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TECHNICAL REPORT

A REPORT ON ELECTROMAGNETIC RADIATION SURVEYS OF VIDEO DISPLAY TERMINALS

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

A REPORT ON ELECTROMAGNETIC RADIATION SURVEYS OF VIDEO DISPLAY TERMINALS

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December 1977

For sale by the Superintendent of Documents, U.S. Government
Printing Office, Washington, D.C. 20402

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DHEW (NIOSH) Publication No. 78-129

ABSTRACT

In a 1977 survey by the National Institute for Occupational Safety and Health (NIOSH), electromagnetic radiation was measured for several models and types of video display terminals (VDT) typically used in the communication field. The values obtained for x-ray, ultraviolet, visible, infrared, and radiofrequency radiation were considerably below current threshold limit values or standards. Data from previous radiation surveys of VDTs by NIOSH and others are also referenced.

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INTRODUCTION

Visual display devices, particularly cathode ray tube displays, have been used quite successfully in military and commercial systems for many years. It is with contemporary information display procedures (i.e., graphics, word processing, and data handling), however, that these visual display devices are finding their greatest application. Video display terminals (VDT) are making inroads into office managerial procedures with their ability to rapidly display letters, numbers, and other symbols. Although exact figures on the number of such devices are not available, it is estimated that between 5 and 10 million units are currently in use (1). The number will increase within the next few years as the many advantages of the VDT become apparent.

In recent years, inquiries have been received by NIOSH from various user groups concerning the potential hazards associated with these devices. Many VDT operators complain of such symptoms as eyestrain, visual deterioration, headaches, changes in normal visual acuity, and, in some cases, changes in color perception, dulling of sensation in fingertips, nausea, temperature and noise discomfort from equipment, and general fatigue.

This report presents data from a survey made by NIOSH in February 1977 after receiving a request from the Newspaper Guild and from a prominent newspaper facility to evaluate their VDT for possible electromagnetic radiation hazards to workers. The request was made after medical examinations revealed the presence of bilateral cataracts in newspaper employees using VDTs. Equipment used is described and the results of all measurements and their significance are discussed with reference to currently accepted exposure standards. In addition, data from previous surveys by NIOSH and others are referenced.

BACKGROUND

Radiation is energy which is emitted, transmitted, or absorbed in wave or particulate form. This energy consists of electric and magnetic forces which, when disturbed in some manner, produce electromagnetic radiation. The known electromagnetic radiations are grouped into a spectrum arranged by frequency and/or wavelength. The spectrum includes the radiofrequency (RF), microwave, infrared (IR), visible, ultraviolet (UV), gamma, and x-ray regions. The regions are not sharply delineated from each other and, in fact, often overlap. It is convenient to divide these regions as shown in Figure 1 due to the nature of the physical and biological effects produced.

In conducting a radiation survey, a working knowledge of the radiation source and its characteristics is required. Basically, the VDT operates similarly to a television set. It contains a source of electrons and a phosphor coated screen (anode) within a specially designed vacuum tube. Under high voltage, electrons are emitted by the electron gun (cathode) and accelerated toward the anode. The gun scans the screen at a predetermined rate and projects electrons according to an electronically induced signal. When the electrons interact with the phosphor coating of the screen, visible radiation is produced and an image is formed.

Several types of electromagnetic radiation are produced in a VDT. Low energy x-rays can be generated in the cathode ray tube and the shunt regulator tube if they are operated at a sufficiently high voltage. UV, visible, and IR radiation are emitted by the phosphor material. RF radiation is produced by certain electronic components and circuits. Discussions with VDT design engineers indicated that the maximum RF radiation generated, including harmonics, should not exceed 250 megahertz (MHz).

Since most regions of the electromagnetic spectrum have been implicated as being cataractogenic, it is necessary in taking measurements to monitor across a broad range of frequencies to insure identification of all electromagnetic radiation emitted by a VDT. In addition, luminance measurements are made to document the levels in regard to eyestrain.

NIOSH SURVEY (1977)

INSTRUMENTATION AND PROCEDURE

Since it was necessary to make measurements in many regions of the electromagnetic spectrum, several types of instruments were used. A brief description of each instrument used in the survey will be given, as well as measurement details.

An EG&G Model 580/585 spectroradiometer was used to detect UV, visible, and IR radiation in terms of power per unit area as a function of wavelength. The expression used for such measurements is spectral irradiance, and the unit is watt per square centimeter per nanometer ($W \cdot cm^{-2} \cdot nm^{-1}$). The values obtained are then summed to obtain the total irradiance for the optical region of interest. All measurements with this instrument were made at a distance of 15 centimeters from the face of the VDT screen. A collimating device was attached to the front of the detector and positioned against the screen face to minimize the effect of ambient light. Figure 2 shows the measurement set-up with this instrument.

The instrument used to measure the luminance (brightness) levels of the VDT screen and surrounding luminous environment was a Spectra Mini-Spot Photometer. The value obtained with this instrument in footlamberts (fL) represents the luminance observed by an operator regardless of actual distance from the VDT screen face. All measurements with this instrument were made at a distance of one meter from the face of the VDT screen.

