CDC
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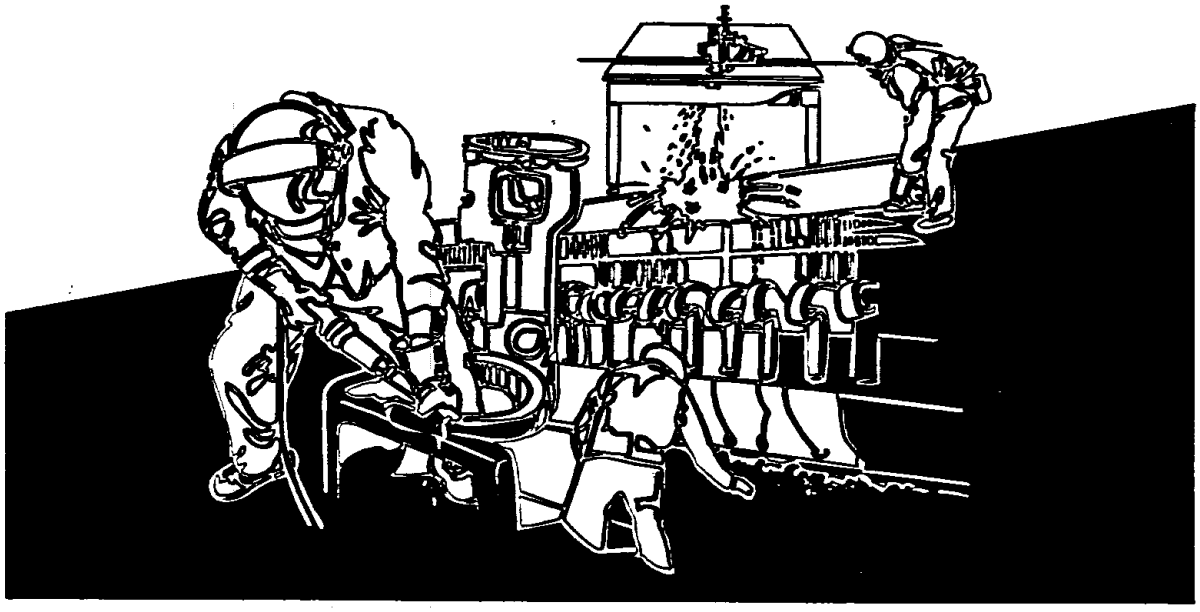
NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 93-1034-2447
GETTER CORPORATION OF AMERICA
CLEVELAND, OHIO



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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 and 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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 93-1034-2447
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GETTER CORPORATION OF AMERICA
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SUMMARY

On August 31, 1993, the National Institute for Occupational Safety and Health (NIOSH) conducted an investigation at the Getter Corporation of America (GCA), located in Cleveland, Ohio. This investigation was performed in response to a management request, which NIOSH received on July 8, 1993, for evaluation of occupational exposure to electric and magnetic fields (EMF) at GCA.

Radiofrequency (RF) and sub-radiofrequency electric and magnetic field measurements were made at various workers' locations under normal work conditions. RF magnetic field levels, in the 400 kilohertz (kHz) frequency region were as high as 25 Amperes squared per meter squared $(A/m)^2$. This level is below the Institute of Electrical and Electronics Engineers (IEEE) C95.1-1991 guideline level of 1681 $(A/m)^2$ for frequencies of 400 kHz.

The maximum sub-radiofrequency electric and magnetic field levels measured in and around the facility were 1300 volts per meter and 450 milligauss (mG), respectively. It should be noted that the electric field level of 1300 volts per meter (V/m) was measured outside the facility and within the electrical utility's right-of-way zone. This maximum level is similar to measurements made by NIOSH investigators under electric transmission lines found in large metropolitan areas. While it is reported here as an occupational exposure value, any individual located under the power line (working or not) would receive this exposure. The maximum magnetic field level was measured outside the facility near a fence surrounding a small electrical sub-station in the rear of the building.

Based on the data collected in this evaluation, and comparison with current occupational exposure criteria, NIOSH investigators concluded that no health hazard existed on the days of measurement from exposure to electric and magnetic fields found at the facility.

KEYWORDS: SIC 5065 (Electronic Parts and Equipment, not elsewhere classified), radiofrequency radiation, electromagnetic fields.

