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C. Eugene Moss, H.P., C.S.S.
Kevin Roegner, C.I.H.

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by C. Eugene Moss, H.P. and Kevin Roegner, C.I.H., of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing was performed by Ellen E. Blythe. Review and preparation for printing was performed by Penny Arthur.

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SUMMARY

On June 12, 1997, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request that was submitted jointly by the Safety Office and AFSCME Local 2910 at the Library of Congress, Washington, D.C. The request covered possible exposure to ultraviolet radiation from mercury vapor lights and electromagnetic field (EMF) exposure from both electrical vaults and anti–theft devices.

Ultraviolet radiation and illumination levels did not exceed applicable occupational guidelines on the days of measurements. However, EMF levels from the KNOGO™ anti–theft devices did exceed the guideline value of 2 Gauss (G) for a frequency of 875 Hertz (Hz). The highest magnetic field reading was 14.7 Gauss (G) measured at waist level near the edge of both panels. Along the top of the panels, levels as high as 7.9 G were documented. Since magnetic field levels decrease as distance from the panels increases, at 12, 24, and 36 inches away from the panels the levels were about 2, 0.5, and 0.3 G, respectively. Measurements made on other KNOGO™ units confirmed the same emission pattern, and variations of magnetic fields were small from one unit to another. Workers, especially security personnel, were observed either leaning on the panels or holding onto them.

EMF levels in the Readers' Registration and Genealogy rooms were below occupational guidelines but in some locations presented sufficient magnetic field strength to produce electromagnetic interference (EMI) issues.

Based on the data collected in this evaluation, NIOSH investigators have determined that employees whose work practices require them to come in contact with KNOGO™ units (such as security guards) are exposed to magnetic fields which exceed guideline levels. Recommendations are made for minimizing such exposures.

Keywords: SIC 8231 (Libraries), ultraviolet radiation, UV, electromagnetic field, EMF

TABLE OF CONTENTS

INTRODUCTION

On June 12, 1997, the National Institute for Occupational Safety and Health (NIOSH) received a joint union and management request for a health hazard evaluation (HHE) at the Library of Congress (LOC) in Washington, D.C. The two requesters were the Professional Guild, represented by the American Federation of State, County, and Municipal Employees (AFSCME) Local 2910 and the LOC Safety Office. The request asked for an evaluation of three different exposure situations. The first was to determine occupational ultraviolet radiation (UVR) exposure to workers from mercury vapor lamps in the National Digital Library located in the Atrium of the Madison Building. The second situation was to investigate video display terminal screen flicker in the Reader Registration and Genealogy Rooms of the Jefferson Building. There was a concern the screen flicker was related to magnetic fields produced by electrical transformers located below the Rooms. The third situation was to determine the magnitude of magnetic fields produced by the book theft detection system located at various sites in the Jefferson, Madison, and Adams Buildings. There were no specific health complaints voiced to NIOSH from any employees, other than concern about occupational exposure levels. On November 4–5, 1997, NIOSH investigators visited the LOC and made measurements relating to the above three situations.

BACKGROUND

Atrium Area of the National Digital Library

The Atrium area, which houses the National Digital Library, is located on the first floor of the Madison Building. The occupational concern centered on levels of UVR incident on workers located inside the area. The UVR is produced by 208 mercury vapor lamps mounted approximately 60 feet above the first floor in the ceiling enclosing the Atrium area. At the time of the measurement, 10 of the lamps had burned out and could not be replaced since they were inaccessible by ladder. These lamps are the main source of illumination in this area and remain on for at least 12 hours per day.

Reader Registration Area and Genealogy Room

All users of library materials must obtain a library number via computer registration techniques from the Reader Registration Room located on the ground floor of the Jefferson Building. The Registration Room (and part of the nearby Genealogy Room) is located over a large electrical vault in the basement which creates electromagnetic interference on the terminals in both these rooms. Union personnel were concerned about long term health effects from viewing unstable video screen images.