Measurements of RF radiation using three detectors were made by slowly scanning every accessible surface of the VDT with the detectors in contact with the housing. A Hewlett-Packard Model 5303B Frequency Counter was used to determine the frequency of RF radiation up to 525 MHz. It was necessary to use a special meter developed for NIOSH use by the National Bureau of Standards to determine the near-field electrical component of RF radiation. This meter is called an EDM-2 Electric Energy Density meter. The EDM-2 reads out in units of joules per cubic meter ($J \cdot m^{-3}$) in the frequency range from 10-500 MHz. The instrument used to measure the near field magnetic component of RF radiation was a Narda model 8607 magnetic field detector. This detector indicated units of watts per square centimeter ($W \cdot cm^{-2}$) in the 10-500 MHz region.

Figure 3 indicates the overall frequency response covered by the instruments used for this evaluation compared to our best estimate of the frequencies emitted by a typical normal operating VDT.

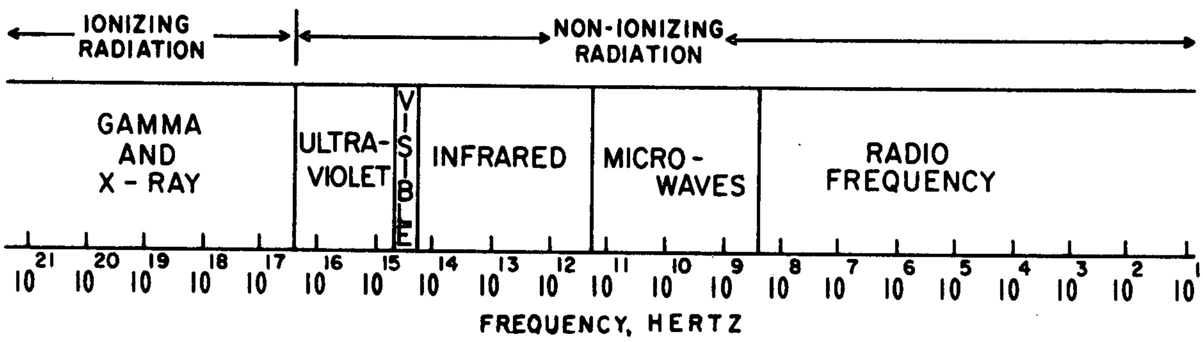


Figure 1. Regions of the electromagnetic spectrum as a function of frequency in Hertz. The divisions between regions are approximations as an exact division can not be defined.

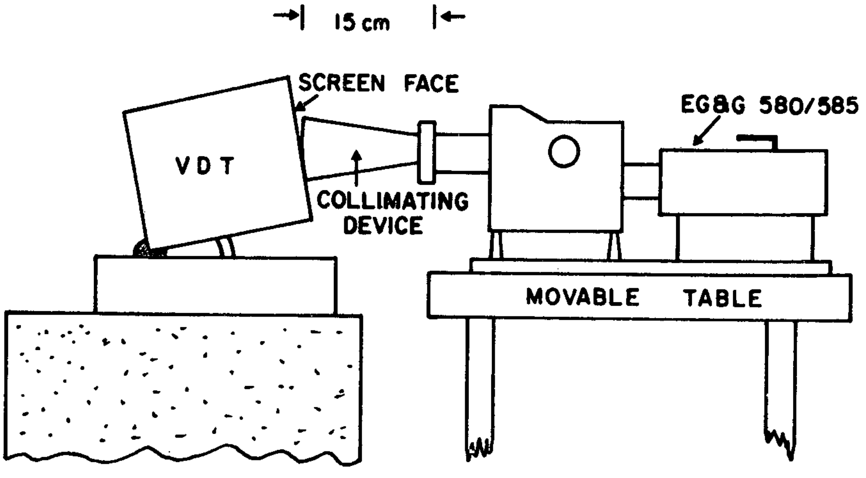


Figure 2. Schematic outline of optical radiation measurement set-up (not to scale)

