Appl. Radiat. Isot. Vol. 45, No. 1, pp. 31–33, 1994
Printed in Great Britain.

0969-8043/94 $6.00 + 0.00

Calibration Techniques for Components of Clinical Dosemeters

LINDA V. E. CALDAS, MARIA DA PENHA P. ALBUQUERQUE and MARCOS XAVIER

Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear, Caixa Postal 11049, Pinheiros, CEP 05422-970, São Paulo, Brazil

(Received 14 December 1992; in revised form 24 May 1993)

The clinical dosemeters are normally calibrated in gamma and x-radiation fields as whole systems (i.e. ionization chamber plus a measuring assembly) in relation to secondary standards, at the Calibration Laboratory of São Paulo. In order to allow the users to send only components for recalibration, a procedure for those who own some ionization chambers and only one electrometer (as is very common), techniques of calibration for such components were compared in the present work, using a standard capacitor and a standard current source based on a radioactive source. The results obtained with these two methods showed a difference lower than 0.7%.

Introduction

Since 1980 the Calibration Laboratory of São Paulo has participated with its secondary standards in the national intercomparisons organized every year by the Secondary Standard Dosimetry Laboratory (SSDL) of Brazil, Instituto de Radioproteção e Dosimetria, Rio de Janeiro. The Laboratory of São Paulo offers calibration services with gamma radiation of ^{60}Co and ^{137}Cs, and low energy x-radiation (60 kV).

According to the national regulations in Brazil, every clinical dosemeter user has to send its system every two years for recalibration at any of the two calibration laboratories of Brazil. Some of these users own more than one ionization chamber (sometimes two or three thimble chambers and one soft x-ray chamber), but only one measuring assembly. Sometimes one of these chambers may have had its graphite part replaced and needs an extra recalibration. Normally the measuring assembly must accompany the chamber and the Radiotherapy Service cannot use any of the other chambers during the calibration period. Calibration of components should be indicated preferentially in this case. It would be necessary to send for recalibration only the chamber. Some calibration laboratories offer this kind of service.

Silva (1981) compared total calibration factors and calibration factors for components of standard dosemeters used at SSDL—Rio de Janeiro, employing as reference current source a system consisting of an ionization chamber and its radioactive check source. This procedure for the determination of component calibration factors was shown to be equivalent to the procedure for the determination of the overall calibration factors and thus may be used as a good quality control measurement in routine calibrations.

The objectives of the present work are to improve the calibration technique of clinical dosemeters, calibrating their components in gamma radiation (^{60}Co), using two different systems (a commercial standard current source and a reference standard capacitor), and to compare these results between themselves and with those of the calibration of the dosemeters as whole systems.

Experimental

Four clinical dosemeters were used for the tests. They are presented in Table 1; two of them belong to radiotherapy services (hospitals) and the others to the Calibration Laboratory. They were calibrated with gamma radiation of a ^{60}Co source (15 TBq) using a reference dosemeter, in the case of the total calibration method.

The secondary standard system for gamma radiation of the Calibration Laboratory of São Paulo consists of an electrometer, model 2560; an ionization chamber, model 2561; a radioactive check device, model 2562, all from Nuclear Enterprises Ltd, with calibration certificate from the National Physical Laboratory (NPL).

The calibration technique of substitution (IAEA, 1979, 1987) was used in the present work.

For the calibration of the components of a clinical dosemeter the following equipment was utilized:

(a) An electrometer Keithley Instruments, model 617, connected to an interface (made

Table 1. Clinical dosemeters utilized for the performed tests. They are all of the Baldwin Farmer type, from Nuclear Enterprises Ltd

	Electrometer		Thimble chamber		
Dosemeter	Model	Serial No.	Model	Serial No.	Owner
A	2502/3	306	2505/3	2214	Hospital
B	2502/3	340	2505/3	2278	Hospital
C	2502	10241	2505/3	312	IPEN
D	2502/3	330	2505/3	2080	IPEN

during the present work) for ionization chambers. Figure 1 presents this interface scheme, based on the interface of the electrometer Keithley, model 6169, that is no longer commercially available. For the interface project, references as (Schreiner, 1966; Kemp and Woodall, 1968; Weiss, 1973; Zsdánszky, 1973; Santry *et al.*, 1987) were very helpful;

