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U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

WASHINGTON, DC 20234

REPORT OF CALIBRATION

CAPINTEC IONIZATION CHAMBER

MODEL PM-3C SERIAL NUMBER CII30.4277

MANUFACTURED BY CAPINTEC INC.
MONTVALE, NJ 07645

SUBMITTED BY BATTELLE NORTHWEST LAB.
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THE CALIBRATION FACTORS GIVEN IN THIS REPORT ARE QUOTIENTS OF THE X- OR GAMMA-RAY EXPOSURE AND THE CHARGE GENERATED BY THAT 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 WERE APPLIED IF NECESSARY. IF THE CHAMBER WAS OPEN TO THE ATMOSPHERE THE MEASUREMENTS WERE 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 EXPOSURE RATE AT THE CALIBRATION POSITION WAS MEASURED BY A FREE-AIR IONIZATION CHAMBER FOR X RADIATION, AND BY GRAPHITE CAVITY IONIZATION CHAMBERS FOR COBALT-60 AND CESIUM-137 GAMMA RADIATION. THE GAMMA-RAY EXPOSURE RATES WERE CORRECTED TO THE DATE OF CALIBRATION, FROM PREVIOUSLY MEASURED VALUES, BY DECAY CORRECTIONS BASED ON HALF-LIVES OF 5.27 AND 30.0 YEARS, FOR COBALT-60 AND CESIUM-137 RESPECTIVELY.

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THE UNCERTAINTY OF THE EXPOSURE-RATE MEASUREMENTS IS BELIEVED TO BE WITHIN ONE PERCENT AND THE ION CURRENT MEASUREMENTS ARE BELIEVED TO BE ACCURATE TO WITHIN A FEW TENTHS OF ONE PERCENT.

THE CALIBRATION FACTORS ARE COMPOSED OF A NUMBER FOLLOWED BY A PLUS OR MINUS SIGN FOLLOWED BY A 2-DIGIT NUMBER. WHEREVER THIS OCCURS IN THE REPORT, THE INITIAL NUMBER IS TO BE MULTIPLIED BY 10 RAISED TO THE POWER INDICATE BY THE SIGN AND THE FINAL 2-DIGIT NUMBER. THE CALIBRATION FACTOR IS GIVEN TO FOUR DIGITS TO PREVENT ROUNDING ERRORS UP TO 0.5 PERCENT WHEN THE FIRST DIGIT IS UNITY.

INFORMATION ON TECHNICAL ASPECTS OF THIS REPORT MAY BE OBTAINED FROM T. P. LOFTUS, RADIATION PHYSICS 0210, NATIONAL BUREAU OF STANDARDS, WASHINGTON, DC 20234, 301-921-2361.

MEASUREMENTS SUPERVISED BY T. P. LOFTUS TPL

REPORT APPROVED BY R. LOEVINGER RL

FOR THE DIRECTOR
BY

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NATIONAL BUREAU OF STANDARDS REPORT OF CALIBRATION

BATTELLE NORTHWEST LAB.
RICHLAND, WA 99352

CAPINTEC IONIZATION CHAMBER
MODEL PM-3C SERIAL NUMBER CII3C.4277
OPEN TO THE ATMOSPHERE WHEN TESTED
COLLECTION POTENTIAL: -3CC.

BEAM CODE	HALF-VALUE LAYER AL (MM)	CL (MM)	CALIBRATION FACTOR 22 DEG C AND 1 ATM	DIST (M)	BEAM SIZE (MM)	EXP RATE (R/S)
S6C	2.3C	C.C89	1.105+C8 R/C	1.5C	C 56	2.3-C2
H5C	4.2C	C.142	1.C88+C8 R/C	.78	C 47	3.6-C3
M1CC	5.CC	C.2C	1.C95+C8 R/C	1.5C	C 56	4.5-C2
M15C	10.2C	C.67	1.C99+C8 R/C	1.5C	C 56	4.C-C2
H1CC	13.5C	1.14	1.111+C8 R/C	.78	C 47	1.6-C3
M2CC	14.9C	1.69	1.1C8+C8 R/C	1.5C	C 56	4.5-C2
H15C	17.CC	2.5	1.119+C8 R/C	.78	C 47	8.3-C3
H2CC	19.8C	4.1	1.125+C8 R/C	.78	C 47	6.4-C3
H25C	21.7C	5.2	1.129+C8 R/C	.78	C 47	5.4-C3
H3CC	23.3C	6.2	1.12C+C8 R/C	.78	C 47	3.4-C3
CS137		1C.8	*1.149+C8 R/C	1.95	C4C6	5.2-C3
CC-6C		14.9	*1.147+C8 R/C	1.95	C379	1.6-C3

– SEE ATTACHED CHANGE –

DURING CALIBRATION THE CAVITY WAS POSITIONED IN THE CENTER OF THE BEAM WITH THE STEM PERPENDICULAR TO THE BEAM DIRECTION. THE WHITE DOT FACED THE SOURCE OF RADIATION.

2.-14 AMPERES WAS THE LEAKAGE CURRENT MEASURED BEFORE CALIBRATION.

1.CC5 WAS THE RATIO OF THE CURRENT MEASURED FOR FULL COLLECTION POTENTIAL TO THE CURRENT FOR HALF COLLECTION POTENTIAL FOR A CURRENT OF 1.0-C9 AMPERES. A DETAILED SATURATION STUDY WAS NOT CARRIED OUT AND NO CORRECTION FOR LACK OF SATURATION WAS APPLIED TO THE DATA.

