NPL Report RSA(EXT) 50

National Physical Laboratory

Changes to the X-ray air kerma primary standards in the period 1 January 1970 to 31 December 1993

R F Angliss

April 1994

The National Physical Laboratory is an Executive Agency of the Department of Trade and Industry

RSA(EXT) 50

April 1994

Changes to the X-ray air kerma primary standards in the period 1 January 1970 to 31 December 1993

R F Angliss
Division of Radiation Science and Acoustics
National Physical Laboratory
Teddington
Middlesex
United Kingdom
TW11 0LW

ABSTRACT

A summary is given of the changes to the NPL primary standards for X-ray exposure and air kerma since 1 January 1970. The effect on secondary standard instrument calibration factors of each change is tabulated and an overall factor calculated to correct calibration factors to the present basis.

© Crown copyright 1994

ISSN 0955-9655

National Physical Laboratory
Teddington, Middlesex, United Kingdom, TW11 0LW

Extracts from this report may be reproduced provided the source is acknowledged.

Approved on behalf of Chief Executive, NPL,
by Dr P Christmas, Head, Division of Radiation Science and Acoustics

CONTENTS

TABLES

1 INTRODUCTION

A number of changes have been made to the NPL primary standards for X-ray exposure and air kerma since 1970 to bring them into line with international recommendations. This report outlines the changes and summarises the changes necessary to correct calibration factors for therapy level beam qualities to the present conditions.

2 CORRECTION FOR HUMIDITY

Prior to 1 September 1979, X-ray calibrations were corrected to ambient conditions of dry air; as from that date to the present day factors have been corrected to 50% relative humidity[1]. To account for this change, calibration factors measured before September 1979 should be multiplied by a humidity correction factor (F_H). For all beam qualities up to and including 2.2.8[2] $F_H = 0.998$ and for quality 2.3.1 $F_H = 0.997$. For all calibration factors obtained from September 1979 $F_H = 1.000$.

3 50 kV PRIMARY STANDARD

A new primary standard was introduced in September 1979 for beam qualities from 2.4.1 to 2.4.11 and 2.1.1 to 2.1.4 [3]. A number of multiplying factors (F_P) have been calculated to enable calibrations obtained with the old primary standard free air chamber to be compared with those obtained with the new primary standard (see Table 1). These factors are dependent on the beam quality.

Table 1: Conversion from old to new 50 kV primary standard
For calibrations made prior to 1 September 1979

Beam Quality	Multiplying Factor (F_P)
2.4.1 - 2.4.2	1.020
2.4.3 - 2.4.5	1.015
2.4.6 - 2.4.11	1.010
2.1.1 - 2.1.4	1.005

Beam qualities 2.2.1 to 2.2.8 and 2.3.1 inclusive were not affected by the introduction of the new primary standard so for calculation purposes for these qualities $F_P = 1.000$ (Tables 3 and 4).

4 REVISED PHYSICAL CONSTANTS

Revised values for the mean energy per ion pair W_{air}/e, the energy fraction lost per ion pair g, graphite to air stopping power ratios for electrons and the ratio of mass energy absorption coefficients for air to graphite, were introduced in January 1992. These changes brought NPL into line with data recommended by the Comité Consultatif pour les Étalons de Mesure des Rayonnement Ionisants (CCEMRI) of the International Committee of Weights and Measures (CIPM) [4]. A correction to take account of the first two factors is given in Table 2 whilst the correction factors for the third and fourth factors are described in the next section.

Table 2: Multiplying factors due to revised values of physical constants
For calibrations prior to January 1992

Beam Quality	Exposure factor (F_E)	Air kerma factor (F_A)
All qualities other than 2.3.1	1.000	1.004
2.3.1	1.000	1.002

5 REVISED 2 MV PRIMARY STANDARD CORRECTION FACTORS

The corrections to the 2 MV primary standard cavity chambers for wall attenuation and scatter, and for lack of electronic equilibrium, have been recalculated using Monte Carlo techniques; the revised values were adopted on 1 January 1992. The calculations were made using the recommended values for the stopping power and mass energy absorption coefficient ratios[4]. To take account of this change calibration factors determined with the 2 MV cavity chambers prior to 1 January 1992 should be multiplied by 0.990 (F_B) to bring them into agreement with calibrations carried out at the present time.

