A Compact ENDF (ACE) Format Specification

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1 Introduction

The ACE format consists of two *types* and many *classes* of data. The data are kept in an ACE Table. The term ACE Table and ACE file are often used interchangeably.

1.1 Types of ACE-Formatted Data

There are two types of ACE-formatted data; simply called Type 1 and Type 2.

Type 1 Standard formatted tables. These tables contain ASCII text and are machine independent; they are readable on every machine.

Type 2 Standard unformatted tables. These tables are binary and can be generated from the Type 1 files. They are more compact and faster to read than the Type 1 ACE Tables but are machine/platform dependent; they are not readable on every machine.

Traditionally Type 2 ACE files were more commonly used because they were smaller in size and faster to read. However due to the fact that they are not portable across machines and platforms they have fallen out of fashion.

1.2 Classes of ACE-Formatted Data

There are many classes of ACE-formatted data:

1. continuous-energy neutron (see Section 4),
2. discrete-reaction neutron,
3. neutron dosimetry (see Section **??**),
4. $S(\alpha, \beta)$thermal (see Section **??**),
5. continuous-energy photoatomic (see Section **??**),
6. continuous-energy electron interaction,
7. continuous-energy photonuclear interaction,
8. multigroup-energy neutron, and
9. multigroup-energy photoatomic.

Each of these classes of data are described later in this document.

An ACE Table is an entity that contains evaluation-dependent data about one of the many classes of data for a specific material—an target isotope, isomer, or element. For a given ZAID, the data contained on a Type 1 and Type 2 tables are identical. Simulations run with one type of data should produce identical results as those run with the other type of data.

1.3 ACE Libraries

A collection of ACE data tables that derive from a single set of evaluation files are typically grouped together in a "library"—not to be confused from the evaluation library from which they derive. Multiple ACE data tables can concatenated into the same logical file on the computer, although this has fallen somewhat out of fashion due to the large amount of data on each ACE table derived from modern evaluation files. Applications that use ACE-formatted data should produce the same results regardless of whether the tables are contained in one logical file on the computer or spread across many.

2 ACE Tables

An ACE Table consists of a Header followed by an array (XSS) containing the actual data. The Header and XSS array are the same regardless of whether the ACE Table is Type 1 or Type 2. Each line in a Type 1 ACE Table is 80 characters or less.

2.1 ACE Header

The first section of an ACE Table is the Header. The ACE Header contains metadata[1] about the ACE Table. The Header consists of four parts:

1. Opening,
2. IZAW array,
3. NXS array, and
4. JXS array.

An example of an ACE Table Header (from ^{1}H in the ENDf71x library) is given in Figure 1 with each part highlighted a different color.

```
 1 1001.80c    0.999167  2.5301E-08   12/17/12
 2 H1 ENDF71x (jlconlin)  Ref. see jlconlin (ref 09/10/2012  10:00:53)      mat 125
 3       0         0.      0         0.      0         0.      0         0.
 4       0         0.      0         0.      0         0.      0         0.
 5       0         0.      0         0.      0         0.      0         0.
 6       0         0.      0         0.      0         0.      0         0.
 7   17969       1001      590         3         0         1         1         0
 8       0          1        1         0         0         0         0         0
 9       1          0     2951      2954      2957      2960      2963      4352
10    4353       5644     5644      5644      6234      6235      6236      6244
11    6245       6245     6246     16721         0     16722         0         0
12       0          0        0         0         0     16723     16724     16725
```

Figure 1: Header example. The (Legacy) Opening (lines 1–2) is in red, the IZAW array (lines 3–6) is in blue, the NXS array (lines 7–8) is in teal, and the JXS array (lines 9–12) is in violet.

Legacy Header Opening There are two slightly different formats for the Header Opening. The most common one found is called here the Legacy Opening and is the one demonstrated in the Header example in Figure 1.

The Legacy Opening consists of several variables given over two 80-character lines. The variables and the Fortran format for reading the variable is given in Table 1

2.0.1 Header Opening

Don't forget the 2.0.1 Header Opening

[1] data about the data

Line	Variable	Format	Description
1	HZ	A10	ZAID (see Section 3.1)
1	AW	E12.0	atomic weight ratio
1	TZ	E12.0	temperature
1	—	1X	(blank space)
1	HD	A10	processing date
2	HK	A70	descriptive string
2	HM	A10	10-character material identifier

Table 1: Variables in the Legacy Opening part of the ACE Header.

Line	Variable	Format	Description
1	VERS	A10	version format string
1	HZ	A24	SZAID (see Section 3.2)
1	SRC	???	evaluation source
2	AW	E12.0	atomic weight ratio
2	TZ	E12.0	temperature
2	—	1X	(blank space)
2	HD	A10	processing date
2	N	I10	number of comment lines to follow
3–(N+2)	—	A70	comment lines

Table 2: Variables in the 2.0.1 Opening part of the ACE Header.

There is a limitation to the number of unique ZA IDs for a given ZA; 100 different IDs, in fact, for each class of ACE Table. To overcome this limitation, a new Header Opening was developed in 2013and updated a few years later to correct some errors. check this

```
2.0.0      1001.710nc                ENDFB-VII.1
0.999167 2.5301E-08 12/17/12     3
The next two lines are the first two lines of 'old-style' ACE.
  1001.80c    0.999167  2.5301E-08   12/17/12
H1 ENDF71x (jlconlin)  Ref. see jlconlin (ref 09/10/2012  10:00:53)      mat 125
```

Figure 2: Header Opening example. The Legacy Opening is shown in blue while the 2.0.1 Opening consists of the red and the blue portions.

Note that a Legacy Header Opening can be contained in the comment section of the 2.0.1 Header Opening. This was designed explicitly to allow backwards compatibility while application codes were modified to be able to handle. An example of this is shown in Figure 1. Codes that cannot read the 2.0.1 Header can be told (typically via an verify correctness xsdirentry) to start reading the ACE Table several lines after the beginning of the 2.0.1 Header.

provide reference

Following the Opening of the Header are three arrays, IZAW, NXS, and JXS respectively. They are each described below. Immediately following the JXS array is the XSSarray.

2.1.1 IZAW Array

The IZAW array follows on the lines immediately following the Header. It consists of 16 pairs of ZA's (`IZ`) and atomic weight ratios (`AW`). The `IZ` entries are still needed for $S(\alpha, \beta)$ Tables to indicate for which isotope(s) the scattering data are appropriate.

The 16 pairs of numbers are spread over 4 lines. The Fortran format for reading/writing the numbers on one line is: `4(I7,F11.0)`.

2.1.2 NXS Array

The NXS array comes on the 2 lines after the IZAW array. The NXS array has 16 integer elements; 8 on each line. The Fortran format for reading/writing the numbers on each line is: `8I9`. The first element of the NXS array indicates how many numbers are in the XSS array. The remainder of the NXS array elements (usually) indicate how many of different pieces of data there is.

2.1.3 JXS Array

The JXS array comes on the 4 lines after the NXS array. The JXS array has 32 integer elements; 8 on each line. The Fortran format for reading/writing the numbers on each line is: `8I9`. The JXS array contains indices to the XSS array where difference pieces of data begins.

The specific definition of the elements of the NXS and JXS arrays are dependent on the class of data in the Table and are defined in the section of this document that describes each class of data.[2] Note that not all elements of the arrays are (currently) being used, allowing for future expansion.

2.2 The XSS Array

After the ACE Header comes the XSS array. It is typically *very* large with hundreds of thousands of elements. It is broken up into blocks with the blocks being dependent on the class of data that is contained in the table. The description and definition of each of these blocks can be found in the descriptions later in this document.

The data is written with 4 floating-point numbers on each 80-character line. All data in the XSS array can be read using the Fortran format: `4E20.0` for each line.

[2] See, for example, Table 3 and Table 4.

```
2.0.0      1001.710nc              ENDFB-VII.1
0.999167 2.5301E-08 12/17/12     3
The next two lines are the first two lines of 'old-style' ACE.
  1001.80c    0.999167  2.5301E-08   12/17/12
H1 ENDF71x (jlconlin)  Ref. see jlconlin (ref 09/10/2012  10:00:53)      mat 125
1.00000000000E-11   1.03125000000E-11   1.06250000000E-11   1.09375000000E-11
1.12500000000E-11   1.15625000000E-11   1.18750000000E-11   1.21875000000E-11
1.25000000000E-11   1.28125000000E-11   1.31250000000E-11   1.34375000000E-11
1.37500000000E-11   1.43750000000E-11   1.50000000000E-11   1.56250000000E-11
1.62500000000E-11   1.68750000000E-11   1.75000000000E-11   1.81250000000E-11
1.87500000000E-11   1.93750000000E-11   2.00000000000E-11   2.09375000000E-11
2.18750000000E-11   2.28125000000E-11   2.37500000000E-11   2.46875000000E-11
2.56250000000E-11   2.65625000000E-11   2.75000000000E-11   2.84375000000E-11
2.93750000000E-11   3.03125000000E-11   3.12500000000E-11   3.21875000000E-11
3.31250000000E-11   3.40625000000E-11   3.50000000000E-11   3.59375000000E-11
```

Figure 3: ACE Header with beginning of XSS array for ^{1}H from the ENDF71x library. Note this uses the 2.0.1 Header with backwards compatibility with the Legacy Header.

3 Unique ACE Table Identifier

This needs to be done.

Each ACE Table needs to have an identifier to uniquely distinguish the data that is contained in the Table.

3.1 ZAID

3.2 SZAID

With the introduction of the 2.0.1 ACE Header, the identifier was modified to better specify the metastable state of the material as well as expand the available space for identifiers.

The new identifier is referred to as a SZAID[3].

