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I. SUMMARY

In November 1990, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Librarian of Congress (LOC) in Washington, D.C. for an evaluation of occupational exposure to electromagnetic radiation (EMR) emitted by video display terminals (VDT) at the Madison Building. This evaluation was prompted by two LOC workers concerned over EMR exposure levels they might be receiving while working on VDTs at two different worksites. EMR measurements were performed on April 3 and July 8, 1991, at selected worksites within the Madison Building.

Measurements for ionizing, ultraviolet (UV), visible (including illumination), and infrared (IR) radiation, along with very low frequency (VLF) and extra low frequency (ELF) electric and magnetic field strength, were made on four similar VDTs at the LOC. In addition, ELF and VLF frequencies were documented and measurements made of electrical current induced in workers from exposure to VDT electric fields.

The maximum x-ray radiation level range measured at the screen face was 2 to 6 counts per minutes (cpm), and the maximum background activity measured in the outside hall was 3 cpm. A reading of 4000 cpm is roughly equivalent to an exposure rate of 0.5 milliroentgens per hour (mR/hr), which is the Food and Drug Administration (FDA) emission standard for television receivers. The maximum screen emissions in the actinic and near UV radiation regions, from any of the four VDTs measured, were non-detectable and 1.7 x 10^{-7} watts per square centimeters (W/cm^2), respectively. The maximum near UV radiation measured from any of the auxiliary light sources near the VDT worksites, as measured at the operator's face, was 3.3 x 10^{-5} W/cm^2. Screen luminance levels ranged from 3.3×10^{-4} to 1×10^{-3} candela per square centimeter (cd/cm^2) without the presence of any auxiliary lights in the immediate work area. The illumination levels in both areas were about the same. In room LM-517 the levels ranged from 100 to 800 lux, and in room LM-513 they ranged from 3 to 900 lux. While there is no precise illumination level recommended for VDT work, the highest level suggested by Illuminating Engineering Society (IES) for office work involving VDT use is given at 50-100 lux. The IR levels emitted by the VDTs ranged from 0.023 to 0.028 milliwatt per square centimeter (mW/cm^2). The IR levels were about three orders of magnitude below the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of 10 mW/cm^2. One of the reasons for such low IR levels is that few phosphors produce radiation in the IR region and the emissions would therefore be at a very low level.

VLF electric and magnetic field strength levels at the operator's facial position in front of the screens ranged from 1.1 to 7.0 volts per meter (V/m) and 10 to 170 milliamperes per meter (mA/m), respectively. ELF electric and magnetic fields measured at these same locations ranged from 1.0 to 8.5 V/m and 5 to 353 mA/m, respectively. The ACGIH has published TLVs for sub-radiofrequency electric and magnetic fields. At 60 hertz (Hz), which is classified as extremely low frequencies (ELF), the electric field strength TLV is 25,000 volts per meter (V/m) and the magnetic field intensity TLV is 800,000 milliamp per meter (mA/m). At 22 kilohertz (kHz), which is classified as very low frequency (VLF), the electric field intensity TLV is 625 V/m and the magnetic field strength TLV is 2176 mA/m.

The maximum induced currents from any of the four terminals, when measured with hands on the keyboards, finger touching the screen, and with the hand placed flat on the screen were 0.0008, 0.0038, and 0.0463 milliamperes (mA), respectively. The American National Standard Institute (ANSI, C95.1 committee) has recently adopted a level of 22 mA for induced body currents at 22 kHz.

Based on the data collected in this survey, it was found that occupational EMR exposures to VDTs at the LOC are relatively low, within the range of other EMR exposure data on VDTs previously reported by NIOSH, and are below current exposure criteria levels. It is, therefore, concluded that the EMR exposures measured from any of the four VDTs evaluated would not be expected to cause adverse health effects.

KEYWORDS: SIC 8231 (Libraries), electromagnetic radiation exposure, video display terminals, VDTs, Library of Congress.