6 SUMMARY

Calibration factors obtained before January 1992 can be converted to the conditions applying from January 1992 by multiplying by the factors (F) given in Tables 3 and 4. These are based on the factors discussed in Sections 2 to 5 above.

7 REFERENCES.

1 NPL. Reference ambient atmospheric conditions for X-ray calibrations.
X-ray Dosimetry Group Technical Memorandum No.4, September 1979

2 NPL. X-ray Exposure and Air Kerma Therapy-level Calibration Service.
Data Sheet DRSA Dh 002

3 NPL. Change in the primary standard of X-ray exposure for therapy-level medium energy X-rays (30 kV - 50 kV) and therapy-level low energy X-rays (8 kV - 50 kV).
X-ray Dosimetry Group Technical Memorandum No.5, September 1979.

4 Moretti, C J. Changes to the National Physical Laboratory Primary Standards for X-ray Exposure and Air Kerma.
Phys. Med. Biol,, 1992, **37**, 5, 1181-1183

Table 3: Calibrations in terms of X-ray exposure
Multiplying factors to convert measurements made prior to 1 January 1992 to the present day

Beam Quality	Period when calibrated at NPL	
	January 1970 to August 1979	September 1979 to December 1991
	$F = F_H \times F_P^* \times F_E$	
2.4.1	1.018	1.000
2.4.2	1.018	1.000
2.4.3	1.013	1.000
2.4.4	1.013	1.000
2.4.5	1.013	1.000
2.4.6	1.008	1.000
2.4.7	1.008	1.000
2.4.8	1.008	1.000
2.4.9	1.008	1.000
2.4.10	1.008	1.000
2.4.11	1.008	1.000
2.1.1	1.003	1.000
2.1.2	1.003	1.000
2.1.3	1.003	1.000
2.1.4	1.003	1.000
	$F=F_H \times F_E$	
2.2.1	0.998	1.000
2.2.2	0.998	1.000
2.2.3	0.998	1.000
2.2.4	0.998	1.000
2.2.5	0.998	1.000
2.2.6	0.998	1.000
2.2.7	0.998	1.000
2.2.8	0.998	1.000
	$F=F_H \times F_E \times F_B$	
2.3.1	0.987	0.990

* For calibrations between September 1979 and December 1991 F_H and F_P are 1.000

Exposure calibrations obtained since January 1992 require no correction as they were made under the present calibration conditions.

Table 4: Calibrations in terms of air kerma
Multiplying factors to convert measurements made prior to 1 January 1992 to the present day

Beam Quality	Period when calibrated at NPL	
	January 1970 to August 1979	September 1979 to December 1991
	$F = F_H \times F_P^* \times F_A$	
2.4.1	1.022	1.004
2.4.2	1.022	1.004
2.4.3	1.017	1.004
2.4.4	1.017	1.004
2.4.5	1.017	1.004
2.4.6	1.012	1.004
2.4.7	1.012	1.004
2.4.8	1.012	1.004
2.4.9	1.012	1.004
2.4.10	1.012	1.004
2.4.11	1.012	1.004
2.1.1	1.007	1.004
2.1.2	1.007	1.004
2.1.3	1.007	1.004
2.1.4	1.007	1.004
	$F=F_H \times F_A$	
2.2.1	1.002	1.004
2.2.2	1.002	1.004
2.2.3	1.002	1.004
2.2.4	1.002	1.004
2.2.5	1.002	1.004
2.2.6	1.002	1.004
2.2.7	1.002	1.004
2.2.8	1.002	1.004
	$F=F_H \times F_A \times F_B$	
2.3.1	0.989	0.992

* For calibrations between September 1979 and December 1991 F_H and F_P are 1.000

Air kerma calibrations obtained since January 1992 require no correction as they were made under the present calibration conditions.