ASSESSMENT OF IONIZING RADIATION FROM PC MONITORS AND TV RECEIVERS

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Abstract.

It is well known that cathode-ray tubes (CRT) emit low level ionizing radiation in the form of X-rays. At present, practically all CRTs are carefully manufactured to reduce such radiation to a minimum which amounts to a small fraction of the total ambient or background radiation due to natural sources. The purpose of this work was to actually measure the radiation levels emitted by standard PC monitors and TV receivers, operating either alone or in computer rooms with large numbers of monitors. Even when such values are low enough to be considered "safe", they are detectable and measurable and we report here our findings. A brief resume of the meaning of the units employed is given in the Appendix.

1. Introduction.

Cathode-ray tubes emit X-rays as a result of electron braking (bremsstrahlung) by the screen and walls of the tube; the amount of radiation increasing proportionally to the accelerating voltage. Research on the effects of ionizing radiation in living tissue is abundant and up to a certain extent, controversial and non conclusive [1]-[3], Even when such discussion is out of the scope of this work, the fact that a vast amount of people are exposed to this low-level radiation for long time intervals cannot be ignored. Not only the screen, but also the lateral surfaces of CRTs emit low-level radiation and cannot be considered as point sources, nor is it valid to extrapolate exposure rates at short distances applying the inverse square law for decay. It is necessary to make measurements at viewing distances in order to assess the actual exposure rates. Measurements performed at 2.5 m from the screen of several receivers show that exposure rates are comparable to those measured at short distances. This is due to the fact that the CRT is not a point source and emission takes place through all the screen and lateral surfaces. The purpose of this work was to measure X-radiation emitted by these devices without entering in evaluations of the possible health risks that such low level radiation poses, nor pretend to extract any conclusions in this aspect.

2. Experimental measurements.

A simple Geiger-Müller counter was used for all the measurements. The instrument is capable of detecting between 0 and 30,000 events per minute, corresponding to exposure rates between 0 and 50 milliroentgens/hour (mR/h). The counter was previously calibrated with a sample of ^{137}Cs. In order to compare the exposure levels produced by CRTs, background radiation was measured in two different urban environments, far from any artificial radiation source. After that, measurements were performed with 10 computer monitors of different manufacturers and models. Of them, eight were color monitors and the other two, older monochromatic monitors. Also measurements were made with five TV receivers, four color and one, older, B/W. Screen size of PC monitors was 14" in all cases, and 21" in TV receivers.

For monitors and receivers, measurements were performed at 5 cm from the screen, at the center and near the corners, as well as laterally, at both sides. At each point, a minimum of 200 samples were recorded. In monitors, all samples were taken with the screen full white. In two cases, measurements were also made with and without screen filters to verify the effect of the filter on this type of radiation. In TV receivers, samples were taken with normal program images. Also, two computer rooms, one with 25 computers, and other with 20 were selected for environmental measurements. In this case, samples were taken at the center of the room and at five points at random, at distances greater than 2 m from the nearest equipment. For this work, a total of about 10,000 samples were taken and analyzed.

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3. Results and their discussion.

A plot of the mean values of total exposure rates; i.e. background plus contribution to radiation from measured equipment, for the most relevant sets of measurements, is shown in figure 1.

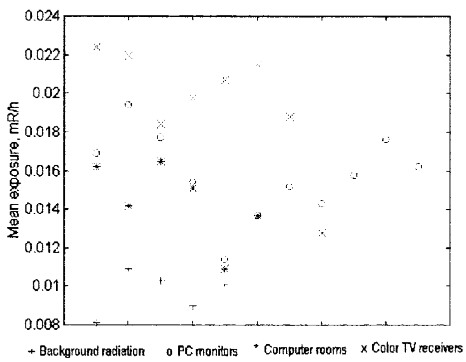

Fig. 1. Mean values of measured exposure rates.

Mean values and standard deviation of recorded exposures in milliroentgens/hour (mR/h) are given in Table 1. Values other than background represent total exposure.

