Evaluation of Accuracy of Accumulated Dose of OB85 Gamma Irradiator

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Abstract: ***The purpose of this experiment was to evaluate the accuracy of accumulated doses used in irradiation and determination of transition timer error of sources in the OB85 Gamma Irradiator installed in Secondary Standard Dosimetry Laboratory at Atomic Energy Authority, Sri Lanka. Accumulated dose is measured using calibrated reference electrometer system (Electrometer: PTW, Model No: UNIDOS, S/No: 20567 and Ion chamber: 600cc, Model No: 2575C, S/No: 459) and compared with the calculated accumulated dose (= ref. dose rate x time) using reference dose rate and respective value of the timer of OB85. The experiment shows that, the transient time of the OB85 gamma irradiator is 1sec. The result concludes that minimum distance for accumulated dose below 1 mSv should be irradiated at 3m distance and 1mSv or above accumulated radiation doses should be irradiated at 1m distance in order to achieve accuracy at least 1%.***

Keywords: Electrometer, Ion chamber, accumulated radiation dose, Irradiator

1. Introduction

A Secondary Standard Dosimetry Laboratory (SSDL) is a laboratory which has been designated by competent national authorities to undertake the duties of providing the necessary link in the traceability of radiation dosimetry to national/international standards for users within that country. An SSDL is equipped with secondary standards which are traceable to the primary standards of laboratories participating in the international measurement system (Primary Standard Dosimetry Laboratories (PSDLs) and the Bureau International des Poids et Mesures (BIPM). SSDLs was set up to improve dosimetric accuracy in radiation dosimetry.

OB85 irradiator (fig.1 (a)) is a protection level dual source irradiator (Cs-137 source and Co-60 source). The irradiator operated through a remote control panel. The remote control panel includes a digital timer for documentation of actual exposure time and for precise termination of irradiation, and emergency stop button.

Electrometer-ion chamber system (Electrometer: PTW, Model No: UNIDOS, S/No: 20567 and Ion chamber: 600cc, Model No: 2575C, S/No: 459) is used for measuring of radiation dose rates in various distances in Secondary Standard Dosimetry Laboratory (SSDL) of Atomic Energy Authority, Sri Lanka.

Electrometer is a micro processor controlled universal field class dosimeter for measuring dose and dose rate in radiation therapy, diagnostic x-ray and radiation protection. Electrometer is prepared for measuring with ionization chamber, semi conductor probes and other solid state probes. The electrometer provides the two measuring modes “dose” and “dose rate”. Measuring mode “dose”: Dose and charge measurements by charge collection on a capacitor. Two capacitors are accessible for the measuring range low and high.

Measuring mode “dose rate”: Dose rate and current measurement by measuring the voltage drop at a resister. Three resistors are accessible for the measuring range low, medium and high.

Figure 1: (a) OB85 Gamma Irradiator (b) 600 cc thin window ionization chamber (c) Electrometer (PTW, UNIDOS)

The 600cc thin window ionization chamber (fig.1 (b)) transduce X, gamma, beta, and electron radiation into an electric current. It is used for the dosimetry of these at high level protection dose rates. When suitably calibrated and with the appropriate window fitted, the ionization chamber can be used to measure exposure in air to photons and skin dose in tissue from beta particles and electrons.

This system (Electrometer and Ion chamber) converts ionization radiation into electrical chargers in order to indicate radiation dose rate in mGy/h. Ion chamber is used to ionize the air and convert the radiation energy into electrical energy, electrometer is used to apply the high voltage into the ion chamber and measure the collected charge of the ion chamber. Currently 600cc and 10*l* ion chambers use in SSDL for measuring of low radiation doses and high doses respectively.

2. Experiment

2.1 Accuracy of Accumulated Dose of OB85 Gamma Irradiator

Accumulated dose is measured using calibrated reference electrometer system (Electrometer: PTW, Model No: UNIDOS, S/No: 20567 and Ion chamber: 600cc, Model No: 2575C, S/No: 459) and compared with the calculated accumulated dose (= ref. dose rate x time) using reference dose rate and respective value of the timer of OB85.

The ion-chamber was placed on the calibration cart at the centre of the radiation beam, at 1 m and connected to the electrometer for measurements. Leave the electrometer system for 1 hr for stabilization. Then pre-irradiation was performed of the chamber for about 3 mSv. The initial pressure and temperature in the irradiation room were recorded. After pre-irradiation the leakage readings of the electrometer were recorded. Then the timer of the OB85 for 0.1mSv dose at 1m distance was set. The initial pressure and temperature in the irradiation room were record. (0.1 mSv is the calculated accumulated dose using the timer of OB85).

The chamber was irradiated using Cs-137 and the electrometer reading, temperature and pressure were recorded. Similarly, five consecutive readings were obtained. After obtaining a set of readings, leakage readings were checked once again and calculated leakage corrected reading. Then temperature/pressure corrections (true value) were applied. The above procedure was repeated to obtain doses at selected distances. Then % error for each accumulated dose at each distance was calculated. This procedure was repeated from 0.2 mSv to 5 mSv.

2.2 Transition Time of Radiation Sources of OB85 Gamma Irradiator

Calibrated reference electrometer system was used for this measurement. The ion-chamber was placed on the calibration cart at the centre of the radiation beam, at 3 m and connected to the electrometer for measurements. Leave the electrometer system for 1 hr.

