CDC
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NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 95–0235–2524
United States Customs Service
Atlanta, Georgia

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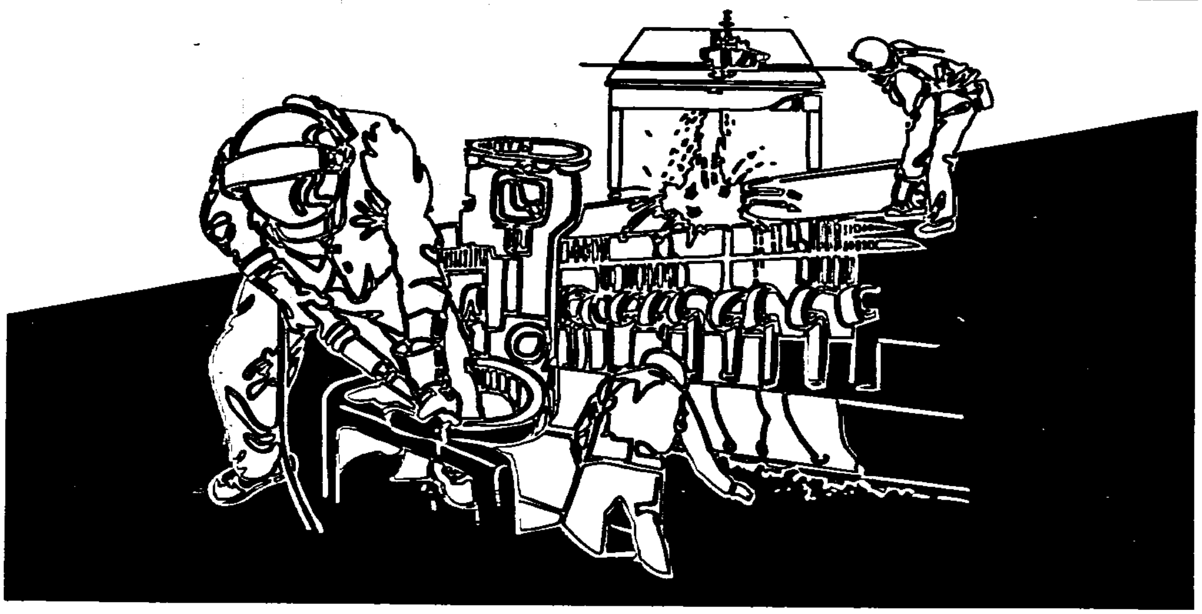

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by C. Eugene Moss, H.P., C.S.S. of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Ladina Saluz, Hazard Evaluations and Technical Assistance Branch, and Don Booher, Industrywide Studies Branch. Desktop publishing by Ellen E. Blythe.

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SUMMARY

On April 21, 1995, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Federal Occupational Health regional headquarters to evaluate potential occupational exposure to sub–radiofrequency electric and magnetic fields at the United States Customs Service (USCS) facility in Atlanta, Georgia. The request was submitted by USCS employees due to concerns of exposure to electric and magnetic fields from an electrical power distribution panel. No medically confirmed reports of health effects were cited in the request.

On May 16, 1995, a site visit was conducted to measure extremely low frequency (ELF) electric and magnetic fields both inside and outside the building. Measurements of electric and magnetic field levels inside the facility, documented on a walk–around mode, ranged from 1.9 to 9 volts per meter (V/m) and 0.1 to 6 milligauss (mG), respectively at most locations. Magnetic field measurements made inside were similar to previous results obtained by the local electrical utility company in their evaluation of the facility. Measurements made outside the facility ranged from 5 to 100 V/m and 0.7 to 6 mG. The mean magnetic field levels for the four workers who wore personal monitors ranged from 1.8 to 9.1 mG. Measurements identified an electric panel in one of the offices producing magnetic field levels in the range of 25 to 220 mG.

There is currently no conclusive evidence to show that chronic exposure to power frequency fields causes adverse health effects. It should be noted, however, that research suggests that health effects related to ELF fields may be linked to many variables, of which field strength is only one. Therefore, depending on these other variables, weaker electric or magnetic fields (as shown in this evaluation) are not necessarily safer than stronger fields. All measured ELF levels in this evaluation were below current occupational exposure ceiling limits.