II. INTRODUCTION

In November 1990, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Librarian of Congress (LOC) in Washington, D.C. for an evaluation of occupational exposure to electromagnetic radiation (EMR) emitted by video display terminals (VDT) at the Madison Building. Concern had been expressed by two workers at two different LOC worksites over EMR exposure levels from VDTs. EMR measurements were performed in the Madison Building on April 3 and July 8, 1991, at the two worker's sites and at two randomly selected worksites, by NIOSH investigators.

III. BACKGROUND

In recent years there have been many articles and scientific papers published on various occupational safety and health issues related to the use of VDTs in the workplace.[1-4] One of the more consistent occupational issues that is constantly voiced about VDT use is concern over occupational EMR exposures from VDTs. In order to better understand the nature of this potential concern it is necessary to understand how the VDT produces EMR.

VDTs contain a large evacuated glass tube called a cathode-ray tube (CRT). The CRT contains a cathode, which produces a source of electrons at one end, and an anode, made up of a fluorescent-coated viewing screen, at the other end. The VDT can produce several types of EMR, depending upon its operating characteristics. Low energy x-rays can be generated by the CRT and electronic damper circuits. Ultraviolet (UV), visible, and infrared radiation (IR) can be emitted at the screen face from excitation of the phosphor by electrons. It is the visible light that is seen by the user on the viewing screen in the form of symbols and letters. The CRT also includes various electrical circuits for focussing the electron beam and for scanning the beam across the fluorescent screen. These circuits produce electric and magnetic field emissions at different frequencies (mainly extremely low frequency [ELF] and very low frequency [VLF]). The major source of the radiofrequency radiation produced by the VDT is generated by the flyback transformer. This device controls the horizontal deflection system and operates at about 15 to 20 kilohertz (kHz). ELF radiation in the range from 0 to 1000 hertz (Hz) is also present and is associated with the vertical deflection system and other electronic components. No microwave radiation is emitted by VDTs since the highest measured frequency in VDTs is in the region around 30 megahertz (mHz).

This request for a complete VDT EMR evaluation by the LOC was prompted by two employees reporting health problems from working on VDTs. The first case involved a worker who reported suffering an "electrical spike" injury to his eyelid while performing VDT work. In the second case, a worker reported the development of a facial basal cell carcinoma from working with VDTs for several years. NIOSH agreed to make an assessment of the VDT work stations for the exposed individuals to determine if the health problems could be related to VDT EMR exposures.

IV. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most

workers may be exposed without experiencing adverse health effects. It is, however, important to note that not all exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity situation. In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects, even if the occupational exposures are controlled at the level set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus, potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information about chemical and physical agents becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH criteria documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational diseases. In evaluating the exposure levels and the recommendations for reducing these levels found in these reports, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

At present there is limited information from OSHA on exposure criteria for workers exposed to physical agents. Criteria for physical agents not covered by OSHA come from either ACGIH, NIOSH, or in some cases from consensus standards promulgated by the American National Standards Institute (ANSI). In this investigation the following evaluation criteria were used:

X-Radiation. The potential for x-ray production from television receivers led the Food and Drug Administration (FDA) in 1973 to develop a performance standard for x-ray emissions. This standard specifies that exposure rates produced by a television receiver shall not exceed 0.5 milliroentgens per hour (mR/hr) at a distance of 5 centimeters from any point on the external surface of the receiver.[5] Discussions with the FDA by NIOSH investigators have indicated that this standard would apply to any type of "video display" device. In addition, under OSHA regulations, a worker can be exposed to 2.5 mR/hr and not exceed the yearly exposure limit.[6]

Optical Radiation. The exposure limits used by the NIOSH investigators to determine optical radiation (ultraviolet, visible, and infrared) occupational exposure are based on an 8-hour exposure level and were developed by the ACGIH.[7] The Illuminating Engineering Society (IES) has developed lighting guideline levels which were used in this evaluation. While there is no precise illumination level recommended for VDT work, the highest level suggested by IES[8] for office work involving VDT use is given at 50-100 lux. However, if fine or distant work is performed (which is often the case), then these illumination levels could be increased to 200-500 lux.

