Storage of numerical neutron source spectra
(Action 25)

The averaged quantity data compiled in EXFOR have to be supplied by the numerical data of incident particle spectra.

Analysis of data, included in EXFOR, have shown that information about neutron spectra, is practically absent in EXFOR.

LEXFOR, Spectrum Average:
Cross sections averaged over a broad incident-projectile energy spectrum may be entered into EXFOR using the proper modifier to REACTION SF8.

Old:
The type of spectrum and its characteristic should be entered **in free text** under the information-identifier keyword **INC-SPECT**.

New:
The type of spectrum and its characteristic should be entered **in numeric data type** (using **special ENTRIES** for neutron spectrum if the spectrum is commonly applied to measurements performed at the neutron source).

1. **To start** these **ENTRIES** from **V0101** (concerning information from Naohiko V is free)

2. **To use** special form of **REACTION** to **define the neutron source**

3. **To use DATA** to enter **neutron spectrum information**

4. **To link ENTRY**(SubEntry) with **averaged data** and
   VENTRY(**V**SubEntry) with **neutron spectrum**

using **STATUS** (**COREL, VSubEntry**) or more specific STATUS code (e.g., NSPCT) **in averaged data Entry** (SubEntry).

The special form of REACTION to define the neutron source

Name of neutron source	In INC-SPECT	SF1-SF7 in REACTION in VEntry
Alpha-Beryllium	**A-BE**	**4-BE-9(A,N)6-C-12,,DE**
Spont.fission of Californium-252	**CF252**	**98-CF-252(0,F) ,, NU/DE**
Spont.fission of Curium-244	**CM244**	**96-CM-244(0,F),, NU/DE**
Spont.fission of Curium-246	**CM246**	**96-CM-246(0,F),, NU/DE**
Spont.fission of Curium-248	**CM248**	**96-CM-248(0,F),,NU/DE**
Deuteron-Beryllium	**D-BE**	**4-BE-9(D,N)5-B-10,,DE**
Deuteron-Carbon 12	**D-C12**	**6-C-12(D,N)7-N-13,,DE**
Deuteron-Carbon 14	**D-C14**	**6-C-14(D,N)7-N-15,,DE**
Deuteron-Deuterium	**D-D**	**1-H-2(D,N)2-HE-3,,DE**
Deuteron-Lithium	**D-LI**	**3-LI-0(D,N)4-BE-0,,DE**
Deuteron-Lithium 7	**D-LI7**	**3-LI-7(D,N)4-BE-8,,DE**
Deuteron-Nitrogen 14	**D-N14**	**7-N-14(D,N)8-O-15,,DE**
Deuteron-Nitrogen 15	**D-N15**	**7-N-15(D,N)8-O-16,,DE**

Deuteron-Tritium	**D-T**	**1-H-3(D,N)2-HE-4,,DE**
Evaporation neutrons	**EVAP**	**13-Al-27(P,X)0-NN-1,,DE** **74-W-0(P,X)0-NN-1,,DE** **82-Pb-0(P,X) 0-NN-1,,DE** **92-U-0(D,X) 0-NN-1,,DE** **...**
Nuclear explosive device	**EXPLO**	**???**
Proton-Beryllium	**P-BE**	**4-BE-9(P,N)5-B-9,,DE**
Proton-Deuterium	**P-D**	**1-H-2(P,N+P)1-H-1,,DE,N**
Photo-neutron	**PHOTO**	**1-H-2(G,N) 1-H-1-,,DE** **13-Al-27(G,X)0-NN-1,,DE** **74-W-0(G,X)0-NN-1,,DE** **92-U-0(G,X)0-NN-1,,DE** **...**
Proton-Lithium 7	**P-LI7**	**3-LI-7(P,N)4-BE-7,,DE** **Or** **3-LI-7(P,X)0-NN-1,,DE**
Polarized neutron source	**POLNS**	**???**
Proton-Tritium	**P-T**	**1-H-3(P,N)2-HE-3,,DE**
Spont.fission of Plutonium-240	**PU240**	**94-PU-240(0,F) ,, NU/DE**
Spont.fission of Plutonium-242	**PU242**	**94-PU-242(0,F) ,, NU/DE**
Reactor (NEUT)	**REAC**	**92-U-FUL ?(0,X) 0-NN-1,,DE**
Thermal column (NEUT)	**THCOL**	**???**

The fields **SF8, SF9** in **REACTION** may be used to indicate, if this spectrum is given in relative (**REL**) values, and if it was obtained by calculation (**CALC**).