[3] pronounced "ess-ZAID"

4 Continuous-Energy and Discrete Neutron Transport Tables

The format of individual blocks found on neutron transport tables is identical for continuous-energy and discrete-reaction ACE Tables; the format for both are described in this section. The blocks of data are:

1. **ESZ Block**—contains the main energy gid for the Table and the total, absorption, and elastic cross sections as well as the average heating numbers. The ESZ Block block always exists. See Section 4.3.1.
2. **NU Block**—contains prompt, delayed and/or total $\overline{\nu}$ as a function of incident neutron energy. The NU Block exists only for fissionable isotopes; that is, if `JXS(2)`$\neq 0$. See Section 4.3.2.
3. **MTR Block**—contains a list of ENDF MT numbers for all neutron reactions other than elastic scattering. The MTR Block exists for all isotopes that have reactions other than elastic scattering; that is, all isotopes with `NXS(4)`$\neq 0$. See Section 4.3.3.
4. **LQR Block**—contains a list of kinematic Q-values for all neutron reactions other than elastic scattering. The LTR Block exists if `NXS(4)`$\neq 0$. See Section 4.3.4.
5. **TYR Block**—contains information about the type of reaction for all neutron reactions other than elastic scattering. Information for each reaction includes the number of secondary neutrons and whether secondary neutron angular distributions are in the laboratory or center-of-masssystem. The TYR Block exists if `NXS(4)`$\neq 0$. See Section 4.3.5.
6. **LSIG Block**—contains a list of cross section locators for all neutron reacitons other than elastic scattering. The LSIG Block exists if `NXS(4)`$\neq 0$. See Section 4.3.6
7. **SIG Block**—contains cross sections for all reactions other than elastic scattering. The SIG Block exists if `NXS(4)`$\neq 0$. See Section 4.3.7.
8. **LAND Block**—contains a list of angular-distribution locators for all reactions producing secondary neutrons. The LAND Block always exists. See Section 4.3.8.
9. **AND Block**—contains list angular distributions for all reactions producing secondary neutrons. The AND Block always exists. See Section 4.3.9.
10. **LDLW Block**—contains a list of energy distributions for all reactions producing secondary neutrons except for elastic scattering. The LDLW Block exists if `NXS(5)`$\neq 0$. See Section 4.3.10.
11. **DLW Block**—contains energy distributions for all reactions producing secondary neutrons except for elastic scattering. The DLW Block exists if `NXS(5)`$\neq 0$. See Section 4.3.11.
12. **GPD Block**—contains the total photon production cross section tabulated on the ESZ energy grid and a 30× matrix of secondary photon energies. The GPD Block exists only for those older evaluations that provide coupled neutron/photon information; that is, if `JXS(12)`$\neq 0$. See Section 4.3.12.
13. **MTRP Block**—contains a list of MT numbers for all photon production reactions. The term "photon production reaction" is used for any information describing a specific neutron-in, photon-out reaction. The MTR Block exists if `NXS(6)`$\neq 6$. See

Section 4.3.3.

14. **LSIGP Block**—contains a list of cross section locators for all photon production reactions. The LSIGP Block exists if `NXS(6)`$\neq 0$. See Section 4.3.6.
15. **SIGP Block**—contains cross sections for all photon production reactions. The SIGP Block exists if `NXS(6)`$\neq 0$. See Section 4.3.13.
16. **LANDP Block**—contains a list of angular-distribution locators for all photon production reactions. The LANDP Block exist if `NXS(6)`$\neq 0$. See Section 4.3.14
17. **ANDP Block**—contains photon angular distributions for all photon production reactions. The ANDP Block exists if `NXS(6)`$\neq 0$. See Section 4.3.15.
18. **LDLWP Block**—contains a list of energy-distribution locators for all photon production reactions. The LDLWP Block exists if `NXS(6)`$\neq 0$. See Section 4.3.10.
19. **DLWP Block**—contains photon energy distributions for all photon production reactions. The DLWP Block exists if `NXS(6)`$\neq 0$. See Section 4.3.11.
20. **YP Block**—contains a list of MT identifiers of neutron reaction cross sections required as photon production yield multipliers. The YP Block exists if `NXS(6)`$\neq 0$. See Section 4.3.16.
21. **FIS Block**—contains the total fission cross section tabulated on the ESZ energy grid. The FIS Block exists if `JXS(21)`$\neq 0$. See Section 4.3.17.
22. **UNR Block**—contains the unresolved resonance range probability tables. The UNR Block exists if `JXS(23)`$\neq 0$. See Section 4.3.18.

4.1 NXS Array

Table 3: NXS array element definitions for NXS ACE Table.

Element	Name	Description
1	—	Length of second block of data (XSS array)
2	ZA	$1000 * Z + A$
3	NES	Number of energies
4	NTR	Number of reactions excluding elastic scattering
5	NR	Number of reactions having secondary neutrons excluding elastic scattering
6	NTRP	Number of photon production reactions
	...	
8	NPCR	Number of delayed neutron precurser families
	...	
15	NT	Number of PIKMT reaction
16	—	0=normal photon production
		-1=do not produce photons

Does NXS[15] apply to every type of data, or just fast tables?

4.2 JXS Array

Table 4: JXS array element definitions for JXS ACE Table.

Element	Name	Location Description
1	ESZ	Energy table
2	NU	Fission ν data
3	MTR	`MT` array
4	LQR	Q-value array
5	TYR	Reaction type array
6	LSIG	Table of cross section locators
7	SIG	Cross sections
8	LAND	Table of angular distribution locators
9	AND	Angular distributions
10	LDLW	Table of energy distribution locators
11	DLW	Energy distributions
12	GPD	Photon production data
13	MTRP	Photon production `MT` array
14	LSIGP	Table of photon production cross section locators
15	SIGP	Photon production cross sections
16	LANDP	Table of photon production angular distribution locators
17	ANDP	Photon production angular distributions
18	LDLWP	Table of photon production energy distribution locators
19	DLWP	Photon production energy distributions
20	YP	Table of yield multipliers
21	FIS	Total fission cross section
22	END	Last word of this table
23	LUNR	Probability tables
24	DNU	Delayed $\overline{\nu}$ data
25	BDD	Basic delayed data (λ's, probabilities)
26	DNEDL	Table of energy distribution locators
27	DNED	Energy distributions
	...	
32	—	

4.3 Format of Individual Data Blocks

4.3.1 ESZ Block

The format of the ESZ Block is given in Table 5.

Table 5: ESZ Block.

Location in XSS	Parameter	Description
S_{ESZ}	$E(l), l = 1, \ldots, N_E$	Energies
$S_{\mathsf{ESZ}} + N_E$	$\sigma_t(l), l = 1, \ldots, N_E$	Total cross section
$S_{\mathsf{ESZ}} + 2N_E$	$\sigma_s(l), l = 1, \ldots, N_E$	Total absorption cross section
$S_{\mathsf{ESZ}} + 3N_E$	$\sigma_{el}(l), l = 1, \ldots, N_E$	Elastic cross section
$S_{\mathsf{ESZ}} + 4N_E$	$H_{el}(l), l = 1, \ldots, N_E$	Average Heating numbers

Note: S_{ESZ} is index of the XSS array where the ESZ Block starts, `JXS(1)`, and N_E is the number of energy energy points, `NXS(3)`.

4.3.2 NU Block

There are four possibilities for the NU Block:

1. **No NU Block.**
   This happens when `JXS(2)`=0.
2. **Either prompt or total $\overline{\nu}$ is given (but not both).**
   The NU array begins at location `XSS(KNU)` where KNU=`JXS(2)`.
3. **Both prompt and total $\overline{\nu}$ are given.**
   The prompt NU array begins at `XSS(KNU)` where KNU=`JXS(2)`; the total NU array begins at `XSS(KNU)` where KNU = `JXS(2)` + ABS(`XSS(JXS(2))`)+1
4. **Delayed $\overline{\nu}$ is given.**
   The delayed $\overline{\nu}$ array begins at `XSS(KNU)` where KNU=`JXS(24)`. Delayed $\overline{\nu}$ must be given in tabulated as described below in Table 7.

The format of the NU Block has two forms (if it exists); polynomial (see Table 6) and tabulated (see Table 7). The format is specified by the LNU flag located in the XSS array at index KNU where KNU is defined above.

Table 6: NU Block—Polynomial function form.

Location in XSS	Parameter	Description
KNU	LNU=1	Polynomial function flag
KNU+1	N_C	Number of coefficients
KNU+2	$C(l), l = 1, \ldots, N_C$	Coefficients

When using the polynomial function form of the NU array, $\overline{\nu}$ is reconstructed as

$$\overline{\nu}(E) = \sum_{l=1}^{N_C} C(l) E^{l-1}, \quad (1)$$

where the energy, E, is given in MeV.

Table 7: NU Block—Tabulated form.

Location in XSS	Parameter	Description
KNU	LNU=2	Tabulated data flag
KNU+1	N_R	Number of interpolation regions
KNU+2	$\mathsf{NBT}(l), l = 1, \ldots, N_R$	ENDF interpolation parameters
KNU+2+N_R	$\mathsf{INT}(l), l = 1, \ldots, N_R$	ENDF interpolation scheme†
KNU+2+2N_R	N_E	Number of energies
KNU+3+2N_R	$E(l), l = 1, \ldots, N_E$	Tabulated energy points
KNU+3+2$N_R + N_E$	$\overline{\nu}(l), l = 1, \ldots, N_E$	Tabulated $\overline{\nu}$ values

† If $N_R = 0$, NBT and INT are omitted and linear-linear interpolation is assumed.

If delayed neutron data exist (when `JXS(24)`>0), the precursor distribution format is given as in Table 8. The decay constant for the first group DEC_1 is given at `XSS(JXS(25))`. The precursor distribution immediately follows as described in Table 8. The indices (locators) of the XSS array where each precursor distribution begins (S_{DNU}) can found using the format described in Section 4.3.10 and Section 4.3.11, where LED=`JXS(26)` and NMT=`NXS(8)`.

Table 8: Delayed $\overline{\nu}$ precursor distribution..

