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## 9 - NEUTRON ENERGY

### Format

Columns 19-26      Minimum (columns 19-22: "E-MIN" field) and maximum (columns 23-26: "E-MAX" field) neutron energy in electron volt.

Numerical values in floating point form : mantissa n.m., exponent + x. The decimal point is included implicitly between columns 19 and 20 (minimum), and 23 and 24 (maximum energy). Enter only the sign of the exponent in columns 21 and 25. If the exponent is zero, use the '+' sign.

Alphabetic codes are also used to describe quantities averaged over typical neutron spectra.

A blank E-MIN field is forbidden.

### Coding Rules

#### a) General rule for numerical values

Both minimum and maximum incident neutron energies should be given, where E-MIN < E-MAX must always be observed. If the incident neutrons are monochromatic, enter the energy in the minimum energy field only.

Examples of coding :

<u>Energy</u>	<u>Code</u>
34 keV	34+4
0.025 eV (2200 m/s)	25-2
14 MeV	14+7

#### b) Negative resonance energies

Column 19 contains a negative sign. The decimal point is unchanged between columns 19 and 20. A single digit value is entered in column 20 with exponent in columns 21 and 22.

-3 eV (-0.3 x 10<sup>1</sup> eV) is coded as -3+1

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### c) Approximate values

If only approximate order of magnitude energies are given, the mantissa fields can be left blank (columns 19, 20, 23, 24) and only the exponents entered.

For example, "in the keV range" should be coded

```
|19|20|21|22|23|24|25|26|
|  |  |  |  |  |  |  |  |
|  |  | + | 3 |  |  | + | 5 |
```

In the minimum energy field such "exponent only" entries have an energy sorting value of  $1.0 \times 10^n$ , and in the maximum energy field  $9.9 \times 10^n$ .

### d) Upper limit only given

The minimum energy field should not be left blank. The appropriate minimum energy deduced from the context of the work should be entered. If this is zero the code for zero energy in the minimum energy field is 00+0. Such a zero limit is appropriate in a limited number of cases :

- theoretical calculations with a zero lower energy limit.
- integrations of experimental or theoretical quantities.
- quantities implying integration or aggregation between the limits zero and E-MAX (e.g. strength function, elastic scattering expressed as a scattering amplitude). While it is clear that most measurements cannot be carried to zero energy, the assumption made in aggregation of the results is that values below the limit of measurement will not affect the result.

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#### **d) Separated Energy Ranges**

If an article covers two or more distinct energy ranges with separate discussions of the deduced quantities, separate entries should be made for CINDA.

For example, a measurement at thermal energy and a separate measurement between 5 keV and 400 keV should be entered twice with energy codes :

<u>Energy</u>	<u>Code</u>
0.025 eV (thermal)	25-2
5 keV to 400 keV	50+3 40+5

This philosophy should not be taken to the extreme to make separate entries for each of a range of monochromatic incident neutron energies.

#### **e) No information given**

The alphabetic code NDG (columns 19-21) should be used only if it is impossible to give even an order of magnitude estimate of the neutron energy range.

For the quantity LDL, for which an incident neutron energy is meaningless, a slash "/" may be entered in column 19 of the E-MIN field.

#### **f) Useful formulae**

$$E_{eV} = 0.5 \times 10^{12} (V \text{ cm/s})^2$$

$$E_{eV} = 81.8 \times 10^{-3} / (\lambda/\text{A})^2$$

$$2200 \text{ m/s} = 0.025 \text{ eV} = 1.8 \text{ A}$$

#### **For Inverse Reactions**

$$E_n = E_a + Q - ((M_B - M_A)/M_B)E_a$$

where the reaction is  $A(a,n)B$

$E_a$  is the energy of  $a$  in the laboratory frame

$M_A, M_B$  are the masses of  $A$  and  $B$

$Q$  is the  $Q$  value for  $aA \rightarrow Bn$

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### **g) Alphabetic Energy Codes for Spectrum Averages**

These codes are intended to describe quantities averaged over typical neutron spectra. They may occasionally be combined with numerical codes or with other alphabetic codes to indicate that both values are given. For instance, a code MAXW 25-2 should be used when both a maxwellian spectrum average and a value for monochromatic neutrons are given.

<u>Code</u> (left adjusted)	<u>Expansion in</u> <u>CINDA Book</u>	<u>Description</u>
COLD	Cold	Subthermal neutron spectrum
MAXW	Maxwl	Maxwellian neutron spectrum at a temperature of 293°K or reactor temperature
PILE	Pile	A reactor spectrum with a non-Maxwellian energy distribution.
FAST	Fast	A Fast-reactor spectrum
FISS	Fiss	An unmoderated fission neutron spectrum
<u>Non spectrum codes</u>		
NDG	None	No data given
SPON	Spont	Spontaneous fission (use only for quantities NU, NUD, NUF, SFN, SFG, FPG, FPB, NFY, FRS, CHG)
TR	Thrsh	Threshold Energy (if possible a numerical value should be given instead), together with a numerical value for E-MAX, or :
TR UP	Thrsh up	if no upper limit is specified above the threshold (if possible, a numerical limit should be given or estimated).

For other neutron spectra, when none of the alphabetic codes applies. a numeric energy value is entered corresponding to the kT value of the spectrum, with an explanation in the free text (e.g. MAXW., KT=30KEV). Such entries should, however, not be combined with or blocked to entries for monoenergetic neutrons.

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### Energy equivalent for sorting

For internal sorting processes, the alphabetic energy codes are assigned numerical energy equivalents

SPON	zero	
COLD	0.001	eV
MAXW	0.025	eV
PILE	0.05	eV
FAST	0.5	MeV
FISS	1	MeV
TR	0.5	MeV → 5 MeV
TR UP	0.5	MeV → 10 MeV

### **h) Combination of codes**

#### Combination of alphabetic codes

Any combination of alphabetic codes is permitted as long as E-MIN<E-MAX is observed, with the following exceptions :

"NDG" must be entered in the E-MIN field and should not be combined with any other code.

"TR" must be entered in the E-MIN field and can only be combined with a numeric code or "UP" (no blank!) in the E-MAX field.

#### Combinations of alphabetic with numeric codes

Any combination of alphabetic with numeric codes is permitted as long as E-MIN<=E-MAX is observed, with the following restriction :

If E-MIN=E-MAX, then the alphabetic code has to be entered in the E-MIN field.

If in a paper both a spectrum average as well as a range of monochromatic neutron values are given, two separate entries should be made

#### Examples of combinations of codes

MAXW25-2	Maxwl 2.5-2	Maxwellian spectrum and 0.025 eV monochromatic neutrons
MAXW PILE	Maxwl Pile	
MAXW FISS	Maxwl Fiss	Both indicated spectrum averages are given
MAXW FAST	Maxwl Fast	
SPON MAXW	Spont Maxwl	