^{3}He – DETECTOR ANALYSIS OF SOME SPECIAL SHIELDING MATERIALS

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ABSTRACT: The shielding properties of commertialy material of Reactor Experiments, Inc. (R/X) were analyzed at the facility which includes bare heavy water experimental reactor RP with external neutron converter– ENC. The fast neutron spectrum measurements in energy range from 1 MeV to 10 MeV was performed using ORTEC semiconductor neutron detector with ^{3}He in diode coincidence arrangement. The neutron spectra have been evaluated from measured pulse–height distribution using numerical code HE3 for computation of detector efficiency in a collimated neutron beam. The neutron dose rates behind ENC with and without sample of R/X material were determined using cubic spline interpolation routine for calculating the corresponding flux–dose rate conversion factors. Satisfactory shielding properties of the examined material in a fast neutron field in measurements and calculations are demonstrated.

INTRODUCTION

The applied measuring technique and computer codes developed for evaluation of neutron spectra and performed shielding calculations are part of previously initiated investigation in neutron spectroscopy and dosimetry at the RB reactor [1]. Using the methods developed for measurement data evaluation, the results which can be applied in radiation protection were obtained. The Reactor Experiments catalogue [2] specifies "good" shielding properties in a fast neutron field for the examined material. In order to check the declared specification, the series of spectroscopy measurements were performed at the facility which includes the RB reactor with external neutron converter–ENC [3]. The ENC transforms the RB thermal neutron leakage flux into a fast neutron flux.

EXPERIMENTS AND CALCULATIONS

Measurements of fast neutron spectra were performed with the equipment placed on a platform behind the ENC at the RB reactor (Fig. 1). The external aluminium plate of the ENC is covered with cadmium sheet to eliminate thermal neutrons in the converted spectrum. Behind the converter was placed a collimator made from borated paraffin. The fast neutron spectra in energy rang from 1 MeV up to 10 MeV were