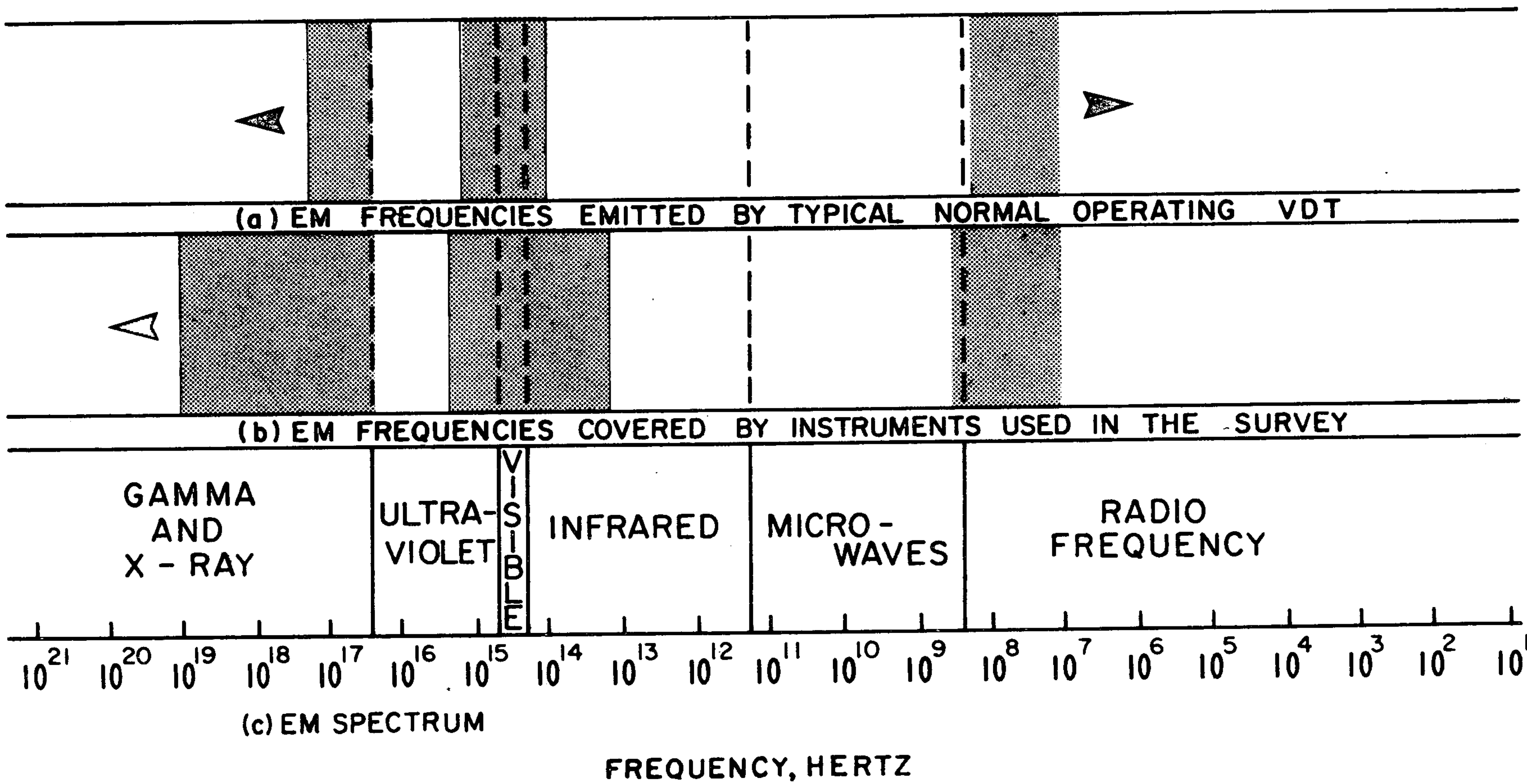


FIGURE 3. EM frequencies emitted by VDTs (a) and covered in survey (b) compared with EM spectrum (c).

MEASUREMENTS -- NON-IONIZING RADIATION

Radiation measurements of UV, visible, IR, and RF levels were obtained for three VDTs located at the newspaper facility with the equipment described in the previous section. The terminals surveyed were a Telco Model 40 located in a wire service department, a Harris Model 1500A located in a news department, and an Incoterm SPD 10/20 located in a business department. Results of the surveys are presented for each of these three terminals. The first two terminals had been used by the two employees who developed cataracts. Selected measurements were made on numerous other terminals on various floors of the newspaper building.

TELCO 40

The video screen used in this terminal is 19 cm wide by 33 cm high. The tube uses a P-4 phosphor, operates at a 15 to 18 kilovolt (kV) tube potential, and is manufactured by Clinton Electronics, Rockford, Illinois. The terminal was located in a small room apart from other VDTs. The brightness of the tube was adjusted to maximum, and the screen filled with letters and symbols. All room lights were turned off during the survey. Although an unidentified source of electromagnetic interference made measurements difficult on several instruments, necessary measurements were made.

a. UV measurements:

The UV spectral irradiance levels for the Telco VDT are shown in column 1 of Table 1. Notice that all measurements between 200 and 370 nm were recorded as zero on the 10^{-10} ampere scale of the spectroradiometer. Due to the presence of electromagnetic noise in the area, it was not possible to use the most sensitive spectroradiometer scale. The integrated UV irradiance from 200 to 400 nm was 2×10^{-9} $W \cdot cm^{-2}$.

b. Visible and IR measurements:

No visible or IR radiation was detected using the 10^{-10} scale.

c. RF Measurements:

Certain positions on the screenface of the VDT were emphasized during the electric field survey with the EDM-2 meter. These positions are shown in Figure 4. All readings obtained are shown in Table 2. Notice that a maximum reading of $1.2 \times 10^{-6} J \cdot m^{-3}$ was observed at the rear surface of the VDT. This RF value was about 25 times greater than the next highest reading. However, when the meter was moved 10 cm away from the rear surface, the RF value dropped to zero even when measured on the most sensitive scale of $3 \times 10^{-9} J \cdot m^{-3}$. The magnetic field measurement using the Narda 8607 meter registered zero on its most sensitive scale of $2 \times 10^{-4} W \cdot cm^{-2}$. On this particular VDT, no frequency higher than 2 MHz was recorded. Consequently, none of these readings have real significance since these meters are not designed for measuring frequencies below 10 MHz.

