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Recent Activities in Measurement Standard and Dosimetry at the GUM, 2011-2013

Adrian Bożydar Knyziak
Główny Urząd Miar (GUM) - Central Office of Measures
Elektoralna 2, 00-139 Warsaw
POLAND

1. Introduction

The laboratory finished modernization of all measuring systems. Now the laboratory is developing the ionization chamber as the primary standard of absorbed dose to water. The laboratory plans to build the water calorimeter in the next year.

2. Air Kerma Standards

The primary standard for air kerma of the GUM for ^{60}Co and ^{137}Cs is a cavity ionization chamber constructed at the Orszagos Mérésügyi Hivatal (now known as the Magyar Kereskedelmi Engedélyezési Hivatal – MKEH), Budapest, Hungary in 1983 (type ND 1005/A, serial number 8303).

The primary standard for air kerma of the GUM for the low- and medium-energy x-ray ranges are 3 plane-parallel chambers constructed at the GUM.

3. Services

GUM offers routine calibration of measuring instruments for national accredited calibration laboratories in terms of air kerma and absorbed dose to water.
GUM is organizing inter-laboratory comparisons for national accredited calibration laboratories for proficiency of calibration services and proficiency in dose reading.

4. Comparisons

2010 – Comparison of the air kerma standards of the GUM and the BIPM in the low- and medium-energy x-ray ranges.
Indirect comparisons were made between the GUM and the BIPM standards of air kerma in the ranges of 10kV to 50 kV and 100 kV to 250 kV. The transfer instruments used were a plane-parallel chamber constructed at the GUM for the low-energy range, and a commercial chamber, type NE 2561, for the medium-energy range. We have 2 reports for the standard of air kerma in the ranges of 10kV to 50 kV [1] and in the ranges 100kV to 250 [2]. The last direct comparison of the air kerma standards in the low- and medium-energy x-ray ranges was in 1996. No previous comparison has been made in 25 kV.

2006 – Comparison of the air kerma standards of the GUM and the BIPM for ^{60}Co and ^{137}Cs gamma radiation.

Direct comparisons of the standards for air kerma in ^{60}Co and ^{137}Cs gamma radiation of the Główny Urząd Miar (GUM), Poland and the Bureau International des Poids et Mesures (BIPM) were carried out in April 2006 in the BIPM ^{60}Co and ^{137}Cs radiation beams. The report was published in August of 2011 [3].

5. Modernization of Measurements System

We built the secondary standard of absorbed dose to water (fig. 1). Our secondary standard is ionization chamber type NE2571, which is calibrated in the BIPM ^{60}Co radiation beam. The ionization chamber is enclosed in a polyethylene housing and positioned with the reference plane at a depth of 5 g cm^{-2}. The water phantom is a cube of side 35 cm with a circle front window of 15 cm diameter and thickness 4 mm.

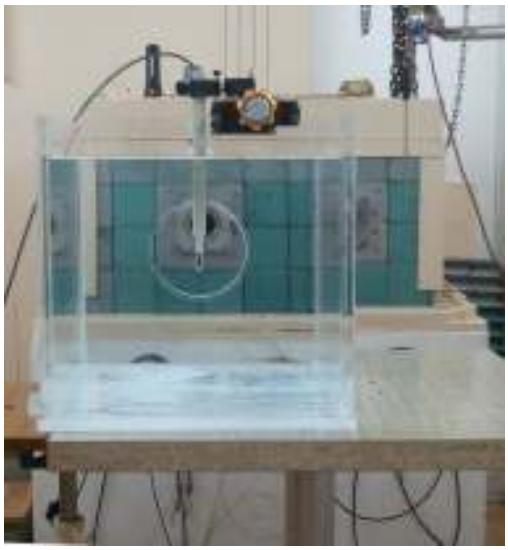

Fig. 1. The measurement system of the absorbed dose to water at the Central Office of Measures