Table 1. Mean exposures

Measurement conditions	γ (mR/h)	σ_γ
Background radiation	0.0107	6.06×10^{-3}
PC monitor off (background)	0.011	6.64×10^{-3}
PC monitor at 5 cm in front of screen	0.0132	7.08×10^{-3}
PC monitor at 5 cm – lateral	0.0132	6.18×10^{-3}
PC monitor at 5 cm in front of screen, with filter	0.013	5.92×10^{-3}
PC minitor at 50 cm, front.	0.0136	4.6×10^{-3}
TV receiver at 2.5 m	0.0154	6×10^{-3}
Computer room (20 PCs)	0.015	7.08×10^{-3}

With the above values, the annual effective dose equivalent can be calculated for each case, assuming a continuous exposure of 24 hours/day during 365 days/year for background radiation, 8 hours/day during 300 days/year for PC monitors and 3 hours/day during 365 days for TV receivers. Calculated values of such annual dose using the above figures are shown in Table 2, in millisievert/year (mSv/y).

Table 2. Annual dose effective equivalent

Condition	Annual dose effective equivalent (mSv/y)
Background only	0.937
Background + PC monitor (8 h/d, 300 d/y) or computer room, same time.	1.041
Background + PC monitor (8h/d, 300 d/y) +TV receiver (3 h/d, 365 d/y)	1.208

Average annual effective dose equivalent from natural background sources depends on many factors [4] including geographical location and height above sea level. Only for comparison purposes of our measurements with other published figures, average natural background in the U.S. ranges between 0.526 mSv/y and 1.31 mSv/y [5]. The total annual effective dose for the U.S. is 3.6 mSv/y, including artificial and natural sources. Of these, the contribution of consumer products is estimated in 0.1 mSv/y. Slightly different figures are given in other sources [6], [7]. NCRP (National Council for Radiation Protection) Report 116 [8] states that the dose limit for general public, based on stochastic effects, excluding medical and natural background exposures, shall be of 1 mSv annual effective dose limit for continuous exposure, and 50 mSv annual equivalent dose limit to lens of eye, skin and extremities.

As can be seen from the figures given in Table 2, the excess annual absorbed dose from PC monitors amounts to 0.104 mSv/y; i.e. 11% above that from background radiation. Observed values for TV receivers were higher, and amount to 17.8% above background. Continuous exposure to both PC monitors and TV receivers during the periods previously indicated, results in an annual dose effective equivalent 28.8% higher than that of background alone. In any case, these values are well below those indicated in the NCRP Report 116 mentioned before (1 mSv/y) for stochastic effects.

4. Statistical analysis of measurements

All sets of values from measurements were statistically analyzed. It was found that, in general, a Gaussian distribution describes well the statistical behavior of ionizing radiation either background or from monitors and receivers. However, we found that the Nakagami distribution [9] fits better in most of the cases, possibly because ot the non symmetrical properties of this distribution that fit better the values larger than the mean. Application of the Nakagami distribution in wireless communications is well known to describe path loss in fading environments.

Figure 2 shows the probability density function (pdf) of background exposure rates in the cities of Santander and the more industrial environment of Torrelavega in Northern Spain.

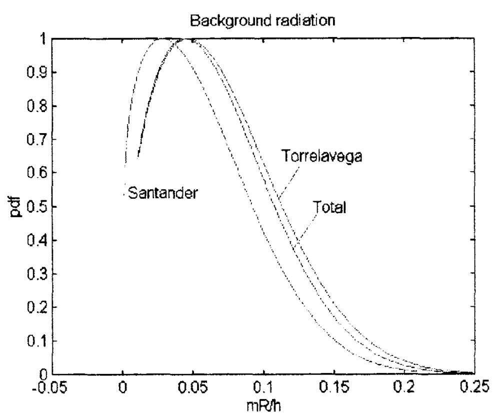

Fig. 2. Background radiation exposure rates.