TABLE 1. UV SPECTRAL IRRADIANCE MEASUREMENTS IN UNITS OF 10^{-10} $W \cdot cm^{-2} \cdot nm^{-1}$ OBTAINED FROM THE THREE VDTs SURVEYED IN THIS STUDY.

WAVELENGTH (nm)	(1) TELCO 40	(2) HARRIS 1500A	(3) INCOTERM SPD 10/20
200	0	0	0
210	0	0	0
220	0	0	0
230	0	0	0
240	0	0	0
250	0	0	0
260	0	0	0
270	0	0	0
280	0	0	0
290	0	0	0
300	0	0.01	0.09
310	0	0.02	0.17
320	0	0.04	0.30
330	0	0.05	0.55
340	0	0.08	0.87
350	0	0.11	1.18
360	0	0.12	1.80
370	0	0.14	2.03
380	0.7	0.15	2.06
390	4.8	0.74	2.91
400	14.6	3.65	7.30

TABLE 2. ELECTRICAL FIELD STRENGTH MEASUREMENTS OF THE TELCO MODEL 40 VDT.

LOCATION*	MAXIMUM READING (10^{-6}J·m^{-3})**	LOCATION	MAXIMUM READING (10^{-6}J·m^{-3})**
1	0	11	0.005
2	0.023	12	0.003
3	0.025	13	0.010
4	0.027	14	0.010
5	0.015	15	0.010
6	0.020	16	0.050
7	0.030	Top	0
8	0.010	Right Side	0.003
9	0.010	Left Side	0
10	0.010	Rear	1.2

* See Figure 4.
** Can convert into V·m^{-1} using conversion V·m^{-1} = $475.3\sqrt{\mu J.m^{-3}}$

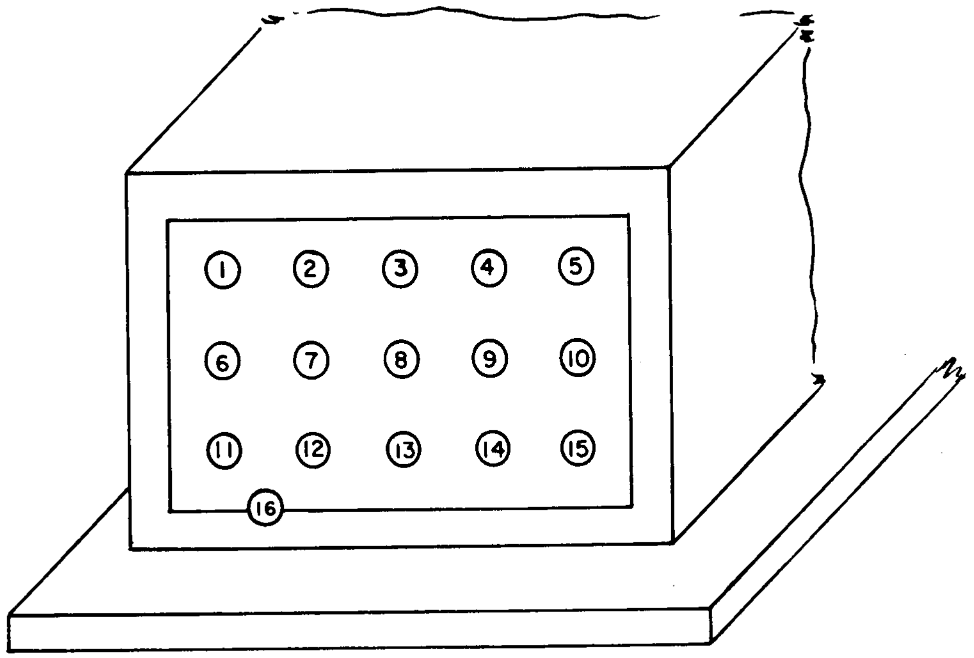


Figure 4. Electric field strength monitoring points on VDT screen face.

d. Luminance measurements:

On the Telco 40 VDT, the brightness values ranged from 1.5 to 2.5 fL for minimum and maximum luminance levels, respectively.

HARRIS 1500A

This VDT is one of the more common models used in the newspaper business. The video screen has a square viewing area of 25 cm x 25 cm. The tube uses a P-31 phosphor, operates at a 23 to 33 kV potential, and is manufactured by Thomas Electronics, Inc., Wayne, New Jersey. As with the first VDT surveyed, the brightness control was adjusted to maximum and the screen filled with a typical message. Because of the size of the room and the numerous ongoing plant operations, it was not possible to eliminate ambient room light (background) during measurements on this unit.

a. UV measurements:

The UV spectral irradiance levels for the Harris 1500A are shown in column 2 of Table 1. The integrated UV irradiance from 200 to 300 nm was zero, and from 300 to 400 nm was $5.1 \times 10^{-10} W \cdot cm^{-2}$, as measured on the most sensitive scale.

b. Visible and IR measurements:

No visible or IR radiation was detected on the most sensitive scale of the spectroradiometer (i.e., 10^{-11} Amperes).

c. RF measurements:

A 27 MHz frequency was registered by the frequency counter at the surface of the unit. This signal was not detected when the counter was positioned approximately 12 cm from the unit. The EDM-2 and the Narda 8607 registered zero on their most sensitive scale ($3\times10^{-9} J\cdot m^{-3}$ and $1\times10^{-4} W\cdot cm^{-2}$, respectively) when positioned next to the VDT housing. All measurements were conducted in the same manner as with the Telco VDT.

d. Luminance measurements:

The luminance values ranged from 2 to 10 fL at the minimum and maximum brightness, respectively.

