2007 International Nuclear Atlantic Conference - INAC 2007
Santos, SP, Brazil, September 30 to October 5, 2007
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: 978-85-99141-02-1

LINEARITY OF THE AIR KERMA VALUES IN RELATION TO EXPOSURE TIMES IN A DENTAL X RADIATION SYSTEM.

Paula S.S. Andrade and Maria da Penha A. Potiens[1]

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
psasaki@ipen.com.br
mppalbu@ipen.br

ABSTRACT

The objective of this study was the evaluation of a dental X radiation system intensity variation studying the linearity of the air kerma rate in relation to the exposure time. This study was performed in a Dabi Atlante dental X radiation system. For the exposure time measurements the cone spacer was positioned perpendicular to the detector and the time was varied from 0 to 1.5s. The air kerma measurements were made in the same conditions for FDD=20.0 cm and 27.5 cm. After that, the obtained values were plotted and a linear adjust was done for each set of measurements. The results showed that the maximum variation obtained was 7% for the third group of measurements for the exposure time of 1.5s. This variation is less than the recommended limit of 20% published by the Brazilian Health Ministry Regulation 453.

1. INTRODUCTION

The assessment and control of the performance characteristics of X-ray generators and tubes is an essential part of a quality assurance programme, considering that the extensive use of X-rays in medicine for diagnosis of injuries and diseases represents the largest man-made source of public exposure to ionizing radiation[1].

The Brazilian Health Ministry Regulation 453, published in June 1998, established basic lines of radiological protection in medical and dental diagnostic radiology, in order to guarantee the health of patients, workers and of the public[2] . In dental area, one of the recommendations is the evaluation of the air kerma values linearity in relation to exposure times.

In order to obtain high quality images, the knowledge of the characteristic curve of the photographic film is essential to find the best contrast region and the best range of exposure time [3]. Therefore, it is very important the knowledge of the air kerma rates and exposure time and their relation must be linear with the maximum deviation less than 20% [2].

The objective of this study is the evaluation of a dental X radiation system intensity variation studying the linearity of the air kerma rate in relation to the exposure time.

2. MATERIALS AND METHODS

The measurements were carried out in a dental X rays machine, Dabi Atlante, model Spectro 70X Seletronic. Its nominal characteristics are: 70 kVp of tube voltage, 8 mA of tube current, inherent filtration of 0.51mmAl and additional filtration of 1.4 mm. The determination of air kerma linearity is part of this system quality control programme, other tests have already been performed [4,5].A Gammex full-function meter with ionization chamber, model RMI 242 was used to measure the air kerma values and the exposure times were measured with a Fabinject instrument, model Dual-Meter. Both instruments were calibrated by IPEN/CNEN-SP and IEE/USP, respectively. They are all represented in Fig. 1.

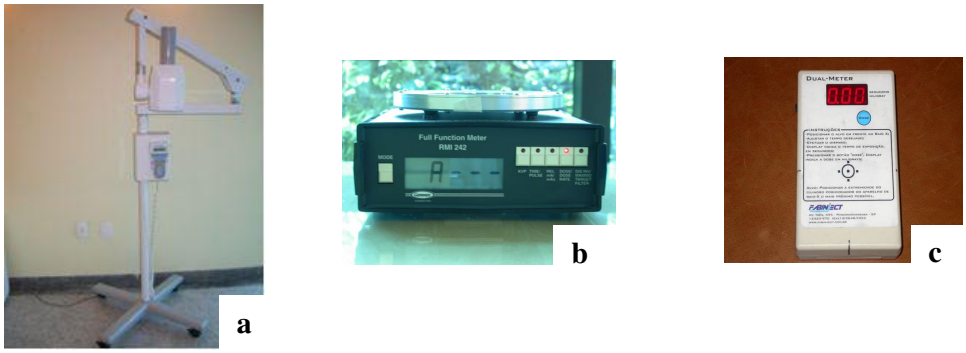

Figure 1. a) Dental X rays machine, Dabi Atlante; b) Gammex full function (ionization chamber); c) Exposure time meter Fabinject, model Dual-meter

For the exposure time measurements the cone spacer was positioned perpendicular to the detector at a focus-detector distance of 20.0 cm (FDD) and the time was varied from 0 to 1.5s, in three series of five measurements each. The air kerma measurements were made in the same conditions for FDD=20.0 cm and d 27.5 cm. The used set-ups to make these measurements are in Fig.2.