Based on a comparison of the data collected in this survey with current occupational criteria, the NIOSH investigators determined that the ELF electric and magnetic fields, both inside and outside the USCS facility, are generally low, approximately the same magnitude reported previously by the electrical utility company, generally within the range of exposure levels in office settings measured by NIOSH investigators in previous evaluations, and well below the current occupational exposure ceiling limit of 10,000 mG. The electrical panel in one of the worker's room has a higher magnetic field level than any measured in other part of the room. Relatively higher field levels were recorded on personal meters when the workers spent more time near the panel.

KEYWORDS: SIC 9311 (public finance, taxation, and monetary policy), electromagnetic fields, EMF, extremely low frequency, ELF.

INTRODUCTION

In April 1995, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the United States Custom Service (USCS) facility in Atlanta, Georgia. NIOSH was requested by the Federal Occupational Health regional headquarters in Atlanta to assist in this evaluation due to concern among some USCS employees about exposure to electric and magnetic fields in the twelve year-old building. NIOSH conducted a field investigation at the USCS facility on May 16, 1995.

The NIOSH investigators were informed that a wall-mounted electrical fuse panel, located in one of the import specialists team offices (three people worked in the area), produced undesirable image movement on a computer monitor. This particular activity created concern within the office about possible adverse health effects, although no reports of medical symptoms were cited in the request.

BACKGROUND

Figure 1 shows a schematic floor plan of the one-story USCS facility. The rectangular shaped (2' x 3' x 6") metal panel box, located in Room A, controlled the flow of electric current to various circuits in approximately half of the facility. NIOSH investigators learned from worker interviews that room A had been used as a storage area prior to being converted to an office.

EVALUATION CRITERIA

At the present time, there are no Occupational Safety and Health Administration (OSHA) or NIOSH exposure criteria for sub-radiofrequency (RF) fields. The American Conference of Governmental Industrial Hygienists (ACGIH) has published Threshold Limit Values (TLVs) for sub-radiofrequency electric and magnetic fields (30 kilohertz and below). The TLV for sub-radiofrequency magnetic fields (B_{TLV}) states occupational exposure from 1 to 300 hertz (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. One millitesla (mT) equals 10 Gauss (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). These ceiling values for frequencies of 300 to 30,000 Hz are intended for both partial- and whole-body exposures. For frequencies below 300 Hz, the TLV for exposure of the extremities can be increased by a factor of 5.

Conversely, the sub-radiofrequency 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 kilohertz (kHz), the ceiling value 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 volts per meter (V/m) is the ceiling value for frequencies from 4 kHz to 30 kHz. These ceiling values for frequencies of 0 to 30 kHz are intended for both partial- and whole-body exposures.

This means, for example, at the power line frequency of 60 Hz, which is classified as extremely low frequency (ELF), the electric field TLV would be 25,000 V/m and the magnetic field TLV would be 1 mT or 10,000 milligauss (mG).

The health and safety basis of the ELF 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.

METHODS

This evaluation was designed to assess occupational exposure to sub-radiofrequency fields in the range from 40 to 800 Hz among workers during a typical daily work regiment. The number and types of measurements performed in this evaluation were not intended to represent an in-depth investigation of exposure to all electric and magnetic fields present in the facility, but were intended to estimate occupational exposure levels from selected sources on the days of measurements.

The following equipment was used in this evaluation:

♦ 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 40 to 800 Hz. The meter has the capability of displaying magnetic field values in three different frequency bandwidths: broadband, which measures from 40 to 800 Hz; harmonic, that measures from 100 to 800 Hz; and the fundamental bandwidth, which measures at 60 Hz.

♦ A Holaday Industries, Inc. model HI 3602 ELF sensor, connected to a HI-3600 survey meter, was used to document both the magnitude of ELF electric and magnetic fields as well as the waveforms produced by these fields. The electric field strength (E) was measured in V/m and the magnetic field strength was measured in mG over the frequency range from 40 to 800 Hz.

In performing this evaluation, the NIOSH investigators utilized data obtained from measurements made at the following locations: (a) on a random sample of fixed locations within the USCS facility, (b) a selected sample of USCS employees, and (c) on a random sample of fixed locations outside the facility.

Fixed Locations within USCS Facility

While electric and magnetic field measurements were made throughout the facility at worker locations, particular emphasis was placed on making ELF measurements in room A and in those rooms or office spaces that surround room A. While measurements were made in most of the rooms at the facility, more measurements were made in those locations indicated by the shaded areas in Figure 1. Approximately 100 measurements were made in a walk-around mode using either Holaday or EMDEX meters held at the investigators' waist level. In several cases repeat measurements were made to validate the readings between the two investigators involved with taking these measurements.