ELF and Sub-RF Electric and Magnetic Fields. The ACGIH has published Threshold Limit Values (TLVs) for sub-radiofrequency electric and magnetic fields.[7] At 60 Hz, which is classified as ELF, the electric field strength TLV is 25,000 volts per meter (V/m) and the magnetic field intensity TLV is 800,000 milliamp per meter (mA/m). At 22 kHz, which is classified as VLF, the electric field intensity TLV is 625 V/m and the magnetic field strength TLV is 2176 mA/m. In addition, ANSI has promulgated standards that are applicable to the same frequency region. ANSI C95.1-1991[9] recommends occupational exposure at 22 kHz should not exceed 614 V/m and 163 A/m. ANSI has also adopted, in the same standard, a level for induced body currents in the frequency range from 3 to 100 kHz. At 22 kHz, this standard limits the induced current to 22 milliamperes.

Table 1 summarizes the maximum occupation values used as the evaluation criteria for each portion of the EMR spectrum measured at the LOC.

V. METHODS AND MATERIALS

Measurements were made on a total of four Northern Telecom 13 inch monochrome VDTs operating at 9 kilovolts. Two of the VDTs were used by the two employees concerned about radiation exposures and two were randomly selected VDTs used as controls by NIOSH. The EMR survey consisted of measurements being made to evaluate x-radiation, UV radiation, luminance, IR radiation, sweep frequencies, illumination, and operator ELF/VLF electric and magnetic field strengths levels. Measurements were performed on all VDTs under the operating conditions at the workstation on the day of measurement. No adjustments of brightness, screen content, or worker's location were made on any terminal. All measurements were performed with the screen full of characters during both day and evening hours.

The following equipment was used to document levels of radiant energy produced by the VDTs:

X-Radiation. A Stoms meter was used to detect any X-ray beams generated by the terminal. The meter, which uses four Victoreen model 1B85 Geiger-Mueller tubes as detectors, is very sensitive and specifically designed to locate small low-energy x-ray beams. The meter is used only to detect, and not to measure, x-rays. In using the meter, measurements were made as close as possible to the screen face surface of the VDT by slowly scanning in both the horizontal and vertical directions while observing for maximum meter needle deflection. The meter reads out in units of counts per minute (cpm). A reading of 4000 cpm is roughly equivalent to an exposure rate of 0.5 mR/hr, which is the FDA emission standard for television receivers.[10] Background radiation levels were made in the hallway outside of the measured worksites.

A Victoreen Model 440 RF/C radiation detector was available to measure x-ray emissions accurately in case any meaningful radiation, i.e. above background, was detected with the Stoms meter. The 440 RF/C is specifically designed to measure x-ray emissions from TV receivers and is shielded against electromagnetic interference. Exposure rates as low as 0.05 mR/hr can be measured, and the overall accuracy is ± 15%.

Optical Radiation. Luminance or brightness levels were measured with a Spectra Mini-Spot photometer having a one degree field of view. Readings were taken at a distance of one meter from the screen face. The minimum luminance that can be read is 0.5 footlamberts (fL) and the overall accuracy is ± 10%. The values were obtained in terms of fL which are converted to candela per square centimeter (cd/cm^2). The luminance of a source is a measure of its brightness when observed by an individual without eye protection, regardless of the distance from source.

Illumination measurements were performed with a calibrated model 500 Litemate photometer system manufactured by Photo Research, Inc. that reads out in units of lux over the wavelength region from 380 to
760 nanometer (nm).

A International Light model 730A radiometer, with specially calibrated detectors, was used to evaluate the UV radiation levels produced in the worksite area as well as from VDTs. One detector was designed to read the actinic UV radiation (200 to 320 nm) in biologically effective units of microwatt per square centimeter ($\mu W/cm^2$), while the other detector measured near UV (320-400 nm) in units of milliwatt per square centimeter (mW/cm^2) with no biologic weighing factor. In evaluating VDT emission levels, all measurements with these instruments were made at contact with the VDT screen face. Evaluation of non-VDT produced UV radiation was made with the instruments held at the operator's eye position.

A Eppley model 901 calibrated thermopile with a quartz window was used to measure irradiance in units of mW/cm^2 over the wavelength range from 200 to 4500 nm. Measurement of the IR emitted by the VDT was made with the Eppley thermopile positioned at 1/2 inch from the screen face.