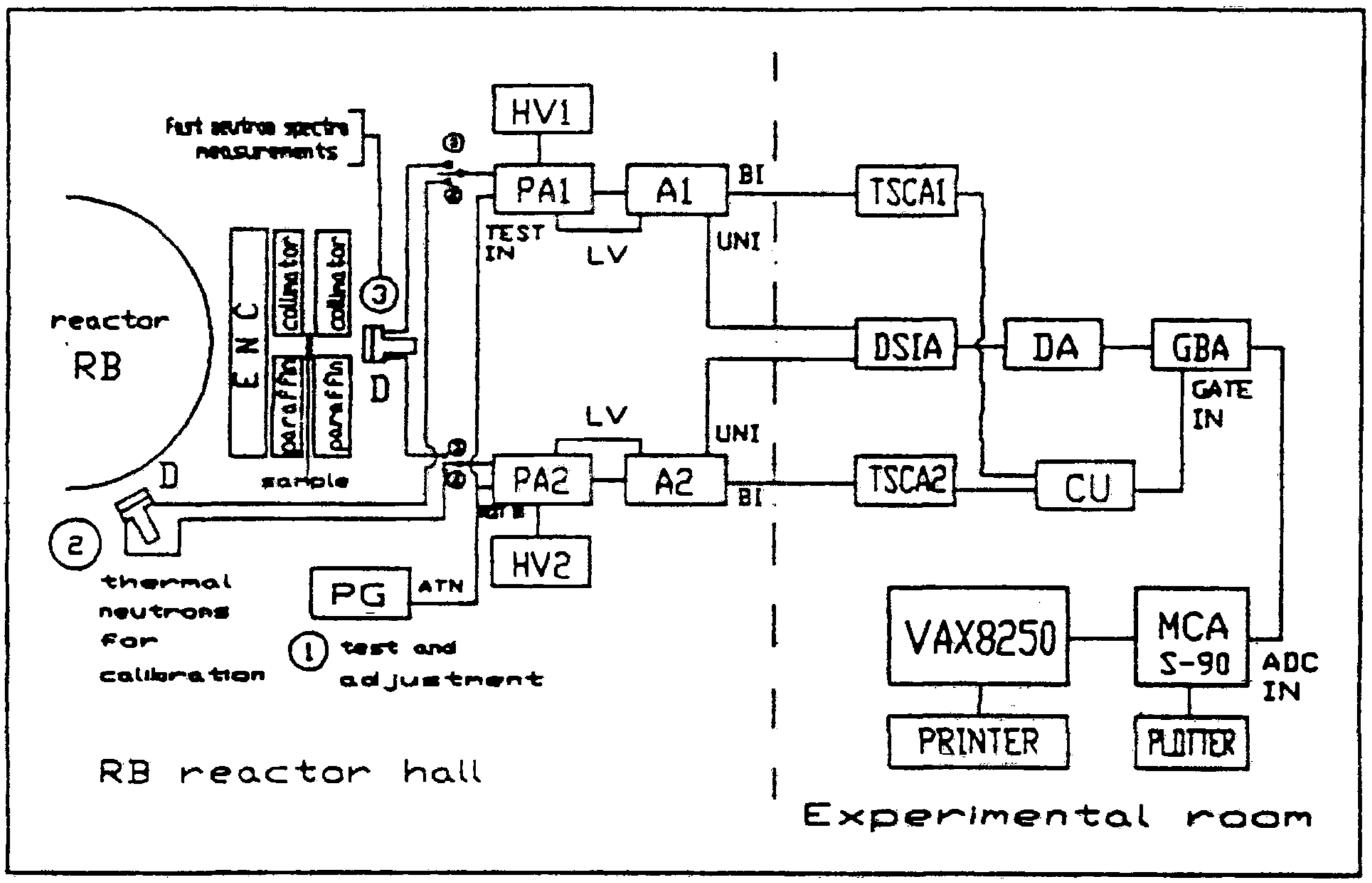

Figure 1. Measuring equipment for fast neutron spectra determination with ^3He detector

Legend:

D - Detector
PA - PreAmplifier
A - Amplifier
HV - High Voltage
TSCA - Timing Single Channel Analyzer
DA - Delay Amplifier
CU - Coincidence Unit
GBA - Biased Amplifier
DSIA - Dual Sum-Invert Amplifier
MCA - Multi Channel Analyzer
PG - Pulse Generator