Location in XSS	Parameter	Description
S_{DNU}	DEC_i	Decay constant for the i-th group
S_{DNU}+1	N_R	Number of interpolation regions
S_{KNU}+2	$\mathsf{NBT}(l), l = 1, \ldots, N_R$	ENDF interpolation parameters†
S_{KNU}+2+N_R	$\mathsf{INT}(l), l = 1, \ldots, N_R$	ENDF interpolation scheme
S_{DNU}+2+2N_R	N_E	Number of energies
S_{DNU}+3+2N_R	$E(l), l = 1, \ldots, N_E$	Tabulated energy points
S_{DNU}+3+2$N_R + N_E$	$P(l), l = 1, \ldots, N_E$	Corresponding probabilities

† If $N_R = 0$, NBT and INT are omitted and linear-linear interpolation is assumed.

Note: S_{DNU} is the index of the XSS array where the delayed $\overline{\nu}$ precursor distribution begins; the first one is at S_{DNU}=`JXS(25)`.

4.3.3 MTR & MTRP Blocks

The format of the MTR Block (for incident neutron reactions) and MTRP Block (for photon production reactions) is given in Table 10. The starting index depends on whether it is the MTR Block or MTRP Block and are given in Table 9.

Block	LMT	NMT
MTR	JXS(3)	NXS(4)
MTRP	JXS(13)	NXS(6)

Table 9: LMT and NMT values for the MTR Block and MTR Block.

Table 10: MTR & MTRP Block.

Location in XSS	Parameter	Description
LMT	MT_1	First ENDF Reaction available
LMT+1	MT_2	Second sENDF Reaction available
...		
LMT+NMT+1	$\mathsf{MT}_{\mathsf{NMT}}$	Last ENDF reaction available

For the MTR Block, $\mathsf{MT}_1, \ldots, \mathsf{MT}_{\mathsf{NMT}}$ are standard ENDF MTnumbers; that is, MT$=16=(n, 2n)$; MT$=17=(n, 3n)$; etc. For a complete listing of MT numbers, see [1, Appendix B].

For the MTRP Block, the MT numbers are somewhat arbitrary. To understand the scheme used for numbering the photon production MTs, it is necessary to realize that in the ENDF format, more than one photon can be produced by a particular neutron reaction that is itself specified by a single MT. Each of these photons is produced with an individual energy-dependent cross section. For example, MT102 (radiatiive capture) might be responsible for 40 photons, each with its own cross section, angular distribution, and energy distribution. We need 40 photon MTs to represent the data; the MTs are numbered 1002001, 1002002, ..., 1002040. Therefore, if ENDF MT N is responsible for M photons, we shall number the photon MTs 1000*N+1, 1000*N+2, ..., 1000*N+M.

4.3.4 LQR Block

The format of the LQR Block, containing the reaction-specific Q-values, is given in Table 11. The index at the start of the LQR Block, S_{LQR}=`JXS(4)`. The number of reactions, NMT, is the same through the ACE Table, NMT=`NXS(4)`.

Table 11: LQR Block.

Location in XSS	Parameter	Description
S_{LQR}	Q_1	Q-value for reaction MT_1
$S_{\mathsf{LQR}}+1$	Q_2	Q-value for reaction MT_2
...		
S_{LQR}+NMT-1	Q_{NMT}	Q-value for reaction $\mathsf{MT}_{\mathsf{NMT}}$

4.3.5 TYR Block

The format of the TYR Block is given in Table 12. The index at the start of the TYR Block, S_{TYR}=`JXS(5)`. The number of reactions, NMT, is the same through the ACE Table, NMT=`NXS(4)`.

Table 12: TYR Block.

Location in XSS	Parameter	Description
S_{TYR}	TY_1	Neutron release for reaction MT_1
$S_{\mathsf{TYR}}+1$	TY_2	Neutron release for reaction MT_2
...		
$S_{\mathsf{TYR}}+\mathsf{NMT}\text{-}1$	$\mathsf{TY}_{\mathsf{NMT}}$	Neutron release for reaction $\mathsf{MT}_{\mathsf{NMT}}$

The possible values of TY are ±1, ±2, ±3, ±4, ±19, 0, and integers greater than 100 in absolute value; the sign indicates the system for scattering: negative=center-of-mass, positive=Lab. Thus if $\mathsf{TY}_i=+3$, three neutrons are released for reaction MT_i and the data on the cross section tables used to determine the exiting neutrons' angles are given in the Lab frame of reference. TY=19 indicates fission. The number of secondary neutrons released is determined from the fission $\overline{\nu}$ data found in the NU Block. $\mathsf{TY}_i=0$ indicates absorption (ENDF reactions MT>100); no neutrons are released. $\|\mathsf{TY}_i\| > 100$ signifies reactions other than fission that have energy-dependent neutron multiplicities. The number of secondary neutrons released is determined from the yield data found in the DLW Block. The MT_is are given in the MTR Block.

4.3.6 LSIG & LSIGP Block

The LSIG Block and LSIGP Block give the locators for cross section array for each reaction MT. A locator is a *relative* index in the XSS array where some piece of data. In this case, the data is the cross section values. The format of the LSIG Block (for incident neutron cross sections) and LSIGP Block (for photon production cross sections) is given in Table 13. The format for the incident neutron cross section arrays is given in Section 4.3.7. The format for the photon production cross sections is given in Section 4.3.13.

All locators are relative to `JXS(7)` for the LSIG Block or `JXS(15)` for the LSIGP Block. That is, LXS=`JXS(7)` for the LSIG Block and LXS=`JXS(15)` for the LSIGP Block. So the actual cross section data begins at the index LOCA+LXS. The MTs are given in the MTR Block and the MTRP Block for the LSIG Block and the LSIGP Block respectively. LOCA_i must be monotonically increasing.

Table 13: LSIG & LSIGP Block.

Location in XSS	Parameter	Description
LXS	$\mathsf{LOCA}_1=1$	Location of cross sections for reaction MT_1
LXS+1	LOCA_2	Location of cross sections for reaction MT_2
...		
LXS+NMT-1	$\mathsf{LOCA}_{\mathsf{NMT}}$	Location of cross sections for reaction $\mathsf{MT}_{\mathsf{NMT}}$

4.3.7 SIG Block

The SIG Block contains the incident neutron cross section data. (The photon production cross section is in the SIGP Block.) The format of the SIG Block is given in Table 14. The cross section data begins at the index specified by the locator from the LSIG Block; the format for which is given in Table 15.

Table 14: SIG Block.

Location in XSS	Description
LXS+LOCA_1-1	Cross section array for reaction MT_1
LXS+LOCA_2-1	Cross section array for reaction MT_2
...	
LXS+LOCA_{NMT}-1	Cross section array for reaction MT_{NMT}

Note: The number of cross section arrays NMT=`NXS(4)`.

The LOCA_i values are given in the LSIG Block and are all relative to `JXS(7)`. The energy grid index IE_i corresponds to the first energy in the grid at which a cross section is given. The MT_is are defined in the MTR Block.

Table 15: Cross section array for the i-th reaction..

Location in XSS	Parameter	Description
LXS + LOCA_i-1	IE_i	Energy grid index for reaction MT_i
LXS + LOCA_i	$N_{E,i}$	Number of consecutive entries for MT_i
LXS + LOCA_i+1	$\sigma_i[E(l)]$ for $l = \text{IE}_i, \ldots, \text{IE}_i + N_{E,i} - 1$	Cross section for reaction MT_i

Note: The energy grid, $E(l)$ is given in the ESZ Block.

4.3.8 LAND Block

The LAND Block contains locators for the angular distributions for all reactions producing secondary neutrons. The LAND Block always exists and begins at S_{LAND}=`JXS(8)`. All locators (LOCB) are relative `JXS(9)`; that is, the angular distribution begins at `JXS(9)`+LOCB_i. The LOCB_i locators must be monotonically increasing. The format of the LAND Block is given in Table 16.

Table 16: LAND Block.

Location in XSS	Parameter	Description
S_{LAND}	LOCB_1=1	Location of angular distribution data for elastic scattering reaction
$S_{\mathsf{LAND}}+1$	LOCB_2	Location of angular distribution data for reaction MT_1
...		
$S_{\mathsf{LAND}}+\mathsf{NMT}$	$\mathsf{LOCB}_{\mathsf{NMT}}$	Location of angular distribution data for reaction $\mathsf{MT}_{\mathsf{NMT}}$

Note: S_{LAND}=`JXS(8)` and NMT=`NXS(5)` is the number of reactions (excluding elastic scattering).

4.3.9 AND Block

The AND Block contains angular distribution data for all reactions that produce secondary neutrons. The format of the AND Block is given in Table 17. The angular distribution data begins at the index specified by the locator LOCBfrom the LAND Block. If LOCB_i=0 (given in the LAND Block), no angular distribution data are given for reaction i and isotropic scattering is assumed in either the Lab or center-of-mass system. The choice of Lab or center-of-mass system depends upon the value for reaction i in the TYR Block. If LOCB_i=-1 no angular distribution data are given for reaction i in the AND Block. The angular distribution data are specified through law=44 in the DLW Block.

Table 17: AND Block.

Location in XSS	Description
`JXS(9)`+LOCB_1-1	Angular distribution array for elastic scattering
`JXS(9)`+LOCB_2-1	Angular distribution array for reaction MT_1
`JXS(9)`+$\mathsf{LOCB}_{\mathsf{NMT}}$-1	Angular distribution array for reaction $\mathsf{MT}_{\mathsf{NMT}}$

Note: The format for the angular distribution of the i-th array is given in Table 18.

Table 18: Angular distribution array for the i-th reaction.