(b) A reference standard capacitor General Radio Co., type 1404-A, with a nominal capacity of 1000 pF and a real capacity of 1000.005 pF;

(c) A stabilized power supply Tectrol (Brazil), model TCH 3000, connected to a multimeter Keithley Instruments, model 177;

(d) A reference standard current source Physikalisch-Technische Werkstätten (PTW), type 2327. It consists mainly of a radioactive $^{90}Sr + ^{90}Y$ source (0.37 Bq), incorporated in the bottom of an ionization chamber PTW-SQK and a control unit PTW-SQN. It provides standard electric currents of 10^{-8}, 10^{-11}, 10^{-12}, 10^{-13} and 10^{-14} A. The beta radiation emitted from the radioactive source is totally absorbed within the ionization chamber. This system was calibrated at the German Primary Standard Dosimetry Laboratory, Physikalisch-Technische Bundesanstalt (PTB).

Results

The calibration factor obtained for the dosemeter as a whole system (total calibration method) and for each component can be seen in Table 2.

Initially electrometers were calibrated. Two different techniques were utilized. The first consisted in using the reference standard capacitor. The electrometers under calibration were connected to the Keithley 617 electrometer and to the capacitor. Then the electric charge was measured. The calibration factors are designed by f^e(cap). In order to confirm the confidence of the capacitor use, a comparison was made using the NPL secondary standard dosemeter. This procedure presented a percentual deviation variation from 0.10 to 0.14%. For the second technique, the PTW standard current source was used connected to the electrometer. The ionization current was measured during a fixed time interval and the electric charge was obtained by the product of the current by the time period. The calibration factors, f^e(cur), are very similar to those obtained using the capacitor; they differ between 0.10 and 0.36%.

In the case of the Baldwin Farmer (BF) type, model 2502, S 10241, it was not possible to determine the calibration factor through the capacitor method, because this electrometer has a circuit limitation for it. In this case the electrometer was calibrated using the current produced by the thimble chamber NE 2505/3 introduced in a reference check device and the measurements were taken at the Keithley 617 electrometer.

The second part of the work consisted in determining the calibration factors of ionization chambers (f_c). The Keithley 617 electrometer was utilized with

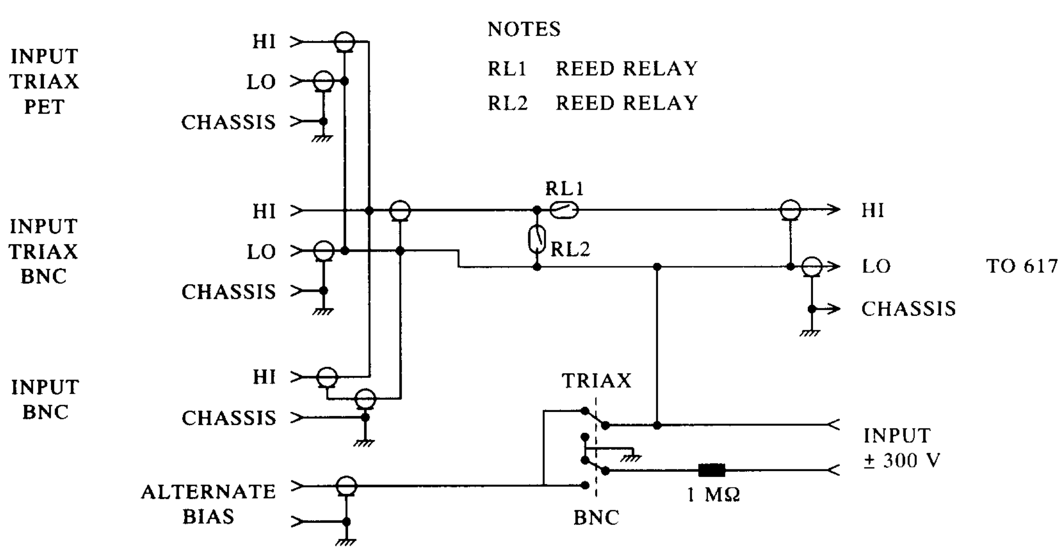

Fig. 1. Schematic circuit of the interface for the coupling of ionization chambers to the Keithley 617 electrometer.