BACKGROUND

The National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation concerning possible employee exposures to various frequencies of electromagnetic fields produced at the Getter Corporation of America (GCA) located in Cleveland, Ohio. GCA is part of the SAES Getters group located in Italy and manufacturers over 50 million getters annually, making this company the largest barium getter manufacturer in the United States. On August 31, 1993, NIOSH investigators performed an evaluation at the GCA facility in Cleveland.

A getter is a small electronic component that is placed inside various vacuum devices such as television picture tubes, infrared image detectors, X-ray image intensifiers, and display devices. When the getter, which contains unique gas absorbers, is heated in a vacuum tube with radiofrequency radiation (approximately 400 kilohertz [kHz]) it becomes activated and releases barium in the getter at a certain prescribed rate. This activated material helps to remove gases in the vacuum device, maintains the required degree of vacuum, and absorbs gas bursts which can occur during abnormal device operation. There are two getter types: evaporable and non-evaporable. Over the last 40 years only the evaporable type, which contains barium, has been manufactured at GCA.

The two locations at GCA that employees are exposed to radiofrequency radiation (RFR) during the manufacturing of the getters are the quality control (QC) and the Technology Laboratory (TL) areas. The QC area is responsible for the testing of selected numbers of getters to insure proper adherence to manufacturing procedures. The TL area is responsible for developing new getters and the improvement of test procedures for the company. Only 13 of the 82 employees who work at GCA are in these two areas.

At the time of this evaluation, potential occupational exposure to RFR at GCA from getter operations could occur from only four radiofrequency (RF) producing systems. Each of these RF systems is designed to produce 3 kilowatts of output power. The occupational exposure is sporadic in both the QC and TL areas. The QC area, which has three RF systems, uses more RFR than the TL area. Moreover, there are only two workers in the TL area, compared to approximately 11 workers in or around the QC area.

During the walk-through portion of the evaluation, interest was expressed by GCA personnel for documenting the levels of extremely low frequency (ELF) electric and magnetic fields that were produced by the high-voltage power transmission lines located in the GCA parking lot and the small electrical sub-station located at the rear of the building immediately behind the power feed room.

EVALUATION DESIGN AND METHODS

In this evaluation, emphasis was placed on documenting occupational exposure to radiofrequency and sub-radiofrequency electric and magnetic fields at the GCA facility in Cleveland, Ohio. The evaluation was designed to measure exposures to all types of electromagnetic fields (EMF) while employees performed their tasks. The limited number of measurements taken in and around the facility were not intended to represent an in-depth evaluation of the radiation fields at the site, but rather to approximate occupational exposure levels on the days of measurement.

The following equipment was used to document levels of EMF produced at GCA:

- A Holaday Industries, Inc. model HI-3602 ELF Sensor, connected to a HI-3600 survey meter, was used to document both the magnitude of 60 hertz (Hz) electric and magnetic fields and the frequency (as well as the waveforms) produced by such fields. The electric field (E-field) strength can be measured either in volts per meter (V/m) or kilovolts per meter (kV/m). The magnetic field strength (H-field) can be expressed in units of gauss (G) or milligauss (mG). One G equals 1000 mG.

- Sub-radiofrequency magnetic field measurements were made with the EMDEX II exposure system, developed by Enertech Consultants, under project sponsorship of the Electric Power Research Institute, Inc. 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 designed to measure, record, and analyze power frequency magnetic fields in units of mG in the frequency range from 30 to 800 Hz. Measurements were made in both the walk-around mode and personal dosimetry mode.

- Holaday Industries Models HI-3600-01 and HI-3600-02 survey meters were used to document the electric and magnetic fields in the very low frequency (1 to 30 kHz) and extremely low frequency (0.1 to 1000 Hertz [Hz]) bands. The electric field (E-field) strength can be measured either in V/m or kV/m. The magnetic field strength (H-field) can be expressed in units of mG. These instruments also provided the ability to record the frequencies, as well as the waveforms, produced by such fields. Frequency measurements were made at locations where personnel worked during the day.

- Holaday Industries Model HI-3005 survey meter coupled to a Holaday Model LFH magnetic field probe was used to document the magnetic field in the frequency range from 0.3 to 10 Megahertz (MHz). This system could measure from 1 to 1000 Amperes squared per meter squared $(A/m)^2$. No measurements could be made

for the electric field in this frequency region due to lack of appropriate frequency response in available NIOSH instrumentation.

