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RADIOACTIVITY ON THE SURFACES OF COMPUTER MONITORS AND TELEVISION SCREENS DUE TO PROGENY PLATEOUT

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ABSTRACT

Computer monitors and television screens can collect radon progeny. Radon decay forming meta-stable progeny, namely, Po-218, Po-214, and Po-210, which are found mostly in positively, charged aerosol particles. These particles are attract by the large negative field of a video display terminals (VDT) leading to buildup of radioactivity on the VDT screen. The charged aerosol particles might drift in the electric field between the VDT and the operator and be accelerated into the operator's face. The aim of this work is to measure these phenomena set of ultra-sensitive TASTRAK detectors used to measure the plateout of positively charged radioactive radon progeny. The track detectors were fixed on the outer monitor screen. For an occupational computer worker spending 200 days per year for 6 hours a day. It was found that the mean dose equivalent was 1.77 mSv, 0.25 mSv/year for normal CRT and LCD monitors respectively.

INTRODUCTION

Recent reports indicate that video display terminals (VDTs) can collect radon progeny from air. This occurs especially when they are turned off and may have negative electric fields, which attract positively, charged radioactive dust. Both the free and attached daughters plate-out by diffusion onto solid surfaces where they are held by the Van der Waals force. Unattached daughters will plateout much more quickly than those attached to aerosols, the plate-out velocities being $2 mm.s^{-1}$ and $0.02 mm.s^{-1}$ respectively [1]. Once the daughter has attached itself to the surface of the face, the subsequent alpha can irradiate the skin. Again, it is possible for the daughter to become detached from the surface after alpha decay (e.g. approximately half of the lead –214 formed by the alpha decay of previously deposited polonium-218 will be lost from the surface in this fashion).

Three studies have shown that video display terminals (VDTs) may getter radioactive radon progeny from the air because of their electric fields [2,3 and 4]. This phenomenon occurs with most types of VDTs, such as television sets and computer monitors. This study is primarily concerned with whether VDT operators might inhale increased radioactivity when the monitor is switched from off to on. This switching may release some of the electostatically gettered particles.

Miles[3] analyzed VDTs and radon and concluded that there was no hazard to VDT operators from plateout of radon progeny on their skin; however, he suggested enhanced inhalation might be a problem. Tuyn and Roger [2] concluded that a VAT does getter radon progeny and thus slightly reduces airborne activity in the vicinity of an operator. Ziemba[4] measured high alpha-particle emissions from VAT screens and suggested there might be some hazard to VDT operators.

CACULATING THE DOSE TO SKIN FROM RADON DAUGHTERS

The method use to estimate doses comes from a theoretical model of the dose from plane sources of alpha activity present on the skin surface [5].

$$D = \frac{NE}{4\rho R_\alpha} \left[2.a.\ln\left(\frac{R\alpha}{r}\right) + 3b.\left\{1 - \frac{r^2}{R_\alpha^2}\right\} \right] r \leq R \quad (1)$$

where
- D = dose rate (MeV. $g^{-1}.s^{-1}$)
- N = Alpha particle activity ($cm^{-2}.s^{-1}$)
- ρ = tissue density ($g.cm^{-3}$)
- R = nominal range of alpha particles (cm)
- a, b = constants
- R = perpendicular distance from source (cm)
- E = energy of the alpha particles (MeV).

This gives a dose rate in $MeV.g^{-1}.s^{-1}$ at a distance r (cm) from the skin surface. This can be rewritten in $mSv.y^{-1}$ and integrated to give a mean dose rate at the estimated position of the surface of the skin [6]. This yields:

$$D = \left(\frac{5 \times 10^{-3} EQN}{4 R_\alpha \rho} \right) .F \quad (2)$$

Where: D = mean annual dose equivalent ($mSv.y^{-1}$)
- E = initial alpha particle energy (MeV)
- Q = alpha particle quality factor (=20)
- N = alpha particle activity ($m^{-2}.s^{-1}$)
- R_α = alpha particle range, slightly less than true range (m)
- ρ = density of epidermal tissue (=1100 $kg.m^{-3}$)

and

$$F = \frac{3b\{2R_\alpha^2 + (R_\alpha + \chi_0)(6\chi_0 - 2q)\}e^{(q-R_\alpha)/\chi_0}}{R_\alpha^2} - \frac{3b\{2\chi_0 + q)^2 + 2\chi_0^2 - R_\alpha^2\}}{R_\alpha^2} + 2a\{e^{(q-R_\alpha)/\chi_0} - \ln(q/R_\alpha) - 1\} - \frac{2a(\chi_0 - q)\{E_i(-R_\alpha/\chi_0) - E_i(-q/\chi_0)\}}{\chi_0 e^{-q/\chi_0}} \quad (3)$$

Where: E_i is the exponential integral function, substituting from the values of ρ and q.

$$\overline{D} = 2.27 \times 10^{-5} \frac{ENF}{R_\alpha} \quad \textbf{(4)}$$

To estimate the calibration factor of the detector, one might assume that N, the alpha particle activity, is the same as the number of alpha tracks observed per m^2 per second on the detector. This number needs to be increased by a factor of four [7] to account for alpha particles emanating from daughters on the surface of the detector which escape detection.

