CALIBRATION OF RADIATION PROTECTION INSTRUMENTS AT SSDL LEVEL IN ISRAEL

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INTRODUCTION

The application of ionising radiation in medicine, industry and research in Israel has reached the same level relative to its population as in other industrialized countries. In order to achieve the maximum benefit from the use of ionising radiation, it is essential that dosimeters should be routinely calibrated with respect to the correct dose or dose rate indication. For this purpose, a Secondary Standard Dosimetry Laboratory (SSDL) was established in Israel in 1976. The main tasks of the laboratory have been in the field of therapy level dosimetry, and at present all radiotherapy facilities in Israel have at least one dosemeter calibrated at the laboratory.

In the last years there has been an increased demand for the calibration of protection level instruments. According to unofficial figures, there are in Israel several thousand instruments of this kind. In spite of the fact that the accuracy requirements for these instruments have been relaxed by one order of magnitude compared with therapy level instruments, the need for dose rates ranging from very low to very high values, and other technical problems make calibrations a difficult task.

The present work describes the actions taken at the Israeli SSDL in order to extend its activities down to the low dose region. Furthermore, preliminary results of the calibration of several typical instruments are presented.

FACILITIES

The set-up used for the calibration of protection level dosimeters is esentially the same as that used for therapy level instruments, except for the fact that a distance of 2 meters between the X-ray focus and the ionisation chamber is adopted. In order to allow continuous variation of the high tension and current of the X-ray generator, special modifications have been carried out. After the modifications, the X-ray generator can be operated at currents down to 0.5 mA, the stability of the high tension being better than 0.5%. In this way, constancy of the output up to ±1% is achieved.

Since the laboratory should be able to calibrate instruments over a wide range of intensities, different series of radiation qualities were adopted (Table 1).

TABLE 1. FILTERED X-RAY RADIATIONS USED AT THE ISRAELI SSDL

Series	Generating Voltage (kVp)	Additional filtration (mm) Pb	Sn	Cu	Al	HVL (mm)
	25			0.2		1.3 Al
Low	50			1.0		5.0 Al
Exposure	75		0.8	0.25	1.0	0.6 Cu
Rate	100		2.5	0.4	1.0	1.4 Cu
(about	125		4.5	0.4		2.1 Cu
50 mR/h)	150	0.9	3.0	2.0	0.8	3.0 Cu
	200	3.0	2.0	0.4	0.8	4.5 Cu
	25	Inherent (about 2 mm Al)				1.0 Al
	40			0.2		2.2 Al
Narrow	60			0.5		5.0 Al
Spectrum	80			2.0	2.0	0.6 Cu
(about	100			5.0	1.6	1.2 Cu
500 mR/h	120		1.0	4.8	0.8	1.8 Cu
	150		2.5	0.4	1.0	2.5 Cu
	200	0.9	3.0	2.0	0.8	4.1 Cu
	250	3.0	2.0	0.4	0.8	5.4 Cu
	60			0.2		3.4 Al
Wide	80			0.5		0.3 Cu
Spectrum	110			2.0	2.0	1.0 Cu
(about	145		0.8	0.25	1.0	1.8 Cu
5000 mR/h)	200		2.5	0.4	1.0	3.3 Cu
	250		4.5	0.4	1.0	4.3 Cu

The qualities adopted are similar to those recommended by ISO (1), except in the 10-50 keV region where filtered radiations are used instead of fluorescent radiations. A detailed discussion about the uncertainties introduced when fluorescent radiations are not used can be found elsewhere (2).

The reference instrument used at the laboratory is a 2550 NPL Protection Level Secondary Standard Dosimeter.

The instrument was originally calibrated at the National Physical Laboratory (UK), but owing to a leak in the chamber it was necessary to replace the rubber ballon, thus invalidating the calibration. The instrument with its new chamber was recalibrated at our laboratory, by comparing it against a 2560 Therapy Level Dosemeter. A high quality 30 c.c. chamber was used as the transfer instrument. It has been estimated that the uncertainties introduced during the transfer process are unlikely to exceed 4% at the 99% confidence level.

