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U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

WASHINGTON, DC 20234.

# REPORT OF CALIBRATION

VICTOREEN CHAMBER

MODEL 415A SERIAL NUMBER 149

MANUFACTURED BY VICTOREEN INSTRUMENT CO.
CLEVELAND, OH 44104

SUBMITTED BY BATTELLE NORTHWEST LABORATORY
RICHLAND, WA 99352

RECEIVED AT NBS ON 1982 AUG 18

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 MM HG)

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 INHERENT FILTRATION OF THE X-RAY TUBE USED FOR THE MF AND HF BEAM QUALITIES IS EQUIVALENT TO 1.5 MM OF ALUMINUM. THIS IS AN AVERAGE VALUE DERIVED FROM MEASUREMENTS AT 60 AND 100 KV. THE INHERENT FILTRATION OF THE X-RAY TUBE USED FOR THE L- BEAM QUALITIES IS 1.0 MM OF BERYLLIUM.

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 GIVEN IN COLUMN 4 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 INDICATED 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 C210, NATIONAL BUREAU OF STANDARDS, WASHINGTON, DC 20234, 301-921-2361.

MEASUREMENTS SUPERVISED BY T. P. LOFTUS T.P.L.

REPORT APPROVED BY R. LOEVINGER RL

FOR THE DIRECTOR
BY

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NATIONAL MEASUREMENT LABORATORY

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NATIONAL BUREAU OF STANDARDS REPORT OF CALIBRATION

BATTELLE NORTHWEST LABORATORY
RICHLAND, WA 99352

VICTOREEN CHAMBER
MODEL 415A SERIAL NUMBER 149
OPEN TO THE ATMOSPHERE WHEN TESTED
COLLECTION POTENTIAL: -300.

| 1 BEAM CODE | 2 CONST POTEN (KV) | 3 EFFECT ENERGY (KEV) | 4 CALIBRATION FACTOR 22 DEG C AND 1 ATM | 5 AL HVL (MM) | 6 DIST (CM) | 7 BEAM SIZE (MM) | 8 EXP RATE (R/S) |
|---|---|---|---|---|---|---|---|
| L-D | 20 | | 1.386+09 R/C = 3.575+05 /KG | .07 | 50 | C 43 | 1.4+09 |
| L-E | 20 | | 1.340+09 R/C = 3.458+05 /KG | .23 | 50 | C 43 | 7.8-02 |
| L-G | 30 | | 1.344+09 R/C = 3.468+05 /KG | .36 | 50 | C 43 | 1.5-01 |
| L-I | 50 | | 1.351+09 R/C = 3.487+05 /KG | 1.02 | 50 | C 43 | 1.9-01 |
| L-K | 75 | | 1.338+09 R/C = 3.453+05 /KG | 1.86 | 50 | C 43 | 2.5-01 |
| L-M | 100 | | 1.316+09 R/C = 3.396+05 /KG | 2.78 | 50 | C 43 | 3.2-01 |
| MFC | 60 | | 1.361+09 R/C = 3.513+05 /KG | 2.79 | 100 | C 33 | 2.5-02 |
| MFE | 75 | | 1.340+09 R/C = 3.458+05 /KG | 3.39 | 100 | C 33 | 4.2-02 |

DURING CALIBRATION THE CAVITY WAS POSITIONED IN THE CENTER OF THE BEAM WITH THE STEM PARALLEL TO THE BEAM DIRECTION.

2.-15 AMPERES WAS THE LEAKAGE CURRENT MEASURED BEFORE CALIBRATION.

1.004 WAS THE RATIO OF THE CURRENT MEASURED FOR FULL COLLECTION POTENTIAL TO THE CURRENT FOR HALF COLLECTION POTENTIAL FOR A CURRENT OF 7.8-11 AMPERES. A DETAILED SATURATION STUDY WAS NOT CARRIED OUT AND NO CORRECTION FOR LACK OF SATURATION WAS APPLIED TO THE DATA.

CHECKED BY P. Lamperti

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EXPLANATION OF COLUMNS IN CHAMBER CALIBRATION TABLE

1 THE BEAM CODE, A COMBINATION OF LETTERS THAT IDENTIFIES IMPORTANT PARAMETERS. THE LETTERS L-, MF, AND HF STAND FOR LIGHT, MODERATE, AND HEAVY FILTRATION RESPECTIVELY. FOR GAMMA RADIATION THE CODE IDENTIFIES THE RADIONUCLIDE.

2 THE CONSTANT POTENTIAL ACROSS THE X-RAY TUBE.

3 THE EFFECTIVE ENERGY. FOR GAMMA RADIATION, THE NUMBER LISTED IN THIS COLUMN IS THE PHOTON ENERGY. FOR X RADIATION, THE NUMBER LISTED IS COMPUTED FROM GOOD-GEOMETRY COPPER ABSORPTION DATA. ABSORPTION COEFFICIENTS, DETERMINED AT SEVERAL POINTS ON THE CURVE, ARE USED TO ESTIMATE THE VALUE OF THE COEFFICIENT AS THE COPPER THICKNESS IS REDUCED TO ZERO. THE PHOTON ENERGY ASSOCIATED WITH THIS COEFFICIENT IS THE 'EFFECTIVE ENERGY'. THE ENERGY VS ABSORPTION-COEFFICIENT DATA USED FOR THIS PURPOSE IS 'WITH RAYLEIGH SCATTERING' TAKEN FROM TABLES IN NSRDS-NBS 29 BY J. H. HUBBELL (1969). THE EFFECTIVE ENERGY IS GIVEN ONLY WHERE IT IS BELIEVED TO BE A MEANINGFUL CHARACTERIZATION OF THE BEAM QUALITY.

