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EXPERIMENTAL POSSIBILITIES AND FAST NEUTRON DOSE MAP OF THE FAST NEUTRON FIELDS AT THE RB REACTOR FACILITY

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Introduction

The RB is an unshielded, zero power nuclear facility with natural and enriched uranium fuel (2% and 80%) and D_2O as moderator [1]. It is possible to create different configurations of nonreflected and partially reflected critical systems and to make experiments in the fields of thermal neutrons. The fields of fast neutrons with "softened" fission spectrum are made by modifying the system: modified experimental fuel channel EFC [2], coupled fast-thermal system in two configurations CFTS-1 and CFTS-2 [3], coupled fast-thermal core HERBE [1]. The intermediate and fast neutron absorbed doses in fast neutron fields are given in this paper.

In first configuration of RB reactor it was almost impossible to perform dosimetric and other experiments. By creating these fields, with in our circumstances available fuel elements, the possibilities for different experiments are greatly improved. Now we can irradiate food samples, soil samples, electronic devices, study material properties, perform various dosimetry experiments, etc.

Fast neutron fields

The EFC is realised by modification of the 80% enriched UO_2 RB reactor fuel elements. EFC is formed inside of the standard RB reactor fuel channel (an aluminium tube 41/43 mm diameter and bottom hermetically sealed) from 10 modified 80% enriched UO_2 fuel segments. During fuel segment modification, central aluminium caliber with outermost "stars" are taken off and the rest of fuel segments is slipped on an aluminium tube 27/28 mm diameter, one after another, as closely as possible. All this arrangement is placed inside the standard fuel channel. Movable aluminium tube is placed inside the EFC experimental space (25/27 mm diameter) filled with aluminium expellers and sample supporters. Thus, the samples or detectors can be easily placed in the reactor or taken out. The EFC is placed in the RB specially designed reactor core with high epithermal neutron flux.

The fast core of coupled fast-thermal system in first configuration CFTS-1 is formed of 80% enriched UO_2 fuel and the natural metal uranium fuel elements forming a blanket. The central area of the fast core is cylindrical experimental space with a diameter from 20 cm to 30 cm and a height of up to 120 cm. The thermal RB core (driver) is formed in a standard RB lattice pitch of 12 cm from 2% enriched metal U fuel elements and 80 % enriched UO_2 fuel elements in the D_2O moderator. In CFTS-2 this 80% UO_2 enriched fast zone is removed and experimental zone is larger. For that reason, neutron spectrum in CFTS-2 is shifted to lower energies in comparing to CFTS-1.

The requirements for minimum modifications in the RB construction and application of available fuel restricted design flexibility of the coupled system HERBE: the central fast core of natural uranium is surrounded by neutron filter zone (cadmium and natural uranium) and convertor zone (enriched uranium fuel, without moderator). The coupling region is heavy water. Thermal core is formed of RB heavy water 80% enriched uranium lattice with 12 cm pitch.

Intermediate and fast neutron spectrum measurements and calculations

The intermediate and fast neutron spectrum are measured by activation technique [5] specially developed for our fast neutron fields. The method of resonance detectors for absolute values of intermediate and threshold detectors for absolute values of fast spectrum are used for these measurements.

The activation method has a few advantages compared with others, especially in the region below 10 keV. They are: simple construction, small dimension, radiation and temperature resistance and good spatial resolution.

The foils are irradiated in predetermined positions in the fast fields. The absolute value of neutron flux is obtained with Au foils. Foil activities are measured by using gamma scintillation technique with specially designed γmeasuring lines and 4πβ absolute counting method, also developed in our Laboratory. The measuring results were evaluated by ACT code based on analytical relations accounting all necessary physical and geometrical corrections which returns foil saturated activity and neutron flux density. These experimental results are used for spectra calculations.

Intermediate spectrum is obtained by KRIFIT code, based on the minimum mean square method using modified Gauss-Newton treatment. The fast spectrum is calculated by HEFEST code basec *on the method of maximal probability.al results*. The neutron spectrum in the center of vertical experimental channel in HERBE fast core is calculated by AVERY code in 25 energy groups. This program calculates the kinetic parameters of coupled core systems using the model of Avery.

Intermediate and fast neutron absorbed doses

Neutron spectra in the air holes of fast neutron fields are calculated with VESNA code in 44 energy groups and condensed to 25 groups. The spectra are normalized using the mentioned absolute spectrum measurements. These spectra are converted in neutron absorbed dose rates by ADOS code based on analytical relations using absorbed dose - neutron flux density conversion factors. The neutron absorbed dose rates are condensed in 4 energy macrogroups. The obtained results with appropriate errors are given in Table 1.

Conclusion

The described fast neutron fields are the first step in realising the first fast experimental neutron reactor in our country. The presented metodology give an opportunity of absolute calibration of these fields.

According to the obtained results of neutron absorbed dose rates in the range between 0.250 ± 0.001 and 0.450 ± 0.001 Gy/(W*h) we can conclude that it is possible to use these fields for different dosimetrical purposes, irradiation and material studies. The samples can have diameter up to 30 cm and cannot be longer than 120cm. There is only one limitation: the realised flux values cannot be larger then 10^{10} n/cm^2.

Energy group	Absorbed neutron dose (Gy/h for 1 W)			
	EFC	CFTS-1	CFTS-2	HERBE
0.80MeV-10.5MeV	0.320 ±0.001	0.151 ±0.001	0.129 ±0.001	0.067 ±0.001
4.65keV-0.8MeV	0.196 ±0.001	0.135 ±0.001	0.112 ±0.001	0.169 ±0.001
0.465eV-4.65keV	0.030 ±0.001	0.025 ±0.001	0.023 ±0.001	0.012 ±0.001
1meV-0.465eV	0.003 ±0.001	0.005 ±0.001	0.006 ±0.001	0.005 ±0.001
1meV-10.5MeV	0.449 ±0.001	0.316 ±0.001	0.270 ±0.001	0.253 ±0.001

Table 1. The absorbed neutron doses in fast neutron fields

References

1. Popović, D. *A Bare Critical Assembly of Natural and Heavy Water*. Vol.12. Proceedings of Second UN International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958.
2. Pešić, M. Marković, H. Šokčić-Kostić, M. Mirić, I. Prokić, P. Strugar, P. *Experimental Fuel Channel for Samples Irradiation at the RB Reactor*. Kernenergie 27 461-464 (1984).
3. Pešić, M. *Coupled Fast-Thermal System at the RB Nuclear Reactor*. Kernenergie 30 142-149 (1987).
4. Pešić, M. Zavaljevski, N. Milošević, M. Stefanović, D. Popović, D. Nikolić, D. Marinković, P. Avdić, S. *A Study on Criticality of Coupled Fast-Thermal Core HERBE at the RB Reactor*. Ann. nuc. 18(7) 413-420 (1991).
5. Šokčić-Kostić, M. *Determining of the Thermal, Intermediate and Fast Neutron Spectrum by Activation Method*. M.Sc.Thesis, University of Belgrade, Faculty of Electrical Egineering, 1990.