Since the use of radioactive sources for checking linearity of the instruments is involved with a considerable cost, it was decided to check this parameter by changing the current of the X-ray machine. For this purpose, a special gold coated transmission monitor chamber was designed by the German factory PTW. This chamber allows the monitoring of beam intensities down to 1 mR/h.

PRELIMINARY RESULTS

The following parameters have been measured during the setting up of the laboratory:

a) HVL
b) Beam homogeneity.
c) Reproducibility of the positioning of the instruments.
d) Reproducibility of the monitor system.
e) Energy dependence of the monitor chambers.
f) Long term reproducibility of the reference instrument.

Parameters of the instrument under test that will be evaluated are as follows:

a) Energy response
b) Linearity
c) Saturation characteristics
d) Directional dependence
e) Temperature dependence
f) Overload characteristics
g) β response
h) Neutron response
i) Transient characteristics

As an example, Figure 1 shows the energy response of some typical instruments used in Israel, while Figure 2 shows the saturation characteristics of a Nuclear Enterprises 30 c.c. chamber. It is evident that owners of radiation protection dosimeters should be aware of these characteristics before choosing the most suitable instrument for a particular application. For instance, the use of an Elscint GSM-1 Geiger Counter might introduce an error of up to 300%, while the use of a Nuclear Enterprises 30 c.c. for the measurement of pulses of radiation (for instance the output of an X-ray machine) will also introduce a significant error.

FUTURE ACTIVITIES OF THE ISSDL

The Soreq branch of the ISSDL is installing a Manganese bath for the absolute calibration of neutron sources. In addition its facilities are scheduled to perform calibrations of radiation protection monitors for neutron and beta radiation. A set of sources produced by Buchler (FRG) and calibrated

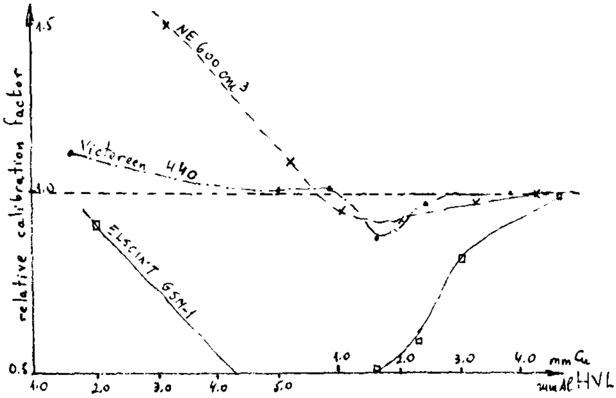

Figure 1. Energy dependence of some typical instruments.

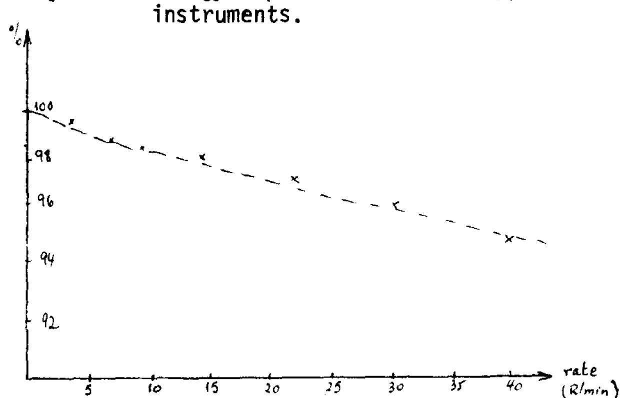

Figure 2. Saturation characteristics of Nuclear Enterprises 30 c.c. chamber (Polarising voltage: 300 V)

at the PTB will serve as the secondary standard for beta radiation.

Absolute calibrations of beta-gamma sources will be performed with a 4π proportional counter and a sodium iodide spectrometer system using beta-gamma coincidence techniques.

REFERENCES

1. Draft International Standard ISO/DIS 4037, X and γ reference radiations for calibrating and determining the energy dependence of dosimeters and doserate meters (1976).
2. Thomson I.M.G., International Standard Reference Radiations and Their Application to the Type Testing of Dosimetric Apparatus, In: National and International Standardization of Radiation Dosimetry, IAEA, 1978.