4 THE CALIBRATION FACTOR DEFINED IN THE BODY OF THE REPORT, IN SPECIAL UNITS (ROENTGENS PER COULOMB) AND IN SI UNITS (RECIPROCAL KILOGRAMS).

5 THE FIRST HALF-VALUE LAYER IN ALUMINUM AS DETERMINED BY A FREE-AIR IONIZATION CHAMBER. THE CALIBRATION FACTORS ARE LISTED IN THE ORDER OF INCREASING AL HVL. THE CU HVLS FOR THE SAME BEAM QUALITIES ARE GIVEN IN THE TABLE ON THE LAST PAGE OF THIS REPORT.

6 THE DISTANCE BETWEEN THE RADIATION SOURCE AND THE DETECTOR CENTER OR THE REFERENCE LINE. FOR THIN-WINDOW CHAMBERS THAT HAVE NO REFERENCE LINE, THE WINDOW SURFACE IS THE CHAMBER REFERENCE.

7 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 GIVEN. FOR SQUARE FIELDS THE LETTER S PRECEDES THE DIMENSION GIVEN. UNLESS OTHERWISE SPECIFIED 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.

8 THE EXPOSURE RATE AT WHICH THE CALIBRATION WAS PERFORMED. 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.

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## LIGHTLY FILTERED X RAYS

| BEAM CODE | CONSTANT POTENTIAL (KV) | DISTANCE (CM) | ADDED FILTER* AL (MM) | HALF-VALUE LAYER AL (MM) | HOMOGENEITY COEFFICIENT 1ST AL HVL/ 2ND AL HVL |
|---|---|---|---|---|---|
| L-B | 10 | 25 | 0 | .029 | 0.79 |
| L-C | 15 | 25 | 0 | .050 | 0.74 |
| L-D | 20 | 50 | 0 | .071 | 0.76 |
| L-E | 20 | 50 | 0.5 | .23 | 0.78 |
| L-G | 30 | 50 | 0.5 | .36 | 0.64 |
| L-I | 50 | 50 | 1.0 | 1.02 | 0.66 |
| L-K | 75 | 50 | 1.5 | 1.86 | 0.63 |
| L-M | 100 | 50 | 2.0 | 2.78 | 0.59 |

* INHERENT FILTRATION APPROXIMATELY 1.0 MM BE.

## MODERATELY FILTERED X RAYS

| BEAM CODE | CONSTANT POTENTIAL (KV) | ADDED FILTER* AL (MM) | ADDED FILTER* CU (MM) | HALF-VALUE LAYER AL (MM) | HALF-VALUE LAYER CU (MM) | HOMOGENEITY COEFFICIENT 1ST AL HVL/ 2ND AL HVL |
|---|---|---|---|---|---|---|
| MFB | 60 | 0 | 0 | 1.62 | | 0.68 |
| MFC | 60 | 2.50 | 0 | 2.79 | 0.090 | 0.79 |
| MFE | 75 | 2.51 | 0 | 3.39 | 0.116 | 0.74 |
| MFG | 100 | 3.50 | 0 | 5.03 | 0.20 | 0.73 |
| MFI | 150 | 3.49 | 0.25 | 10.25 | 0.66 | 0.89 |
| MFK | 200 | 3.49 | 0.50 | 13.20 | 1.24 | 0.92 |
| MFM | 250 | 3.50 | 1.01 | 15.80 | 2.23 | 0.92 |
| MFO | 250 | 3.47 | 3.20 | 18.30 | 3.25 | 0.98 |

* INHEPENT FILTRATION APPROXIMATELY 1.5 MM AL

## HEAVILY FILTERED X RAYS

| BEAM CODE | CONSTANT POTENTIAL (KV) | ADDED FILTER* AL (MM) | ADDED FILTER* CU (MM) | ADDED FILTER* SN (MM) | ADDED FILTER* PB (MM) | HALF-VALUE LAYER AL (MM) | HALF-VALUE LAYER CU (MM) | EFFECTIVE ENERGY (KEV) |
|---|---|---|---|---|---|---|---|---|
| HFC | 50 | 2.50 | 0 | 0 | 0.10 | 4.19 | 0.14 | 33 |
| HFE | 100 | 2.50 | 0 | 0 | 0.50 | 11.20 | 0.74 | 70 |
| HFG | 150 | 2.50 | 4.00 | 1.51 | 0 | 16.96 | 2.45 | 117 |
| HFI | 200 | 2.47 | 0.60 | 4.16 | 0.77 | 19.60 | 4.09 | 167 |
| HFK | 250 | 2.50 | 0.60 | 1.04 | 2.72 | 21.55 | 5.25 | 210 |

* INHERENT FILTRATION APPROXIMATELY 1.5 MM AL

## GAMMA RAYS

| RADIO-NUCLIDE | ENERGY (KEV) | CALCULATED CU HALF-VALUE LAYER (MM) |
|---|---|---|
| CS137 | 662 | 10.8 |
| CO-60 | 1250 | 14.9 |