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Measurement of the Exposure Rate Due to Low Energy x-Rays Emitted from Video Display Terminals

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Thermoluminescent dosimeters of $CaSO_4$:Dy have been used to measure the low energy x-rays emitted from Video Display Terminals (VDTs). For each terminal, three points were measured with five dosimeters at each point. The points were at distances of 5 and 50 cm in front of the screen and at 65 cm with an angle of approximately 50°. The last two positions approximate to positions of the lenses of the eye and the gonads respectively. A survey of 50 VDTs at a distance of 5 cm from the screen resulted in exposure rates nearly fifteen times below the exposure rate of 0.5 mR h^{-1} (0.129 μC kg^{-1} h^{-1}) which is the limit recommended by the International Atomic Energy Agency (IAEA), Safety Series No. 9 (1967) *Basic Safety Standards for Radiation Protection.*

Introduction

With the rapid development in the use of video display terminals (VDTs) in many fields of human activity, and admitting that these devices emit low energy x-rays, it is necessary to measure the exposure rate to operators to establish possible health hazards. Recently published reports have discussed the general radiation risk expected for operators working daily at VDTs.

A large number of measurements around VDTs have been made using different techniques such as large NaI(Tl) scintillation detectors with low-background counting facilities,[1] a large area xenon proportional counter,[2] thermoluminescent pellets of LiF(TLD-100) and electret dosimeters.[3] All of these measurements were made at a distance of 5 cm in front of the screen. Some of the studies mentioned reported "no detectable radiation" or "nothing above background", and the reported values are not of the same order of magnitude. These results have not satisfied workers and researchers.

In order to clarify the underlying facts relating to these discussions, an extensive survey programme was started. For the measurement of low energy x-rays emitted from VDTs, thermoluminescent dosimeters (TLD) of $CaSO_4$:Dy produced by the Dosimetric Materials Production Laboratory of IPEN were used.

$CaSO_4$:Dy Teflon dosimeters developed in this laboratory[4] have been used for personnel and environmental monitoring. While the lower exposure limit required to be measured in personnel monitoring is about 2.58×10^{-6} C kg^{-1} (10 mR), exposures as low as 3.87×10^{-8}; C kg^{-1} (150 μR) should be measurable with good precision in environmental studies using $CaSO_4$:Dy dosimeters.

Material and Methods

Thermoluminescent dosimeter grade $CaSO_4$:Dy phosphor was prepared by following the method of evaporation in a sealed system.[5] Sintered TLD pellets were obtained from a homogeneous mixture of $CaSO_4$:Dy phosphor and Teflon powders, taken in a weight-ratio of 1:1. Pellets of this mixture weighing 50 mg each with 6.0 mm diameter and a thickness of 0.8 mm, were first cold-pressed and then sintered.

The thermoluminescent (TL) response of these pellets was determined using the Harshaw TL Reader, Model 2000 A + B. The linear heating rate was set as 9.7°C s^{-1}; and the reading cycle was performed within 36 s, with a constant flux of N_2 of 4 L min^{-1}. Light emission was integrated in the temperature interval between 220 and 350°C. Prior to irradiation, the samples were subjected to an annealing at 300°C for 3 h. They were then irradiated under the same conditions and the measurements were carried out about 24 h later. Each reported value corresponds to the average of five measurements.

Procedures

A survey program of 50 VDTs was performed. At each terminal, three points were measured, with five pellets in each point, at distances of 5 and 50 cm in front of the screen and at 65 cm with an angle of 50°, as shown in Fig. 1. The last two positions are equivalent to the lenses of the eye and gonads respectively.

Two cases were considered:

(a) Badges fixed in front of the screen with wood supports;

(b) Badges used by operators working approximately 6 h daily, and placed on collars and belts at approximate distances of 50 and 65 cm respectively.

Units in isolated rooms and units closely disposed in a large room were also tested. The last case is a normal working condition in Date Processing Centres. Special care was taken in relation to the time of use of the units. Recently manufactured units without routine use and units with different times of use in routine work were measured.

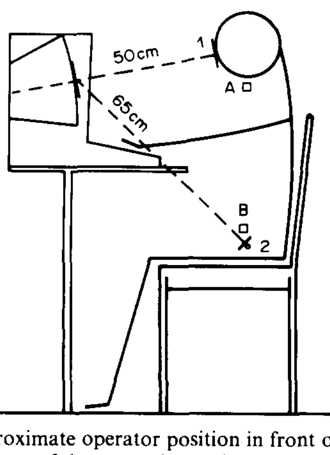

Fig. 1. Approximate operator position in front of the VDT. 1 and 2—lenses of the eye and gonad positions respectively. A and B—badge positions used by operators.