- Frequency of the RF generators in units of kHz was documented with a Lepel Corporation KC wavemeter.

Since the RF output was not continuous (operations were performed for short periods of time over the course of the work day), all documented magnetic field measurements were corrected for the work cycle duration before comparison with applicable occupational exposure criteria. This was accomplished by multiplying the measured (or estimated) duty cycle factor by the recorded exposure level. The duty cycle is defined as the total length of RF on-time (in seconds) measured during any six minute sampling period. The duty cycle is expressed as a fraction, and for this evaluation was estimated to be 0.50.

All EMF measurements were taken during daylight hours and generally at positions considered to be typical of occupational exposure (one meter away and one meter from the floor), except where otherwise noted. Where possible, at least two readings were taken at each measurement site and the results averaged.

RFR measurements in the TL area were taken at every 45 degrees around the vacuum tube, containing the getter. These measurements were made at a tube height of 50 inches above the floor and at distances of 38 centimeters (cm) and 76 cm from the tube. The distances of 38 and 76 cm were selected to reflect situations where the operator might stand or locate hand or arms.

Workers who tested the getters, and hence were exposed to RF energy in the QC area, were located approximately one foot from the nearest tube. Six RF systems are each connected to a separate vacuum tube, each containing one getter. All of the vacuum tubes are mounted at a 45 degree angle (i.e., the top of the tubes face the operators). All of the vacuum tubes are evacuated for approximately 4 minutes to a prescribed level. Power is then applied for about 30 seconds to each RF system, one at a time, until all six getters are tested. This 30 second time period, per getter tube, is sufficient to permit the barium to be emitted from the getter and start to deposit on the walls of the tube. The total on-time of the RFR is six times 30 seconds or about 180 seconds. After the six getters have been tested, the operator opens the system and places six new getters in clean tubes and starts the entire cycle over. Using the 6 minute duty factor concept from the American National Standards Institute (ANSI) would suggest a duty factor of 50%. Measurements were made at the face and hand positions near the six vacuum tubes, since the operators would normally stand at that location during getter testing.

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. Finally, evaluation criteria may change over the years as new information about chemical and physical agents become 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, Occupational Safety and Health Administration (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 ANSI.

A. Radiofrequency Fields

The basis of the Institute of Electrical and Electronics Engineers (IEEE) RF standard is to minimize adverse biological effects due to excessive heating of internal body tissues. The human body absorbs maximally in the frequency region from 30 to 300 MHz. Outside this region, much less energy is absorbed by the body from the radiation field.

At the present time, there are no OSHA or NIOSH exposure criteria for RF frequencies below 10 MHz. Since the ACGIH has published its intention to change its present TLV on RF levels to reflect the IEEE C95.1-1991 guideline values, only the IEEE standard levels will be referred to in this evaluation. That standard calls for a level of 1681 $(A/m)^2$ at 400 kHz.

B. Sub-Radiofrequency Electric and Magnetic Fields

At the present time, there are no OSHA or NIOSH exposure criteria for RF fields. The ACGIH has published TLVs for sub-radiofrequency electric and magnetic fields. The TLV for magnetic fields (B_{TLV}) states "routine occupational exposure should not exceed:

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

where f is the frequency in hertz." One millitesla (mT) equals 10 G. Conversely, the electric field TLV states "occupational exposures should not exceed a field strength of 25 kV/m from 0 to 100 Hz. For frequencies in the range of 100 Hz to 4 kHz, the TLV is given by:

$$E_{TLV} \text{ (in V/m)} = 2.5 \times 10^6/f$$

where f is the frequency in hertz. A value of 625 V/m is the exposure limit for frequencies from 4 kHz to 30 kHz."

This means, for example, at 60 Hz, which is classified as extremely low frequency (ELF), the electric field intensity TLV is 25,000 V/m and the magnetic flux density TLV is 1 mT or 10,000 mG.

The basis of the electric field TLV is to minimize occupational hazards arising from spark discharge and contact current situations. The magnetic field TLV addresses induction of magnetophosphenes in the visual system and production of induced currents in the body.

RESULTS AND DISCUSSION

A. Radiofrequency Radiation Levels in Technology Laboratory Area

The highest 400 kHz RF magnetic field level measured in the TL of GCA on the days of measurement was 50 $(A/m)^2$. This level was measured at a distance of 38 cm from the tube and at a location where the power supply was located. All other measured levels were less than 4 $(A/m)^2$. Using the value of 50 $(A/m)^2$ for the laboratory worker exposure at 38 cm corresponds to a duty factored occupational

exposure (assuming 50%) of 25 $(A/m)^2$. This level is below the IEEE C95.1 guideline level of 1681 $(A/m)^2$ for 400 kHz.