INCOTERM SPD 10/20

This VDT has a video screen measuring 16.5 cm wide by 23.9 cm high. The tube uses a P-39 phosphor, operates at a 12 to 14 kV potential, and is manufactured by Ikegami Electronics, New York City. All measurements were taken at maximum brightness with a filled screen in ambient light.

a. UV measurements:

The UV spectral irradiance levels for the Incoterm VDT on the most sensitive scale are shown in Column 3 of Table 1. The integrated UV irradiance from 300 to 400 nm was $1.9 \times 10^{-9} W\cdot cm^{-2}$.

b. Visible and IR measurements:

No visible or IR radiation was detected on the most sensitive scale.

c. RF measurements:

A 20 MHz frequency was detected by the frequency counter when held in contact with the VDT housing on the right side. This signal was not detected when the counter was 10 cm from the unit. As in the case of the Harris 1500A, both the EDM-2 and Narda 8607 meters registered zero on their most sensitive scale during the Incoterm survey. All measurements were conducted in the same manner as described for the Telco model.

OTHER VDT UNITS

RF and luminance measurements obtained on randomly selected VDT units at the newspaper facility generally confirm those values reported for the above three VDT units. Table 3 reflects luminance measurement made on a

TABLE 3. ADDITIONAL LUMINANCE MEASUREMENTS OBTAINED FROM RANDOMLY SELECTED VDT UNITS DURING SURVEY.

MODEL	NUMBER OF UNITS SURVEYED	RANGE OF MAXIMUM BRIGHTNESS (fL)	RANGE OF MINIMUM BRIGHTNESS (fL)
Harris 1500A	13	4-21	1-3
Telco 40	4	3-5	1-2
Harris 2200	4	3-5	2
IBM-3277	1	7	6
TOTAL	22	3-21	1-6

total of 22 VDT units. All RF magnetic and electric field measurements obtained on the 22 units were zero on the most sensitive detector scale. In making measurements on a VDT on another floor, a reading of 1×10^{-3} W·cm^{-2} was obtained with the Narda 8607. The reading still persisted when the terminals were de-energized. From this it was concluded that the source of radiation was not VDT related. Since readings of the same magnitude were obtained in the adjoining computer area, and at nearby windows, it was postulated that signals from nearby TV and radio stations were directly exciting the detectors.

PRE 1977-NIOSH SURVEYS

MEASUREMENTS - IONIZING RADIATION

Due to the interest in this increasingly popular device and the scarcity of references to data concerning potential hazards, the following section reports some of the findings from literature reviews and from a previous NIOSH survey (1975).

Background

Numerous X-radiation surveys have been reported on various VDT makes and models. In every one of these surveys the findings have revealed that X-ray levels emitted by VDT rarely exceed background. For example, in 1970 and 1972, Dr. Walter Mauderli made measurements on the same Harris 1100 VDT in Florida to determine if radiation levels increase as a function of VDT age (2). He concluded that any aging effect, if it existed at all, "would have the tendency to shift the energy spectrum of the produced X-rays to lower values -- thus reducing the penetrating power of the radiation." He also stated that no readings could be found which exceeded the natural background level. In 1973, Mauderli made a radiation survey on a Harris 1500 VDT and concluded that the unit has an X-ray output level at any accessible location which was below 0.02 $mR \cdot hr^{-1}$. Also, in 1973, the U. S. Department of Labor made X-ray measurements on two Harris VDTs at United Press International's newsroom in New York City and found radiation levels on the order of background radiation (3). In 1974, the State of Maryland made an X-ray survey on 74 different VDTs at the Baltimore Sun plant (4). Their report stated, "In no case did the level found exceed the background radiation level. That is to say, the X-radiation produced by the VDTs was essentially zero."

NIOSH, in 1975, was asked to perform an X-ray survey at the same newspaper and at another facility. The radiation results from this survey were obtained using a Victoreen Model 440 RF/C X-ray survey meter. This meter is shielded against response to RF radiation and measures low energy X-rays in units of milliroentgens per hour ($mR \cdot hr^{-1}$). Background readings taken at frequent intervals ranged from 0.16 to 0.70 $mR \cdot hr^{-1}$. Readings from an internal calibration source were also recorded to insure that the meter was functioning properly throughout the measurements.

Methods

All measurements were performed by slowly scanning over the display screen, which was filled with letters and symbols, as in a normal operation. Approximately 20% of the VDTs were measured on all six surfaces with the remaining VDTs being surveyed on all surfaces except the bottom. The gross X-ray levels recorded ranged from 0.12 to 0.85 $mR \cdot hr^{-1}$. The unit with the highest momentary value recorded (0.85 $mR \cdot hr^{-1}$) was rechecked at the conclusion of the survey and a reading of 0.20 $mR \cdot hr^{-1}$ was obtained. The momentary high level is attributable to background fluctuations. When these levels are compared with the background readings, it is apparent that no measurable radiation was observed. Table 4 indicates the range of X-ray levels, in $mR \cdot hr^{-1}$, measured on the various VDT types.

