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Activities in radiation dosimetry at the GUM

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1. Air Kerma Standards

The primary standard for air-kerma of the GUM for low- and medium- energy x-ray ranges (below 10kV, from 10kV to 60kV, from 30kV to 320kV) are 3 parallel plate chambers constructed at the GUM. Now, the laboratory is recalculating (EGSnrc, BEAMnrc, FLUKA/FLAIR) and determining the correction factors for ISO 4037 and EN 61267 quality radiation.

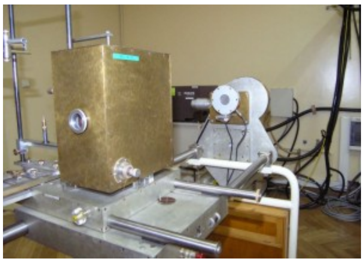

Fig. 1. The primary standard for air-kerma of the GUM for low energy x-ray ranges on irradiation bench

Fig. 2. The primary standard of air-kerma of the GUM for medium energy x-ray ranges on irradiation bench

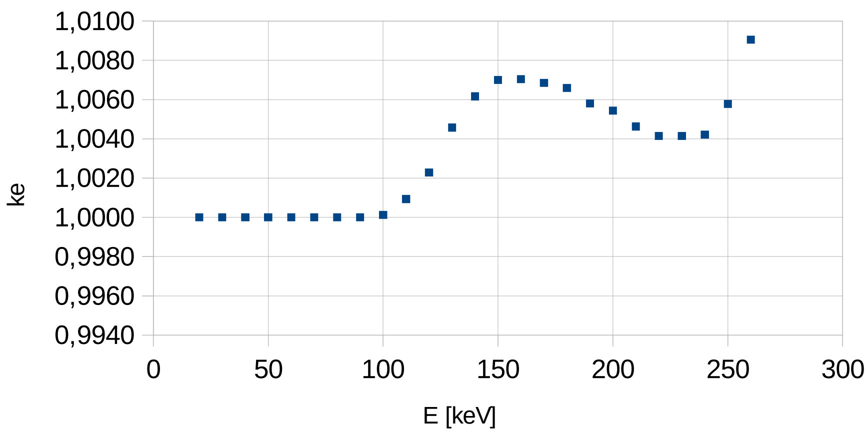

Fig. 3. Calculated electron-loss correction factor for the GUM medium-energy free-air chamber standard in EGSnrc (FAC code)

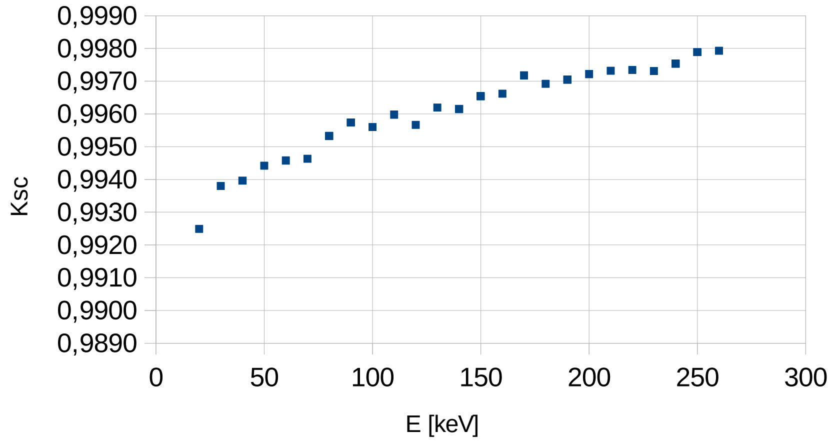

Fig. 4. Calculated photon-scatter correction factor for the GUM medium-energy free-air chamber standard in EGSnrc (FAC code)

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).

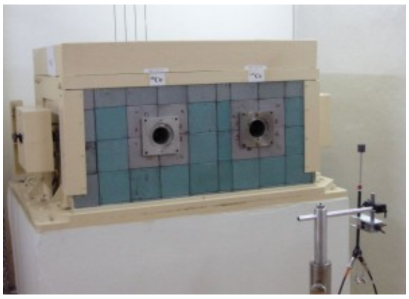

Fig. 5. The primary standard of air kerma of the GUM for ^{60}Co and ^{137}Cs
(a ionization chamber type ND 1005/A, serial number 8303) on irradiation bench

In 2016 we have assembled our new primary standard (a ionization chamber IGNAŚ-IC16#001). In this year, we have determined correction factors for ^{137}Cs and ^{60}Co gamma radiation. The volume of ionization chamber was determined by radiographic method [2]. Correction factors k_{wall} and k_{an} was determined in EGSnrc.In next year, we would like to comparison of the air kerma standards of the GUM and the BIPM for ^{60}Co and ^{137}Cs gamma radiation.