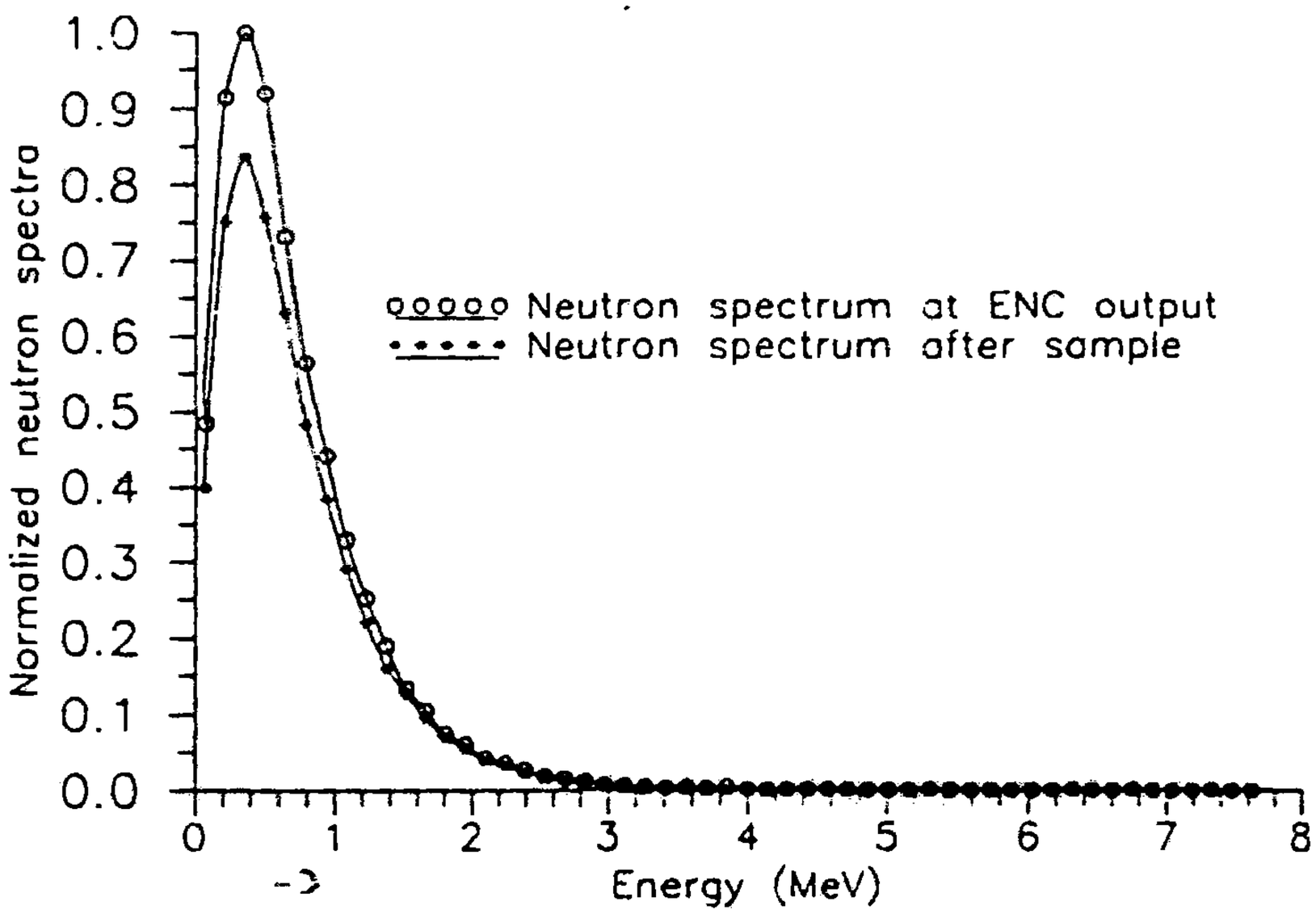

Figure 2. Normalized neutron spectrum at ENC output and attenuated by the R/X sample