In February 1977, a major insurance company surveyed 67 VDTs at the same newspaper facility where measurements were made for this study (5). The maximum X-ray level measured at the screen face from all these units was 0.2 $mR \cdot hr^{-1}$. The VDTs surveyed at that time included the following models: Harris 1500A, Harris 1520, Data Speed 40, Data Disc 66121, and IBM 3277. The insurance company indicated that, since the background ranged from 0.1 to 0.3 $mR \cdot hr^{-1}$, no measurable X-ray radiation was being emitted by the units surveyed.

No X-ray measurements were made during the 1977 NIOSH survey for two reasons. First, the X-ray results from the insurance company and from previous NIOSH measurements on similar VDTs, both at the same and another newspaper plant, indicate no X-ray emission; and second, the results of X-ray measurements made by other groups on the same type VDTs indicated no occupational exposure when the equipment was properly shielded, as specified by the manufacturers.

TABLE 4. X-RAY EXPOSURE LEVELS FOR VDTs*.

VDT TYPE	NUMBER OF UNITS SURVEYED	RANGE OF X-RAY LEVELS ($mR \cdot hr^{-1}$) MAXIMUM	MINIMUM
Harris 1500A	75	0.85	0.13
IBM 3270	39	0.25	0.12
Infrarex 1303	11	0.22	0.14
Background		0.70	0.16

* Data are from the surveys made at both the newspaper and the other industrial facility

DISCUSSION

This section discusses results of pertinent electromagnetic radiation measurements and of medical examinations conducted at the newspaper facility.

ELECTROMAGNETIC RADIATION RESULTS

The potential electromagnetic radiation hazards from the VDTs surveyed in the NIOSH 1977 report may be evaluated by comparing the maximum observed reading in any of the regions with currently accepted standards. Table 5 summarizes the information. Note all values reported in Table 5 are below current safety standards. The symbol ND in the table indicates that energy levels were too low to be detected by the appropriate instrument on the most sensitive scale. All measurements were obtained with the detector probes in contact with the VDT screen face. This means that even these low "emission" levels must be further reduced by geometrical consideration in order to characterize the exposure at the eye position of the operator, typically 0.5 to 1 meter (m) from the screen. Therefore, it is appropriate to state that radiation levels at a distance of 0.5 to 1 m away from the VDT will be even lower than the values which appear in Table 5.

Based on the above measurements, the current safety standards, and present knowledge of biological effects, the VDTs surveyed do not appear capable of producing levels of radiation presenting an occupational ocular radiation hazard.

MEDICAL

The two workers with cataracts, one a 35-year-old male and the other a 29-year-old male, were interviewed by a physician who obtained detailed occupational and medical histories. Their medical records at the newspaper medical department and reports of two independent ophthalmological examinations conducted in 1977 were reviewed. In addition, in the case of the 29-year-old male, reports were received of four ophthalmological examinations performed between November 1970 and February 1976 by an ophthalmologist who is now deceased.

The duration of exposure to VDT units at the newspaper was approximately four months for the 35-year-old male and one year for the 29-year-old male. In addition, the 29-year-old worker was exposed during a three-month training period (approximately one hour per day for a few days each week) beginning late November 1975.

Both of the ophthalmologists who examined the two workers in 1977 reported finding bilateral posterior cataracts. In addition, the 34-year-old male was noted to have evidence of some retinal degeneration. Attempts to obtain

TABLE 5. COMPARISON OF MAXIMUM VDT RADIATION LEVELS MEASURED AT THE SCREEN FACE WITH CURRENTLY ACCEPTED STANDARDS.

RADIATION REGION	MAXIMUM VDT MEASURED LEVEL	OCCUPATIONAL EXPOSURE STANDARD	REFERENCE	
Ultraviolet	$2 \times 10^{-9} W \cdot cm^{-2}$	$1 \times 10^{-3} W \cdot cm^{-2}$	NIOSH CD	(8)
Visible (luminance)	21 fL	2.92×10^{3} fL	ACGIH TLV	(7)
Infrared	ND*	$10^{-2} W \cdot cm^{-2}$	ACGIH TLV	(7)
RF-Electric Field Strength	ND*	$2 \times 10^{2} V \cdot m^{-1}$	ANSI	(8)
RF-Magnetic Field Strength	ND*	$5 \times 10^{-1} A \cdot m^{-1}$	ANSI	(8)
X-ray	$0.85\ mR \cdot hr^{-1}$**	$2.5 mR \cdot hr^{-1}$***	OSHA	(9)

* Not detectable
** Includes background level
*** Based on the average annual dose limit of 5000 mR divided by 2000 working hours per year.

records of previous ophthalmological examinations on this worker were not successful. However, the reports of the previous ophthalmological examination on the 29-year-old male showed the first indication of a posterior polar cataract in the right eye on February 26, 1976, a time coinciding with the onset of his continuous daily exposure to the VDT units. (As noted previously, there was a training period of brief intermittent exposure over about three months before he used the units on a regular basis.)

