen by Institute			83,141	15			
$(n;n',\alpha)$		NNA2		80,138	18	1022		22
⋮								
$(n;p,p')$				88,147	26			
⋮								
$(n;p,\alpha)$						1109		
⋮								
$(n;d,d')$								
⋮								
$(n;\alpha,\alpha')$				86,145	14	1109		108
⋮								
Derived Cross Section Data for Emission of Three Lighter Particles and Residual Nucleus (Deexcitation not made explicit)								
$(n;n',n'',n''')$		N3N8		90,148	6	1017	36	
$(n;n',n'',p)$					30			
$(n;n',p,p')$								
$(n;n',n'',\alpha)$						1024		
$(n;n',\alpha,\alpha')$						1029		
⋮								
$(n;\alpha,\alpha',\alpha'')$				89				

Table 2. CATEGORIES DERIVED CROSS SECTION DATA (Continued)

Derived Sum Cross Sections	General Category C-Number	REFERENCE SYSTEMS: CINDA MK2	REFERENCE SYSTEMS: NUCLEAR ABSTRACTS	EXPERIMENTAL and DERIVED DATA SYSTEMS: SCISRS-1 TYPE	EXPERIMENTAL and DERIVED DATA SYSTEMS: SCISRS-2 C-No.	EVALUATED DATA SYSTEMS: AWRE C-No.	EVALUATED DATA SYSTEMS: ROC T-No.	EVALUATED DATA SYSTEMS: ENDF-A NREAC
(n; Total)		TOT2		114	1	1001	0	1
(n; Nonelastic)		SNE3		113	3	1003		3
(n; Absorption)		ABS4		48,49	27	(1027)		27
(n; Disappearance) (n; Emission)		REM6				(1101)		
Fitted Formula Parameters†								
Phase Shifts, δ_{ω}^{ℓ}	To be chosen by Institute						3	
Effective Range Params							24	
Optical Model Params								
Individual Resonance Params		RES3		19-42		5151-5155	25, 26,27	
Average Resonance Params		STF4		43-46		6151		NDTYP7
Level Density Formulae Parameters		LDL3		120				
Potential Scattering S.S.		POT7		96-98				
$S(k^2,\beta)$		(TSL9)					2	NDTYP8
$S(\alpha,\beta)$		(TSL9)				7002	38	NDTYP8
Dispersion Data		(TSL9)						NDTYP8
Phonon Spectra		(TSL9)					39	NDTYP8

*CATEGORY IDENTIFIERS

† Meaningful only when formulas are fully specified.

Table 2. CATEGORIES DERIVED CROSS SECTION DATA (Continued)

Derived Fission Cross Sections	General Category C-Number	CATEGORY IDENTIFIERS* REFERENCE SYSTEMS CINDA MK2	NUCLEAR ABSTRACTS	EXPERIMENTAL and DERIVED DATA SYSTEMS SCISRS-1 TYPE	SCISRS-2 C-No.	EVALUATED DATA SYSTEMS AWRE C-No.	ROC T-No.	ENDF-A NREAC
(n; Fission n)	To be chosen by Institute	NF2	Yes	66,68	7	1018-1021	11-14	18-21
(n; Fission, Prompt γ)		SFG8		115		12018 13018	18	
(n; Fission, Prompt n)		NU5 SFN7		116	33	2018 3018	16	NDTYP (10)
(n; Fission, p)				(52)			21	
(n; Fission, d)				(52)			21	
(n; Fission, t)				(52)			21	
(n; Fission, He^3)				(52)			21	
(n; Fission, α)				(52)			21	
⋮								
(n; Fission, Fragment Nuclide, e.g. Xe^{135})		NFY9					21	
(n; Fission, Delayed γ)		FPG2		54			21+57	
(n; Fission, Delayed e)							21+56	
(n; Fission, Delayed n)		NUD6			34		17	NDTYP (10)
$\eta = \bar{\nu}\sigma_{nF}/\sigma_{nA}$		ETA3		53	35			NDTYP 11
$\alpha = \sigma_{n\gamma}/\sigma_{nF}$		ALF4			36	4102		NDTYP 12
(n; Fission, Three Heavy Fragment Nuclides)				(52)			21	