Location in XSS	Parameter	Description
`JXS(9)`+LOCB_i-1	N_E	Number of energies at which angular distributions are tabulated.
`JXS(9)`+LOCB_i	$E(l), l = 1, \dots, N_E$	Energy grid

Continued on next page

Table 18: Angular distribution array for the i-th reaction (continued)

Location in XSS	Parameter	Description
JXS(9)+$\mathsf{LOCB_i}+N_E$	$L_C(l), l = 1, \ldots, N_E$	Location of tables associated with $E(l)$

The angular distribution arrays (Table 18) contains additional locators, L_C; the sign of these locators is a flag:

- if $L_C(l) > 0$, then $L_C(l)$ points to a 32 equiprobable bin distribution (see Table 19);
- if $L_C(l) < 0$, then $L_C(l)$ points to a tabulated angular distribution (see Table 20);
- if $L_C(l) = 0$, then distribution is isotropic and no further data is needed.

Table 19: Format for the 32 equiprobable bin distribution.

Location in XSS	Parameter	Description
JXS(9)+$\lvert L_C(l)\rvert - 1$	$P(1, K)$ $K = 1, \ldots, 33$	32 equiprobable cosine bins for scattering at energy $E(1)$.

Table 20: Format for the tabulated angular distribution..

Location in XSS	Parameter	Description
$\mathsf{LDAT}_l + 1$	JJ	Interpolation flag†
$\mathsf{LDAT}_l + 2$	N_P	Number of points in the distribution
$\mathsf{LDAT}_l + 3$	$CS_{\text{out}}(j), j = 1, \ldots, N_P$	Cosine scattering angular grid
$\mathsf{LDAT}_l + 4$	$\text{PDF}(j), j = 1, \ldots, N_P$	Probability density function
$\mathsf{LDAT}_l + 5$	$\text{CDF}(j), j = 1, \ldots, N_P$	Cumulative density function

† 0 histogram interpolation,
1 linear-linear interpolation

Note: $\mathsf{LDAT}_l = \texttt{JXS(9)} + |L_C(l)| - 1$

4.3.10 LDLW & LDLWP Block

The LDLW Block and LDLW Block give the locators for the energy distribution for every reaction that produces secondary neutrons or secondary photons (respectively). The format of the LDLW Block (for secondary neutrons) and LDLW Block (for secondary photons) is given in Table 22. The locators for the delayed neutron precursors (see Section 4.3.2) also use the same format. The format for the distribution arrays is given in Section 4.3.11.

The LDLW Block exists if NXS(5)$\neq 0$ while the LDLWP Block exists if NXS(6)$\neq 0$. The starting index, LED, depends on what data is being read; the starting values and the number of locators, NMT, are given in Table 21.

Block	LED	NMT
LDLW	`JXS(10)`	`NXS(5)`
LDLWP	`JXS(18)`	`NXS(5)`
delayed neutrons	`JXS(26)`	`NXS(8)`

Table 21: LED and NMT values for the LDLW Block and LDLWP Block.

Table 22: LDLW Block.

Location in XSS	Parameter	Description
LED	LOCC_1	Location of energy distribution data for reaction MT_1 or group 1 (if delayed neutron)
LED+1	LOCC_2	Location of energy distribution data for reaction MT_2 or group 2 (if delayed neutron)
...		
LED+NMT-1	$\mathsf{LOCC}_{\mathsf{NMT}}$	Location of energy distribution data for reaction $\mathsf{MT}_{\mathsf{NMT}}$ or group NMT (if delayed neutron)

Note: The LOCC_i must be monotonically increasing.

All locators point to data *relative* to JED (see Section 4.3.11) in the XSS array. The MT values are given in the MTR Block for LDLW Block or MTRP Block for LDLWP Block.

4.3.11 DLW & DLWP Block

Which of these formats really need to still be supported? ENDF has stopped supporting a number of these 30+ years ago.

The DLW Block contains secondary energy distributions for all reactions producing secondary neutrons—expect for elastic scattering. The DLWP Block contains secondary energy distribution for all photon-producing reactions. Both the DLW Block and DLWP Block have the same format. The energy distributions are given starting with a locator, LOCC, which were given in the LDLW Block and LDLWP Block. The locators are relative to the JED parameter. The value for JED and NMT (the number of reactions) is dependent on whether it is the DLW Block or DLWP Block. These values are given in Table 23.

Block	JED	NMT
DLW	`JXS(11)`	`NXS(5)`
DLWP	`JXS(19)`	`NXS(6)`
delayed neutrons	`JXS(27)`	N/A

Table 23: JED and NMT for the DLW Block and DLW Block.

Table 24: DLW.

Location in XSS	Description
JED+LOCC_1-1	Energy distribution array for reaction MT_1
JED+LOCC_2-1	Energy distribution array for reaction MT_2
...	
JED+$\mathsf{LOCC}_{\mathsf{NMT}}$-1	Energy distribution array for reaction $\mathsf{MT}_{\mathsf{NMT}}$

The i-th array has the form shown in

Table 25: Format for the secondary energy distribution..

Location in XSS	Parameter	Description
JED+LOCC_i-1	LNW_1	Location of next law.†
JED+LOCC_i	LAW_1	Name of this law
JED+LOCC_i+1	IDAT_1	Location of data for this law relative to JED
JED+LOCC_i+2	N_R	Number of interpolation regions to define law applicability regime
JED+LOCC_i+3	$\mathsf{NBT}(l), l = 1, \ldots, N_R$	ENDF interpolation parameters
JED+LOCC_i+3+N_R	$\mathsf{INT}(l), l = 1, \ldots, N_R$	ENDF interpolation scheme‡
JED+LOCC_i+3+2N_R	N_E	Number of energies
JED+LOCC_i+4+2N_R	$E(l), l = 1, \ldots, N_E$	Tabulated energy points
JED+LOCC_i+4+2$N_R + N_E$	$P(l), l = 1, \ldots, N_E$	Probability of law validity*
JED+$\mathsf{IDAT}_1 - 1$	$\mathsf{LDAT}(l), l, \ldots, L$	Law data for LAW_1.
JED+$\mathsf{LNW}_1 - 1$	LNW_2	Location of next law
JED+LNW_1	LAW_2	Name of this law
JED+LNW+1	IDAT_2	Location of data for this law relative to JED
...		

† If $\mathsf{LNW}_i = 0$ then LAW_1 is used regardless of other circumstantes.
‡ If $N_R = 0$, NBT and INT are omitted and linear-linear interpolation is assumed.
* If the particle energy $E < E(1)$, then $P(E) = P(1)$. If $E > E(N_E)$, then $P(E) = P(N_E)$. If more than one law is given, then LAW_1 is used only if $\xi < P(E)$ where ξ is a random number between 0 and 1.

The format for the law data depends on the law. The length, L, of the law data array, LDAT, is determined from parameters with LDAT. The various LDAT arrays and their formats are given in the following tables. Laws 2 (Table 27) and 4 (Table 28) are used to describe spectra of secondary photons from neutron collisions. All laws—except for Law 2—are usd to describe the spectra of scattered neutrons.

In the following tables, we provide relative locations of data in the LDAT array rather than the absolute locations in the XSS array. Table 25 defines the starting location of the LDAT array within the XSS array.

4.3.11.1 LAW=1—Tabular Equiprobable Energy Bins

Table 26: LAW=1 (From ENDF Law 1).

Location	Parameter	Description
LDAT(1)	N_R	Number of interpolation regions between tables of E_{out}
LDAT(2)	NBT$(l), l = 1, \ldots, N_R$	ENDF interpolation parameters
LDAT(2+N_R)	INT$(l), l = 1, \ldots, N_R$	ENDF interpolation scheme†
LDAT(2+2N_R)	N_E	Number of incident energies tabulated
LDAT(3+2N_R)	$E_{\text{in}}(l), l = 1, \ldots, N_E$	List of incident energies for which E_{out} is tabulated
LDAT(3+2$N_R + N_E$)	NET	Number of outgoing energies in each E_{out} table
LDAT(4+2 $* N_R + N_E$)	$E_{\text{out}_1}(l), l = 1, \ldots,$ NET $E_{\text{out}_2}(l), l = 1, \ldots,$ NET ... $E_{\text{out}_{N_E}}(l), l = 1, \ldots,$ NET	E_{out} tables‡

† If $N_R = 0$, NBT and INT are omitted and linear-linear interpolation is assumed.
‡ E_{out} tables consist of NET boundaries of NET-1 equally likely energy intervals. Linear-linear interpolation is used between intervals.

4.3.11.2 LAW=2—Discrete Photon Energy

Table 27: LAW=2—Discrete Photon Energy.

Location	Parameter	Description
LDAT(1)	LP	Indicator of whether the photon is a primary or non-primary photon
LDAT(2)	EG	Photon energy or binding energy

Note: If LP=0 or LP=1, the photon energy is EG. If LP=2, the photon energy is

$$\mathsf{EG} + \left(\frac{\mathsf{AWR}}{\mathsf{AWR}+1}\right) E_N$$

where AWR is the atomic weight ratio and E_N is the incident neutron energy.

4.3.11.3 LAW=3—Level Scattering

$$\mathsf{LDAT}(1) = \left(\frac{A+1}{A}\right)|Q| \tag{2}$$

$$\mathsf{LDAT}(2) = \left(\frac{A}{A+!}\right)^2 \tag{3}$$

$$E_{\text{out}}^{\text{CM}} = \mathsf{LDAT}(2) * (E - \mathsf{LDAT}(1)) \tag{4}$$

where

$$E_{\text{out}}^{\text{CM}} = \text{outgoing center-of-mass energy}$$
$$E = \text{incident energy}$$
$$A = \text{atomic weight ratio}$$
$$Q = Q - \text{value}$$

The outgoing neutron energy in the laboratory system is:

$$E_{\text{out}}^{\text{LAB}} = E_{\text{out}}^{\text{CM}} + \left\{E + 2\mu_{\text{CM}}(A+1)(EE_{\text{out}}^{\text{CM}})^{1/2}\right\}/(A+1)^2 \tag{5}$$

where μ_{CM} is the cosine of the center-of-mass scattering angle

What is $EE_{\text{out}}^{\text{CM}}$?

