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NIST
United States Department of Commerce
National Institute of Standards and Technology
Gaithersburg, MD 20899 USA

REPORT OF CALIBRATION

Report date:	July 26, 1994
DG 9762/94	TFN 253808
Submitted by:	Battelle Pacific NW Laboratories Richland, WA 99352
Received at NIST:	March 23, 1994
Capintec Chamber	Model PM-30 Serial Number CII30.7502

The calibration factors given in this report are quotients of the air kerma and the charge generated by the radiation in the ionization chamber. The average charge used to compute the calibration factor is based on measurements with the wall of the ionization chamber at the stated polarity and potential. Leakage corrections are applied if necessary. If the chamber is open to the atmosphere, the measurements are normalized to one standard atmosphere and 22 degrees Celsius. Use of the chamber at other pressures and temperatures requires normalization of the ion currents to these reference conditions.

The normalizing factor F is computed from the following expression:

$$F = (273.15 + T) / (295.15\, H),$$

where,

T is the temperature in degrees Celsius, and

H is the pressure expressed as a fraction of a standard atmosphere. (1 standard atmosphere = 101.325 kilopascals = 1013.25 millibars = 760 millimeters of mercury)

The air-kerma rate at the calibration position is measured by a free-air ionization chamber for X radiation and by graphite cavity ionization chambers for ^{60}Co and ^{137}Cs gamma radiation. The gamma-ray air-kerma rates are corrected to the date of calibration (from previously measured values) by decay corrections based on half-lives of 5.27 years for ^{60}Co and 30.0 years for ^{137}Cs.

Air kerma is related to exposure by the equation:

$$K = 2.58\text{E-}04\ (W/e)\ X / (1 - g),$$

where,

K is air kerma in grays (Gy)

W/e is the mean energy per unit charge expended by electrons in dry air in joules per coulomb (J/C)

X is the exposure in roentgens

g is the fraction of the initial kinetic energy of secondary electrons dissipated in air as bremsstrahlung.

The following values are used at NIST: W/e = 33.97 J/C, g = 0.0032 for ^{60}Co gamma rays, g = 0.0016 for ^{137}Cs gamma rays, and g = 0.0000 for x rays with energy less than 300 keV.

To obtain exposure in roentgens, divide air kerma in grays by
8.79E-03 for ^{60}Co gamma rays,
8.78E-03 for ^{137}Cs gamma rays, and
8.76E-03 for x rays less than 300 keV.

No correction is made for the effect of water vapor on the instrument being calibrated. It is assumed that both the calibration and the use of that instrument take place in air with a relative humidity between 10% and 70% where the humidity correction is nearly constant.

The overall uncertainty of the calibration described in this report is 1%, of which 0.7% is assigned to the uncertainty in the air-kerma rate of the NIST beam. The overall uncertainty is formed by taking two times the quadratic sum of the standard deviations of the mean for component uncertainties obtained from replicate determinations, and assumed approximations of standard deviations for all other uncertainty components; it is considered to have the approximate significance of a 95% confidence limit.[1]

Information on technical aspects of this report may be obtained from P. J. Lamperti, Radiation Physics C229, National Institute of Standards and Technology, Gaithersburg, MD 20899, (301) 975-5591.

Calibrations performed by Paul J. Lamperti *PL*

Report reviewed by Paul J. Lamperti *PL*

Report approved by Bert M. Coursey *Bert M. Coursey*

For the Director
National Institute of Standards and Technology
by *Randall S. Caswell*

Randall S. Caswell, Chief
Ionizing Radiation Division
Physics Laboratory

[1]Details of the uncertainty analysis are given in: Lamperti, P.J., Loftus, T.P., and Loevinger, R., "Calibration of X-Ray and Gamma-Ray Measuring Instruments at the National Bureau of Standards", NBS Special Publication 250-16 (1987).

July 26, 1994
DG 9762/94

National Institute of Standards and Technology

Report of Calibration

Battelle Pacific NW Laboratories
Richland, WA 99352

Capintec Chamber
Model PM-30 Serial Number CII30.7502
Wall potential: -350 volts (with respect to the inner electrode)
Rotation: the serial number faced the source of radiation
Orientation: the cavity was positioned in the center of the beam with the stem perpendicular to the beam direction

Beam Code	**Half-Value Layer**		**Calibration Factor[2] 22°C and 1 atm**	**Dist**	**Beam Size**	**Air-Kerma Rate**
	Al	**Cu**				
	(mm)	(mm)	(Gy/C)	(m)	(mm)	(Gy/s)
M60	1.68	0.052	1.007×10^{6}	1.00	C45	7.0×10^{-4}
H40	2.9	0.093	9.599×10^{5}	0.50	C43	2.8×10^{-5}

The calibration factor is shown to four digits to prevent rounding errors up to 0.5 %.

[2]Details of the calibration procedure are given in: Lamperti, P.J., Loftus, T.P., and Loevinger, R., "Calibration of X-Ray and Gamma-Ray Measurements at the National Bureau of Standards", NBS Special Publication 250-16 (1987).