An EMDEX meter was used to obtain estimates of the magnetic fields present at several locations in room A as a function of height above the floor. In addition, detailed walk-around measurements were made at various sites around the electrical panel.

Selected Personal Field Measurements

EMDEX meters were put on four selected workers for approximately four hours to determine their exposure to magnetic fields as part of their daily work regiment. Two of the workers were members of the import specialist team in room A. All data obtained with the EMDEX meters were acquired in the broadband, harmonic, and fundamental frequency bandwidth. The EMDEX meters were worn around the worker's waist in special sashes provided by NIOSH and each worker was instructed not to wear the meter out of the building during the day. If they had to leave the building, they were instructed to leave the meter on their desk.

Fixed Locations Outside Building

Electric and magnetic field measurements were made at all entryways immediately outside the facility, in the paved area immediately in front of the facility, and in the parking lot on two different days. Measurements were also made at the corners of the facility.

RESULTS

Fixed Locations within USCS Building

Electric and magnetic fields typically ranged from 2 to 4 V/m and 0.1 to 6 mG at locations throughout the facility. The only exceptions to this generalization were situations where unique office ELF sources existed, such as electric fans and pencil sharpeners. Table 1 shows a listing of some selected magnetic field measurements obtained in this evaluation.

A series of measurements with one EMDEX meter set at 1.5 second and used in a walk-around mode were made in room A at different locations as a function of height above the floor. With the exceptions of (a) areas close to the back and front of the electrical panel in room A, and (b) locations in close proxmity to other ELF sources [see discussion later in report], all levels ranged from 1 to 5 mG and 3 to 9 V/m. The magnetic field levels for the areas near the panel measured anywhere from 25 to 220 mG. There was no dependency of either electric or magnetic field levels in room A with distance above the floor. However, measurements around the electrical panel did depend on the location. For example, measurements made in back of the panel were higher than the front. This is probably due to the presence of electrical cables located nearer the back side of the panel. The difference in magnetic readings of the back to the front was approximately twice which suggests higher exposure levels to those workers who spend a long time near the filing cabinet that is located at the rear of the panel.

Selected Personal Field Measurements

Personal measurements, using the EMDEX meters that were worn at the worker's waist position, were made on four individuals. The day's data was collected every 3.0 seconds. Two of the individuals sampled were workers residing in room A. One worker was the Port Director, and the fourth worker was located in room B. In addition to these personal measurements, one EMDEX meter was placed about 3 feet from the electrical panel. All of these results are shown in Table 2. The mean magnetic field levels for the four workers who wore the EMDEX meter ranged from 1.8 to 9.1 mG in broadband, harmonics, and fundamental modes. The average magnetic field levels for the fundamental mode ranged from 1.82 to 8.42 mG. This finding that the broadband component is almost equal to the fundamental component suggests that exposure is mainly due to power line frequencies. The highest personal magnetic field levels were obtained on the two individuals who worked in room A. The large measurement in standard deviation for those two workers suggests movement of the workers in the room as they performed their jobs.

Magnetic field levels documented with the EMDEX meter placed 3 feet from the panel and in the back area of room A were small, i.e., less than 2 mG on average. During the time period data was collected with the EMDEX meter, it was moved to two positions in the empty back section of the room. This was done to obtain a better estimate of levels that might have been recorded had a worker occupied the section. The obtained results suggest that, unless the meter was in very close contact with the panel, the average field strengths would be small. This finding is consistent with the well known drop off rate of magnetic fields with distance.

Figures 2 and 3 show time-magnetic field intensity plots associated with two of the workers wearing EMDEX meters in room A. The NIOSH investigators recorded the time when the worker used the file cabinet that was located near the rear of the electrical panel. The figures clearly show higher field levels when either of the two worker were in the vicinity of the filing cabinet. A similar pattern is shown in Figure 4 by the supervisor, who does not work in room A, but came into the room and stood next to the file cabinet for a short period of time (around 1:30 P.M.). The NIOSH investigators do not know the origins of the other small peaks depicted in Figure 4. These figures clearly demonstrate that:

1. The electrical panel in room A has a higher magnetic field level associated with it than any other area of the room, and

2. The highest magnetic fields are recorded when the worker spends more time near the file cabinet—and hence the electrical panel.