When the activity of alpha particles in the air are homogeneously distributed and the detector is exposed to the 2π geometry, the alpha particle activity N is related to the number of alpha tracks observed ρ by the relation [6]

$$\rho = \frac{1}{4} N..t.R_\alpha.\cos^2\theta_c \quad \textbf{(5)}$$

where: R_α is the effective range of alpha particles in air, t is the total exposure time and θ_c is the critical angle of etching (≈ 10° for TASTRAK detector).

To calculate the dose received by a computer occupational worker, it is necessary to take into account the time spent in front of the computer monitor screen. The dose calculated by Eq. **(2)** could be considered as continuous dose. This is obviously unrealistic. For an operator working on a regular base of h hours per day for d-days per year, the total dose D_T per year is to be:

$$D_T = \left[\frac{h}{24}\overline{D} + \frac{24-h}{24}D_b\right]\frac{d}{365} + D_b\frac{365-d}{365} \quad (6)$$

Where:

D_T = mean operator's dose ($mSv\ y^{-1}$)

$\overline{D}$ = Mean continuous dose ($mSv.y^{-1}$)

D_b = Mean background dose ($mSv.y^{-1}$)

h = Hours spent at VDT per day (for work days)

EXPERIMENTAL PROCEDURE

This experiment is designed to measure radon daughters in normal room air, which plate-out on a VDT Screen by virtue of the fact that VDT screens carry a static electric charge and therefore preferentially attract the radon daughters. During radioactive decay radon-222 will transform to another element called a radon daughter, in this case polonium-218. Polonium-218 is also radioactive similarly emitting an alpha particle and transforming to lead-214. This sequence of events emitting an alpha particle and transforming to lead-214. This sequence of events continues until stable lead, lead-206 is formed. The immediate daughters of radon-222 have short half-lives, less minutes, and for this reason they are known as radon short lived daughters. Of these polonium-218 and polonium-214 emit alpha particles.

Radon short-lived daughters are present in air along with radon. However, their behavior differs from radon because they are invariably ionic which means they tend to attach themselves to natural aerosol particles in air. These particles in turn stick to surfaces such as walls and ceilings, process known as plateout. The experiment works on the assumption that the static charge on the screen transfers to the surface of the plastic stuck to the screen face that the plastic itself also becomes charged to some extent. This charge attracts plateout particles; hence the plastic is fixed numbered face outwards and there are only a few tracks to be seen on the rear surface (that which was pressed against the screen).

Different types of monitors were selected for this investigation, Cathode Ray Tube (CRT) use a beam of electrons to stimulate phosphors and thus make the image. Aperture Grilles consists of a phosphor pattern of stripes rather than dots on the display face. Each stripe contains phosphors for all three primary colors red, green and blue. Active matrix Liquid Crystal Display (LCD) depends on thin film transistors and capacitors (TFT). This technology is used in the flat panel liquid crystal displays of notebook.

For each monitor type fifteen detectors were distributed on the outer screen. An additional monitor was used as control and kept switched off to estimate the background dose D_b. The monitors were switched on during normal working hours (6 hours, five days a week) for eight weeks. number side out, using Sellotape across the corners. Hang the other piece of TASTRAK in the air in another part of the room nearby. Make a note of the numbers on the plastic and which was stuck on the screen. If possible leave the screen switched on for 24 hours continuously, or two or three days daytime use, to give time for particles to collect. After 24 hours re-wrap the pieces of plastic in foil, package carefully and return it for processing to view with an Optical Microscope.

RESULTS

The effect of regular use of computer monitors on the exposure dose to the occupational workers has been studied. The calculations are based on the assumption that computer occupational workers spend six hours per working day for 200 days per year in front of monitor screen as shown in Table (1).

Table (1) The annual dose exposed to occupational workers spend 6 hours per working day for 200 days per year in front of the monitor screen

Product title	Display type	Diagonal size	Resolution	Track Density rate ($m^{-3}.s^{-1}$)	Annual dose ($mSV.y^{-1}$)
Viewsonic	CRT	17 in	1280 x 1024	35.4 ± 0.6	1.71 ± 0.04
Sony	CRT	17 in	1280 x 1024	22.2 ± 0.4	1.61 ± 0.03
KDS	CRT	17 in	1280 x 1024	36.3 ± 0.7	1.77 ± 0.05
Viewsonic	Shadow Mask	17 in	1600 x 1200	18.2 ± 0.3	0.89 ± 0.04
KDS	Shadow Mask	17 in	1600 x 1200	22.1 ± 0.4	1.07 ± 0.02
Viewsonic	Aperture Grill	19 in	1600 x 1200	14.1 ± 0.3	0.69 ± 0.04
Sony	Aperture Grill	19 in	1800 x 1440	12.1 ± 0.4	0.59 ± 0.04
KDS	Aperture Grill	19 in	1600 x 1200	15.2 ± 0.4	0.74 ± 0.04
Sony	Flat panel display, TFT active matrix	15 in	1024 x 765	6.2 ± 0.4	0.30 ± 0.04
KDS	Flat panel display TFT active matrix	17 in	1280 x 1024	5.1 ± 0.4	0.25 ± 0.4

It is recommended to take into account this dose when estimating the total annual exposure dose for computer workers.

To decrease the hazard while using computer screens regularly, we recommended

- to use LCD computer screens
- to keep away from the screen as possible
- to minimize the use of touch screens and light pens.

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