Electric and Magnetic Fields. Specially designed VLF and ELF instrumentation that were manufactured by Holaday Industries, Inc. were used in the survey. Models HI-3600-01 and HI-3600-02 survey meters were used to measure the electric and magnetic fields in the VLF and ELF frequency bands. Spatial distribution of these fields is shown in Figure 1. The instruments also provided the ability to measure the emitted radiation frequencies. NIOSH investigators made operator exposure measurements at the location where the operator normally performs VDT tasks. Figure 2 shows how these meters are used in making these measurements.

E-field induced body currents were measured by applying a conductive wristband to the arm of the operator. The wristband was connected to one input terminal of a Fluke model 8060A digital multimeter, in the
microampere (μA) measurement mode, while the other test lead was connected to the chassis of the VDT taken to be ground potential.

All equipment used to document exposure to EMR fields had been calibrated within six months of use either by NIOSH or their respective manufacturer.

VI. RESULTS

Detailed results on each VDT evaluated are shown in Tables 2-5. Since all the VDTs measured in this evaluation were similar, a photograph of a typical surveyed VDT station is shown in Figure 3.

The maximum x-ray radiation level range measured at the screen face was 2 to 6 cpm, and the maximum background activity measured in the outside hall was 3 cpm.

The maximum screen emissions in the actinic and near UV regions from any of the four VDTs measured were non-detectable and 1.7×10^{-7} W/cm^2, respectively. The maximum near UV measured from any of the auxiliary sources near the VDT worksites, as measured at the operator's eye, was 3.3×10^{-5} W/cm^2. Since one of the exposed worker's physician had advised his client to avoid exposure to UV radiation in the "B spectrum" (280 to 320 nm), particular attention was taken in documenting UV-B exposure levels at all applicable worksites. All measurements for UV-B radiation in this worker's area of operation were recorded as non-detected.

Screen luminance levels ranged from 1 to 3 fL without the presence of any auxiliary lights in the immediate work area. When the auxiliary light sources were turned on the range of screen luminance levels increased slightly from 2 to 4 fL.

The room illumination levels in the VDT workspace (without the presence of any auxiliary light sources) in both areas were about the same. In room LM-517 the levels ranged from 100 to 800 lux, and in room LM-513 they ranged from 3 to 900 lux. At two locations these levels increased when the auxiliary light sources were turned on.

The IR levels ranged from 0.023 to 0.028 mW/cm^2.

ELF electric and magnetic field levels in the operator's facial area ranged from 1.0 to 8.5 V/m and 5 to 353 mA/m, respectively. VLF electric and magnetic fields were 1.1 to 7 V/m and 10 to 170 mA/m, respectively at the same facial location.

The maximum induced body current in the operator's arm at any of the VDTs, was 46.3 µA and occurred when the entire hand was placed on the screen face.

VII. DISCUSSION AND CONCLUSIONS

EMR Evaluation. The results of scanning the front screen in both directions did not indicate levels of ionizing radiation from any of the four VDTs, much different from those of background levels measured in the hallway. The maximum x-ray emission detected was 6 cpm, or approximately 0.8 microroentgens per hour (µR/hr). This level is about 1000 times below the FDA emission level and at least 3000 times below the OSHA standard. This observation of low x-ray emission from VDTs has been shown before in other VDT studies.[10-12]

Auxiliary light sources, found in three of the four VDT worksites surveyed, were used to provide additional task lighting to the work area other than what was provided by the installed ceiling lights. The presence of auxiliary light sources in both VDT work areas did increase the overall illumination levels in the work area, and could create some VDT screen glare problems under certain viewing conditions. If the auxiliary light sources were

used frequently at two of the locations, they probably would create visual fatigue. However, the NIOSH investigators were told by three of the operators that these sources were not used frequently.

