CALIBRATION OF MEDICAL LINEAR ACCELERATORS IN LOUISIANA USING TASK GROUP 21 PROTOCOL

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ABSTRACT

The model 10 x 5-0.6 MDH ion chamber, the MDH series 1015 x-ray monitor and the Mark II SCRAD calibration phantom for high energy dosimetry were used to ascertain dose outputs from the medical linear accelerators in the State of Louisiana. Using Task Group 21 Protocol, the value for the Ngas in the ion chamber was first determined. Twenty-five medical linear accelerators were assessed for dose to water per monitor unit at dmax using the MDH system. The nominal accelerating potentials for the photons were from 3.1 MV to 12.8 MV. Ratios of TG-21/SCRAD were determined for each accelerator. For accelerators which had been calibrated by the resident medical physicist using TG-21 Protocol, the agreement was within 0.5% in most cases.

INTRODUCTION

For many years Regulatory Agencies in almost every state in the United States have been using the MDH system for routine calibration of diagnostic x-ray equipment. The MDH has proven to be very reproducible, sturdy, and easily carried by inspectors who may visit several facilities each day.

Due to the large increase in the number of linear accelerators installed for cancer therapy in the U.S., it is an advantage to have a portable system for assessing the calibration of the high energy machines. Task Group 21 of the American Association of Physicists in Medicine has provided a new Protocol for the determination of absorbed dose for high energy photon and electron beams [1]. However, nothing is available in the literature for any of the values needed to calculate Ngas for the model 10 x 5 - 0.6 MDH ion chamber when used with the acrylic portable calibration phantom, Mark II SCRAD.

RESULTS

The model 10 x 5 - 0.6 ion chamber is one of a series of plug-in chambers designed for use with the MDH series 1015 x-ray monitors. The 0.6 ion chamber has an outer wall of delrin which is 0.508 mm. The inner wall of air equivalent conducting plastic is also 0.508 mm. According to the prints supplied by MDH Industries, Inc., the inner and outer walls are separated by 0.305 mm of air gap. The electrode, 0.1321 cm in diameter, is made of air equivalent conducting plastic. A cavity inside diameter of 6.50 mm was used. Using a density of 1.04 g/cm 3, the thickness of the wall material was determined to be 0.106g/cm 2. The Nx value of 0.997 R/scale division, Aion equal to 0.999, and correction of 1.011 for change in National Bureau of Standards Co-60 calibration on March 7, 1986 was provided by the calibration laboratory of K & S Associates of Nashville, Tennessee. From the other values of Awall = 0.998, α = 0.46, (L/ρ) wall/air = 1.112, (u/ρ) air/wall = 0.928, (L/ρ) cap/air = 1.087 and (u/ρ) air/cap = 0.937.

The ratio of Ngas/Nx was calculated to be 8.499 x 10 -3 Gy/R from the following equation:

$$\mathrm{Ngas/Nx} = K\,(W/e)\,\mathrm{Aion\ Awall\ Bwall}\,(L/\rho)\,\mathrm{wall/air}\,(u/\rho)\,\mathrm{air/wall} + (1-\alpha)\,(L/\rho)\,\mathrm{cap/air}\,(u/\rho)\,\mathrm{air/cap} \quad (1)$$

where K = 2.58 x 10 -4 C/kgR, (W/e) = 33.7 J/C, Bwall = 1.005 If one multiplies 8.499 x 10 -3 Gy/R by 0.997 (R/scale division) and divides by 1.011, a value of 8.38 x 10 -3 (Gy/scale division) is obtained for Ngas.

For a photon beam, the MDH reading (R/monitor unit) can then be multiplied by 8.499 x 10 -3 Gy/R and divided by 8.38 x 10 -3 (Gy/scale division) to obtain the scale division/monitor unit (M/u). Then Dmedium/u can be calculated from:

$$\mathrm{Dmedium/u} = (M/u)\,\mathrm{Ngas}\,(L/\rho)\,\mathrm{med/air\ Pwall\ Pion\ Prepl} \quad (2)$$