Book Detection Theft System

The LOC has long been concerned about ways to prevent theft of books and other library materials. Approximately 10 years ago, the LOC installed a security system that uses detection principals based on metal detection. A thin adhesive strip containing a special metal alloy is securely fastened inside each library item, such as a book. When that item comes into contact with a magnetic field, a change in induced electromagnetic signal occurs. This signal change can then be electrical amplified and processed, resulting in a detection signal such as a audible alarm.

The magnetic book security systems used at LOC are manufactured by KNOGO™ North America, Inc. Each system at the LOC consists of two or more plastic panels (antenna) connected to a metallic base plate which is anchored into the floor. When a library item (containing the special alloy strip) is carried through the panels an audible alarm is sounded, alerting the nearby security guards of a possible theft. NIOSH investigators noted that in several instances the security guards were located within 18 inches of the panels and, in some

instances, would lean directly on the panels during their work shifts.

MEASUREMENTS AND METHODS

Measurements

Irradiance measurements of UVR emitted from mercury vapor lamps mounted in the Atrium were made at the desks of four LOC employees at work on the days of measurements. A fifth location near the Atrium entrance was used to represent levels the public would obtain upon entering the area. These measurements were made with the UVR detectors held at eye height and aimed at a white sheet of paper on a table top, to estimate the reflected UVR irradiance that could enter the eye. In addition to both near and far UVR levels, measurements were made of illumination levels incident on the table.

Magnetic field measurements were made in both the Reader Registration and Genealogy Rooms of the Jefferson Building. Detailed area measurements were made at several locations near the tables that housed computers used in the Reader Registration room. Locations on the floor and along the wall as well as in front and above the computer terminals were measured for sub–radiofrequency (both extremely low frequency [ELF] and very low frequency [VLF]) magnetic fields. ELF area measurements were made at various desk locations in the Genealogy room.

One KNOGO™ system was randomly selected for magnetic field evaluations by NIOSH investigators to aid in making subsequent measurements on the other KNOGO™ systems at the LOC. Preliminary measurements made on that KNOGO™ system suggested electric field strength levels were considerably below the Threshold Limit Values (TLV®) and therefore were not further evaluated. Measurements of magnetic fields associated with the selected KNOGO™ system were made both inside and outside the panels, as well as at 12 and 24 inches from the side panels. A total of 48 measurements were made inside the area defined by the panels and 6 were made away from the panels. All measurements were made at locations either where security guards typically stand or may work during the course of a typical workday. Finally, a number of background measurements were made below the panels at the floor level, and when the unit was not operating.

The findings from the selected KNOGO™ system were helpful in evaluating other book detection systems in the Madison, Jefferson, and Adams Buildings. A few measurements were made on other units to confirm the locations of the maximum exposure levels. In addition, when measurements were made it was noted where workers stood and what work task was being performed.

Equipment

The following equipment was used to measure levels of UVR, illumination, and sub–radiofrequency magnetic fields:

- Illumination levels were obtained with a hand held model 500 Litemate photometer that reads out in units of lux over the wavelength region from 380 to 760 nanometer (nm).

- An International Light radiometer, model 700, with specially calibrated detectors was used to evaluate the UVR levels. One detector was designed to read the actinic UV radiation (200 to 315 nm) in biologically effective units of microwatts per square centimeter ($\mu W/cm^2$), while the other detector measured near UV (320–400 nm) in units of milliwatts per square centimeter (mW/cm^2) with no biologic weighting factor.

- A Holiday Industries, Inc. Model HI-3637 three axis VLF magnetic field strength meter was used to make isotropic measurements of the magnetic field produced by the KNOGO™ systems. The magnetic field is measured over the frequency region from 2 to 400 kilohertz (kHz) and the

dynamic range of the meter is 6 mG to 400 G when using special probe adapters.

- Sub–radiofrequency magnetic fields were measured with an EMDEX II™ exposure system. The EMDEX II™ is a programmable data–acquisition meter which measures the orthogonal vector components of the magnetic field through its internal sensors. Measurements can be made in the instantaneous read or storage mode. The system was originally designed to measure, record, and analyze power frequency magnetic fields in units of milligauss (mG) in the frequency range from 40 to 800 hertz (Hz). However, the system has been modified to read up to 140 Gauss (G) over the frequency range from 40 to 3000 Hz.