A comparison of the results observed between background radiation and the worst cases measured in PC monitors and TV receivers can be seen through the pdf's in figure 3. It must be stressed that the curves for monitors and receivers include the effects of background. Therefore, the actual exposure rates due to such equipments are the total exposures less background.

In the environment of computer rooms, the recorded exposure levels are very similar to those observed for stand alone monitors, as can be seen in figure 4.

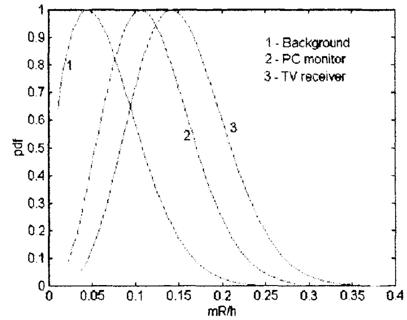

Fig. 3. Exposure rates from background, PC monitors and TV receivers.

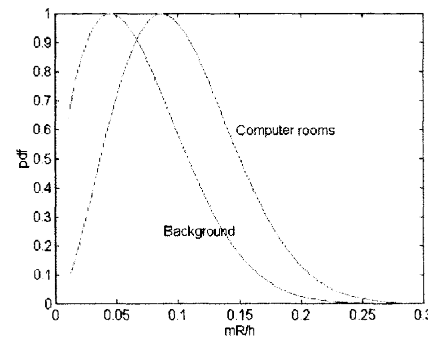

Fig. 4. Exposure rates in computer rooms compared with background

5. Conclusions.

In all the observed cases, exposure rates produced by PC monitors and TV receivers, were higher than that of background radiation. On the average this amounts to an excess annual equivalent dose of 0.1 mSv/y for continuous exposure to PC monitors during 8 hours a day, 300 days per year. This value is similar to that observed in PC room environments with 20 monitors operating. Standard TV receivers appear to radiate more than PC monitors, even at 2.5 m from the screen, this is probably due to the larger screen size of the former.

No attempt is made to derive any conclusion regarding possible health effects from the exposures measured in this experiment.

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Appendix.

Units used in this work.

Roentgen (R). This is a unit used to measure a quantity called exposure. This can only be used to describe the amount of gamma or X-rays, and only in air. One roentgen is equal to depositing an electric charge of 2.58×10^{-4} coulombs per kg of dry air. It is a measure of the ionizations of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma and X-rays.

Sievert (Sv). Is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. One Sievert is equivalent to 100 rem (roentgen equivalent man)

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Biographies

Constantino Pérez-Vega was born in Asturias, Spain, in 1942. He is an Electronics and Communications Engineer from the Escuela Superior de Ingeniería Mecánica y Eléctrica of México (1965) and Ph.D. in Telecommunications Engineering from the University of Cantabria in Santander, Spain (1997). He held several technical managing positions in the Mexican Government Radio and Television System since 1972, and was Director of Engineering at the Instituto Mexicano de Televisión, as well as Technical Advisor at the Dirección General de Radio, Televisión y Cinematografía of the Secretaría de Gobernación in México up to 1988. He has been also dedicated to teaching since 1966 in México, and from 1989 until present, he is Professor at the University of Cantabria in the areas of Television and Communication Systems.

José M. Zamanillo was born in Madrid, Spain, in 1963. He received a B.Sc. and Ph.D. in Physics from the University of Cantabria, Spain, in 1988 and 1996 respectively . Since 1988 he has been devoted to education and research at the University of Cantabria where he is Associate Professor. He has been engaged in various European and Spanish projects, mainly in the fields of microwaves and device modelling. Presently, his research interests include linear and non-linear modelling of GaAs MESFETs, HEMTs and (HBTs).

Juan A. Saiz Ipiña was born in Santander, Spain. He recived the B.Sc and Ph.D. degrees in Physics from the University of Cantabria, Spain, and has been with the Communications Engineering Department there since 1990, where he is Associate Professor. His research interests are in the fields of computational methods in Electromagnetics, numerical analysis of waveguides and scattering problems.