Table 1. Exposure rate: VDTs measured in a isolated room

	Manufacturer A Distance screen-badge (cm) 5	 50	 65
Mean exposure rate	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$
Fixed badges	0.95×10^{-2}	0.85×10^{-2}	0.72×10^{-2}

Table 2. Exposure rate: VDTs closely disposed in a large room

	Manufacturer A Distance screen-badge (cm) 5	 50	 65
Mean exposure rate	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$
Fixed badges	0.95×10^{-2}	1.11×10^{-2}	0.85×10^{-2}
Operators badges	—	0.95×10^{-2}	0.90×10^{-2}

Table 3. Exposure ratio: VDTs closely disposed in a large room

	Manufacturer B Distance screen-badge (cm) 5	 50	 65
Mean exposure rate	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$
Fixed badges	0.80×10^{-2}	1.32×10^{-2}	1.14×10^{-2}
Operators badges	—	0.90×10^{-2}	0.67×10^{-2}

Table 4. Exposure rate: VDTs closely disposed in a large room

	Manufacturer C Distance screen-badge (cm) 5	 50	 65
Mean exposure rate	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$
Fixed badges	1.06×10^{-2}	1.14×10^{-2}	1.39×10^{-2}
Operators badges	—	0.83×10^{-2}	1.03×10^{-2}

Table 5. Exposure rate: VDTs closely disposed in a large room

	Manufacturer D Distance screen-badge (cm) 5	 50	 65
Mean exposure rate	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$
Fixed badges	1.78×10^{-2}	—	–
Operators badges	—	1.78×10^{-2}	1.30×10^{-2}

Table 6. Exposure rate: VDTs closely disposed in a large room

	Manufacturer E Distance screen-badge (cm) 5	 50	 65
Mean exposure rate	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$	$\mu C\,kg^{-1}\,h^{-1}$
Fixed badges	1.21×10^{-2}	—	—
Operators badges	—	1.30×10^{-2}	1.18×10^{-2}

The badges were specially prepared in polyethylene 0.3 mm thick and the dosimeters were sealed in 0.2 mm thick polyethylene film. Ten similar badges were taken for natural background measurements, they were always stored in a separate room free from radiation sources. All badges were kept in this same room when not in use.

The exposure time of the dosimeters to the VDTs was fixed at 250 h.

Parameters

The following parameters were taken for the exposure rate determination.

1—Nominal high voltage: $V = 20$ kV
2—Effective energy of x-rays: $E_{eff} = 10$ keV
3—Polyethylene thickness: $d = 0.5$ mm
4—Linear absorption coefficient in polyethylene at 10 keV $\mu_{pol} = 1.5633\ cm^{-1}$
5—Fading correction mean factor: $f_d = 1.05$

Exposure rate determination

The total exposure was determined for each dosimeter pellet by multiplying the TL response by the calibration factor and subtracting the natural background. The value obtained was corrected for thermal fading and for energy dependence of the TL response and for the x-ray absorption in the polyethylene thickness. The mean exposure for each badge was then determined. The resulting exposure value was taken for the exposure rate calculation.

Results

The results obtained are shown in Tables 1 to 6.

These responses are typical of each model tested. The maximum standard deviation from the mean value from each badge was $\leqslant 3\%$.

The spread of exposure rates for each model was always $\leqslant 7\%$, without any evident trend for the time the unit was in use.

In the case of VDTs closely disposed in a large room, the exposure rate at 50 cm was found to be larger than at 5 cm. This result shows that there is some contribution to operators from neighbouring VDTs. This result was not verified when the measurement was performed with a single VDT in an isolated room, Table 1.

In Table 4, the exposure rate at 65 cm was always larger than at 50 cm. This result was attributed by the workers to the inclination of the tube, which was different from the others in the series.

Conclusions

The results in this study indicate that the x-ray exposure rates from the devices tested are approximately fifteen times less than 0.5 mR h^{-1} (0.129 $\mu C\,kg^{-1}\,h^{-1}$), which is the limit recommended by the International Atomic Energy Agency (IAEA), for a distance of 5 cm in front of the screen.[6]

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