Fixed Locations Outside Building

Levels of ELF electrical and magnetic fields measured outside at the corners of the facility and at distances 20 feet from the edge of the building ranged from 5 to 100 V/m and 0.7 to 6 mG.

DISCUSSION

Measurement Results

Data obtained at the USCS facility on the day of measurement in both the personal and walk–around survey modes clearly suggest that:

1. As explained earlier and shown in Table 2, the dominant source of EMF exposure throughout the facility is due to power line frequencies involving magnetic fields.

2. The highest personal exposures occurred on the two individuals who occupied room A where the electrical panel is located. It is noted in Figure 1 that the facility has two distinct areas (rooms A and I) where electrical panels are located. However, occupational exposure to ELF is of importance only in room A since no workers are located in room I.

3. The measured exposure was highest on the worker who spent more time near the file cabinet which was located adjacent to the rear of the electrical panel.

4. The measured magnetic field on the day of measurement at the rear of the electrical panel—which is close to the front of the filing cabinet—was approximately twice that measured at the same distance, for the front side of the panel.

5. Levels of magnetic fields measured at the desks of the two workers in room A were typically in the 1 to 5 mG and 1–18 V/m range. For comparison purposes, the maximum ELF measurements made outside at the corners of the facility and at distances 20 feet away ranged from 0.7 to 6 mG and 5–100 V/m.

Based on these findings, the NIOSH investigators believe the exposure potential is directly related to the length of time any of the team workers spends in close proximity to the electric panel. On the day of evaluation, it was apparent that workers on the import specialist team in room A had to go to the file cabinet to get certain information. When this was done the workers would be in closer proximity to the rear of the electrical panel and thereby increase their average magnetic field exposure. It was also observed that once a file was retrieved many times the worker would read its contents while standing at the file cabinet–or close to the electrical panel. Such activity is clearly shown by the time intensity curves in Figures 2 and 3 for room A workers. This general finding is also suggested by the measured results obtained by Georgia Power on May 27, 1994. It was found then that locations in and around the electrical panel were higher than at the workers desks.

"Non–Essential" ELF Exposure

Sources of ELF field exposure were prevalent throughout the USCS facility. NIOSH investigators observed a wide range of items contributing to total ELF magnetic field exposure. Many items, such as VDTs and photocopy machines, are essential to the modern office environment. Others, however, could be considered "non-essential" and their presence should be re-evaluated by employees concerned about their overall exposure to ELF electric and magnetic fields. Electromagnetic field strength decreases in proportion to at least the square of the distance from the source. Thus, while "non-essential" sources in an employee's own work space may be relevant to his or her total exposure, such sources in a neighbor's work space should be of much less concern. These sources included the items listed below.

electric clocks	various electric lamps
surge protectors	AM/FM radios
microwave oven	laser printers
electric space heaters	electric calculators
FAX machines	photocopy machines
power strips	VDTs
small electric refrigerator	coffee pot
electric pencil sharpeners	dictaphones
microfiche machines	electric typewriters

While measurements were not made exclusively on all of the above sources in this evaluation, results from previous NIOSH evaluations and other literature have clearly shown that very high localized magnetic field levels can and do exist in close proximity to these types of sources. In fact, the magnetic field levels from these sources at close distances are orders of magnitude higher than what is reported in this evaluation for the average magnetic field levels. It should be kept in mind, however, that workers do not normally remain extremely near such sources for long periods of time and that the magnetic fields fall off quickly as a function of distance from the source. This suggests that overall exposure contribution from these sources should be small. Nevertheless, the elimination of many of these non-essential sources from the workplace would produce a reduction in ELF fields.

Video Display Terminal Screen Distortion

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 adverse health effect levels. 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 fields at the USCS facility was created when it was observed that screen images on a VDT located close to the electrical panel were slightly distorted. Similar type screen problems have been reported to occur at magnetic field levels as low as 100 mG in these NIOSH evaluations.

Shielding of Magnetic Fields

The use of shielding material is often used in controlling potential occupational exposures to various physical agents. Unfortunately, shielding of magnetic fields in the power line frequencies is not a very effective manner since they can pass through most common objects without being significantly affected. The two best methods to reduce magnetic field strengths are to limit the worker's time of exposure and to increase the distance between the source and worker.