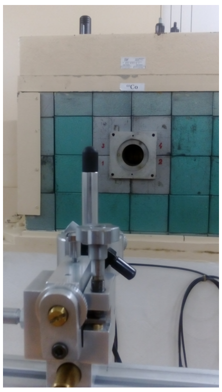

Fig. 6. The new primary standard of air kerma of the GUM for ^{60}Co and ^{137}Cs
(a ionization chamber IGNAŚ-IC16#001) on irradiation bench

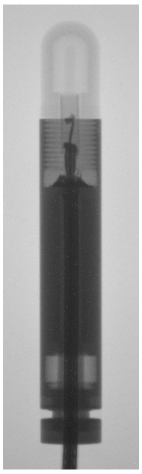

Fig. 7. The assembled a ionization chamber IGNAŚ-IC16#001 (radiography)

Table 1. Characteristics of the GUM standard of air kerma

Parameter	Ionization chamber
	IGNAŚ-IC16#001
Material ionization chamber	Graphite
Height cylinder [mm]	20.00
Outer diameter graphite cylinder [mm]	12.50
Wall thickness chamber [mm]	2.50
Diameter chamber [mm]	7.50
Material collecting electrode	Graphite
Diameter collecting electrode [mm]	2.50
Nominal cavity volume [cm3]	0.45
Graphite density qc [g/cm3]	1.81
Manufacturer of graphite	POCO
Material graphite	Ultrapur Graphite EDM-3
Impurity graphite [%]	99.997
Real cavity volume [cm3]	0.447
Insulator	Polyethilene
Applied Voltage [V]	300
Reference point	Chamber center

Table 2. Physical constants and correction factors with their estimated relative uncertainties of the GUM standards for Cs137 radiation beam

	Values	uncertainty	
		100si	100ui
Physical Constants			
ρ_o dry air density [kg/m3]	1.2045		0.01
$(\mu_{en}/\rho)_{a,c}$	0.9999		0.05
$s_{c,a}$	1.0010		0.11
W/e	33.97		0.15
g	0.0012		0.02
Correction factors			
k_{sat} recombination losses	1.0001	0.03	
k_{pol} polarity	0.9946	0.03	
k_{stem} stem scattering	0.9962	0.03	
k_h humidity	0.9970		0.03
k_{wall} wall attenuation and scattering	1.0158	0.01	
k_{an} axial non-uniformity	1.0002	0.02	
k_{rn} radial non-uniformity	1.0002		0.02
V chamber volume [cm3]	0.4465		0.10
I ionization current [pA]	1.2121	0.06	
quadratic summation		0.08	0.22
combined uncertainty		0.24	

Table 3. Physical constants and correction factors with their estimated relative uncertainties of the GUM standards for Co60 radiation beam

	Values	uncertainty	
		100si	100ui
Physical Constants			
ρ_o dry air density [kg/m3]	1.2045		0.01
$(\mu_{en}/\rho)_{a,c}$	0.9985		0.05
$s_{c,a}$	1.0010		0.11
W/e	33.97		0.15
g	0.0032		0.02
Correction factors			
k_{sat} recombination losses	1.0001	0.01	
k_{pol} polarity	0.9945	0.02	
k_{stem} stem scattering	0.9970	0.04	
k_h humidity	0.9970		0.03
k_{wall} wall attenuation and scattering	1.0110	0.01	
k_{an} axial non-uniformity	1.0009	0.02	
k_{rn} radial non-uniformity	1.0002		0.02
V chamber volume [cm3]	0.4465		0.10
I ionization current [pA]	1.7914	0.03	
quadratic summation		0.06	0.22
combined uncertainty		0.23	

This ionization chamber will be ionometric primary standard for absorbed dose to water for ^{60}Co gamma radiation, until our water calorimeter will be finished. The laboratory is calculating (FLUKA/FLAIR) and determining the correction factors.

2. Absorbed Dose to Water Standard

The laboratory has built measuring system for the secondary standard of absorbed dose to water. As the secondary standard ionization chamber type NE2571 is used, which is calibrated in the BIPM ^{60}Co radiation beam. The ionization chamber is enclosed in a polyethylen housing and positioned with the reference plane at 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. 8. The secondary standard of absorbed dose to water of the GUM for ^{60}Co on irradiation bench

The laboratory team have just built a graphite calorimeter. Now, the calorimeter is being tested in the medium energy x-ray ranges.