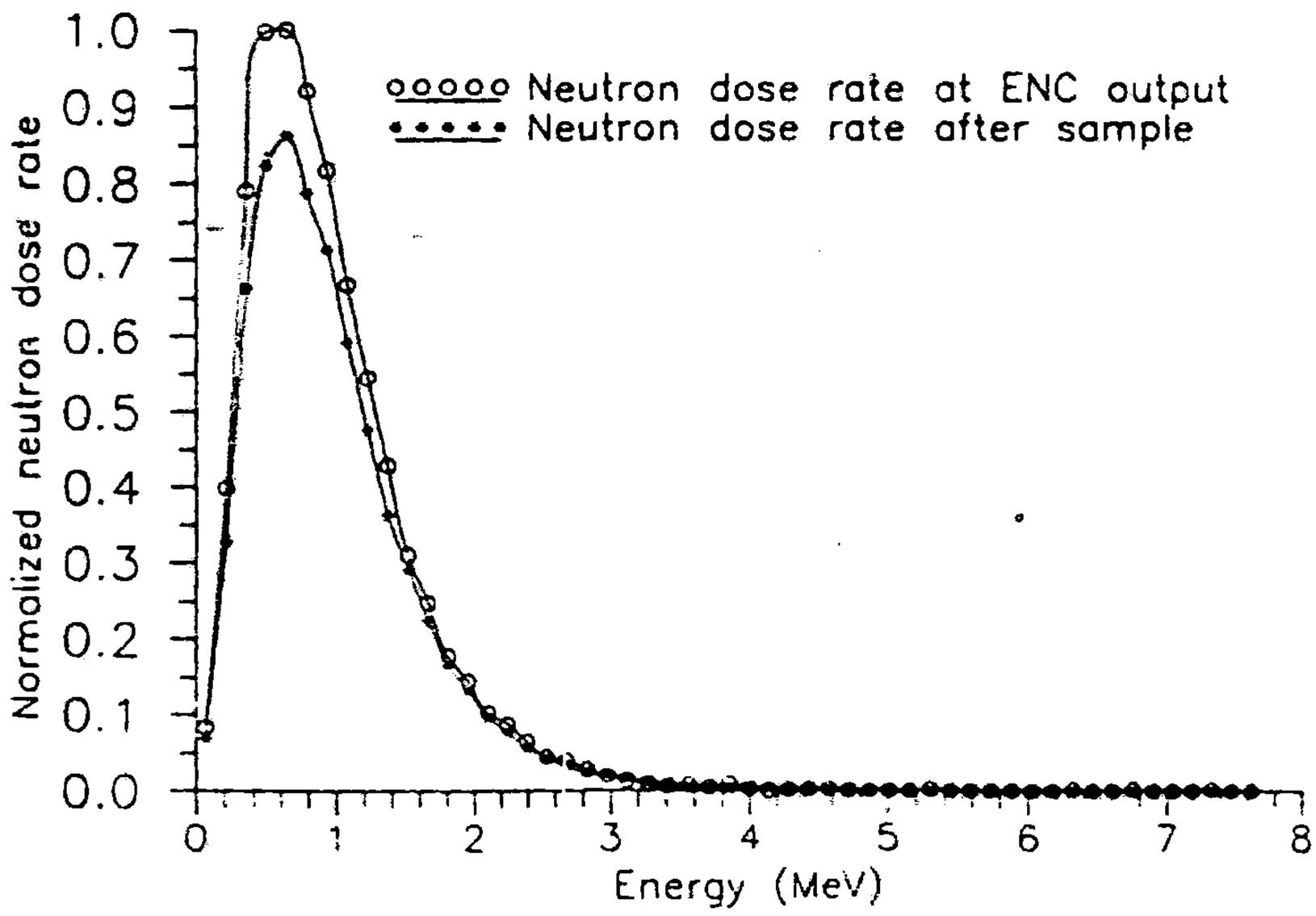

Figure 3. Normalized neutron dose rate at ENC output and attenuated by the R/X sample

measured by ORTEC semiconductor neutron detector with ^{3}He in diode coincidence arrangement. Calibration of ^{3}He spectrometer was carried out in a thermal neutron field at the RB reactor. The energy resolution and efficiency are determined at gas pressure from 0.5 MPa. The pulses due to gamma radiation, ^{3}He recoil nuclei from neutron elastics scattering, and coincidence background response from reactions occurring in the silicon of the diodes are greatly reduced using the coincidence unit with the short resolving time. A separate gas system with ^{3}He for the detector head filling is developed for the improved background measurement method.

Efficiency of the spectrometer was determined taking into account neutron transport and geometrical characteristic of the detector. The detector head is placed normally at the collimated neutron beam. Corrections of experimental data for efficiency of the spectrometer are performed by developed numerical code HE3 [4]. The neutron cross sections used for ^{3}He (n,p) reaction are from ENDF/B–IV library [5]. Calculations of energy dependent efficiency of spectrometer was carried out taking into account actual dimensions of the spectrometer head and angular anisotropy of ^{3}He (n,p) T reaction, neglecting multiple scattering of neutrons in active volume of the detector (cylindrical form, radius 3.6 mm, height 1 mm). Evaluation is based on the Monte Carlo simulations of processes in detector. Corrections for the energy discrimination level setting and the ranges of the p and T particles according to gas pressure and temperature are included in the HE3 numerical code. A pulse subtraction originated from (n.d) reaction from pulses originated from foreground spectrum is included in spectrum evaluation [6]. The normalized neutron spectra with and without the sample of R/X277 material (25 mm thick) behind the ENC are shown in Fig. 2. These neutron spectra are used for fast neutron's attenuations factor determination in the sample. For a given neutron energy group structure. the corresponding flux–dose rate conversion factors are calculated using cubic spline interpolation routine of the IMSL library [7]. The interpolation has been performed in log–log scale of the point wise recommended conversion factors data [8]. Obtained results are presented in Fig. 3.

CONCLUSION

With the developed methods for measurements and calculations, it is possible to determine attenuation factors of other shielding characteristics of sample material which have been calculated of predicted only by theory. It should be useful in studying the actual spectrum changes over an entire spectral range.

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