All equipment used in this evaluation had been calibrated within six months either by NIOSH or the respective manufacturer.

EVALUATION CRITERIA

At present, there is limited information from the Occupational Safety and Health Administration (OSHA) on exposure criteria for workers exposed to physical agents. Criteria for physical agents not covered by OSHA come from either the American Conference of Governmental Industrial Hygienists (ACGIH), NIOSH, or from consensus standards promulgated by the American National Standards Institute (ANSI).

Ultraviolet Radiation

UVR is an invisible radiant energy produced naturally by the sun and artificially by arcs operating at high temperatures. Examples of these latter sources include germicidal and blacklight lamps, carbon arcs, welding and cutting torches, electric arc furnaces, and various laboratory equipment.

Since the eyes and skin readily absorb UVR, they are particularly vulnerable to injury. The severity of radiation injury depends on exposure time, intensity of the radiation source, distance from the source, wavelength, sensitivity of the individual, and presence of sensitizing agents. Sunburn is a common example of the effect of UVR on the skin. Repeated UVR exposure of lightly pigmented individuals may result in actinic skin: a dry, brown, inelastic, wrinkled skin. Actinic skin is not normally debilitating, but is a warning that conditions such as actinic keratosis, squamous cell epithelioma, and basal cell epithelioma may develop. Since UVR is not visible, the worker may not be aware of an exposure at the time it is occurring. Workers also need to be aware that the presence of certain photosensitizing agents on the skin can produce exaggerated sunburn when exposed to certain UVR wavelengths. Absorption of the UVR by the eye and eyelids can cause conjunctivitis.

Lesions may also be formed on the cornea as a result of high exposure levels (photokeratitis). Such injuries usually manifest themselves 6 to 12 hours after exposure. The injuries may be very painful and incapacitating, but impairment is usually temporary.

The most recent revision of the Ultraviolet Radiation Threshold Limit Values as recommended by ACGIH are used by NIOSH investigators to protect workers.

Illumination

Poor room or task lighting conditions can lead to asthenopia (eye strain). While the etiology of eye strain is debatable, it appears that repeated occurrences probably do not lead to any permanent eye damage. Workers over 40 years of age will probably encounter more symptoms of eye strain (headache, tired eyes, and irritation) since they require higher illumination levels to perform a similar job than younger workers. Recommended illumination levels are given by the Illumination Engineering Society (IES) of North America and these levels vary according to the task demands of the worker. In general, illumination of 20 to 50 footcandles (200 to 500 lux) is recommended for visual tasks of high contrast or large size.

Sub–Radiofrequency Magnetic Fields

At the present time, there are no OSHA or NIOSH exposure criteria for sub–radiofrequency (RF) fields. ACGIH has published Threshold Limit Values (TLVs®) for sub–radiofrequency magnetic [B–fields] fields (30 kilohertz [kHz] and below). The TLV for sub–radiofrequency magnetic fields (B_{TLV}) states occupational exposure from 1 to 300 Hz should not exceed the ceiling value given by the equation:

$$B_{TLV} \text{ (in mT)} = 60/f$$

where f is the frequency in hertz and mT is the magnetic flux density in millitesla. One mT equals 10 G. For frequencies in the range of 300 to 30,000 Hz, occupational exposures should not exceed the ceiling value of 0.2 mT (2 G). The operating frequency for the KNOGO™ units was found in the manufacturer's literature to be 875 Hz. The ceiling value for frequencies of 300 to 30,000 Hz are intended for both partial– and whole–body exposures.

The basis of the sub–radiofrequency B–field TLV addresses induction of magnetophosphenes in the visual system and production of induced currents in the body. Prevention of cancer is not a basis for this TLV because exposure to sub–radiofrequency magnetic fields has not been conclusively linked to cancer.

RESULTS

Ultraviolet Radiation

Table 1 shows that the highest near (315 to 400 nm) and actinic (200 to 315 nm) UVR levels measured in the Atrium area were 10 $\mu W/cm^2$ and 0.01 effective $\mu W/cm^2$ respectively, as measured at the position of a worker's face. It was observed by the NIOSH investigators that four of the five workers in the Atrium at the time of measurement wore glasses. Since prescription glasses tend to further attenuate the UVR levels, especially for radiation in the 200 to 315 nm region, the levels incident on the eye and facial area may be even lower than those shown in Table 1. Both the near and actinic levels were below the ACGIH TLV and are not considered by the investigators to be an optical or skin hazard to LOC workers.