In April of this year we plan to complete construction of our ionization chamber which we want to use as the primary standard of absorbed dose to water (fig. 2). It has cylindrical design which is the most common form for primary cavity standard. Nominal volume of the chamber will be about 0,6 cm^3 . The main components are the wall (cylindrical cap) and the central electrode made of ultra-pure graphite, the insulating material, the venting holes on the bottom at the both sides, the electrical connections to the wall and the central electrode and the guard electrode. The cavity is surrounded almost completely by graphite with only a small amount of insulating material and guard electrode exposed at the bottom of the central electrode. The chamber body will be assembled from three graphite components: the bottom, the cylindrical cap and central electrode. The graphite elements: outer electrode and central electrode before assembly will be measured at Length and Angle Department of the Central Office of Measures. We plan to assembly our ionization chamber in April and start measuring. We finished examination of our three prototype ionization chambers (AK12A, AK12B, AK13A). The results for ionization chamber type AK13A is presented in (tab. 1).

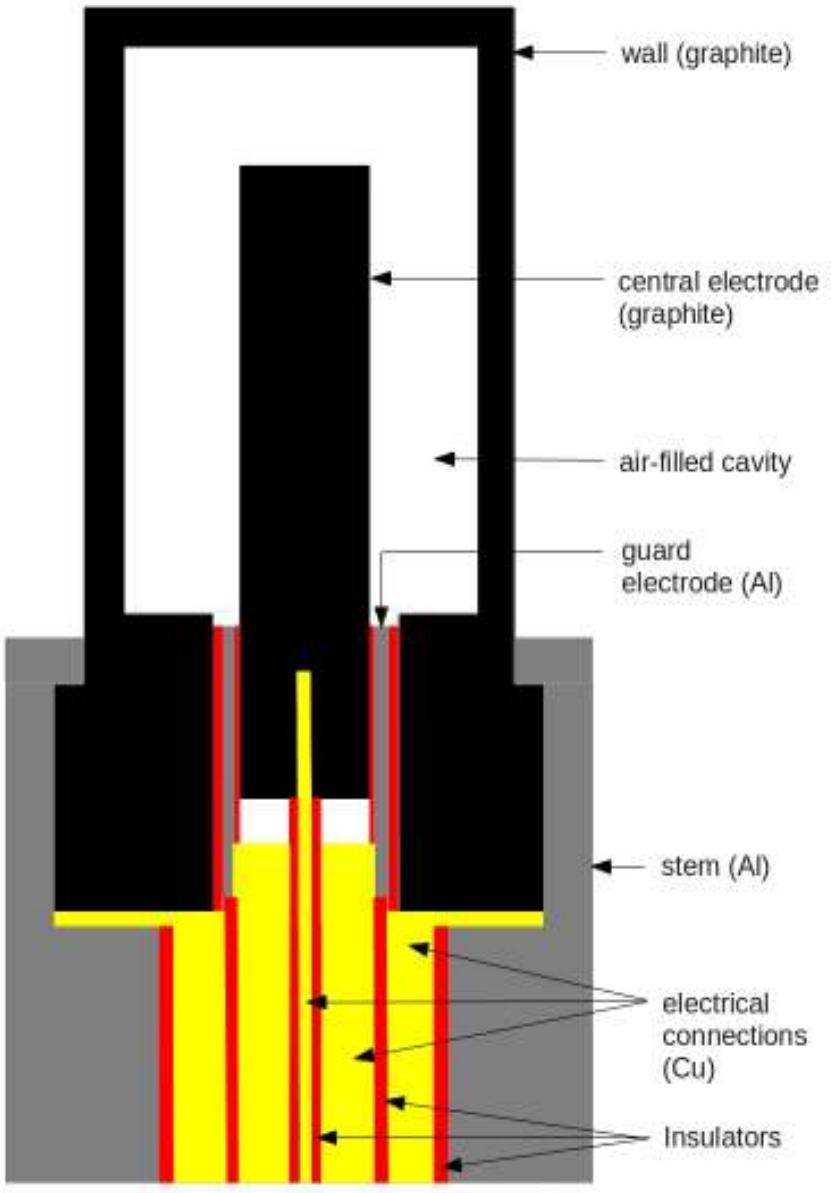

Fig. 2. The ionization chamber (AK13B) as the primary standard of absorbed dose to water at the Central Office of Measures