The cataracts found in the two employees are compatible with those reported from exposure to radiant energy, but they are also compatible with those seen congenitally or those associated with other etiologies, such as diabetes or steroids. However, the workers' medical histories did not disclose any pertinent information to suggest any such etiologies for the cataracts. Since the survey did not indicate any significant occupational electromagnetic radiation levels, the etiology of the cataracts remains undetermined.

Estimates of the incidence of cataract in the United States by age and sex range from 330,000 to 900,000 cases per year with the incidence for women considerably higher than for men (10).

PHOSPHORS

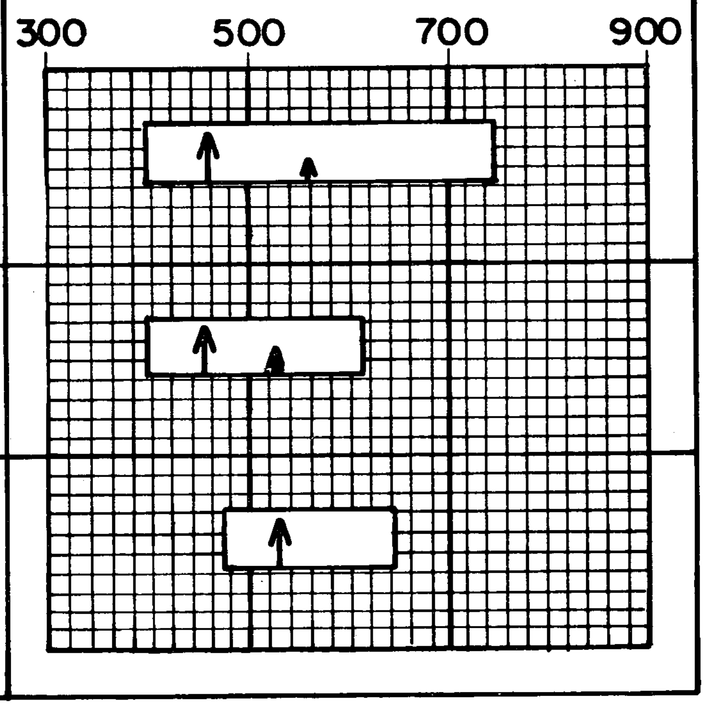
Information can be viewed on a VDT because of the manner in which electrons interact with the phosphor coating present on the screen of a cathode ray tube. Phosphors are chemical substances which exhibit fluorescence (i.e., emit visible light) when excited by ultraviolet radiation or X-rays for example. The amount of visible light produced by a phosphor is proportional to the amount of excitation energy. Every phosphor has a property that allows it to emit light for a very short time after the excitation energy has been removed. This particular property is called persistence, and is extremely important in viewing information presented on the screen.

Table 6 indicates some of the characteristics of the phosphors generally used in VDTs, and specifically those encountered in these measurements. The open blocks containing the arrows represent the spectra associated with the given phosphor. The arrows indicate the position of spectral emission peaks. Notice that the spectral output of these phosphors is limited to a fairly narrow spectral range. Much of the work done in categorizing phosphor properties has been performed by the Joint Electron Device Engineering Council (11).

Table 7 confirms the findings that very little UV radiation can be emitted by the VDT. As explained earlier, the level of visible radiation emitted by the phosphors was below the detection limit of the spectroradiometer. Furthermore, the table substantiates the fact that no IR radiation could be detected (since none is emitted). Finally, no measurements were observed which would suggest an increased radiation level of any type as a function of age of VDT. Not every phosphor made is classified in Reference 11; however, most of the phosphors used in VDTs are catalogued and referenced by the organization (11). Using that reference, a spectral energy distribution was made of all phosphors listed, as of November 1975, and is shown in Table 7.

Table 6. Spectral characteristics of phosphors found in VDTs measured in this report (2).

PHOSPHOR DESIGNATION	WAVELENGTH OF PROMINENT SPECTRAL PEAK		SPECTRAL RANGE (nm)
	MAXIMUM	OTHER	
P4 (SULFIDE)	460	560	
P 31	520	455	
P 39	525	—	