In this evaluation one possible technique, to control the higher magnetic field levels in the back area near the panel, assuming movement of the switchboards to a further distance from the back wall is not possible, would be to designate the back area as storage. Since the back area has higher ELF levels, minimizing the time that workers spend in the room, or moving work areas further from the back area, are also measures that could be considered.

CONCLUSIONS

The NIOSH investigators determined that the ELF electric and magnetic field strength levels, both inside and outside the USCS facility are generally low, approximately the same magnitude reported previously by the local electrical utility company, generally within the range of exposure levels in office settings measured in previous NIOSH evaluations, and are well below the current occupational exposure ceiling limit of 10,000 mG recommended by the ACGIH.

REFERENCES

1. ACGIH [1994]. Threshold limit values for chemical substances and physical agents and biological exposure indices for 1994-1995. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

Table 1
Magnetic Field Strength Measurements*
May 16, 1995
U.S. Customs, Port of Atlanta
Atlanta, Georgia
HETA 95-0235
DFOH Project No. BCA95TRGA224

Location	Maximum Reading (milligauss)
Team 437: front of electrical panel, 6' from floor	200
Team 437: front of electrical panel, 3.5' from floor	100
Team 437: desk closest to electrical panel, chest height (seated)	1.5
Team 437: desk farthest from electrical panel, chest height (seated)	1.7
Hallway outside team 437, directly adjacent to electrical panel, head height	1.6
File Room**: immediate right quadrant when entering room	1
File Room**: immediate left quadrant when entering room	1.1
File Room**: far left quadrant when entering room	1.5
File Room**: far right quadrant when entering room	1.5
File Room**: center of room	1.1
Hallway outside File Room**	0.9
Entry Section: range in open areas	2
Entry Section: by conference table	1.6
Entry Section: by reception desk	1.1
Typical 2' working distance from VDT	1.4
Copy Room: adjacent to front entrance (middle of room)	1.2
Electric pencil sharpener (on/off)	1800/4
Wall clock (electric/battery-operated)	200
Receiving Dock: inside/outside	0.6/0.6
Receiving Dock: by telephone panel	1.6

Table 1 (Continued)

Location	Maximum Reading (milligauss)
Receiving Dock: electrical panel room at panels	500
Receiving Dock: electrical panel room, middle of room	20
Pepsi machine: (by can dispenser/by coin return)	1.4/1.1
Paper shredder: working distance waist height	20
Break Room: TV at screen/normal 5' viewing distance	20/0.5
Break Room: can opener	200
Break Room: toaster	10
Break Room: microwave oven	170
Break Room: refrigerator	4
Break Room: toaster/broiler	30
Break Room: in-sink garbage disposal	1.2
File Room across from File Room**	0.7
Port Director reception area	2
Electric screwdriver	10
Coffee pot	3
Telecommunications panel room	50
Desktop cooling fan	1000
Water fountain: on	175
Desk lamp	8

*Measurements collected with a Holaday Instruments HI-3627 ELF magnetic field strength meter
**File room where Team 437 proposes to move

Table 2
EMDEX Results on Workers
U.S. Customs, Port of Atlanta
Atlanta, Georgia
HETA 95–0235
DFOH Project No. BCA95TRGA224

Topic	Mode	Min.	Max.	Mean	Std. Dev.	Median	Geo. Mean	Std. Dev.	N	mG-Hr	Distribution of Reading (%)		
		in milligauss (mG)									<2 mG	<4 mG	<10 mG
Worker 1	B	0.41	222.4	9.12	21.61	3.01	3.88	2.98	5106	38.81	26	63	82
	F	0.01	219.2	8.42	20.31	2.81	3.49	3.37					
	H	0.11	65.6	3.09	7.72	0.51	0.91	3.83					
Worker 2	B	0.51	36.1	3.03	1.48	3.31	2.74	1.62	5086	12.86	20	85	99
	F	0.01	34.9	3.02	1.43	3.31	2.71	1.70					
	H	0.11	9.7	0.31	0.47	0.31	0.26	1.56					
Worker 3	B	0.41	148.5	4.12	6.91	2.21	2.64	2.26	4825	16.56	31	82	88
	F	0.01	146.5	3.92	6.67	2.21	2.51	2.32					
	H	0.11	31.3	1.14	1.97	0.51	0.63	2.68					
Worker 4	B	0.41	14.21	1.83	0.98	1.51	1.67	1.51	4903	7.48	70	98	99
	F	0.01	14.21	1.82	0.98	1.41	1.65	1.52					
	H	0.11	3.11	0.34	0.15	0.31	0.31	1.48					
Near Panel	B	0.61	31.7	1.17	1.73	1.01	1.06	1.28	2005	1.95	99	99	99
	F	0.01	30.5	1.15	1.63	1.01	1.04	1.32					
	H	0.21	9.7	0.34	0.61	0.31	0.30	1.32					