Pre-irradiation was performed of the chamber for about 3 mSv. The initial pressure and temperature in the irradiation room were recorded. The leakage readings of the electrometer after pre-irradiation were recorded. The timer of the OB85 was set for 12 min and the timer of the electrometer was set for 15 min. The initial pressure and temperature in the irradiation room were recorded. The chamber was exposed using Cs-137 and the electrometer reading, temperature and pressure were recorded. Then three consecutive readings were obtained. After obtaining a set of readings, leakage readings were checked once again and calculated leakage corrected reading. Then temperature/pressure corrections (This reading is equal to M_A, t_A =12 min) was applied.

Then the timer of the OB85 was set for 4 min and the timer of the electrometer was set for 15 min. Start electrometer first and the perform three consecutive exposures, each 4 min (immediately after completion of a exposure of OB85, the next exposure should be performed. Three exposures should be done within 15 min) and repeat the step number 7 to 10. The transition time of the source was calculated. (n=3, t_B = 12 min)

3. Results and Discussion

In this work, irradiation distances which are suitable for measure the accumulated radiation doses in order to achieve at least 1% accuracy are discussed. Timer error of the OB85 gamma irradiator is discussed as well. The timer of the OB85 for each dose at relevant distance was set and chamber was irradiated using Cs-137. After obtaining a set of readings, % error for each accumulated dose from 0.1 mSv to 1 mSv at each distance was calculated using the equation (1).

$$\% \text{ Error} = \frac{(\text{True value} - \text{Measured Value})}{\text{True value}} . 100 \quad (1)$$

Table 1: Data with % error obtained from measurements.

Distance (m)	*Ref. Dose rate of OB 85 (Use measured data Points (D^0)/(mSv/h)*	*OB 85 Timer Setting (S) (T)*	*Accumulated dose D^0xt =D (mSv)*	*Corrected electrometer results In $H_p(10)$ mSv (H) = Hp (10)*	*Actual exposure Time(T) H/D^0=t (S)*	*% Error of Timer (T-t) x100 / T*	*% dose Error (D-H) x 100 / D*
1	36.387	10	0.101	0.091	9	10	+9
1	36.711	49	0.500	0.486	48	2.04	+2.8
1	36.387	89	0.900	0.890	88	1.05	+1.1
1	36.376	99	1.000	0.992	98	0.85	+0.9
2	9.135	39	0.100	0.097	38	2.44	+3
2	9.135	394	1.000	1.003	395	-0.25	-0.3
3	4.053	89	0.100	0.099	88	1.12	+1
3	4.046	267	0.300	0.298	266	0.37	+0.6
3	4.046	445	0.500	0.498	444	0.22	+0.4
3	4.046	801	0.900	0.898	800	0.12	+0.2
4	2.260	149	0.094	0.099	158	-6.29	-5.3

According to the table no 01, table no 02 represent the suitable distances for each accumulated radiation doses which can measure with the maximum % error less than or equal to 1.

Table 2: Data with % error obtained from measurements

Accumulated Dose (mSv)	*Distance (m)*	*Error %*
0.1	3	+1
0.3	3	+0.6
0.5	3	+0.4
0.9	3	+0.2
1	1	+0.9
2	1	+0.9
≥5	1	+0.9

In the experiment, we observed the % error 0.9 for 1 mSv. Therefore accumulated radiation doses above 1 mSv have the % error less than or equal to 0.9. Therefore, 1m distance suitable for measure the 1mSv or above accumulated radiation doses and 3m distance suitable for measure the less than 1 mSv accumulated radiation doses.

Transition time of the sources in the OB85 Gamma Irradiator installed in Secondary Standard Dosimetry Laboratory is important to apply correction for accumulated dose if error is significant. Transition time is the time taken by the source (Cs-137/Co-60) to come to the irradiation position and time taken to go to the shield position after the irradiation.

Timer error can be calculated using the equation 2.
Timer error, ج= $(M_B t_A - M_A t_B) / (nM_A - M_B)$ (2)
$M_1 = M_A / (t_A +$ ج$)$

Where, M_1 is reading per unit time, M_A is the integrated reading in a time t_A , M_B is the integrated reading in n short exposures of time t_B/n.

Observations:
M_A = 3.3301 mGy/h t_A= 12 min M_B = 3.3394 mGy/h t_B = 12 min n=3

Calculations:
Substituting these value eqn (2),
ج= $(M_B t_A - M_A t_B)/(nM_A-M_B)$
= (3.3394 x 12 – 3.3301x 12) / (3x 3.3301-3.3394) = 0.01667 min
= 1.0001 s
Timer error (ج) is 1sec.

According to the experimental data, timer error is 1s. Timer error should be taken into account in irradiation if error is significant. According to the experimental data, timer error should not be taken into account because it is a very small value compare to the irradiation time.

4. Conclusions

1m distance suitable for measure the 1mSv or above accumulated radiation doses and 3m distance suitable for measure the less than 1 mSv accumulated radiation doses in order to archive at least 1% accuracy.

Timer error of the OB85 gamma irradiator is 1 s. Therefore, timer error should not be taken into account in irradiation.

5. Acknowledgement

The author thanks P.L.Jayasinghe for his guidance and the encouragement given to complete this study. He has always given his full support and has shared his valuable time to make this work success.

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