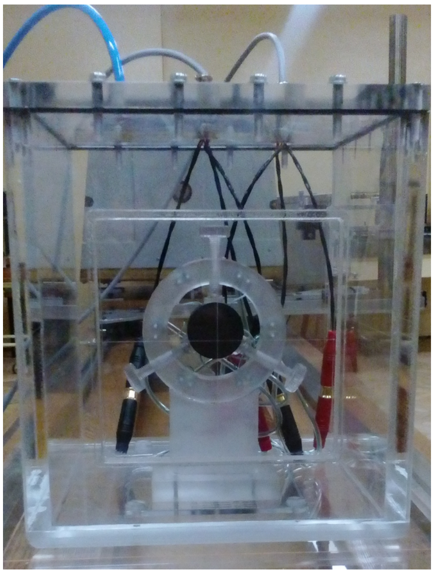

Fig. 9. First version of the assembled graphite calorimeter of the GUM

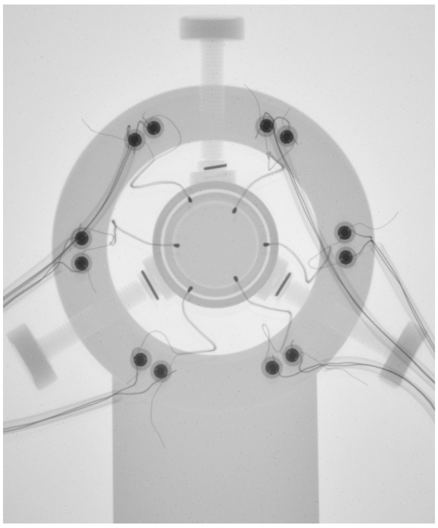

Fig. 10. First version of the assembled graphite calorimeter (radiography)

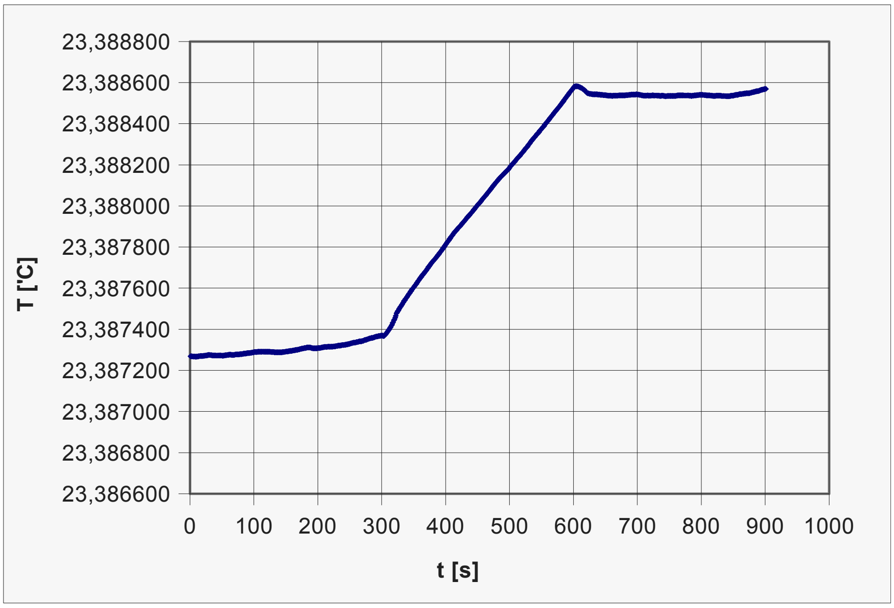

Fig. 11. Example of temperature rise measurement for the BIPM250 x-ray beam (first test)

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.

Conferences and Publications:

1. P. Tulik, A. B. Knyziak, A. Paszcza, M. Derlaciński, E. Kaczorowska: Odtwarzanie i przekazywanie jednostki dawki pochłoniętej w wodzie z wykorzystaniem kalorymetru grafitowego, Conferece of Polish Society of Medical Physics, Letters in Oncology Science 2017, 14(S1), 60
2. A. B. Knyziak, W. Rzodkiewicz: New X-ray testing methods of aerosol products for industrial radiography, Nuclear Instruments and Methods in Physics Research Section A, 2017, Vol. 844, 141-146
3. A. B. Knyziak, W. Rzodkiewicz: Measurement methods of ionization current and electric charges in radiation dosimetry; Nuclear Instruments and Methods in Physics Research Section A, 2016, Vol. 822, 1-8
4. A. B. Knyziak, M. Derlaciński, W. Rzodkiewicz: FROM AIR KERMA TO ABSORBED DOSE TO WATER, 50th Congress of Polish Society of Medical Physics
5. A. B. Knyziak, M. Derlaciński, W. Rzodkiewicz: REPRODUCTION AND DISSAMINATION OF AIR KERMA RATE FOR X AND GAMMA RADIATION, 50th Congress of Polish Society of Medical Physics