Illumination

The maximum illumination level measured in the Atrium was 390 lux, which is within the recommended illumination range of 200 to 500 lux suggested by the IES.

Magnetic Fields

Reader Registration and Genealogy Rooms

The EMDEX™ unit was set to a broadband mode and measurements were made at waist levels. Results were recorded as the investigator walked around chairs, tables, and computers in the Reader Registration and Genealogy Rooms. The highest reading in the Readers Registration Room was 50 mG found near the floor in the southeast corner of the room. The maximum reading obtained in the Genealogy Room was 96 mG, near the computer terminal located on the genealogy room help desk. Results of area magnetic field measurements made in the electrical vault area on the basement floor indicated that the fields also were slightly higher in certain sections of the Genealogy room than in the Reader Registration room. It was apparent to the NIOSH investigators that on the day of measurement, these magnetic field levels did cause a slightly unstable screen image on some, but not all, of the terminals in the room.

KNOGO™ Units

The highest ELF magnetic field reading on the selected KNOGO™ unit was 14.7 G measured at waist level near the edge of both panels. Along the

top of the panels levels as high as 7.9 G were documented. Measurements made with the EMDEX™ unit held between the two panels at waist level produced about 0.8 G. These magnetic field levels decrease the further away from the panels workers are located. For example, at 12, 24, and 36 inches away from the panels the levels are about 2, 0.5, and 0.3 G, respectively.

Measurements made on other KNOGO™ units confirmed the same emission pattern of magnetic fields as on the selected unit. Variations of magnetic fields were small from one unit to another for the same location. Workers, mainly security personnel, were observed to be within a meter of the side panels and often were seen either leaning on the panels or holding onto them.

DISCUSSION AND CONCLUSIONS

Ultraviolet Radiation Levels in the Atrium

The Library of Congress Safety Services had their industrial hygiene consultant conduct an evaluation of the lighting conditions in 1995. The findings from that evaluation indicated that exposures did not exceed TLV guideline limits. However, the consultant did recommend that administrative measures be implemented to prohibit LOC personnel from being in the Atrium for more than 8 hours during any 24 hour period. NIOSH investigators do not believe this recommendation is necessary, especially in view of the following: lower measured levels, greater number of bulbs being burned out, and the documentation of low reflected levels into the eyes.

It was noted during this evaluation that stable readings were not obtained when UVR detectors were aimed at certain lamps in the ceiling. The NIOSH investigators believe this finding is an indication that on the day of measurements some of the lamps were losing their ability to emit uniform UVR. This suggests that lamp maintenance is not being properly performed. NIOSH investigators agree with the consultant's recommendation for replacing the mercury vapor lamps with either incandescent and/or fluorescent lamps. This could perhaps be done by installing these lamps on a new, lower, drop ceiling.

Illumination Levels

The illumination levels measured by the consultant and NIOSH are quite similar. However, it was noted that the levels measured in 1995 typically were 400 lux while measurements made in 1997 ranged from 200 to 390 lux. These lower illumination results in 1997, which are in agreement with the finding of reduced UVR levels, suggests that without replacement these lamps will eventually burn out. The NIOSH investigators agree with the consultant's recommendation for encouraging use of auxiliary lamps at work stations by individuals experiencing difficulty in reading and writing. Since viewing work tasks may become harder as the illumination levels decline, there is a need to solve the problem of removing and replacing these lamps.

Magnetic Fields

The book detection systems can be activated by metal objects other than the metal strip placed in the books. In fact, during this investigation it was noted that some metal wrist watches would cause the alarm to sound and on several occasions, a slight movement of the side panels would also cause the alarm to activate.