It has been shown by other NIOSH studies[13-14] that the electric and magnetic fields strength levels decrease rapidly with increasing distance from the VDT. This suggests that VDT exposure to EMR fields could become more a function of the manner in which the VDT is used (i.e., the distance the operator sits from the display) rather than the emissions of the terminal. It should be noted that because of terminal location, some of the ELF results were hard to measure without moving the existing workstation barriers. As a result, some of the levels varied due to nearby VDTs.

Since the electric and magnetic ELF/VLF field strength measurements were taken after normal work hours (when the operators were absent), measurements were made at the work position (i.e. the distance between the screen face and the mid-point of the chair seat used by the operator) that NIOSH investigators had observed work being performed by the regular operator. All of these particular measurements were performed with NIOSH personnel serving in the role of the operator.

It is noted that electric fields produced by VDTs can be strongly perturbed by the presence of objects near the VDT, such as other terminals, walls, barriers, and operators. For example, the degree to which the operator's body can influence the electric field is apparent because the facial exposure is greater than that which the rest of the body receives. As a result of the complicated manner in which the human body couples with the E- and H-fields, it was necessary to evaluate the current which is induced in the operator body by non-uniform ELF/VLF fields.

Since the operator's arm, wrist, and fingers have to be close to the VDT in order to operate it, three different measurements were made at each workstation. The highest induced current level occurred when the entire hand was placed in contact with the screen. These measurements generally agreed with a previous NIOSH study.[14] In that study, it was shown that the measured current levels were found to be quite variable among operators. The study reported a maximum induced current range of 7.3 to 424 µA when the operator's hand was in contact with VDT screen faces (different manufacturer than those evaluated at the LOC). When the ANSI induced body current limit is compared to the values measured for VDT operators at the LOC (35 to 46.3 µA), it is apparent that exposures are almost 1000 times below the permitted ANSI limit.

During the conduct of this induced current evaluation none of the regular operators were at the workstation. Therefore, it was necessary to record these induced currents using NIOSH personnel. On one occasion, it was possible to compare these values using NIOSH personnel with a LOC VDT operator who worked at a terminal other than the four being tested. The body current recorded for that woman was 20% higher than those recorded for NIOSH personnel (who were males). Even with these higher measured current levels for a LOC worker, the measured levels are still well below occupational concerns.

The only quantity measured at the LOC VDT worksites that exceeded suggested guideline values was the illumination. It is apparent that the use of the auxiliary light sources yield higher illumination levels than those recommended by IES. However, no complaints were

voiced by the workers. One of the workstations did have greatly reduced room lighting levels. This was accomplished by disconnecting the lamps in the fixture.

None of the EMR levels produced by the VDTs at the LOC exceeded currently applicable EMR exposure limits. In fact, the x-ray, near and far UV, luminance, and IR radiation levels are not only below current standards, but are also far below the thresholds for producing biological injury, and in some cases, were not detectable.

Examination of the measured emitted electric and magnetic field strength values obtained in this study shows that in no instance do either the VLF or ELF fields, as measured at the operator's position, exceed the ACGIH TLVs. Based on these findings, it is concluded that occupational exposures to VDT electric or magnetic field emissions at the LOC are relatively low, within the range of other exposure data on VDTs previously reported by NIOSH, and are substantially less than the recommended ACGIH TLVs for both ELF and VLF electric and magnetic field intensities.

Medical Aspects. As reported earlier, this evaluation was prompted by two employees reporting health problems from working on VDTs. The problems reported were an "electrical spike" injury to the eyelid, and the development of a facial basal cell carcinoma.

The investigators were unable to determine the cause of the reported electrical spike injury incurred by one worker. Attempts were made to simulate possible VDT arcing phenomena by pushing the VDT's "off-on" button many times in a short duration. No arcing occurred on any of the VDTs evaluated on the days of measurement. To our knowledge, no such similar incident has ever been reported by a VDT operator.

Medical records support the fact that one worker had undergone treatment for facial basal cell carcinoma. While UV radiation levels may influence the development of such tumors, the amount of occupational UV radiation received by the worker from the VDT was found to be about 3000 times less than what would be found outdoors on a clear day.

