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TRANSFORMATION OF THE MENDL-2 AND WIND TRANSMUTATION LIBRARIES TO THE ENDF6-FORMAT

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1 Introduction

The present paper deals with the transformation to the ENDF6-format of two important high-energy activation libraries that were created at IPPE/INPE Obninsk, Russia. The Medium Energy Nuclear Data Library, MENDL [1], contains residual production cross sections for neutrons with energies up to 100 MeV incident on stable and unstable nuclei. In total, 57,000 threshold reactions are included for elements ranging from Aluminium to Polonium. The Waste Incineration Nuclear Data library, WIND [2], contains fission and residual production cross sections for neutrons up to 100 MeV for Uranium, Neptunium and Plutonium isotopes. Both libraries are important for activation studies on Accelerator-Driven Systems. They serve as a good starting point for extension of the present activation libraries to higher energies, as requested by the applied community.

A drawback of the MENDL and WIND libraries, in their original format, is that they are not represented in the commonly used ENDF6-format. An alternative method to store the residual production cross sections has been used which entails a huge extension of the ENDF6-format (see Appendix). It is not probable that the connection of the data, in this anomalous format, with applied calculations will be achieved with a processing code like NJOY. Nevertheless, the importance of these data calls for a transformation to a representation in which they can be applied.

A code has been written to transform the MENDL and WIND libraries to the ENDF6-format. The ENDF6-representation of the data is as proposed in a NEA report [3]. Next, the transformed libraries have been checked with the ENDF6 preprocessing tools CHECKR, FIZCON and PSYCHE [4]. In the process of transformation and ENDF6-checking, several errors have been corrected.

2 Data transformation

2.1 The original MENDL and WIND libraries

In the Appendix, parts of the original MENDL-file for one nucleus (^{56}Fe) are given. Detailed reaction paths, such as $(n, 2n)$, $(n, 3n)$, etc., as specified in the ENDF6-format, have been retained as much as possible. For production of other nuclides, vacant MT-numbers have been used to store the residual production cross section. At the same time, reaction paths are lumped to obtain the same residual nucleus.

2.2 The new file

In the new file, see Appendix, all information is stored in MT5 of MF3 and MF6. We have constructed a total reaction cross section σ_{reaction} by adding all partial residual production cross sections of the original MENDL evaluation and have stored the results in MF3/MT5. The yields $Y(Z, A)$ of each produced residual nucleus are given in MF6/MT5. These can be multiplied with MF3/MT5 to obtain the (original) residual production cross sections $\sigma(Z, A)$:

$$\sigma(Z, A) = Y(Z, A) * \sigma_{\text{reaction}} \tag{1}$$

For the actinides in the WIND library, the method is the same. The only extra addition is MF3/MT18, where the fission cross sections are stored. With regard to the physics in the MENDL and WIND libraries, we stress again that we have created reaction cross sections by adding all partial cross sections, i.e. they are not originating from an independent source.

3 Conclusion

The MENDL and WIND libraries have been transformed to ENDF6-format and have been checked with ENDF6 utility codes. With this transformation, no information is lost. The new libraries are available, together with documentation on the transformation and the resolved errors, at the NEA Data Bank [5]. The size is 52.3 Mb (MENDL) and 0.8 Mb (WIND), respectively. A possible next step is to combine these data with low-energy (i.e. < 20 MeV) activation libraries such as ECNAF [6]. This would require a transformation from the data of ECNAF to the format as described in this paper, using MF6 for isomeric branching.

References

[1] Yu.N. Shubin *et al.*, IAEA report, INDC(CCP)-385, May 1995.
[2] A. Yu. Konobeyev *et al.*, IAEA report, INDC(CCP)-384, July 1995.
[3] A.J. Koning, NEA-report NEA/NSC/DOC(93) 6, 1993.
[4] C. Dunford, ENDF Utility Codes Release 6.10, IAEA-NDS-29, November 1995.
[5] NEA Data Bank homepage: *http://www.nea.fr/dbforms/evatapes.cgi*
[6] D.W. Muir and A.J. Koning, *Sec. Int. Conf. ADTT*, Kalmar, June 3-7 1996.

Appendix: Original vs. ENDF6 libraries

Original MENDL file for ^{56}Fe

Part of the directory (taken from the comments section):

```
 MT =219 (N,3P)           CROSS-SECTION  (  V 54 PRODUCTION )  2656 1451
 MT =220 (N,N3P)+(N,2PD)  CROSS-SECTION  (  V 53 PRODUCTION )  2656 1451
 MT =221 (N,2N3P)+(N,X)   CROSS-SECTION  (  V 52 PRODUCTION )  2656 1451
```

Part of the MT-section for ^{53}V-production:

```
 2.6056E+04 5.6000E+01          0          0          0           02656 3220
-2.8400E+07-2.8400E+07          0          0          1          412656 3220
        41          2                                              2656 3220
 2.8907E+07 0.0000E+00 3.5000E+07 5.8300E-17 3.6000E+07 2.9500E-132656 3220
 3.7000E+07 9.2500E-12 3.8000E+07 1.4800E-10 3.9000E+07 7.4800E-102656 3220
 4.0000E+07 5.6900E-09 4.1000E+07 2.7300E-08 4.2000E+07 1.1600E-072656 3220
```

ENDF6 MENDL file for ^{56}Fe transformed to ENDF6

Total directory (3 lines only):

```
                                1         451          70          12656 1451
                                3           5          34          12656 1451
                                6           5        1032          12656 1451
```

Part of MF3/MT5-section for total reaction cross section (as created from MENDL):

```
 2.605600+4 5.600000+1          0          0          0           02656 3  5
 0.000000+0 0.000000+0          0          0          1          912656 3  5
         91          2                                              2656 3  5
 1.000000-5 0.000000+0 5.000000+5 0.000000+0 1.000000+6 0.000000+02656 3  5
 1.500000+6 0.000000+0 2.000000+6 0.000000+0 2.500000+6 0.000000+02656 3  5
 3.000000+6 2.081081-7 3.500000+6 3.181081-6 4.000000+6 6.154054-62656 3  5
 4.500000+6 3.488703-5 5.000000+6 8.714000-5 5.500000+6 1.088200-32656 3  5
                  ......
 3.300000+7 1.162613+0 3.400000+7 1.153188+0 3.500000+7 1.163068+02656 3  5
 3.600000+7 1.148448+0 3.700000+7 1.137674+0 3.800000+7 1.128077+02656 3  5
```

Part of MF6/MT5-section for ^{53}V-production:

```
 2.305300+4 5.300000+1          0          0          1          422656 6  5
         42          2                                              2656 6  5
 1.000000-5 0.000000+0 2.890700+7 0.000000+0 3.500000+7 5.01260-172656 6  5
 3.600000+7 2.56868-13 3.700000+7 8.13062-12 3.800000+7 1.31196-102656 6  5
 3.900000+7 6.68393-10 4.000000+7 5.122233-9 4.100000+7 2.458432-82656 6  5
 4.200000+7 1.052336-7 4.300000+7 3.554592-7 4.400000+7 9.478331-72656 6  5
```