4.3.11.4 LAW=4—Continuous Tabular Distribution

Table 28: LAW=4 (From ENDF-6 LAW=1).

Location	Parameter	Description
LDAT(1)	N_R	Interpolation scheme between tables of E_{out}
LDAT(2)	NBT$(l), l = 1, \ldots, N_R$	ENDF interpolation parameters
LDAT(2+N_R)	INT$(l), l = 1, \ldots, N_R$	ENDF interpolation scheme†
LDAT(2+2N_R)	N_E	Number of energies at which distributions are tabulated
LDAT(3+2N_R)	$E(l), l = 1, \ldots, N_E$	Incident neutron energies
LDAT(3+2$N_R + N_E$)	L$(l), l = 1, \ldots, N_E$	Locations of distributions‡

† If $N_R = 0$, NBT and INT are omitted and linear-linear interpolation is assumed.
‡ Relative to `JXS(11)` (neutron reactions), `JXS(19)` (photon-producing reactions), or `JXS(27)` (delayed neutrons).

The data associated with each incident neutron energy begins at the location L(l). The format for the data is given in Table 29, where for $E(1)$ let K=3+2$N_R + 2N_E$.

Table 29: Secondary energy distribution for each incident energy in LAW=4..

Location	Parameter	Description
	Data for $\mathbf{E(1)}$	
LDAT(K)	INTT$'$	Interpolation parameter
LDAT(K+1)	N_p	Number of points in the distribution
LDAT(K+2)	$E_{\text{out}}(l), l = 1, \ldots, N_p$	outgoing energy grid
LDAT(K+2 + N_p)	$\text{PDF}(l), l = 1, \ldots, N_p$	Probability Density Function
LDAT(K+2 + $2N_p$)	$\text{CDF}(l), l = 1, \ldots, N_p$	Cumulative Density Function
	Data for $\mathbf{E(2)}$—same format for $E(1)$	
	...	
	Data for $\mathbf{E(N_E)}$—same format for $E(1)$	

The first element in the data is INTT$'$ or the interpolation parameter, which is a combination of two other parameters:

1. the number of discrete photon lines, N_D, and
2. the interpolation scheme for the subsequent data, INTT.

INTT has two valid values:

INTT=1 histogram distribution, and

INTT=2 linear-linear distribution.

If the value of INTT$' > 10$, then

$$\text{INTT}' = 10N_D + \text{INTT}$$

where INTT is the interpolation scheme and the first N_D values of N_p points describe discrete photon lines. The remaining $(N_p - N_D)$ values describe a continuous distribution. In this way, the distribution may be discrete, continuous, or a discrete distribution superimposed upon a continuous background.

4.3.11.5 LAW=5—General Evaporation Spectrum

Table 30: LAW=5 (From ENDF-6, MF=5, LF=5).

Location	Parameter	Description
LDAT(1)	N_R	Interpolation scheme
LDAT(2)	$\text{NBT}(l), l = 1, \ldots, N_R$	between T's
LDAT(2+N_R)	$\text{INT}(l), l = 1, \ldots, N_R$	
LDAT(2+$2N_R$)	N_E	Number of incident energies tabulated
LDAT(3+$2N_R$)	$E(l), l = 1, \ldots, N_E$	Incident energy table
LDAT(3+$2N_R + N_E$)	$\theta(l), l = 1, \ldots, N_E$	Tabulated function of incident energies

Continued on next page

Table 30: LAW=5 (From ENDF-6, MF=5, LF=5) (continued)

Location	Parameter	Description
LDAT($3+2N_R+2N_E$)	NET	Number of X's tabulated
LDAT($4+2N_R+2N_E$)	$X(l), l=1,\ldots,$ NET	Tabulated probabilistic function

$$E_{\text{out}} = X(\xi)\theta(E) \tag{6}$$

where:
$X(\xi)$ is a randomly sampled table of X's, and
E is the incident energy.

This looks slightly different than the one in the ENDF-6 document. It may be similar, but we should double check.

4.3.11.6 LAW=7—Simple Maxwell Fission Spectrum

Table 31: LAW=7 (From ENDF-6, MF=5, LF=7).

Location	Parameter	Description
LDAT(1)	N_R	Interpolation scheme between T's
LDAT(2)	NBT(l), $l=1,\ldots,N_R$	
LDAT($2+N_R$)	INT(l), $l=1,\ldots,N_R$	
LDAT($2+2N_R$)	N_E	Number of incident energies tabulated
LDAT($3+2N_R$)	$E(l), l=1,\ldots,N_E$	Incident energy table
LDAT($3+2N_R+N_E$)	$\theta(l), l=1,\ldots,N_E$	Tabulated function of incident energies
LDAT($3+2N_R+2N_E$)	U	Restriction energy

The outgoing energy, E_{out}, can be calculated as

$$f(E \to E_{\text{out}}) = \frac{\sqrt{E_{\text{out}}}}{I}\, e^{-E_{\text{out}}/\theta(E)} \tag{7}$$

where:
I is the normalization constant

$$I = \theta^{3/2}\frac{\sqrt{\pi}}{2}\,\text{erf}\left(\sqrt{(E-U)/\theta}\right) - \sqrt{(E-U)/\theta}\; e^{-(E-U)/\theta}, \tag{8}$$

θ is tabulated as a function of incident energy, E; and
U is a constant introduced to define the proper upper limit for the final particle energy such that $0 \leq E_{\text{out}} \leq (E-U)$.

4.3.11.7 LAW=9—Evaporation Spectrum

Table 32: LAW=9 (From ENDF-6, MF=5, LF=9).

Location	Parameter	Description
LDAT(1)	N_R	Interpolation scheme between T's
LDAT(2)	NBT$(l), l = 1, \ldots, N_R$	
LDAT(2+N_R)	INT$(l), l = 1, \ldots, N_R$	
LDAT(2+2N_R)	N_E	Number of incident energies tabulated
LDAT(3+2N_R)	$E(l), l = 1, \ldots, N_E$	Incident energy table
LDAT(3+2$N_R + N_E$)	$\theta(l), l = 1, \ldots, N_E$	Tabulated function of incident energies
LDAT(3+2$N_R + 2N_E$)	U	Restriction energy

The outgoing energy, E_{out}, can be calculated as

$$f(E \to E_{\text{out}}) = \frac{\sqrt{E_{\text{out}}}}{I} \, e^{-E_{\text{out}}/\theta(E)} \tag{9}$$

where:

I is the normalization constant

$$I = \theta^2 \left[1 - e^{-(E-U)/\theta} \left(1 + \frac{E-U}{\theta} \right) \right], \tag{10}$$

θ is tabulated as a function of incident energy, E; and

U is a constant introduced to define the proper upper limit for the final particle energy such that $0 \leq E_{\text{out}} \leq (E - U)$.

Note: Equation 9 is the same as Equation 7; just the definitions of I in Equation 8 and Equation 10 are different.

4.3.11.8 LAW=11—Energy Dependent Watt Spectrum

Table 33: LAW=11 (From ENDF-6, MF=5, LF=11).

Location	Parameter	Description
LDAT(1)	N_{R_a}	Interpolation scheme between a's
LDAT(2)	NBT$_a(l), l = 1, \ldots, N_{R_a}$	
LDAT(2+N_{R_a})	INT$_a(l), l = 1, \ldots, N_{R_a}$	
LDAT(2+2N_{R_a})	N_{E_a}	Number of incident energies tabulated for $a(E_{\text{in}})$ table
LDAT(3+2N_{R_a})	$E_a(l), l = 1, \ldots, N_{E_a}$	Incident energy table
LDAT(3+2$N_{R_a} + N_{E_a}$)	$a(l), l = 1, \ldots, N_{E_a}$	Tabulated a's
let L $= 3 + 2\,(N_{R_a} + N_{E_a})$		

Continued on next page

Table 33: LAW=11 (From ENDF-6, MF=5, LF=11) (continued)

Location	Parameter	Description
LDAT(L)	N_{R_b}	Interpolation scheme between b's
LDAT(L+1)	$\mathrm{NBT}_b(l), l = 1, \ldots, N_{R_b}$	
LDAT(L+1+N_{R_b})	$\mathrm{INT}_b(l), l = 1, \ldots, N_{R_b}$	
LDAT(L+1+2N_{R_b})	N_{E_b}	Number of incident energies tabulated for $b(E_{\mathrm{in}})$ table
LDAT(L+2+2N_{R_b})	$E_b(l), l = 1, \ldots, N_{E_b}$	Incident energy table
LDAT(L+2+2$N_{R_b} + N_{E_b}$)	$b(l), l = 1, \ldots, N_{E_b}$	Tabulated b's
LDAT(L+2+2$N_{R_b} + 2N_{E_b}$	U	Rejection energy

The outgoing energy, E_{out}, can be calculated as

$$f(E \rightarrow E_{\mathrm{out}}) = \frac{e^{-E_{\mathrm{out}}/a}}{I} \sinh\left(\sqrt{bE_{\mathrm{out}}}\right) \tag{11}$$

where:

I is the normalization constant

$$I = \frac{1}{2}\sqrt{\frac{\pi a^3 b}{4}} e^{(ab/4)} \left[\mathrm{erf}\left(\sqrt{\frac{E-U}{a}} - \sqrt{\frac{ab}{4}}\right) + \mathrm{erf}\left(\sqrt{\frac{E-U}{a}} + \sqrt{\frac{ab}{4}}\right)\right] - ae^{-(E-U)/a}\sinh\sqrt{b(E-U)}; \tag{12}$$

a and b are tabulated energy-dependent parameters; and

U is a constant introduced to define the proper upper limit for the final particle energy such that $0 \leq E_{\mathrm{out}} \leq (E - U)$.

4.3.11.9 LAW=22—Tabular Linear Functions

Table 34: LAW=22 (From UK Law 2).