The ACGIH TLV for 875 Hz (the operating frequency for the KNOGO™ units) is 2 G. Since the security guards were observed leaning on the panels, they can be exposed to magnetic fields approximately 7 to 8 times in excess of the TLV. It does not appear, however, that LOC workers and visitors who walk through the panels are exposed to more than 1 G. While LOC workers may be concerned about EMF magnetic field exposure at

levels below current occupational limits, there is currently no conclusive evidence to show that chronic exposure to such fields causes adverse health effects. It is noted, however, that research suggests that health effects related to EMF fields may be linked to many variables, of which field strength magnitude is only one.

The LOC guards should not support themselves by placing their arms on the side panels of KNOGO™ systems and lean on them for two reasons. The first reason is to minimize exposure to ELF magnetic fields. The second reason is that the side panels of the KNOGO™ units are sensitive to movement and several units were slightly unstable.

The Safety Office was not aware of when these systems had been calibrated or inspected by their manufacturer or installer. In addition, several of the KNOGO™ units were not turned on, yet were located in front of doors not manned by LOC guards. In some cases the units were located in front of emergency exits which could impede egress during an emergency. Furthermore, the gift shop in the building lobby used two KNOGO™ units as a theft deterrent system even though no items in the shop had metal strips placed in them. It was noted that on the second day the KNOGO™ book unit did sound in the gift shop because someone entered the gift shop with a book from another library (having a metal strip).

Electromagnetic Interference

Sensitivity of electronic devices, such as a video display terminal (VDT) monitor, to electromagnetic fields does not necessarily mandate concern about human health effects. Quite often electronic sensitivity level, or electromagnetic interference (EMI) issues, can occur at levels orders of magnitude below what is considered adverse health effect levels. Viewing of unstable screen images from a monitor may be difficult to read and could lead to health concerns such as visual tracking limitations and ergo–ophthalmology problems. NIOSH has found in several previous evaluations that VDT monitors are affected by unwanted magnetic fields. In fact, initial concern about the presence of ELF magnetic fields in the Readers Registration Room at the Jefferson Building was created when it was observed that screen images on several VDT monitors located above the electrical vault were slightly distorted the closer they were to sources of power line frequencies. Similar type screen problems have been reported to occur at magnetic field levels as low as 100 mG in these NIOSH evaluations.

The use of shielding material is often used in controlling potential occupational exposures to various physical agents. Unfortunately, shielding of magnetic fields at power line frequencies is expensive and often not very effective since the fields can pass through most common objects without being significantly affected. Other approaches to reduce magnetic fields strengths are to limit the worker's time of exposure, increase the distance between the source and worker, or to redesign the work area thereby minimizing exposure to high field strength areas.

RECOMMENDATIONS

1. The security guards should maintain a one meter distance from the KNOGO™ units.

2. Due to their high magnetic fields, the KNOGO™ units should not be used as replacements for non–functioning security metal detectors. It is also suggested that these units be serviced by the manufacturer to achieve a lower operating magnetic field level.

3. When purchasing new computer terminals, the LOC should require manufacturers to demonstrate protection against EMI. While unshielded computer monitors are extremely sensitive to magnetic fields, it is possible to obtain software programs which help impede 60 Hz power line magnetic fields from causing VDT image signal distortion. The local electrical power distributor may be able to assist the LOC in obtaining such programs.

4. Sites such as the Readers Registration and Genealogy Rooms where electromagnetic interference occurs, should be marked on master facility plans. Identification of such areas could help to abate future occupational and electronic issues involving personnel relocation.

5. The lamps in the Atrium area should be maintained or replaced.

Table 1
Maximum occupational optical radiation levels measured on desk tops in the Atrium of the Madison Building

LOCATION	ACTINIC UV (effective $\mu W/cm^2$)	NEAR UV ($\mu W/cm^2$)	ILLUMINATION (Lux)
Desk 1	0.006	10	234
Desk 2	0.005	9	390
Desk 3	0.02	9	240
Desk 4	0.02	8	260
Desk 5	0.02	10	200
ACGIH TLV	0.1	1000	
IES			200 to 500

Actinic UV wavelength ranges from 200 to 315 nanometers (nm).
Near UV wavelength ranges from 320 to 400 nm.
$\mu W/cm^2$ = microwatts per square centimeters
ACGIH = American Conference of Governmental Industrial Hygienists
IES = Illuminating Engineering Society

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