B. Radiofrequency Radiation Levels in Quality Control Area

Measurements in the QC area were made at the face, hand, and waist position of operators standing near the six tube jig. The highest level recorded at the hand position (resting on the table holding the tubes) was 10 $(A/m)^2$, and at the face was 50 $(A/m)^2$. Measurements made at locations 1.22 meters (m) from the units in all directions were non-detectable for the equipment used. The level of 50 $(A/m)^2$, when corrected for duty factor, corresponds to a level of 25 $(A/m)^2$ which is below the IEEE guideline value.

C. Sub-Radiofrequency Electric and Magnetic Fields

The maximum ELF electric and magnetic field levels, measured on the day of evaluation at 11:00 a.m. (midway between the two towers supporting the high voltage transmission lines located above the parking lot used by GCA workers, approximately 30.5 cm from the building), were 1300 V/m and 23 mG, respectively. Next to the building, the electric and magnetic fields were 0.2 V/m and 0.1 mG. The highest ELF levels found along the outdoor fence which surrounds the small sub-station, in the rear of the building, were 10 V/m and 450 mG. It should be noted that no workers were seen at this location and it appeared that this location had a very low traffic pattern. ELF levels in the power feed room ranged from 2 to 60 V/m and 5.5 to 150 mG, at locations near the electrical panels. At present, this room is not occupied by any worker.

A ELF magnetic field value of 13 mG was recorded near the operator's head position in the QC area, when the EMDEX unit was positioned near the top of the tube jig. While this level is not abnormally high, it is unique in that it originates from ELF fields produced during the RF activation.

The two NIOSH investigators wore EMDEX units on their waist during the entire evaluation period of approximately 5 hours. The average broadband levels (representing frequency range between 40 and 800 Hz) for these two EMDEX units ranged between 7.11 and 7.44 mG. These average values are of the same magnitude that have been found in previous NIOSH evaluations.

CONCLUSIONS

The summary of all occupational EMF measurements made at GCA is shown in Table 1. The highest occupational RFR level measured was 25 $(A/m)^2$ in both the TL and QC areas. The highest sub-radiofrequency electric and magnetic field measured at or near the

GCA facility was 1300 V/m and 450 mG. The 1300 V/m level was measured at ground level under the electrical wires outside the building and the 450 mG level was measured at the fence line of the sub-station located in the rear of the building. This 450 mG measurement was not of occupational significance since no workers were present and rarely visited the location. The maximum ELF magnetic field measured inside the facility on the evaluation day was 315 mG and was recorded on the EMDEX units of the NIOSH investigators as they toured the power feed room in the rear of the building. This area is not of occupational significance since no workers were located in the power feed room.

Based on the data collected in this evaluation, and comparison with current occupational criteria, the NIOSH investigators concluded that no health hazard existed on the days of measurement from exposure to electric and magnetic fields.

REFERENCES

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1. GCA Company
2. NIOSH
3. OSHA, Region V

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Table 1

Summary of EMF Measurements as a Function of Location, Source, Intensity, Field, and Presence of Workers

Getter Corporation of America
Cleveland, Ohio
HETA 93-1034
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Source Type	Source Location	Worker Present	Field Type	Field Strength	
				Electric	Magnetic
Transmission Line	Outside-Side of Building	No	60 Hz	0.2–1300 V/m	0.1–23 mG
Electrical Sub-Station	Outside-Rear of Building	No	60 Hz + Harmonies	1–10 V/m	0.2–450 mG
Power Feed Room	Inside-Rear of Building	No	60 Hz + Harmonies	2–60 V/m	5.5–150 mG
RFR	QC Area	Yes	0.3–0.4 kHz	–	0.1–25 $(A/m)^2$
	TL Area	Yes	350–400 kHz	–	2–25 $(A/m)^2$

Abbreviations:

Hz	=	Hertz
kHz	=	Kilohertz
$(A/m)^2$	=	Amperes squared per meter squared
RFR	=	Radiofrequency radiation
QC	=	Quality control
TL	=	Technology laboratory
V/m	=	Volts per meter
mG	=	milligauss