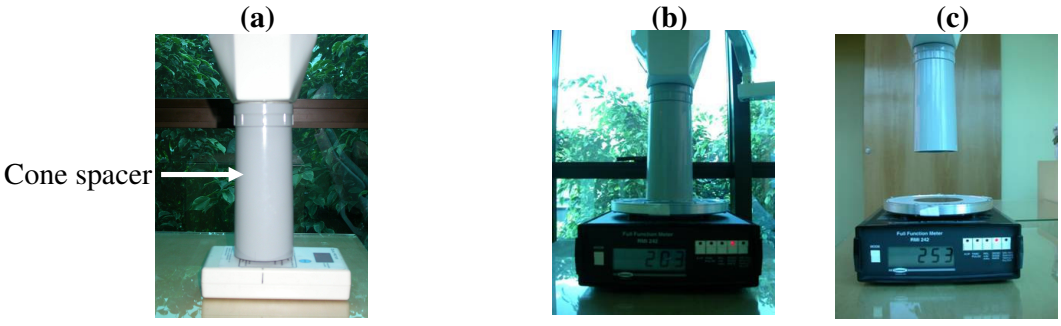

Figure 2. Set-ups of measurement : a) Exposure time b) air kerma values, FDD=20.0 cm and c) air kerma values, FDD= 27.5 cm

3. RESULTS

The results obtained for exposure times, Table 1, showed a variation between the nominal and the measured value always less than 10%, as recommended by publication 453 [2]. In this system the nominal values are normally corrected by the exposure times measured by the X radiation system itself depending on line voltage. For example, in the third measurement to the series 3 the nominal value was corrected to 1.646 seconds, which means a difference of only 0.84%.

Table 1. Measured exposure times with the Fabinject detector.

Nominal exposure time (s)	Measured exposure time (s)		
	Series 1	Series 2	Series 3
0	0	0	0
0.50	0.5480±0.0020	0.524±0.009	0.502±0.009
1.00	1.0340±0.0024	0.992±0.009	0.994±0.029
1.50	1.538±0.012	1.478±0.010	1.660±0.014

The air kerma values measurements for nominal exposure times from 0.0 to 1.5 seconds made for FDD= 20.0 cm and 27.5 cm are described in Tables 2 and 3. The maximum variation obtained for the measured air kerma values was 4.8% between the different exposure times and distances.

Table 2. Air kerma values (K) and associated exposure time (t) to FDD = 20.0 cm, obtained using the ionization chamber of the Gammex meter.

Nominal exposure time (s)	**Serie 1**		**Serie 2**		**Serie 3**	
	K (mGy)	t **(s)**	**K (mGy)**	t **(s)**	**K (mGy)**	t **(s)**
0	0	0	0	0	0	0
0.50	0.869±0.008	0.534±0.004	0.862±0.004	0.546±0.011	0.880±0.003	0.530±0.000
1.00	1.769±0.006	1.036±0.009	1.721±0.006	1.082±0.005	1.8030±0.0023	1.050±0.006
1.50	2.657±0.006	1.632±0.008	2.644±0.005	1.624±0.010	2.689±0.008	1.572±0.018

Table 3. Air kerma values (K) and associated exposure time (t) to FDD = 27.5 cm, obtained using the ionization chamber of the Gammex meter.

Nominal exposure time (s)	Serie 1		Serie 2		Serie 3	
	K (mGy)	t **(s)**	**K (mGy)**	t **(s)**	**K (mGy)**	t **(s)**
0	0	0	0	0	0	0
0.50	0.758±0.004	0.530±0.005	0.738±0.006	0.5440±0.0024	0.766±0.008	0.540±0.000
1.00	1.525±0.009	1.054±0.004	1.540±0.018	1.038±0.052	1.540±0.004	1.102±0.005
1.50	2.348±0.015	1.598±0.007	2.374±0.011	1.384±0.007	2.395±0.035	1.520±0.059

After that, the obtained values, Table 2 and 3, were plotted and a linear adjust was done for each set of measurements, as shown in Fig. 3