Explanation of Chamber Calibration Tables

The beam code identifies important beam parameters. For x radiation there are four groups, L, M, H, and S which stand for light, moderate, heavy, and special filtration, respectively. The number following the letter is the constant potential across the x-ray tube. For gamma radiation, the beam code identifies the radionuclide.

The half-value layers (HVL) in aluminum and in copper have been determined by a free-air chamber for x radiation. The copper HVL's for ^{60}Co and ^{137}Cs are calculated. The calibration factors are listed in order of increasing aluminum HVL within each group.

The homogeneity coefficient is 100(1st HVL/2nd HVL).

The calibration factor is defined on the first page of this report.

The distance is that between the radiation source and the detector center or the reference line. For thin-window chambers with no reference line, the window surface is the plane of reference.

The beam size is the perpendicular distance from the center line of the calibration beam to the fifty percent intensity line. For circular fields, the letter C precedes the dimension; for square fields the letter S precedes the dimension and the chamber axis is perpendicular to a side of the square.

The effective energy is shown for those beams where it is a meaningful characterization of the beam quality. The effective energy for gamma radiation is the photon energy and for x radiation it is computed from good-geometry copper attenuation data. The initial slope of the attenuation curve is used to determine the attenuation coefficient and the photon energy associated with this coefficient is the "effective energy."[3] For beam codes H50-H300, the effective energy is well represented by the equation: effective energy = 0.861V - 6.1 where V is the constant potential in kilovolts.

The air-kerma rate at the time of calibration is shown in the last column. ***If the chamber is used to measure an air-kerma rate significantly different from that used for the calibration, it may be necessary to correct for recombination loss.***

[3]The energy vs attenuation-coefficient data used for this purpose were taken from J. H. Hubbell, Int. J. Appl. Radiat. Isot. 33, 1269 (1982).

Conventional Calibration Conditions for X- and Gamma-Ray Measuring Instruments

Beam Code	Added Filter				Half-Value Layer		Homogeneity Coefficient		Effect. Energy	Distance	Air-Kerma Rate	
	Al (mm)	Cu (mm)	Sn (mm)	Pb (mm)	Al (mm)	Cu (mm)	Al (mm)	Cu (mm)	(keV)	(cm)	Minimum (μGy/s)	Maximum (mGy/s)
L10	0				0.029		79			25	0.01	15.
L15	0				0.030		74			25	0.01	37.
L20	0				0.071		76			50	0.01	29.
L30	0.265				0.22		60			50	0.01	3.5
L40	0.50				0.49		57			50	0.01	3.5
L50	0.639				0.75		58			50	0.01	3.5
L80	1.284				1.83		58			50	0.01	3.5
L100	1.978				2.8		58			50	0.01	3.5
M20	0.230				0.152		79			50	0.01	4.4
M30	0.50				0.36		64			50	0.01	2.6
M40	0.786				0.73		66			50	0.01	3.5
M50	1.021				1.02	0.032	66	62		50	0.01	3.5
M60	1.541				1.68	0.052	68	64			7.0	1.7
M100	5.0				5.0	0.20	72	55			8.8	2.6
M150	5.0	0.25			10.2	0.67	87	62			8.8	3.5
M200	4.1	1.12			14.9	1.69	95	69			8.8	2.6
M250	5.0	3.2			18.5	3.2	98	86			8.8	1.7
M300	4.0		6.5		22.	5.3	100	97			4.4	0.70
H10	0.105				0.048		89			25	0.01	0.026
H15	0.500				0.152		87			25	0.01	0.026
H20	1.021				0.36		88			50	0.01	0.026
H30	4.13				1.23	0.038	93	94		50	0.01	0.026
H40	4.05	0.26			2.9	0.093	94	95		50	0.01	0.026
H50	4.0			0.10	4.2	0.142	92	90	38		2.6	0.57
H60	4.0	0.61			6.0	0.24	94	89	46		0.18	0.044
H100	4.0	5.2			13.5	1.14	100	94	80		0.26	0.017
H150	4.0	4.0	1.51		17.0	2.5	100	95	120		0.35	0.087
H200	4.0	0.60	4.16	0.77	19.8	4.1	100	99	166			0.052
H250	4.0	0.60	1.04	2.72	22.	5.2	100	98	211		0.01	0.044
H300	4.1		3.0	5.0	23.	6.2	99	98	252		2.6	0.026
S75	1.504				1.86		63			50	13.	3.5
S60	4.0				2.8	0.089	75	70			13.	0.52
^{137}Cs						10.8			662			0.87
^{60}Co						14.9			1250			22.

The inherent filtration is approximately:

1.0 mm Be for beam codes L10-L100, M20-M50, H10-H40, and S75;

3.0 mm Be for beam codes M60-M300, H50-H300, and S60.

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Accept
T H Walker
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For the Director
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