

## Recent Activities in Neutron Metrology at the Czech Metrology Institute (CMI)

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The activities of the Neutron Metrology Group at CMI can be divided into five topic areas:

1. Absolute measurement of neutron emission from radionuclide neutron sources.
2. Radionuclide source based fluence standards.
3. Low resolution neutron spectrometry for neutron dosimetry.
4. Neutron transport calculations.
5. Comparisons and demonstrations of equivalence.

### **1. Absolute measurement of neutron emission from radionuclide neutron sources.**

The manganese bath installed at CMI is used as a primary standard for absolute measurement of neutron emission from radionuclide sources. The aqueous solution of manganese sulphate does not circulate during activation, so the device is very simple. Since 1993 the calculation of individual corrections, required for relating the measured count rate to the absolute neutron emission, has been replaced by the Monte Carlo calculation of neutron capture by manganese nuclei. The efficiency of the NaI(Tl) detector, which is used for the determination of activity of  $^{56}\text{Mn}$  in the bath, was regularly checked except last year, when the irradiation service on the research reactor was spoiled by floods. Manganese bath is traceable to the CMI primary standard for activity.

### **2. Radionuclide source based fluence standards.**

Presently the neutron fields created by means of Am-Be, bare and moderated  $^{252}\text{Cf}$  sources are available for tests of neutron survey meters. Last year a detailed description of neutron field around moderated  $^{252}\text{Cf}$  source was done by means of the Bonner sphere spectrometer. Contributions of scattered neutrons at distances from 36.3 cm up to 286.3 cm were determined using distance variation method based on generalized model developed at PTB Braunschweig. Neutron fluence rate at measuring points were converted to ambient dose equivalent rate and these values were fitted by empirical function [1]. Moderated  $^{252}\text{Cf}$  source was also used for the irradiation of personal neutron dosimeters on ISO phantom. In this case the fluence rate at the measuring point was converted to personal dose equivalent.

### **3. Low resolution neutron spectrometry for neutron dosimetry.**

The Bonner spheres spectrometer (BSS) of CMI consists of 13 polyethylene spheres with the following nominal diameters in inches: 2, 2.5, 3, 3.5, 4, 4.5, 5, 6, 7, 8, 10, 12, 15. The mean polyethylene density is  $0.921\text{ g/cm}^3$ . A central cylindrical proportional counter in use is of

type 0.5 NH 1/1K made by a French firm LMT. Its sensitive volume 0.88 cm in diameter and 1 cm in height is filled with  $^3\text{He}$  gas under pressure approx. 1 MPa. The response matrix was calculated with the MCNP transport code and adjusted to the experimental calibration with monoenergetic neutrons at PTB Braunschweig, Germany. The BSS is used for the characterization of neutron fields on working places, e.g. at nuclear power plants around reactor shielding or at the interim storage for spent nuclear fuel. Last measurements were devoted to the experimental determination of photoneutron spectra around the Varian Clinac 2100C machine using BSS in which track detectors CR39 in close contact with  $^{10}\text{B}$  radiators served as a detector of thermal neutrons. This work is still ongoing.

#### **4. Neutron transport calculations.**

At the CMI the MCNP code is used for many years. The code was utilized for the calculation of the response matrix of the BSS, for the evaluation on neutron capture in manganese bath, for the design of different shields and other tasks. Last year it was applied among others to the description of neutron and photon fields in a very close vicinity of the source, which is intended for intracavitary therapy and for brachytherapy [2].

#### **5. Comparisons and demonstrations of equivalence.**

Neutron Metrology Group at CMI participates in “Neutron emission rate CCRI(III)-K9.AmBe comparison and has applied for EUROMET project #608. In 2002 solved six from eight problems of QUADOS comparison devoted to the numerical dosimetry.

#### **References**

- [1] Miloslav Králík, CMI Report 911-02/2002, October 2002  
Parameters of a neutron field around moderated  $^{252}\text{Cf}$  source
  
- [2] Miloslav Králík, Veronika Olšovcová, CMI Report 911-01/2002, June 2002  
Parameters of a neutron field around  $^{252}\text{Cf}$  source for intracavitary therapy and for brachytherapy (in Czech)