Fig. 3. The ionization chamber (prototype AK13A)

Tab. 1. The results for ionization chamber type AK13A

QUANTITY	VALUE	RELATIVE STANDARD UNCERTAINTY $100u_{iA}$	$100u_{iB}$
density of graphite/(g/cm^3)	2.17	-	-
volume/(cm^3)	0.6285	-	0.03
voltage/(V)	-300	-	-
k_{pol} (polarity)	0.99497	0.05	-
k_s (recombination losses)	1.00039	0.05	-
k_{ps} (PMMA envelope)	0.99901	0.02	-
k_{pf} (phantom window)	0.99897	0.02	-
k_h (humidity)	0.99800	-	0.06
$N_{Co\text{-}60}$/(Gy/C)	6.066E+7	0.31	-
ionization current/(pA)	-	0.01	-
leakage current/(pA)	>0.003	-	-
long term stability/(%)	>0.10	-	-

In 2012 the laboratory bought the new X-ray system for the medium energy x-ray ranges and changed measuring system for ionization currents. After change of equipment all the measurements was repeated for the comparisons BIPM-GUM. The results of measurements before and after modernization are not different more than 0.10%.
In 2012 we finished the measuring system for determination size of focus x-ray tube.
In May of this year we plan to complete construction of measurement system for non-invasive method for determination of the volumetric content of polyurethane foam cans.
In June of this year we plan to complete construction the measurement system for the calibration of kV Meters (dose, kVp, exposure time).

6. Future

In the near future we would like to extend our services for such fields as: radiography, computed tomography, mammography (W-Mo).
In the next year the laboratory plans to build the water calorimeter as primary standard for absorbed dose to water and computed tomography for industrial applications.

7. Publication and Reports (2011-2012)

[1] D.T. BURNS, P. ROGER, A.B. KNYZIAK, „Key comparison BIPM.RI(I) – K2 of the air – kerma standards of the GUM, Poland and the BIPM in low – energy x-rays”, Metrologia, nr 50, 2013
[2] D.T. BURNS, C. KESSLER, A.B. KNYZIAK, „Key comparison BIPM.RI(I) – K3 of the air – kerma standards of the GUM, Poland and the BIPM in medium– energy x-rays”, Metrologia, nr 49, 2011

[3] P.J. ALLISY-ROBERTS, C.KESSLER, D. T. BURNS, M. DERLACIŃSKI, J. KOKOCIŃSKI, “Comparison of the air kerma standards of the GUM and the BIPM for ^{60}Co and ^{137}Cs gamma radiation”, Metrologia, nr 48, 2011
[3] A.B. KNYZIAK, “Wykorzystanie elektrometru Keithley typ 6430 jako dawkomierza terapeutycznego (Use of electrometer type Keithley 6430 for the construction of therapeutic dosimeters)”, Materiały Konferencyjne - Metrologia Wspomagana Komputerowo 2011, Waplewo 2011
[4] A.B. KNYZIAK, M.DERLACIŃSKI, “Stanowisko dawki pochłoniętej w wodzie w Głównym Urzędzie Miar (The measurement system of the absorbed dose to water at the Central Office of Measures)”, Konferencja Podstawowe Problemy Metrologii, Krynica Górska 2012
[5] A.B. KNYZIAK, “Wykorzystanie elektrometru Keithley 6517A w układzie kompensacji Townsend'a (Keithley 6517A electrometer use in the Townsed's compensation method)”, XLIV Międzyuczelniana Konferencja Metrologów, Ustroń 2012