B = Broadband measurements
F = Fundamental measurements
H = Harmonic measurements
N = Number of measurements made at 3 second intervals

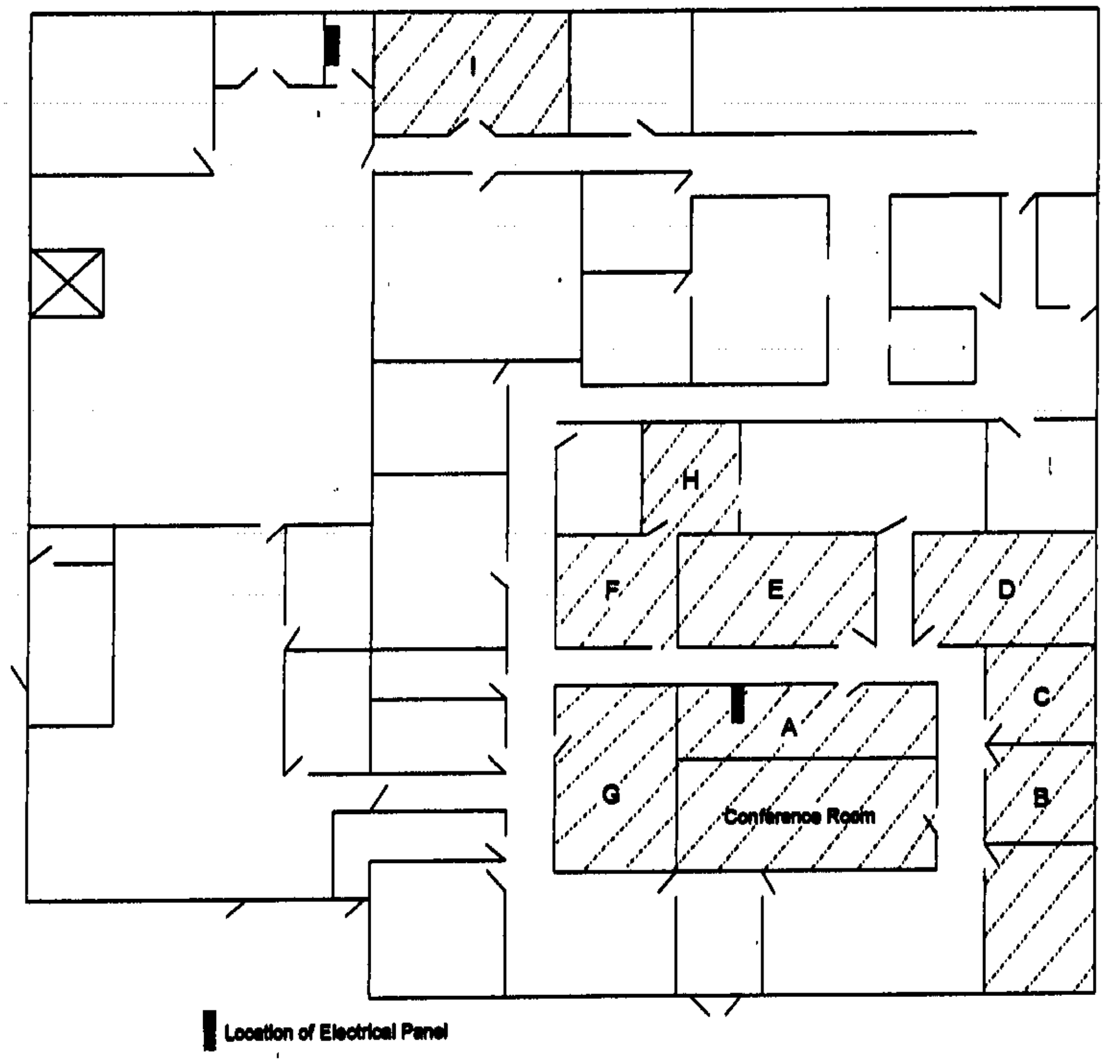

Figure 1. Schematic floor plan of USCS facility. The shaded areas represent locations where detailed measurements were performed inside facility.