Table 2. Calibration factors obtained from the calibration for components and the whole system

Dosemeter	f^e(cap) (nC/s.u.)	f^e(cur) (nC/s.u.)	f_c (R/nC)	$f_c \times f^e$(cap) (R/s.u.)	$f_c \times f^e$(cur) (R/s.u.)	f_c^e (R/s.u.)
A	0.2196	0.2204	4.64	1.019	1.023	1.016
B	0.2216	0.2220	4.56	1.010	1.012	1.016
C	0.1862*	0.1902	5.82	1.084	1.108	1.087
D	0.2177	0.2180	4.65	1.013	1.015	1.016

f^e(cap), Calibration factor of the electrometer, using the capacitor.
f^e(cur), Calibration factor of the electrometer, using the current source.
f_c, Calibration factor of the ionization chamber.
f_c^e, Total calibration factor (whole system calibrated).
s.u., Scale unit.
*Calibration factor determined using the Keithley 617 electrometer and a N.E. thimble ionization chamber (2505/3).

the interface, exposing the chambers to the gamma radiation of ^{60}Co and using as reference chamber the already described secondary standard. The factor obtained for the thimble chamber 2505/3, S 2080, does not differ from that determined by the Secondary Standard Dosimetry Laboratory of Rio de Janeiro (4.65 R/nC). This chamber was later also calibrated at the SSDL of Institut für Strahlenschutz, GSF, Neuherberg, Germany; the obtained calibrated factor (4.654 R/nC) for gamma radiation of ^{60}Co differed by $<0.10\%$ from that obtained in São Paulo and Rio de Janeiro. This result shows an agreement among the applied procedures in three different laboratories.

The determination of the total calibration factors (f_c) in gamma radiation fields of ^{60}Co, using the secondary standard, made up the final stage of the work. These results were comparable to those obtained by the multiplication of partial calibration factors $f_c \times f^e$(cap) and $f_c \times f^e$(cur), presenting differences of 0.29–0.59% in the case of the capacitor use and of 0.10–0.69% in the case of the current source use. However, for the electrometer S 10241, which calibration factor was determined using the Keithley electrometer as already explained, the difference was 1.9%, a value comparable to the associated uncertainties of secondary standard dosemeters (IAEA, 1979).

Conclusion

The calibration technique for components of a clinical dosemeter can be applied, using either a standard capacitor or a standard current source. The obtained differences are all smaller than the uncertainties (normally around 2.5%) determined in routine calibration work of clinical dosemeters with gamma radiation of ^{60}Co at the Calibration Laboratory of São Paulo. This method constitutes one of the preliminary tests, when the whole system (complete clinical dosemeters) is received for recalibration, increasing the quality control programme of the procedure.

Acknowledgements—The authors acknowledge the technical assistance of Dipl.-Phys. H. Eckerl and Eng. U. Nahrstedt during the calibration period of one of the ionization chambers at Institut für Strahlenschutz, GSF, Neuherberg, Germany.

References

IAEA (1979) Calibration of dosemeters used in radiotherapy. *Technical Report Series No. 185.* IAEA, Vienna.
IAEA (1987) Absorbed dose determination in photon and electron beams. An international code of practice. *Technical Report Series No. 277.* IAEA, Vienna.
Kemp L. A. W. and Woodall J. E. (1968) Evaluation of high insulation dry-reed switch for electrometer applications. *Electronic Engng*, 236 (May).
Santry D. C., Bowes G. C. and Munzenmayer K. (1987) Precision electronics for ionization chamber measurement. *Appl. Radiat. Isot.* **38,** 879.
Schreiner R. S. (1966) Current integrating or charge measuring considerations. *Electronic Industries* (May).
Silva T. A. (1981) Experimental comparison between total calibration factors and calibration factors for components of standard dosemeters used at SSDL Rio de Janeiro. M.Sc. Thesis. COPPE-Federal University of Rio de Janeiro, Brazil.
Weiss H. M. (1973) 4π-γ Ionization chamber measurement. *Nucl. Instrum. Methods* **112,** 291.
Zsdánszky K. (1973) Precise measurement of small currents. *Nucl. Instrum. Methods* **112,** 299.