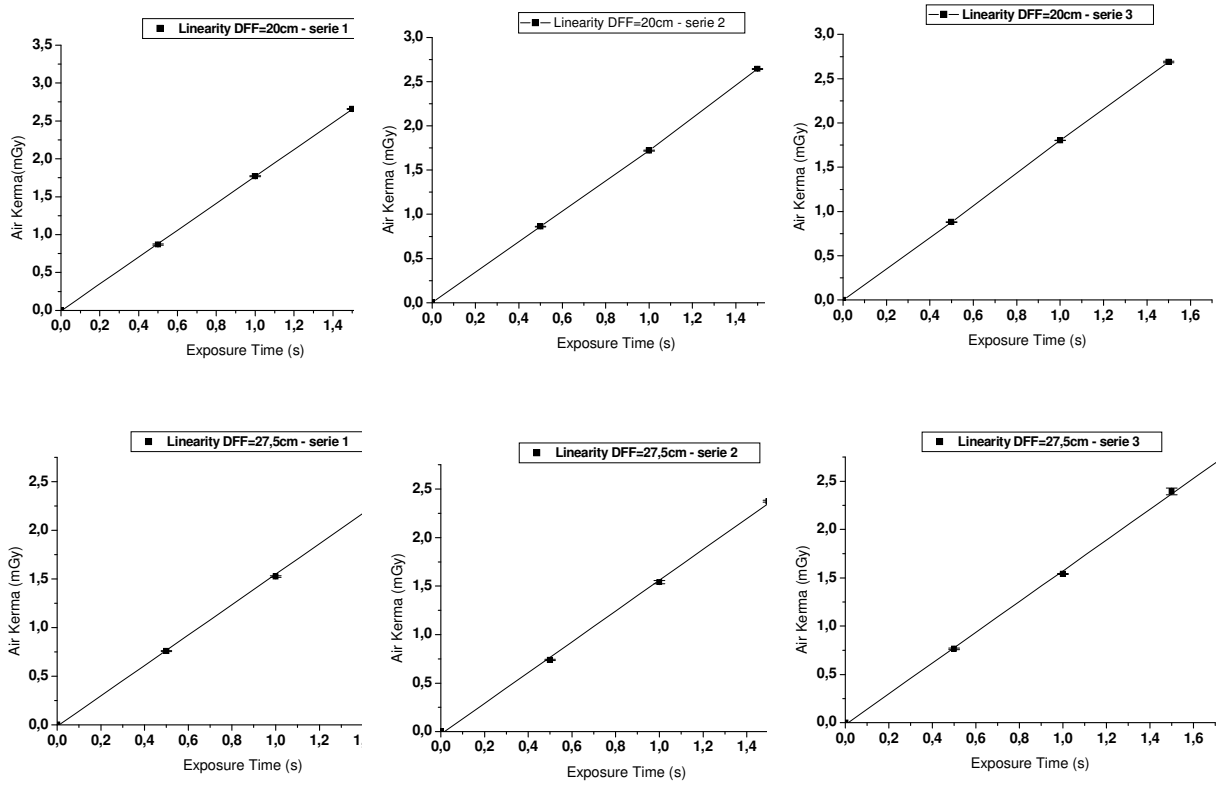

Figure 3. Linear adjust for each series of air kerma measurements in relation to exposure time for 0, 0.5, 1 and 1.5 s.

The linear adjusts showed that the maximum variation obtained was 7% for the third group of measurements for the exposure time of 1.5s to the FDD 27.5 cm. This variation is less than the recommended limit of 20% published by the Brazilian Health Ministry Regulation 453.

4. CONCLUSIONS

The assessment and control of the performance characteristics of dental X-ray generators and tubes is an essential part of a quality assurance programme and must follow specific requirements as showed in the methodology applied in this study.

ACKNOWLEDGMENTS

The authors are thankful to CNPq, FAPESP and FINEP for partial financial support.

REFERENCES

1. S.C. Bushong, *Radiologic Science for Technologists: Physics, Biology and Protection.* Mosby-Year Book Incorporation, St. Louis, MO, USA (1997).
2. Brazilian Health Ministry publication 453. *Diretrizes básicas de Proteção Radiológica em Radiodiagnostico Médico e Odontológico*. Ministério da Saúde, Portaria Federal 453. Diário Oficial da União, Brasília, Brazil (1998).
3. L.E. Bryant, P. McEntire,. *Radiography and radiation testing*. American Society for Nondestructive Testing - Nondestructive Testing Handbook, 2nd ed.; EUA (1985).
4. P.S.S. Andrade, M.P.A. Potiens, "Implementação de um procedimento para a avaliação de kV aplicado em tubos de raios X odontológicos", *Proceeding of 2005 International Nuclear Atlantic Conference - INAC 2005,* Santos, SP, Brazil, August 28 to September 2. CD-ROM (2005).
5. P.S.S. Andrade, M.P.A. Potiens, **"**Evaluation of the Field Size in Dental Diagnostic Radiology System**"**, *Proceeding of Second European IRPA Congress on Radiation Protection*, Paris, France, May 15 to 19, CD-ROM (2006).