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Proposal from J-Ch Sublet, A Koning, R A Forrest and J Kopecky

Objective

To provide a format frame for high energy activation files. In activation files, used for activation-transmutation, it is necessary to completely specify the reaction mechanism in particular for the emitted particles and the residual. The number of open channels increases with energy as the number of combinations of the emitted particles increases. However, the MT's description has many advantages and proven performance and reliability when carrying out activation-transmutation calculation.

Current status

Reaction types (MT) are identified by an integer number from 1 through 999 with the addition of the (LR) flag to describe simple, complex or breakup reactions and decay modes of the residual nucleus. Appendix B of ENDF-102 Formats and Procedures defines the assigned reaction types. Traditionally, 38 MT's have been defined from number 2 to 117 that have been judged to be important for fission reactor type transport calculations below 20 MeV. MT numbers 152 to 200 are unassigned.

Proposal

Calculation with nuclear reaction model code, such as TALYS, indicate that the addition of 50 more defined MT numbers would make any reaction description complete (+/- 10 mb) up to an incident energy of 60 MeV, for all foreseeable light and heavy target nuclides. Some of those MT numbers are by no mean more exotic than some already defined. As an example, the (n,dα) (official ENDF format: MT-117) has been judged as deserving its own MT number, there should be no reason to stop there. A huge advantage of the MT description is that it allows full covariance information to be given in the file (MF-33).

While, the importance of extending MT numbers does not only play a role in activation files representation, it also could impact transport files. Also, quite importantly, direct comparison with the experimental data base EXFOR in the higher energy range can be achieved. Excitation function shape and cross sections systematic, statistical analysis can also be accounted for during validation and verification processes. Important applications include: fission reactors cycle and shielding, accelerator shielding, waste management, fusion studies, isotopes production, irradiation facility, etc.

It is proposed to assign those additional 50 MT's, given in bold in Table 1, filling up the unassigned 152 to 200 range. It allows to keep up with actual activation file format as used in European Activation File EAF series and described below:

MF	Description
1	General information, comments
2	Resonance parameter, scattering radius
3	Total reaction channels
8	Flag, file pointer, dictionary
9	Isomeric branching ratio, for non threshold reaction
10	Split threshold reaction channels
33	Covariance of neutron cross sections
40	Covariance for production of radioactive nuclei

Currently, the FISPACT activation code makes full use of all those features (including the variance) and is probably the only code that is able to use large scale high energy neutron, proton or deuteron and soon gamma induced activation data. Once the upper energy limit of 60 MeV is reached it is proposed that one takes advantage of giving a "spallation" like, total reaction cross section in MF-3 using the MT-5 accompanied with the gas and nuclides activation yields stored in MF-6 adding the following MF:

MF	Description
6	Activation yields for MT-5
39	Covariance for radionuclides production yields

Here we purposely frame the formats to provide all the necessary data needed not only at the ENDF level but also during the activation data file processing, verification and validation processes.

Table 1 Reaction types in EAF-2007.

Reaction Type	**MT number**
(n,n′)	4
(n,2nd)	11
(n,2n)	16
(n,3n)	17
(n,f)	18
(n,n′α)	22
(n,n´3α)	23
(n,2nα)	24
(n,3nα)	25
(n,n′p)	28
(n,n′2α)	29
(n,2n2α)	30
(n,n′d)	32
(n,n′t)	33
(n,n′h)	34
(n,n´d2α)	35
(n,n´t2α)	36
(n,4n)	37
(n,2np)	41
(n,3np)	42
(n,n´2p)	44
(n,n´pα)	45
(n,γ)	102
(n,p)	103
(n,d)	104
(n,t)	105
(n,h)	106
(n,α)	107
(n,2α)	108
(n,3α)	109
(n,2p)	111
(n,pα)	112
(n,t2α)	113
(n,d2α)	114
(n,pd)	115
(n,pt)	116
(n,dα)	117
(n,5n)	**152**
(n,6n)	**153**
(n,2nt)	**154**
(n,tα)	**155**
(n,4np)	**156**

(n,3nd)	**157**
(n,n´dα)	**158**
(n,2npα)	**159**
(n,7n)	**160**
(n,8n)	**161**
(n,5np)	**162**
(n,6np)	**163**
(n,7np)	**164**
(n,4nα)	**165**
(n,5nα)	**166**
(n,6nα)	**167**
(n,7nα)	**168**
(n,4nd)	**169**
(n,5nd)	**170**
(n,6nd)	**171**
(n,3nt)	**172**
(n,4nt)	**173**
(n,5nt)	**174**
(n,6nt)	**175**
(n,2nh)	**176**
(n,3nh)	**177**
(n,4nh)	**178**
(n,3n2p)	**179**
(n,3n2α)	**180**
(n,3npα)	**181**
(n,dt)	**182**
(n,n´pd)	**183**
(n,n´pt)	**184**
(n,n´dt)	**185**
(n,n´ph)	**186**
(n,n´dh)	**187**
(n,n´th)	**188**
(n,n´tα)	**189**
(n,2n2p)	**190**
(n,ph)	**191**
(n,dh)	**192**
(n,hα)	**193**
(n,4n2p)	**194**
(n,4n2α)	**195**
(n,4npα)	**196**
(n,3p)	**197**
(n,n´3p)	**198**
(n,3n2pα)	**199**
(n,5n2p)	**200**