Location	Parameter	Description
LDAT(1)	N_R	
LDAT(2)	$\mathrm{NBT}(l), l = 1, \ldots, N_R$	Interpolation parameters
LDAT(2+N_R)	$\mathrm{INT}(l), l = 1, \ldots, N_R$	
LDAT(2+2N_R)	N_E	Number of incident energies tabulated
LDAT(3+2N_R)	$E_{\mathrm{in}}(l), l = 1, \ldots, N_E$	Number of incdident energies for E_{out} tables
LDAT(3+2$N_R + N_E$)	$\mathrm{LOCE}(l), l = 1, \ldots, N_E$	Locators of E_{out} tables
Data for $E_{\mathrm{in}}(1)$ Let $\mathsf{L} = 3 + 2N_R + 2N_E$:		

Continued on next page

Table 34: LAW=22 (From UK Law 2) (continued)

Location	Parameter	Description
LDAT(L)	NF_1	
LDAT(L+1)	$P_1(K), K = 1, \ldots, \mathsf{NF}_1$	
LDAT(L+1+NF$_1$)	$T_1(K), K = 1, \ldots, \mathsf{NF}_1$	
LDAT(L+1+2NF$_1$)	$C_1(K), K = 1, \ldots, \mathsf{NF}_1$	
Data for $E_{\text{in}}(2)$:		
...		

The following equations seem very wrong, but they are no better in the original.

If

$$E_{\text{in}}(l) \le E < E_{\text{in}}(l+1) \tag{13}$$

then, for a given random number, $\xi \in [0, 1)$, if

$$\sum_{k=1}^{k=K} P_i < \xi \le \sum_{k=1}^{k=K} P_i(k) \tag{14}$$

then

$$E_{\text{out}} = C_i(K)\,(E - T_i(K))\,. \tag{15}$$

4.3.11.10 LAW=24

Table 35: LAW=24 (From UK Law 6).

Location	Parameter	Description
LDAT(1)	N_R	Interpolation scheme
LDAT(2)	$\mathsf{NBT}(l), l = 1, \ldots, N_R$	between T's
LDAT(2+N_R)	$\mathsf{INT}(l), l = 1, \ldots, N_R$	
LDAT(2+2N_R)	N_E	Number of incident energies tabulated
LDAT(3+2N_R)	$E_{\text{in}}(l), l = 1, \ldots, N_E$	List of incident energies for which T is tabulated
LDAT(3+2$N_R + N_E$)	NET	Number of outgoing values in each table
LDAT(4+2$N_R + N_E$)	$T_1(l), l = 1, \ldots, \mathsf{NET}$	Tables have NET boundaries
	$T_2(l), l = 1, \ldots, \mathsf{NET}$	with NET-1 equally likely
	...	intervals. Linear-linear
	$T_{N_E}(l), l = 1, \ldots, \mathsf{NET}$	interpolation is used between intervals.

The outgoing energy, E_{out} can be calculated as:

$$E_{\text{out}} = T_k(l) * E \tag{16}$$

where:
$T_k(l)$ is sampled from the tables and
E is the incident energy.

4.3.11.11 LAW=44—Kalbach-87 Formalism

Table 36: LAW=44 (From ENDF-6 MF=6 LAW=1, LANG=2).

Location	Parameter	Description
LDAT(1)	N_R	Interpolation scheme between tables of E_{out}
LDAT(2)	NBT$(l), l = 1, \ldots, N_R$	ENDF interpolation parameters
LDAT(2+N_R)	INT$(l), l = 1, \ldots, N_R$	ENDF interpolation scheme†
LDAT(2+2N_R)	N_E	Number of energies at which distributions are tabulated
LDAT(3+2N_R)	$E(l), l = 1, \ldots, N_E$	Incident neutron energies
LDAT(3+2$N_R + N_E$)	L$(l), l = 1, \ldots, N_E$	Locations of distributions‡

† If $N_R = 0$, NBT and INT are omitted and linear-linear interpolation is assumed.
‡ Relative to `JXS(11)` (neutron reactions), `JXS(19)` (photon-producing reactions), or `JXS(27)` (delayed neutrons).

The data associated with each incident neutron energy begins at the location L(l). The format for the data is given in Table 37, where for $E(1)$ let K=3+2$N_R + 2N_E$.

Table 37: Secondary energy distribution for each incident energy in LAW=44.

Location	Parameter	Description
	Data for E(1)	
LDAT(K)	INTT′	Interpolation parameter
LDAT(K+1)	N_p	Number of points in the distribution
LDAT(K+2)	$E_{\text{out}}(l), l = 1, \ldots, N_p$	outgoing energy grid
LDAT(K+2 + N_p)	PDF$(l), l = 1, \ldots, N_p$	Probability Density Function
LDAT(K+2 + 2N_p)	CDF$(l), l = 1, \ldots, N_p$	Cumulative Density Function
LDAT(K+2 + 3N_p)	$R(l), l = 1, \ldots, N_p$	Precompound fraciton r
LDAT(K+2 + 4N_p)	$A(l), l = 1, \ldots, N_p$	Angular distribution slope value a
	Data for E(2)—same format for $E(1)$	
	...	

Continued on next page

Table 37: Secondary energy distribution for each incident energy in LAW=44 (continued)

Location	Parameter	Description
	Data for $\mathbf{E(N_E)}$—same format for $E(1)$	

The first element in the data is INTT$'$ or the interpolation parameter, which is a combination of two other parameters:

1. the number of discrete photon lines, N_D, and
2. the interpolation scheme for the subsequent data, INTT.

INTT has two valid values:

INTT=1 histogram distribution, and

INTT=2 linear-linear distribution.

If the value of INTT$' > 10$, then

$$\mathsf{INTT}' = 10N_D + \mathsf{INTT}$$

where INTT is the interpolation scheme and the first N_D values of N_p points describe discrete photon lines. The remaining $(N_p - N_D)$ values describe a continuous distribution. In this way, the distribution may be discrete, continuous, or a discrete distribution superimposed upon a continuous background.

The angular distributions for neutrons are then sampled from:

$$p(\mu, E_{\text{in}}, E_{\text{out}}) = \frac{1}{2}\frac{A}{\sinh(A)}\left[\cosh(A\mu) + R\sinh(A\mu)\right]. \tag{17}$$

Is this equation specific to the format or to MCNP?

4.3.11.12 LAW=61—Like LAW=61, but tabular angular distribution instead of Kalbach-87

Table 38: LAW=61.

Location	Parameter	Description
LDAT(1)	N_R	Number of interpolation regions
LDAT(2)	NBT$(l), l = 1, \ldots, N_R$	ENDF interpolation parameters
LDAT(2+N_R)	INT$(l), l = 1, \ldots, N_R$	ENDF interpolation scheme†
LDAT(2+2N_R)	N_E	Number of energies at which distributions are tabulated
LDAT(3+2N_R)	$E(l), l = 1, \ldots, N_E$	Incident neutron energies
LDAT(3+2$N_R + N_E$)	L$(l), l = 1, \ldots, N_E$	Locations of distributions‡

Continued on next page

Table 38: LAW=61 (continued)

Location	Parameter	Description

† If $N_R = 0$, NBT and INT are omitted and linear-linear interpolation is assumed.
‡ Relative to JXS(11) (neutron reactions), JXS(19) (photon-producing reactions), or JXS(27) (delayed neutrons).

The data associated with each incident neutron energy begins at the location $\mathsf{L}(l)$. The format for the data is given in Table 39, where for $E(1)$ let $\mathsf{K}{=}3{+}2N_R + 2N_E$.

Table 39: Secondary energy distribution for each incident energy in LAW=61.

Location	Parameter	Description
	Data for E(1)	
LDAT(K)	INTT′	Interpolation parameter
LDAT(K+1)	N_p	Number of points in the distribution
LDAT(K+2)	$E_{\text{out}}(l), l = 1, \ldots, N_p$	outgoing energy grid
LDAT(K+2 + N_p)	$\text{PDF}(l), l = 1, \ldots, N_p$	Probability Density Function
LDAT(K+2 + $2N_p$)	$\text{CDF}(l), l = 1, \ldots, N_p$	Cumulative Density Function
LDAT(K+2 + $3N_p$)	$\mathsf{LC}(l), l = 1, \ldots, N_p$	Location of tables associated with incident energies $E(l)$. See Table 40
	Data for E(2)—same format for $E(1)$	
	...	
	Data for E($\mathbf{N_E}$)—same format for $E(1)$	

If the value of $\mathsf{INTT}' > 10$, then

$$\mathsf{INTT}' = 10N_D + \mathsf{INTT}$$

where INTT is the interpolation scheme and the first N_D values of N_p points describe discrete photon lines. The remaining $(N_p - N_D)$ values describe a continuous distribution. In this way, the distribution may be discrete, continuous, or a discrete distribution superimposed upon a continuous background.

The J-th array for the tabular angular distribution has the form shown in Table 40. For the angular distribution, the locators L are relative to JXS(11) for neutron reactions or JXS(19) for photon-producing reactions. Thus,

$$\mathsf{L} = \texttt{JXS(11)} + |\mathsf{LC}(J)| - 1 \text{ (for neutron reactions)},$$
$$\mathsf{L} = \texttt{JXS(19)} + |\mathsf{LC}(J)| - 1 \text{ (for photon-producing reactions)}.$$

Table 40: Angular distribution for LAW=61.

Location	Parameter	Description
LDAT(L+1)	JJ	Interpolation flag
LDAT(L+2)	N_P	Number of points in the distribution
LDAT(L+3)	$CS_{\text{out}}(j), j = 1, \ldots, N_P$	Cosine scattering angular grid
LDAT(L+3+N_P)	$\text{PDF}(j), j = 1, \ldots, N_P$	Probability density function
LDAT(L+3+2N_P)	$\text{CDF}(j), j = 1, \ldots, N_P$	Cumulative density function

4.3.11.13 LAW=66—N-body phase space distribution

Table 41: LAW=66 (From ENDF-6 MF=6 LAW=6).