Non-VDT Observations. During the conduct of this evaluation three non-VDT issues arose. These issues were: 1) the presence of small step-down transformers located in the Madison Building which produced localized elevated levels of ELF magnetic fields; 2) EMR evaluation of an electrical room in area LM-5 located near terminals 1 and 2; and 3) overview of the wiring configuration on the fifth floor near the VDT stations.

First, it was noted that ELF fields, at 60 Hz, were being emitted from a electrical closet in close proximity to terminals 3 and 4. Apparently, during the survey of the worksite, the door leading to this particular electrical closet had been left ajar. With the door open, the NIOSH investigators observed elevated magnetic field levels in the order of 400-1000 mA/m at the door. Upon further investigation, it was learned that all of the electrical closets at the Madison Building contained small step-down transformers used to fulfill the electrical requirements in a given area. The existence of these transformers, installed overhead in these closets (about 7-8 feet from the floor), were known to the electrical department and procedures had been developed requiring the doors to always be closed. The transformers are the dry-type and do not contain PCBs. EMR measurements were made in several electrical closets that did indeed suggest that high magnetic fields could be obtained at close distances to these transformers. However, as the distance increased from

these transformers, the fields were greatly reduced. At the distance these transformers were located from the VDTs measured, and with the doors closed, the levels would be considerably below the TLVs and therefore not be considered an occupational concern. Nevertheless, with the number of electrical closets that exist within the building, a more complete evaluation of the magnetic fields levels from these transformers needs to be performed by the LOC to insure that other occupational exposures are not occurring.

Second, since two of the VDTs which were measured were located near a VDT controller room, additional information was obtained about its electrical power requirements. The controller room is located in room LM 517 and contains 12 Northern Telecom Model 294C control units. The external AC power voltages for each controller ranges from 100 to 115 volts at current levels not to exceed 5.9 amperes. EMR measurements were also made both in and outside of the controller room in room LM 517 because of its proximity to the VDTs.

Results of the EMR survey indicated that levels of ELF magnetic field strengths ranged as high as 1700 mA/m at contact with the controller surface, 300-500 mA/m at various walkway locations in the room, and 140 mA/m at the doorway leading into the controller room. For comparison, magnetic field strength in the hallway outside of the offices was as high as 7 mA/m. Maximum electric field strength (both in and out of the room) was 6 V/m and 2 V/m, respectively. All of these results were below ACGIH TLVs.

The controller room does have a door on it, but the door is often open due to heat levels that can build up. During the measurements, no LOC worker was observed to enter the controller room or even stand near its doorway.

Third, prior to initiating any ELF and VLF measurements, the NIOSH investigators requested engineering drawings and schematics, as well as specifications describing the electrical distribution system in the spaces around the worksites to be measured. The NIOSH investigators also asked the LOC to identify any potential MW/RF sources that could emit EMR into the VDT work areas. NIOSH was informed that the electrical circuitry associated with the lighting distribution system consisted of 277/480 volts, three phase, 60 Hz. All of the electrical outlets in the work area were rated at 120/208 volts, three phase, 60 Hz. The fire alarm system operated at 24 volts, single phase, 60 Hz. The telephone equipment on the floor was serviced by twisted pair cabling carrying 48 volts (DC) with a maximum amperage of 80 mA. Each display terminal requires external AC power of 85 to 115 volts and 2.5 amperes. It was estimated by LOC personnel that the coaxial cables connecting the VDTs carry voltages of +5 to -12 V DC with a maximum amperage of 160 mA.

No MW/RF sources were identified either by LOC correspondence or on the drawings submitted. In addition, NIOSH performed a radiation survey at each VDT site using a NARDA Isotropic Probe Model 8621D connected to a Radiation Monitor Model 8616. This probe/monitor system is designed to measure EMR in the frequency range from 0.3 to 40 gigahertz at a sensitivity of 0.01 mW/cm^2. No readings in the vicinity of the VDTs were detectable with this measurement system.

