
ARTICLE

Verification of the ABBN-RF2010 constants in calculations of shielding benchmarks

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Currently the library of 299-group constants ABBN-RF2010 is presented in two formats ABBN and MATXS. They are based on the nuclear data files ROSFOND2010, which were processed using NJOY code. The data of ROSFOND2010 are also presented in format ACE for MCNP code calculations. The present verification of the library ROSFOND2010 in critical calculations was practically completed. The test results of the library of nuclear data ROSFOND2010 in shielding benchmark calculations using international databases SINBAD and ICSBEP are presented in this work. They are lead and iron spheres of various radiuses with ^{242}Cf source in center of spheres from international handbook ICSBEP and benchmark experiments, such as Winfrith Graphite and JANUS Phase I from database SINBAD. Calculations were performed with codes KATRIN and TORT, using constants ABBN-RF2010 in both formats ABBN and MATXS. Preparation of constants for calculations was performed using CONSYST and TRANSX codes respectively. Comparison of calculation results with experimental data is given.

Keywords: *ROSFOND2010; ABBN-RF2010; CONSYST; TRANSX; MATXS; KATRIN; ICSBEP; SINBAD; nuclear data; continuous data; group data; benchmarks*

1. Introduction

The library ABBN-RF2010 is a new version of system of group constants, which recommended for engineering, researching and verification calculations. The previous version ABBN-93 [1] was based on the library of evaluated nuclear data FOND-2.2 and it has 28-group structure of neutron data and 15-group structure of photon data. For a few numbers of fuel nuclides and structure materials 299-group structure of neutron data and 127-group structure of photon data were used.

The new system of constants ABBN-RF is based on library of evaluated nuclear data ROSFOND [2]. This system has 299-group structure of neutron data and 127-group structure of photon data for all near 640 nuclides of library ROSFOND. It was modified due to verifications and a new system of constants ABBN-RF2010 is based on library of evaluated nuclear data ROSFOND2010.

Now the ABBN-RF2010 system has 2 formats to present microscopic data – the standard format ABBN for neutron and photon data and the format MATXS. Data from library ROSFOND2010 were processed using NJOY [3] code in formats ABBN and MATXS. Input files for NJOY for these formats were same with the exception of the number of sigma zero. The ABBN format has 26 dilution cross sections, and MATXS has 9.

Programs for obtaining macroscopic constants using data in formats ABBN and MATXS are very close. For preparing cross sections from ABBN format is traditionally used the RF CONSYST [4] code and from format MATXS the USA code TRANSX [5].

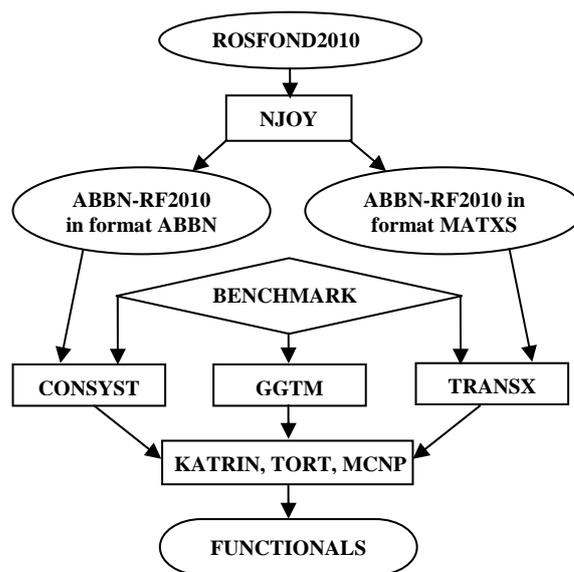


Figure 1. General scheme of calculations.

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At present verification of the library in calculations of critical assemblies practically completed, so we need to test our constants system in shield benchmark calculations.

Calculations conducted on two 3-dimension programs, used discrete ordinate Sn-method, KATRIN [6] and TORT [7]. Geometries for benchmarks were made using universal program GGTM from the BOT3P [8] system. This program can create geometry for various programs, such as TORT, THREEDANT [9], MCNP [10] and KATRIN too.

For testing benchmarks from ICSBEP Handbook [11] were chosen - iron and lead spheres of various radiuses with californium source in centre of spheres, and from data base SINBAD [12] - Winfrith Graphite Benchmark experiment and JANUS phase I (neutron transport through mild and stainless steel).