* THE CHAMBER WALL THICKNESS WAS INCREASED FOR THIS BEAM QUALITY BY ADDITION OF THE SHELL SUPPLIED WITH THE CHAMBER.

CHECKED BY P. Lamperti

EXPLANATION OF CHAMBER CALIBRATION TABLE

The beam code identifies important beam parameters. For x radiation the letters L, M, H, and S stand for light, moderate, heavy, and special filtration, respectively, and 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 in aluminum and in copper have been determined by a free-air chamber for x radiation. The Cu HVLs for ^{60}Co and ^{137}Cs are calculated. The calibration factors or correction factors are listed in order of increasing Al HVL.

The calibration factor or correction factor is defined on the first page of this report. If the chamber was open to the atmosphere, the factor has been normalized to the temperature and pressure shown at the top of the column. When the entry is a calibration factor, it is in special units (roentgens per coulomb). When the entry is a correction factor, it is dimensionless. If the correction factor is followed by a number, the number gives the approximate percent of full-scale electrometer reading at which the calibration was performed.

The distance shown 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 50 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. If no letter precedes the dimension a special field was used and its dimensions are given in a note at the bottom of the table.

The exposure rate at which the calibration was performed is given in the last column. If the chamber is used to measure an exposure rate that is significantly different from that used for the calibration it may be necessary to correct for recombination loss.

The effective energy is given on the last page of this report for those beams for which it is believed to be a meaningful characterization of the beam quality. For gamma radiation the effective energy is the photon energy.

For x radiation the effective energy is computed from good-geometry copper attenuation data. The initial slope of the attenuation curve is used to determine an attenuation coefficient, and the photon energy associated with this coefficient is the "effective energy". The energy vs attenuation-coefficient data used for this purpose are taken from J.H. Hubbell, Int. J. Appl. Radiat. Isot. 33, 1269 (1982). For beam codes H50 to H300, the effective energy in kilo-electron volts is well represented by $E_{eff} = 0.861\ V - 6.1$, where V is the constant potential in kilovolts.

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CONVENTIONAL CALIBRATION CONDITIONS FOR X- AND GAMMA-RAY MEASURING INSTRUMENTS

Beam Code	Previous Code	Added Filter Al (mm)	Cu (mm)	Sn (mm)	Pb (mm)	Half-Value Layer Al (mm)	Cu (mm)	Homogeneity Coefficient Al	Cu	Effective Energy (keV)	Distance (cm)	Exposure Rate Min. (mR/s)	Max. (R/s)
L10	L-B	0				0.029		79			25	0.001	1.7
L15	L-C	0				0.050		74			25	0.001	4.2
L20	L-D	0				0.071		76			50	0.001	3.3
L30		0.265				0.22		60			50	0.001	0.4
L40		0.50				0.49		57			50	0.001	0.4
L50		0.639				0.75		58			50	0.001	0.4
L80		1.284				1.83		58			50	0.001	0.4
L100	L-M	1.978				2.8		59			50	0.001	0.4
M20		0.230				0.152		79			50	0.001	0.5
M30	L-G	0.50				0.36		64			50	0.001	0.3
M40		0.786				0.73		66			50	0.001	0.3
M50	L-I	1.021				1.02	0.032	66	62		50	0.001	0.4
M60	MFB	1.51				1.68	0.052	68	64			0.8	0.2
M100	MFG	5.0				5.0	0.20	72	55			1.0	0.3
M150	MFI	5.0	0.25			10.2	0.67	87	62			1.0	0.4
M200		4.1	1.12			14.9	1.69	95	69			1.0	0.3
M250	MFO	5.0	3.2			18.5	3.2	98	86			1.0	0.2
M300		4.0		6.5		21.9	5.3	100	97			0.5	0.08
H10		0.105				0.048		89			25	0.001	0.003
H15		0.500				0.152		87			25	0.001	0.003
H20		1.021				0.36		88			50	0.001	0.003
H30		4.13				1.23	0.038	93	94		50	0.001	0.003
H40		4.05	0.26			2.9	0.093	94	95		50	0.001	0.003
H50	HFC	4.0			0.10	4.2	0.142	92	90	38		0.3	0.065
H60		4.0	0.61			6.0	0.24	94	89	46		0.02	0.005
H100		4.0	5.2			13.5	1.14	100	94	80		0.005	0.002
H150	HFG	4.0	4.0	1.51		17.0	2.5	100	95	120		0.03	0.010
H200	HFI	4.0	0.60	4.16	0.77	19.8	4.1	100	99	166		0.02	0.006
H250	HFK	4.0	0.60	1.04	2.72	21.7	5.2	100	98	211		0.03	0.005
H300		4.1		3.0	5.0	23.3	6.2	99	98	252		0.04	0.003
S75	L-K	1.504				1.86		63			50	0.001	0.4
S60	MFC	4.0				2.8	0.089	75	70			0.3	0.06
Cs-137	Cs-137						10.8			662		1.5	0.1
Co-60	Co-60						14.9			1250		1.5	2.5

For the x-ray beam codes, the letter indicates light, moderate, heavy, and special filtration, and the number is the constant potential in kilovolts.

The inherent filtration is approximately
1.0 mm Be for beam codes L10-L100, M20-M50, H10-H40, and S75; and
3.0 mm Be for beam codes M60-M300, H50-H300, and S60.

The half-value layers for Cs-137 and Co-60 are calculated.

The homogeneity coefficient is taken as 100 x 1st HVL/2nd HVL.