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IX. AUTHORSHIP AND ACKNOWLEDGMENTS

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2. NIOSH
3. OSHA, Region II

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TABLE 1

Maximum Measured EMR Values
at LOC Compared to
Occupational Exposure Limit

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EMR Region	Maximum Measured Level	Exposure Limit
X-Ray	0.8 µR/hr	2.5 mR/hr[a]
Actinic UVR (200 - 315 nm)	ND[b]	0.1 eff × 10^{-6} W/cm^{2}[e]
Near UVR (320 - 400 nm)	3.3 × 10^{-5} W/cm^{2}	1.0 × 10^{-3} W/cm^{2} for[e] periods > 16 minutes
Illumination (400 - 760 nm)	1400 lux	200 - 500 lux[b]
Luminance (400 - 760 nm)	1 × 10^{-3} cd/cm^{2}	1.0 cd/cm^{2} in[e] 8-hour day
Infrared (760 - 1400 nm)	0.028 mW/cm^{2}	10 mW/cm^{2} in[e] 8-hour day
VLF-E (22 kHz)	7 V/m	614 V/m[c]
VLF-H (22 kHz)	170 mA/m	2176 mA/m[e]
ELF-E (60 Hz)	8.5 V/m	25,000 V/m[e]
ELF-H (60 Hz)	353 mA/m	800,000 mA/m[e]
Induced Currents	46.3 µA	22 mA[d]

[a] U.S. Department of Labor, 1980a
[b] ND - Non-Detectable
[c] From Illuminating Engineering Society[8]
[d] From American National Standard Institute
[e] American Conference of Governmental Industrial Hygienists

TABLE 2

DATA SHEET FOR TERMINAL 1

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HETA 91-070

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LOCATION: LM-517 MODEL NUMBER: 298-E2
DISPLAY TERMINAL TYPE: Northern Telecom VLF SWEEP (kHz): 22.06
SERIAL/STATION NUMBER: M-29905 ELF SWEEP (Hz): 51.06

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MAXIMUM X-RAY LEVEL (c/m) Horizontal = 6
Vertical = 4
Background = 3

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MAXIMUM SCREEN NEAR UV (W/cm^2) = 1.3×10^{-7}
MAXIMUM NEAR UV (W/cm^2)[w/ aux. light] = 5.5×10^{-6}
MAXIMUM SCREEN ACTINIC UV ($\mu W/cm^2$) = ND
MAXIMUM SCREEN LUMINANCE (cd/cm^2) = 3.3×10^{-4}
MAXIMUM SCREEN IR (mW/cm^2) = 0.028
ILLUMINATION (lux) Terminal top = 300
At screen face = 100
In work area = 100 - 800
w/ auxiliary light = 700

==========

OPERATOR POSITION EXPOSURE RMS FIELD STRENGTH VALUES

Field	Abdomen	Chest	Face
VLF E (V/m)	2.7	3.3	7.0
VLF H (mA/m)	120	140	170
ELF E (V/m)	5.8	6.3	8.5
ELF H (mA/m)	22	22	30

==========

OPERATOR RMS INDUCED CURRENTS

Hand Position	Induced Current (μA)
Hands on keyboard	0.3
Finger touching screen	3.8
Hand placed flat on screen	40.2

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General Waveform shape:

See Figure 4

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TABLE 3

DATA SHEET FOR TERMINAL 2

LIBRARY OF CONGRESS
WASHINGTON, D.C.
HETA 91-070

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LOCATION: LM-517 MODEL NUMBER: 298 E2
DISPLAY TERMINAL TYPE: Northern Telecom VLF SWEEP (kHz): 22.06
SERIAL/STATION NUMBER: M-29972 ELF SWEEP (Hz): 51.06

==========

MAXIMUM X-RAY LEVEL (c/m) Horizontal = 4
Vertical = 4
Background = 3

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MAXIMUM SCREEN NEAR UV (W/cm^2) = 1.1×10^{-7}
MAXIMUM NEAR UV (W/cm^2)[w/ aux. light] = 2.8×10^{-6}
MAXIMUM SCREEN ACTINIC UV ($\mu W/cm^2$) = ND
MAXIMUM SCREEN LUMINANCE (cd/cm^2) = 1×10^{-3}
MAXIMUM SCREEN IR (mW/cm^2) = 0.023
ILLUMINATION (lux) Terminal top = 400
At screen face = 200
In work area = 100 - 800
w/ auxiliary light = N/A