General scheme of calculations is present in Figure 1.

2. Description of experiments

2.1. Iron and lead spheres of various radiuses with californium source in centre

Benchmarks contains two stages:

1) Measurements of neutron spectra from ^{252}Cf source self and through the iron spheres, radiuses 10, 15, 20, 25, 30, 35 and 50 cm with ^{252}Cf source in center.

2) Measurements of neutron spectra through the lead spheres, radiuses 10, 20 and 30 cm with ^{252}Cf source in center.

More details for benchmarks you can find in ICSBEP Handbook Part 8 ALARM-CF-FE-SHIELD-001 and ALARM-CF-PB-SHIELD-001.

2.2. Winfrith Graphite Benchmark experiment

The purpose of this benchmark was a determination of the accuracy using methods for calculation of neutron part of heat. For this task were measurements reaction rates in graphite up to 70 cm. The following reaction rates were measured: Al27 (n, alpha) Na24, Rh103 (n, n') Rh103m, In115 (n, n') In115m, S32 (n, p) P32 in various layers of shield array: 0, 5, 10, 15, 20, 30, 40, 50, 60, 70 cm.

More details for the benchmark you can find in SINBAD Winfrith Graphite Benchmark (ASPIS).

2.3. JANUS phase I (neutron transport through mild and stainless steel)

The purpose of this benchmark was to test the prediction of neutron penetration through stainless steel when the incident spectrum was typical of that emerging from a fast reactor.

In the experiment the following reaction rates were measured: Mn55 (n, gamma) Mn56, Rh103 (n, n') Rh103m, Au197 (n, gamma) Au198/Cd, S32 (n, p) P32 in various layers of shield array. Also were measured spectra of neutron in B6, B10 and B14.

More details for the benchmark you can find in

SINBAD JANUS phase I (neutron transport through mild and stainless steel).

3. System of constant ABBN-RF2010 and calculation programs

Microscopic cross sections were processed by NJOY code in both formats ABBN and MATXS using the same input parameters with the exception of number of dilution cross-sections (sigma zero). All data files of the ROSFOND library were processed.

Macroscopic cross sections were prepared using codes CONSYST and TRANSX, and the calculated macroconstants were written in the format ANISN. Next, an ARVES code transferred data into format FMAC-M for calculations with the code KATRIN. The GIP code was used for preparation constants for calculations with the code TORT. These phases are not shown in the general scheme of calculations.

4. Results of calculations

In this work accuracy of the group approach in the shielding benchmarks was studied. Only neutron task was examined.

In section of 4.1 the results of calculations using group data with precise results of calculations from Monte Carlo method were compared.

In sections of 4.2 and 4.3 the results of calculations using group data with experimental data were compared.

In the paper for economy of place we present only one of full set of reaction rates for each experiment, although were obtained results on all reactions - results of calculation of reaction rate Rh103 (n, n') Rh103m.

4.1. Iron and lead spheres of various radiuses with californium source in centre

Results of calculations using MCNP code with continuous energy were chosen as a datum mark. Group calculations were conducted also using MCNP code.

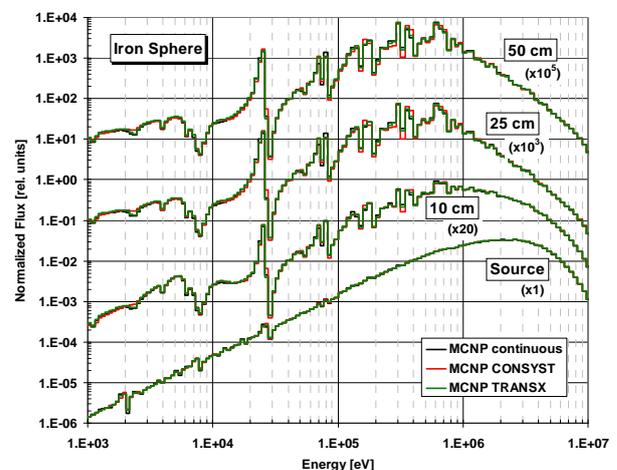


Figure 2. Neutron spectra through iron sphere, radiuses 10, 25 and 50 cm and from source self.