Location	Parameter	Description
LDAT(1)	NPSX	Number of bodies in the phase space
LDAT(2)	A_P	Total mass ratio for the NPSX particles.

The outgoing energy is

$$E_{\text{out}} = T(\xi) E_i^{\max} \tag{18}$$

where

$$E_i^{\max} = \frac{A_p - 1}{A_p} \left(\frac{A}{A+1} E_{\text{in}} + Q \right) \tag{19}$$

and $T(\xi)$ is sampled from:

$$P_i(\mu, E_{\text{in}}, T) = C_n \sqrt{T} \left(E_i^{\max} - T\right)^{3n/2-4} \tag{20}$$

4.3.11.14 LAW=67—Laboratory Angle-Energy Law

Table 42: LAW=67 (From ENDF-6 MF=6 LAW=7).

Location	Parameter	Description
LDAT(1)	N_R	Interpolation scheme between tables of E_{out}
LDAT(2)	$\text{NBT}(l), l = 1, \ldots, N_R$	ENDF interpolation parameters
LDAT(2+N_R)	$\text{INT}(l), l = 1, \ldots, N_R$	ENDF interpolation scheme†

Continued on next page

Table 42: LAW=67 (From ENDF-6 MF=6 LAW=7) (continued)

Location	Parameter	Description
LDAT($2+2N_R$)	N_E	Number of energies at which distributions are tabulated
LDAT($3+2N_R$)	$E(l), l = 1, \ldots, N_E$	Incident neutron energies
LDAT($3+2N_R + N_E$)	$\mathsf{L}(l), l = 1, \ldots, N_E$	Locations of distributions‡

† If $N_R = 0$, NBT and INT are omitted and linear-linear interpolation is assumed.
‡ Relative to `JXS(11)` (neutron reactions), `JXS(19)` (photon-producing reactions), or `JXS(27)` (delayed neutrons).

The data associated with each distribution begins at location L(l). The format for the data is given in Table 43, where for $E(1)$ let $\mathsf{K} = 3 + 2N_R + 2N_e$.

Table 43: Angular distribution for LAW=67.

Location	Parameter	Description
LDAT(K)	INTMU	Interpolation scheme†
LDAT(K+1)	NMU	Number of secondary cosines
LDAT(K+2)	XMU(l), $l = 1, \ldots,$ NMU	Secondary cosins
LDAT(K+2+NMU)	LMU(l), $l = 1, \ldots,$ NMU	Locations of data for each secondary cosine. See Table 44

† **INTMU=1** histogram distribution,
INTMU=2 linear-linear distribution.

The format for the secondary energy distribution (for each cosine bin, XMU) is given in Table 44. For the energy distribution, the locators, LMU, are relative to `JXS(11)` or `JXS(19)`. Thus,

$$\mathsf{L}_l = \texttt{JXS(11)} + \mathsf{LMU}(l) \text{ (for neutron reactions)},$$
$$\mathsf{L}_l = \texttt{JXS(19)} + \mathsf{LMU}(l) \text{ (for photon-producing reactions)}.$$

Table 44: Secondary energy distribution for each cosine bin in LAW=67.

Location	Parameter	Description
LDAT(L_l)	INTEP	Interpolation parameter between secondary energies†
LDAT($\mathsf{L}_l + 1$)	NPEP	Number of secondary energies

Continued on next page

Table 44: Secondary energy distribution for each cosine bin in LAW=67 (continued)

Location	Parameter	Description
$\mathsf{LDAT}(\mathsf{L}_l+2)$	$E_P(l), l=1,\ldots,\mathsf{NPEP}$	Secondary energy grid
$\mathsf{LDAT}(\mathsf{L}_l+2+\mathsf{NPEP})$	$\mathrm{PDF}(l), l=1,\ldots,\mathsf{NPEP}$	Probability density function
$\mathsf{LDAT}(\mathsf{L}_l+2+2\mathsf{NPEP})$	$\mathrm{CDF}(l), l=1,\ldots,\mathsf{NPEP}$	Cumulative density function

† **INTEP=1** histogram distribution,
INTEP=2 linear-linear distribution.

4.3.11.15 Energy-Dependent Neutron Yields

There are additional numbers to be found for neutrons in the DLW Block and DLWP Block. For those reactions with entries in the TYR Block that are greater than 100 in absolute value, there must be neutron yields, $Y(E)$ provided as a function of neutron energy. The neutron yields are handled similarly to the average number of neutrons per fission, $\nu(E)$ that is given for the fission reactions. These yields are a part of the coupled energy-angle distributions given in File6 of ENDF-6 data.

The i-th array has the form given in Table 45, where $\mathsf{KY}=\mathsf{JED}+|\mathsf{TY}_i|-101$.

Table 45: Energy-Dependent Neutron Yields.

Location	Parameter	Description
KY	N_R	Number of interpolation regions
KY+1	$\mathsf{NBT}(l), l=1,\ldots,N_R$	ENDF interpolation parameters
KY+1+N_R	$\mathsf{INT}(l), l=1,\ldots,N_R$	ENDF interpolation scheme†
KY+1+$2N_R$	N_E	Number of energies
KY+2+$2N_R$	$E(l), l=1,\ldots,N_E$	Tabular energy points
KY+2+N_R+N_E	$Y(l), l=1,\ldots,N_E$	Corresponding energy-dependent yields

† If $N_R=0$, NBT and INT are omitted and linear-linear interpolation is assumed.

4.3.12 GPD Block

The GPD Block contains the *total* photon production cross section, tabulated on the energy grid given in the ESZ Block, the size of which is given by `NXS(3)`. The GPD Block only exists if `JXS(12)`$\neq 0$.

There are 30 groups for the incident neutron energies, the boundaries of which are shown in Table 46. For each incident neutron energy group, the outgoing photon energies are discretized into 20 equiprobable energy groups, thus creating a 30×20 matrix. The outgoing energies are given in the GPD Block as shown in Table 47. Note that this matrix is only used for older tables that do not provide expanded photon production data.

The format of the this Block is given in Table 47. The XSS array index at the start of the GPD Block, S_{GPD}=`JXS(12)`.

Table 46: Discrete neutron energy boundaries.

Group #	Upper Boundary (MeV)	Group #	Upper Boundary (MeV)
1	1.39×10^{-10}	16	0.184
2	1.52×10^{-7}	17	0.303
3	4.14×10^{-7}	18	0.500
4	1.13×10^{-6}	19	0.823
5	3.06×10^{-6}	20	1.353
6	8.32×10^{-6}	21	1.738
7	2.26×10^{-5}	22	2.232
8	6.14×10^{-5}	23	2.865
9	1.67×10^{-4}	24	3.68
10	4.54×10^{-4}	25	6.07
11	1.235×10^{-3}	26	7.79
12	3.35×10^{-3}	27	10.0
13	9.23×10^{-3}	28	12.0
14	2.48×10^{-2}	29	13.5
15	6.76×10^{-2}	30	15.0

Table 47: GPD Block.

Location in XSS	Parameter	Description
S_{GPD}	$\sigma_\gamma(l), l = 1, \ldots, \mathsf{NES}$	Total photon production cross section
S_{GPD}+NES	$E_1(K), K = 1, 20$	20 equiprobable outgoing photon energies for incident neutron $E < E_N(2)$
S_{GPD}+NES+20	$E_2(K), K = 1, 20$	20 equiprobable outgoing photon energies for incident neutron $E_N(2) \leq E < E_N(3)$
...		
S_{GPD}+NES+(i-1)*20	$E_i(K), K = 1, 20$	20 equiprobable outgoing photon energies for incident neutron $E_N(i) \leq E < E_N(i+1)$
...		
S_{GPD}+NES+(30-1)*20	$E_2(K), K = 1, 20$	20 equiprobable outgoing photon energies for incident neutron $E \geq E_N(30)$

4.3.13 SIGP Block

The SIGP Block contains the photon production cross section data. The format of the SIGP Block is given in Table 48. The cross section data begins at the index specified by the locator, LOCA_i, given in the LSIG Block (see Section 4.3.6). All indices to the XSS array are *relative* to `JXS(15)`.

Table 48: SIGP Block.

Location in XSS	Parameter	Description
`JXS(15)`+LOCA_1-1	MFTYPE_1	Cross section array for reaction MT_1
`JXS(15)`+LOCA_2-1	MFTYPE_2	Cross section array for reaction MT_2
...		
`JXS(15)`+$\mathsf{LOCA}_{\mathsf{NMT}}$-1	$\mathsf{MFTYPE}_{\mathsf{NMT}}$	Cross section array for reaction $\mathsf{MT}_{\mathsf{NMT}}$

Note: The number of photon production cross section arrays NMT=`NXS(6)`.

The format of the i-th cross section array has two possible forms depending on the first number in the array, MFTYPE.

Table 49: Photon production array if MFTYPE=12 or 16.

Location in XSS	Parameter	Description
JXS(15)+$\mathsf{LOCA_i}$-1	MFTYPE	12 or 16
JXS(15)+$\mathsf{LOCA_i}$	MTMULT	Neutron MT whose cross section should multiply the yield
JXS(15)+$\mathsf{LOCA_i}$+1	N_R	Number of interpolation regions
JXS(15)+$\mathsf{LOCA_i}$+2	$\mathsf{NBT}(l), l = 1, \ldots, N_R$	ENDF interpolation parameters†
JXS(15)+$\mathsf{LOCA_i}$+2 $+N_R$	$\mathsf{INT}(l), l = 1, \ldots, N_R$	ENDF interpolation scheme
JXS(15)+$\mathsf{LOCA_i}$+2 $+2 * N_R$	N_E	Number of energies at which the yield is tabulated
JXS(15)+$\mathsf{LOCA_i}$+3 $+2 * N_R$	$E(l), l = 1, \ldots, N_E$	Energies
JXS(15)+$\mathsf{LOCA_i}$+3 $+2 * N_R + N_E$	$Y(l), l = 1, \ldots, N_E$	Yields

† If $N_R = 0$, NBT and INT are omitted and linear-linear interpolation is used.