Such form of record of the neutron source spectrum allows us to use the existing EXFOR rules. We need to make only small changes in rules for **SF9** in **REACTION** – to permit using of **CALC**.

In **COMMENT** or in the line with **REACTION** we can write the additional information about given spectrum: codes and libraries used in calculations, components of the used neutron filter, etc.

To introduce new special entries for neutron spectrum allows:

1) To refrain from repetition of neutron spectrum information in Entries with data, obtained with the same neutron source spectrum.
In addition, it is necessary to note that neutron spectrum may be given as calculated one using different ENDF & codes, and as experimental values, so this information may contain very large quantity of data.

2) To facilitate data search of neutron source spectrum.
It may be found using Entries with V through link with EXFOR Service.
It is important for experimenters, evaluators, compilers.

To demonstrate an example of such V entries, let us consider subentry 32217003, where the filtered neutron spectrum was used in measurements of the averaged radiation cross section on Ta. There were two types of spectrum: calculated neutron spectrum and experimental one, obtained by differentiation of the instrumental proton recoil spectrum. We can use one entry V0102 for this filtered neutron spectrum. In subentry V0102001, as usual, we describe general information using keywords TITLE, AUTHOR, INSTITUTE, ….

ENTRY	V0102	20110408				V0102	0 1
SUBENT	V0102001	20110408				V0102	1 1
BIB	7	10				V0102	1 2
TITLE	Measurements of neutron capture cross-section for					V0102	1 3
	tantalum at the neutron filtered beams					V0102	1 4
AUTHOR	(O.Gritzay,V.Libman,A.V.Chyzh,V.F.Razbudey)					V0102	1 5
INSTITUTE	(4UKRIJD)					V0102	1 6
REFERENCE	(C,2008KYIV,,548,2008) Result on 59 keV was					V0102	1 7
	presented at the NPAE-Kyiv2008,ID# 86-95.					V0102	1 8
FACILITY	(REAC,4UKRIJD) Reactor WWR-M					V0102	1 9
INC-SOURCE	(REAC) Neutron filters installed in horizontal channel					V0102	1 10
	of the reactor.					V0102	1 11
HISTORY	(20110408) UKRNDC					V0102	1 12
ENDBIB	10	0				V0102	1 13
NOCOMMON	0	0				V0102	1 14
ENDSUBENT	13	0				V0102	199999

For calculated neutron spectrum we can use subentry V0102002, for experimental one it may be used the subentry V0102003. To note that this neutron spectrum was created from the reactor one at the reactor with U-235 fuels, I propose to write the fields SF1-SF7 in REACTION as **(92-U-FUL?(0,X)0-NN-1,,DE,N**.