Calculations of the benchmark were conducted in two stages:

- 1) Calculations of neutron spectra from ^{252}Cf source self and through the iron spheres, radiuses 10, 15, 20, 25, 30, 35 and 50 cm with ^{252}Cf source in center (Figure 2).
- 2) Calculations of neutron spectra through the lead spheres, radiuses 10, 20 and 30 cm with ^{252}Cf source in center (Figure 3).

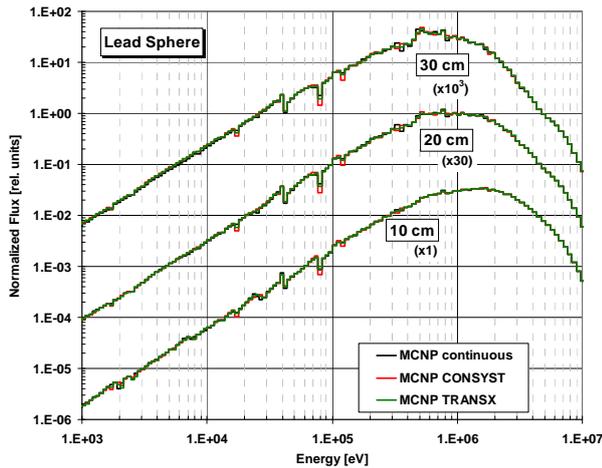


Figure 3. Neutron spectra through lead sphere, radiuses 10, 20 and 30 cm.

As we can see all results are close with each other.

4.2. Winfrith Graphite Benchmark experiment

Table 1 presents experimental results and results of calculation of reaction rate inelastic scattering of neutrons Rhodium in various layers of shielding facility. For this experiment results of calculations on KATRIN code were shown.

Table 1. Experimental data and results of calculation reaction rate Rh103 (n, n').

Graphite Distance [cm]	Experi-mental Data [s^{-1}]	Calculation (KATRIN) [s^{-1}]	
		ABBN	MATXS
0	3.48E-17	3.055E-17	3.638E-17
5	1.76E-17	1.517E-17	1.907E-17
10	9.80E-18	8.452E-18	1.102E-17
15	5.43E-18	4.796E-18	6.418E-18
20	3.05E-18	2.738E-18	3.740E-18
30	9.82E-19	9.026E-19	1.265E-18
40	3.30E-19	2.981E-19	4.233E-19
50	1.18E-19	1.049E-19	1.476E-19
60	4.41E-20	3.814E-20	5.257E-20
70	1.95E-20	1.435E-20	1.929E-20

4.3. JANUS phase I (neutron transport through mild and stainless steel)

Table 2 presents experimental results and results of calculation of reaction rate inelastic scattering of neutrons Rhodium in various layers of shielding facility. For this experiment results of calculations on TORT code were shown.

Table 2. Experimental data and results of calculation reaction rate Rh103 (n, n') Rh103m.

Measu-ment Position	Experi-mental Data [s^{-1}]	Calculation (TORT) [s^{-1}]	
		ABBN	MATXS
B2	1.97E-17	1.768E-17	2.072E-17
B3	8.23E-18	7.489E-18	8.858E-18
B4	4.64E-18	4.249E-18	4.848E-18
B5	2.78E-18	2.614E-18	2.762E-18
B6	2.28E-18	2.132E-18	2.132E-18
B7	1.42E-18	1.364E-18	1.309E-18
B8	9.35E-19	8.758E-19	8.018E-19
B9	6.03E-19	5.667E-19	4.890E-19
B10	3.90E-19	3.693E-19	2.984E-19
B11	2.53E-19	2.415E-19	1.819E-19
B12	1.62E-19	1.579E-19	1.106E-19
B13	1.03E-19	1.028E-19	6.712E-20
B14	6.65E-20	6.600E-20	4.050E-20
B15	4.28E-20	4.014E-20	2.420E-20
B16	2.85E-20	2.784E-20	1.418E-20
B17	1.89E-20	1.998E-20	8.521E-21

As we can see from **Table 1** and **Table 2** experimental data and calculation data are close.

5. Conclusion

Paper contains results of calculations spheres from iron and lead obtained with use constants in continuous energy and group structure. All results are close with each other. The obtained data showed closeness results of calculations of group constants and continuous energy constants.

In this work preliminary results of calculations 3-D benchmarks with codes KATRIN and TORT using ABBN-RF2010 group data library are presented. The obtained data showed closeness results of calculations of group constants and experimental data.

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