Table 50: Photon production cross section array if MFTYPE=13.

Location in XSS	Parameter	Description
JXS(15)+$\mathsf{LOCA_i}$-1	MFTYPE	13
JXS(15)+$\mathsf{LOCA_i}$	IE	Energy grid index
JXS(15)+$\mathsf{LOCA_i}$+1	N_E	Number of consecutive entries
JXS(15)+$\mathsf{LOCA_i}$+2	$\sigma_{\gamma,i}[E(K)]$, $K = \mathsf{IE}, \ldots, \mathsf{IE} + N_E - 1$	Photon production cross sections for reaction MT_i

4.3.14 LANDP Block

Should this section be merged with Section 4.3.8? It is just a minor difference. The combination is done similarly in Section 4.3.10.

The LANDP Block gives locator information for angular distribution arrays for photon production reactions and exists if NXS(6) $\neq 0$. All locators (LOCB) in the LANDP Block are *relative* to JXS(17); that is, the angular distribution arrays begin at JXS(17) + $\mathsf{LOCB_i}$. The number of photon-producing reactions is NMT=NXS(6). The $\mathsf{LOCB_i}$ must be monotonically increasing. The MTs are defined in the MTRP Block (see Section 4.3.3). The format of the LANDP Block is given in Table 51.

Table 51: LANDP Block.

Location in XSS	Parameter	Description
JXS(16)	LOCB_1=1	Location of angular distribution data for reaction MT_1
JXS(16)+1	LOCB_2	Location of angular distribution data for reaction MT_2
...		
JXS(16)+NMT-1	$\mathsf{LOCB}_{\mathsf{NMT}}$	Location of angular distribution data for reaction $\mathsf{MT}_{\mathsf{NMT}}$

Note: The LOCB_i must be monotonically increasing. The format for the angular distribution of the i-th reaction is given in Table 53.

4.3.15 ANDP Block

The ANDP Block contains angular distribution data for all photon-producing reactions and exists if NXS(6) $\neq 0$. The format of the ANDP Block is given in Table 52; the format of each angular distribution array is given in Table 53. The angular distribution data begins at the index specified by the locator, LOCB, from the LANDP Block; if $\mathsf{LOCB}_\mathsf{i} = 0$, there are no angular distribution data given for reaction i and isotropic scattering is assumed in the Lab system.

Table 52: ANDP.

Location in XSS	Description
JXS(17)+LOCB_1-1	Angular distribution array for reaction MT_1
JXS(17)+LOCB_2	Angular distribution array for reaction MT_2
...	
JXS(17)+$\mathsf{LOCB}_{\mathsf{NMT}}$-1	Angular distribution array for reaction $\mathsf{MT}_{\mathsf{NMT}}$

Note: NMT=NXS(6) is the number of photon-producing reactions.

Table 53: Angular distribution array for the i-th photon-producing reaction.

Location in XSS	Parameter	Description
JXS(17)+LOCB_i-1	N_E	Number of energies at which angular distributions are tabulated.
JXS(17)+LOCB_i	$E(l), l = 1, N_E$	Energy grid

Continued on next page

Table 53: Angular distribution array for the i-th photon-producing reaction (continued)

Location in XSS	Parameter	Description
JXS(17)+LOCB$_i$+N_E	$L_C(l), l = 1, \ldots, N_E$	Location of tables associated with $E(l)$[†]
JXS(17)+$L_C(1) - 1$	$P_1(K), K = 1, \ldots, 33$	32 equiprobable cosine bins for scattering at energy $E(1)$
JXS(17)+$L_C(2) - 1$	$P_2(K), K = 1, \ldots, 33$	32 equiprobable cosine bins for scattering at energy $E(2)$
...		
JXS(17)+$L_C(N_E) - 1$	$P_{N_E}(K), K = 1, \ldots, 33$	32 equiprobable cosine bins for scattering at energy $E(N_E)$

[†] All values of $L_C(l)$ are *relative* to JXS(17). If $L_C(l) = 0$, no table is given for energy $E(l)$ and scattering is assumed to be isotropic in the Lab system.

4.3.16 YP Block

The YP Block contains a list of MT identifiers of neutron cross sections that are used as yield multipliers in Equation 21 to calculate the photon production cross sections and are referenced by the MTMULT parameter in Table 49. The YP Block exists if NXS(6) $\neq 0$. The format of the YP Block is given in Table 54.

Table 54: YP Block.

Location in XSS	Parameter	Description
JXS(20)	NYP	Number of neutron MTs to follow
JXS(20)+1	MTY$(l), l = 1, \ldots,$ NYP	Neutron MTs.

4.3.17 FIS Block

The FIS Block contains the total fission cross section. The FIS Block exists if JXS(21) $\neq 0$, but is generally not provided; the total fission cross section is redundant as the total fission cross section is the summation of first-, second-, third-, and fourth-chance fission (MT=19,20,21, and 38);

$$\sigma_{f,\mathrm{t}}(E) = \sigma_{(n,f)} + \sigma_{(n,nf)} + \sigma_{(n,2nf)} + \sigma_{(n,3nf)}. \tag{22}$$

The format of the FIS Block is given in Table 55.

Table 55: FIS Block.

Location in XSS	Parameter	Description
JXS(21)	IE	Energy grid index
JXS(21)+1	N_E	Number of consecutive entries
JXS(21)+2	$\sigma_f[E(l)], K = \mathsf{IE}, \ldots, \mathsf{IE} + N_E - 1$	Total fission cross sections

Note: The energy $E(l)$ is given in the ESZ Block.

4.3.18 UNR Block

The UNR Block contains the unresolved resonance range probability tables. It exists if JXS(21) $\neq 0$. The UNR Block has several flags that have special meaning:

ILF The ILF flag is the inelastic competition flag.

- **ILF** < 0 The inelastic cross section is zero within the entire unresolved energy range.
- **ILF** > 0 The value of ILF is a special MT number whose tabulation is the sum of the inelastic levels.
- **ILF** $= 0$ The sum of the contribution of the inelastic reactions will be made using a balance relationship involving the smooth cross sections.

An exception to this scheme is typically made when there is only one inelastic level within the unresolved energy range, because the flag can then just be set to its MT number and the special tabulation is not needed.

IOA The IOA is the other absorption flag for determining the contribution of "other absorptions" (no neutron out or destruction reactions).

- **IOA** < 0 The "other absorption" cross section is zero within the entire unresolved resonance range.
- **IOA** > 0 The value of IOA is a special MT number whose tabulation is the sum of the "other absorption" reactions.
- **IOA** $= 0$ The sum of the contribution of the "other absorption" reactions will be made using a balanced relationship involving the smooth cross sections.

An exception to this scheme is typically made when there is only one "other absorption" reaction within the unresolved energy range, because the flag can then just be set to its MT number and the special tabulation is not needed.

IFF The IFF is the factors flag.

- **IFF** $= 0$ The tabulations in the probability tables are cross sections.
- **IFF** $= 1$ The tabulations in the probability tables are factors that must be multiplied by the corresponding "smooth" cross sections to obtain the actual cross sections.

The format of the UNR Block is given in Table 57. The $P(i, j, k)$ values, where

- $i = 1, \ldots, N$,
- $j = 1, \ldots, 6$,
- $k = 1, \ldots, M$,

are what make up the probability tables. The argument j has special meaning depending on its value as shown in Table 56.

Table 56: Possible values for the j argument.

j	Description
1	cumulative probability
2	total cross section/factor
3	elastic cross section/factor
4	fission cross section/factor
5	(n,γ) cross section/factor
6	neutron heating number/factor

Table 57: UNR Block.

Location in XSS	Parameter	Description
`JXS(23)`	N	Number of incident energies where there is a probability table.
`JXS(23)`+1	M	Length of probability table.
`JXS(23)`+2	INT	Interpolation parameter between tables.†
`JXS(23)`+3	ILF	Inelastic competition flag.
`JXS(23)`+4	IOA	Other absorption flag.
`JXS(23)`+5	IFF	Factors flag.
`JXS(23)`+6	$E(i), i = 1, \ldots, N$	Incident energies.
`JXS(23)`+6+N	$P(i,j,k)$	Probability tables.

† 2 linear-linear interpolation,
5 log-log interpolation

The ordering of the probability table entries, $P(i,j,k)$ is given in Table 58, which begins at PTABLE = `JXS(23)` + 6 + N.

Table 58: Order of probability table elements $P(i,j,k)$.

Location in XSS	Parameter	Description
PTABLE	CDF_1	Cumulative probabilities†for energy $i = 1$
PTABLE+M	$\sigma_{t,1}$	Total cross section/factors for energy $i = 1$
PTABLE+$2M$	$\sigma_{s,1}$	Elastic cross section/factors for energy $i = 1$
PTABLE+$3M$	$\sigma_{f,1}$	Fission cross section/factors for energy $i = 1$
PTABLE+$4M$	$\sigma_{(n,\gamma),1}$	(n,γ) cross section/factors for energy $i = 1$
PTABLE+$5M$	H_1	Heating number/factors for energy $i = 1$

Continued on next page

Table 58: Order of probability table elements $P(i, j, k)$ (continued)

Location in XSS	Parameter	Description
...		
PTABLE $+(i-1)*6M$	CDF_i	Cumulative probabilities for energy i
...		
PTABLE $+(N-1)*6M+5M$	H_N	Heating numbers/factors for energy $i = N$

† The cumulative probabilities are monotonically increasing from an implied (but not included) lower value of zero to the upper value of $P(i, 1, k = M) = 1.0$.