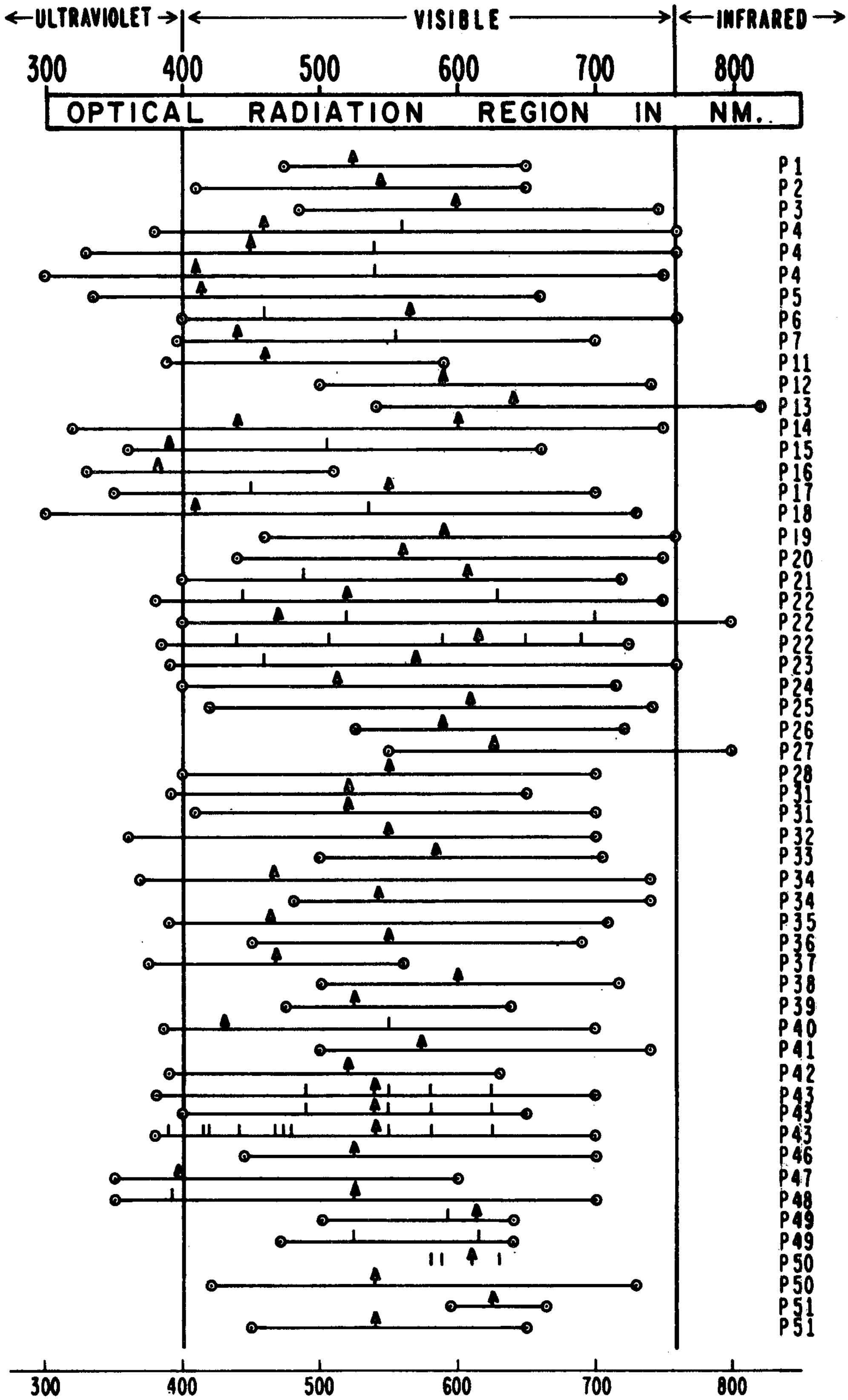


TABLE 7. Estimated spectral energy distribution characterisics of all phosphors modified from JEDEC A/O November 1975.

As can be seen from this list, only three phosphors emit in the IR range while 25 emit in the UV. All IR emitting phosphors in the list produce considerably less than 20% of the total optical spectrum in the IR. With the exceptions of P-15, P-16, and P-47, most of the UV emitting phosphors also produce very little of their total optical spectrum in the UV region (the average is 10 to 20%). Such a list could be of value in possibly averting any future concern associated with optical radiation.

EYESTRAIN

A review of the literature of VDT indicates that no specific occupationally-induced disease has, to date, been documented so as to imply the VDT as the causative agent. Complaints of eyestrain (aesthenopia), however, often are voiced. And, with the many VDTs in use, the number of complaints could be quite large.

Eye fatigue and associated symptomatology experienced by people working on VDTs may be similar to the fatigue encountered by workers in other occupations (12). Many factors related to the worker, such as his visual acuity, the task to be performed, the VDT itself, the work environment, and the background lighting, will affect the probability that an individual will experience the above symptoms. Obviously, work posture, equipment layout, age of worker, length of time spent on VDT, environmental lighting, presence of eye glasses or contact lens, use of antireflection coatings, and latent visual defects are a few factors which will affect the incidence of eye fatigue.

More definitive studies are required to identify the impact of these factors. Some research has been performed by the Armed Services (e.g., on air traffic controllers) and by VDT manufacturers. Two excellent reviews of this subject were prepared by Hart (13) and Ostberg (14).

OTHER MEASUREMENTS

Very little published information was available on VDT radiation levels and measurement techniques prior to the NIOSH involvement. After obtaining the results presented in this report, and discussing the related problems with many people, several additional measurement exercises to validate these results were conducted by non-government facilities. NIOSH has reports from two different facilities examining different VDT models. These reports essentially confirm the data presented in this report. A small difference exists in the numbers obtained in measurements, but in no case did any VDT unit come near exceeding the recommended standard. Frequencies were identified by using a frequency analyzer, with none being detected above 250 MHz, as previously mentioned.

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☆ U.S. GOVERNMENT PRINTING OFFICE: 1978— 757-141/6778

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