==========

OPERATOR POSITION EXPOSURE RMS FIELD STRENGTH VALUES

Field	Abdomen	Chest	Face
VLF E (V/m)	1.1	1.5	2.8
VLF H (mA/m)	98	114	160
ELF E (V/m)	2.2	3.1	5.1
ELF H (mA/m)	5	8	28

==========

OPERATOR RMS INDUCED CURRENTS

Hand Position	Induced Current (µA)
Hands on keyboard	0.4
Finger touching screen	2.7
Hand placed flat on screen	35.1

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General Waveform shape:

See Figure 4

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TABLE 4

DATA SHEET FOR TERMINAL 3

LIBRARY OF CONGRESS
WASHINGTON, D.C.
HETA 91-070

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LOCATION: LM-513 MODEL NUMBER: 298E-2
DISPLAY TERMINAL TYPE: Northern Telecom VLF SWEEP (kHz): 22.06
SERIAL/STATION NUMBER: M-30092 ELF SWEEP (Hz): 51.06

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MAXIMUM X-RAY LEVEL (c/m) Horizontal = 2
Vertical = 4
Background = 3

==========

MAXIMUM SCREEN NEAR UV (W/cm^2) = 1.7×10^{-7}
MAXIMUM NEAR UV (W/cm^2)[w/ aux. light] = 3.3×10^{-5}
MAXIMUM SCREEN ACTINIC UV ($\mu W/cm^2$) = ND
MAXIMUM SCREEN LUMINANCE (cd/cm^2) = 3.3×10^{-4}
MAXIMUM SCREEN IR (mW/cm^2) = 0.023
ILLUMINATION (lux) Terminal top = 100
At screen face = 100
In work area = 30-900
w/ auxiliary light = 1400

==========

OPERATOR POSITION EXPOSURE RMS FIELD STRENGTH VALUES

Field	Abdomen	Chest	Face
VLF E (V/m)	1.31	2.26	2.76
VLF H (mA/m)	11	20.1	25.5
ELF E (V/m)	2	2.3	2.4
ELF H (mA/m)	263	354	353

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OPERATOR RMS INDUCED CURRENTS

Hand Position	Induced Current (μA)
Hands on keyboard	0.5
Finger touching screen	3.7
Hand placed flat on screen	38.1

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General Waveform shape:

See Figure 4

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TABLE 5

DATA SHEET FOR TERMINAL 4

LIBRARY OF CONGRESS
WASHINGTON, D.C.
HETA 91-070

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LOCATION: LM-513 MODEL NUMBER: 298E-2
DISPLAY TERMINAL TYPE: Northern Telecom VLF SWEEP (kHz): 22.06
SERIAL/STATION NUMBER: M-30043 ELF SWEEP (Hz): 51.06

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MAXIMUM X-RAY LEVEL (c/m) Horizontal = 2
Vertical = 2
Background = 3

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MAXIMUM SCREEN NEAR UV (W/cm^2) $= 1.7 \times 10^{-7}$
MAXIMUM NEAR UV (W/cm^2)[w/ aux. light] $= 2.5 \times 10^{-5}$
MAXIMUM SCREEN ACTINIC UV ($\mu W/cm^2$) = ND
MAXIMUM SCREEN LUMINANCE (cd/cm^2) $= 6.7 \times 10^{-4}$
MAXIMUM SCREEN IR (mW/cm^2) = 0.022
ILLUMINATION (lux) Terminal top = 300
At screen face = 100
In work area = 3-900
w/ auxiliary light = 1100

==========

OPERATOR POSITION EXPOSURE RMS FIELD STRENGTH VALUES

Field	Abdomen	Chest	Face
VLF E (V/m)	1.5	1.7	2
VLF H (mA/m)	10	50	60
ELF E (V/m)	1.0	1.0	1.4
ELF H (mA/m)	141	221	254

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OPERATOR RMS INDUCED CURRENTS

Hand Position	Induced Current (μA)
Hands on keyboard	0.8
Finger touching screen	3.2
Hand placed flat on screen	46.3

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General Waveform shape:

See Figure 4

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