The nominal accelerating potential for each accelerator could not be determined since the SCRAD phantom could not be divided into 8.8 cm and 17.6 cm depth blocks. The nominal accelerating potentials were obtained either from the medical physicist at each center or from appropriate literature. For accelerators visited, the nominal accelerating potentials were close to the five values listed below. From these nominal accelerating potentials, appropriate values needed to solve equation (2) can be found in the tables of reference [1]. The Dmedium/u for a particular nominal accelerating potential can then be determined by multiplying the factor listed in the table below times the reading on the MDH/100 mu and pressure correction. Temperature corrections were not necessary since the MDH has a thermistor incorporated in its electronics which automatically compensates for variation in tmeperature. This thermistor was checked by K & S Associates and observed to be functioning properly. Room temperatures were recorded at each accelerator for possible later reference.

NAP	FACTOR
3.1	9.34 x 10 -3
4.3	9.301 x 10 -3
5.5	9.273 x 10 -3
9.0	9.206 x 10 -3
12.5	9.147 x 10 -3

NAP = Nominal accelerating potential (MV)

$$\mathrm{Factor} = [(8.499.10\text{-}3)\,(L/\rho)^{\mathrm{med}}_{\mathrm{air}}\,\mathrm{Pwall\ Pion\ Prepl}]$$

From ESC, the correction for excess scatter from the acrylic phantom, (u/ρ) water/medium and % depth dose, the dose to water per monitor unit at dmax can then be calculated. The results obtained from twenty five linear accelerators are given below. Several accelerators were visited before the value of Ngas had been calculated. At that time a SCRAD type calculation was performed usually at a depth of 8 cm in the acrylic. After completion of the Ngas calculations, those values using

Task Group 21 at 8 cm depth were higher than expected. Values subsequently measured with the 0.6 ion chamber at dmax in the acrylic gave excellent agreement.

For facilities which had converted to Task Group 21 Protocol, % error values obtained with the MDH and a recent calibration by the resident medical physicist are listed. Positive% error indicates a higher MDH value obtained. It is interesting to note that the ratio of Task Group 21 values to SCRAD values are considerably greater than one (1). Also, a higher ratio is usually seen for the higher energy machine. This ratio indicates, as one expects, that facilities using SCRAD Protocol are over dosing as compared to physicists using Task Group 21 Protocol.

F	S.E. (MV)	NAP (MV)	$\frac{Dw}{u}$	De (cm)	TG/SC	% E
1	4	3.1	1.106	8	1.022	
2	4	3.1	1.127	8	1.022	
3	4	3.1	1.035	1	1.023	
4	4	3.1	1.040	1	1.024	+0.29
5	4	3.1	1.0065	8	1.032	
6	4	3.1	1.016	1	1.023	
7	4	3.1	1.062	8	1.023	
8	6	5.5	1.045	8	1.028	+3.80
9	6	5.5	0.992	1.5	1.029	
10	6	4.3	1.023	1.5	1.020	
11	6	4.3	1.047- 1.006	8/1.5	1.01- 1.02	+0.60
12	6	4.3	1.023	1.5	1.020	
13	6	4.3	1.033	1.5	1.019	+0.48
14	6	4.3	1.023	1.5	1.020	
15	6	5.5	1.030	1.5	1.029	
16	6	4.3	0.975	1.5	1.009	-2.60
17	6	4.3	1.023	1.5	1.023	-1.56
18	10	9.0	1.028	2.5	1.031	
19	10	9.0	1.036	2.5	1.036	-0.70
20	10	9.1	1.019	2.5	1.038	
21	10	9.0	1.051	8	1.036	
22	10	9.0	1.057- 1.006	8/2.5	1.036- 1.044	
23	10	9.0	0.913	2.5	1.036	-9.52
24	15	12.45	1.024	8	1.034	+2.45
25	15	12.8	0.991	3	1.022	

F = Facility; S.E. (MV) = Stated Energy (MV); NAP (MV) = NAP (MV); Dw/u = Dwater/u; De (cm) = Depth (cm); TG/SC = TG-21/SCRAD; % E = % Error.

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REFERENCE

[1] Task Group 21, Radiation Therapy Committee, American Association of Physicists in Medicine, "A Protocol for the Determination of Absorbed Dose From High-Energy Photon and Electron Beams," Medical Physics, vol. 10, No. 6, pp 741-771, Nov./Dec., 1983.