SUBENT	V0102002	20110408				V0102	2 1
BIB	2	8				V0102	2 2
REACTION	(92-U-235(0,X)0-NN-1,,DE,N,REL,CALC) Using JENDL-3.3					V0102	2 3
					and CENDL-2	V0102	2 4
COMMENT	Calculation was done by FILTER.5 using JENDL-3.3 for					V0102	2 5
	Ni-58(83.15 g/cm2),V(24.44 g/cm2),Al(5.4 g/cm2),					V0102	2 6
	B-10(0.5 g/cm2), and using CENDL-2 for S(147.78 g/cm2)					V0102	2 7
	Calculated energy line is 58.9 keV, purity about 99%.					V0102	2 8
	The limits of 95% response function for the 59 keV					V0102	2 9
	filter spectrum were defined as 52.2 to 60.1 keV.					V0102	2 10
ENDBIB	8	0				V0102	2 11
NOCOMMON	0	0				V0102	2 12
DATA	2	1543				V0102	2 13
E	DATA					V0102	2 14
EV	ARB-UNITS					V0102	2 15
50000.15	7.05730E-11					V0102	2 16
50019.84	7.85371E-11					V0102	2 17
50039.52	8.42285E-11					V0102	2 18
50040.20	9.14716E-11					V0102	2 19
50059.21	9.89061E-11					V0102	2 20
63945.89	6.82944E-26					V0102	2 1557
64018.24	7.01394E-26					V0102	2 1558
ENDDATA	1545	0				V0102	2 1559
ENDSUBENT	1558	0				V0102	299999
SUBENT	V0102003	20110408				V0102	3 1
BIB	2	6				V0102	3 2
REACTION	(92-U-235(0,X)0-NN-1,,DE,N,REL,EXP)					V0102	3 3
COMMENT	Ni-58(83.15 g/cm2),V(24.44 g/cm2),Al(5.4 g/cm2),					V0102	3 4
	B-10(0.5 g/cm2), and S(147.78 g/cm2) were used as					V0102	3 5
	filter components.					V0102	3 6
	Experimental shape was obtained by differentiation of					V0102	3 7
	the instrumental proton recoil spectrum LND-281.					V0102	3 8
ENDBIB	6	0				V0102	3 9
NOCOMMON	0	0				V0102	3 10
DATA	3	431				V0102	3 11
E	DATA	DATA-ERR				V0102	3 12
EV	ARB-UNITS	ARB-UNITS				V0102	3 13
48755.56	0.000	0.000				V0102	3 14
48793.33	0.487	0.008				V0102	3 15
48831.11	0.698	0.013				V0102	3 16
48868.89	0.720	0.013				V0102	3 17

…

63945.89	6.82944E-26						V0102	2	1557
64018.24	7.01394E-26						V0102	2	1558
ENDDATA	1545	0					V0102	2	1559
ENDSUBENT	1558	0					V0102	299999	
SUBENT	V0102003	20110408					V0102	3	1
BIB	2	6					V0102	3	2
REACTION	(92-U-235(0,X)0-NN-1,,DE,N,REL,EXP)						V0102	3	3
COMMENT	Ni-58(83.15 g/cm2),V(24.44 g/cm2),Al(5.4 g/cm2),						V0102	3	4
	B-10(0.5 g/cm2), and S(147.78 g/cm2) were used as						V0102	3	5
	filter components.						V0102	3	6
	Experimental shape was obtained by differentiation of						V0102	3	7
	the instrumental proton recoil spectrum LND-281.						V0102	3	8
ENDBIB	6	0					V0102	3	9
NOCOMMON	0	0					V0102	3	10
DATA	3	431					V0102	3	11
E	DATA	DATA-ERR					V0102	3	12
EV	ARB-UNITS	ARB-UNITS					V0102	3	13
48755.56	0.000	0.000					V0102	3	14
48793.33	0.487	0.008					V0102	3	15
48831.11	0.698	0.013					V0102	3	16
48868.89	0.720	0.013					V0102	3	17

...

64924.44	0.014	0.003					V0102	3	442
64962.22	0.002	0.000					V0102	3	443
65000.00	0.001	0.000					V0102	3	444
ENDDATA	433	0					V0102	3	445
ENDSUBENT	444	0					V0102	399999	
ENDENTRY	3	0					V0102	99999999	

In COMMENT or in the line with REACTION we can write the additional information about given spectrum: libraries used in calculations, components of the used neutron filter, etc.

To give information about the used neutron spectrum in the subentry 32217003 with the measured average cross section data we can use the keyword **STATUS** with (**COREL**,V0102002) and (**COREL**,V0102003).

SUBENT	32217003	20110318	20110323	20110323	3148	32217	3	1
BIB	5	25				32217	3	2
REACTION	(73-TA-181(N,G)73-TA-182,,SIG,,AV)					32217	3	3
DECAY-DATA	(73-TA-182,114.74D)					32217	3	4
STATUS	(COREL,V0102002) Calculated neutron spectrum					32217	3	5
	(COREL,V0102003) Experimental neutron spectrum					32217	3	6