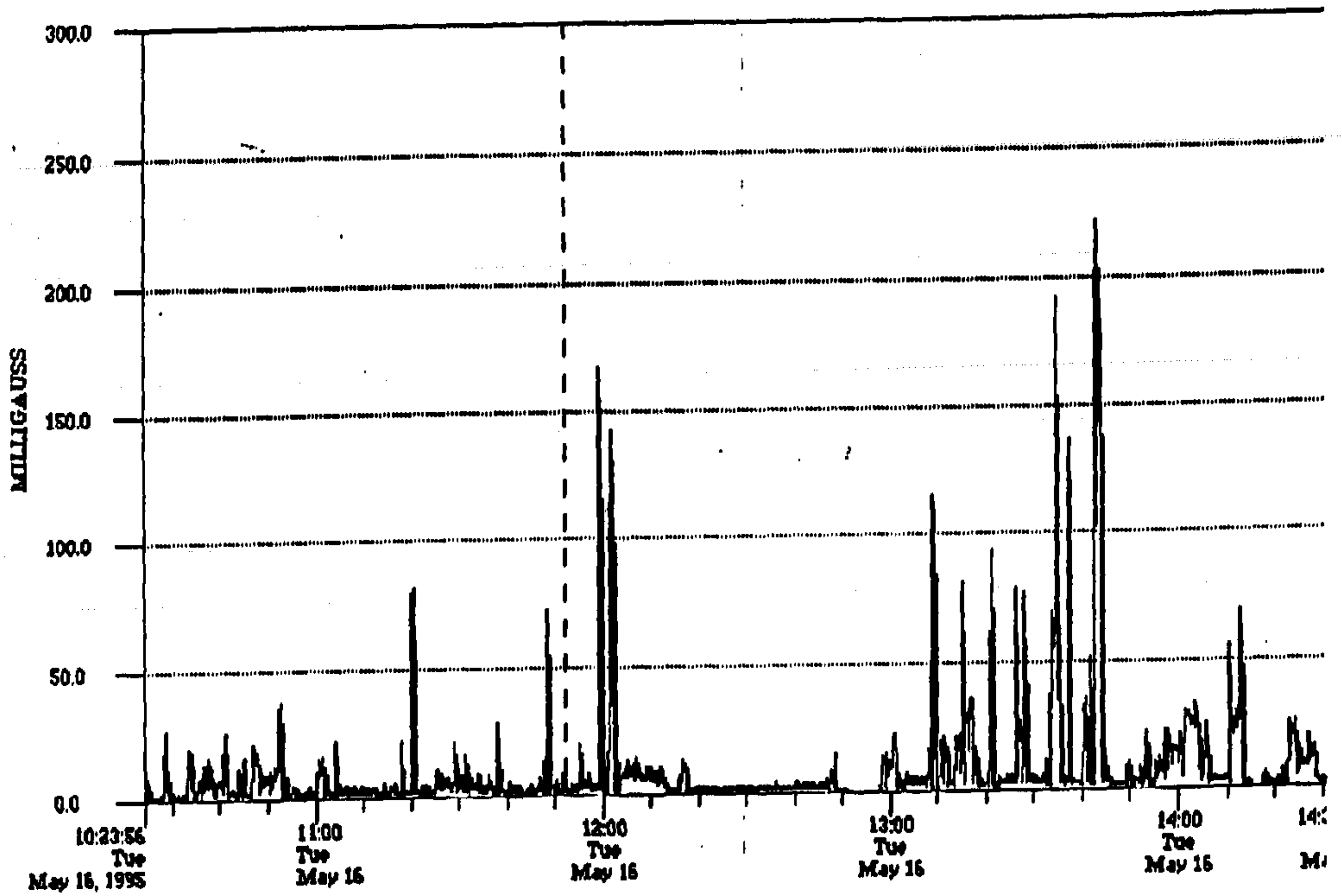

Figure 2. Time–magnetic field intensity relationship for first worker in room A. The high peaks (i.e., >50 mG) clearly were associated with standing next to filing cabinet.

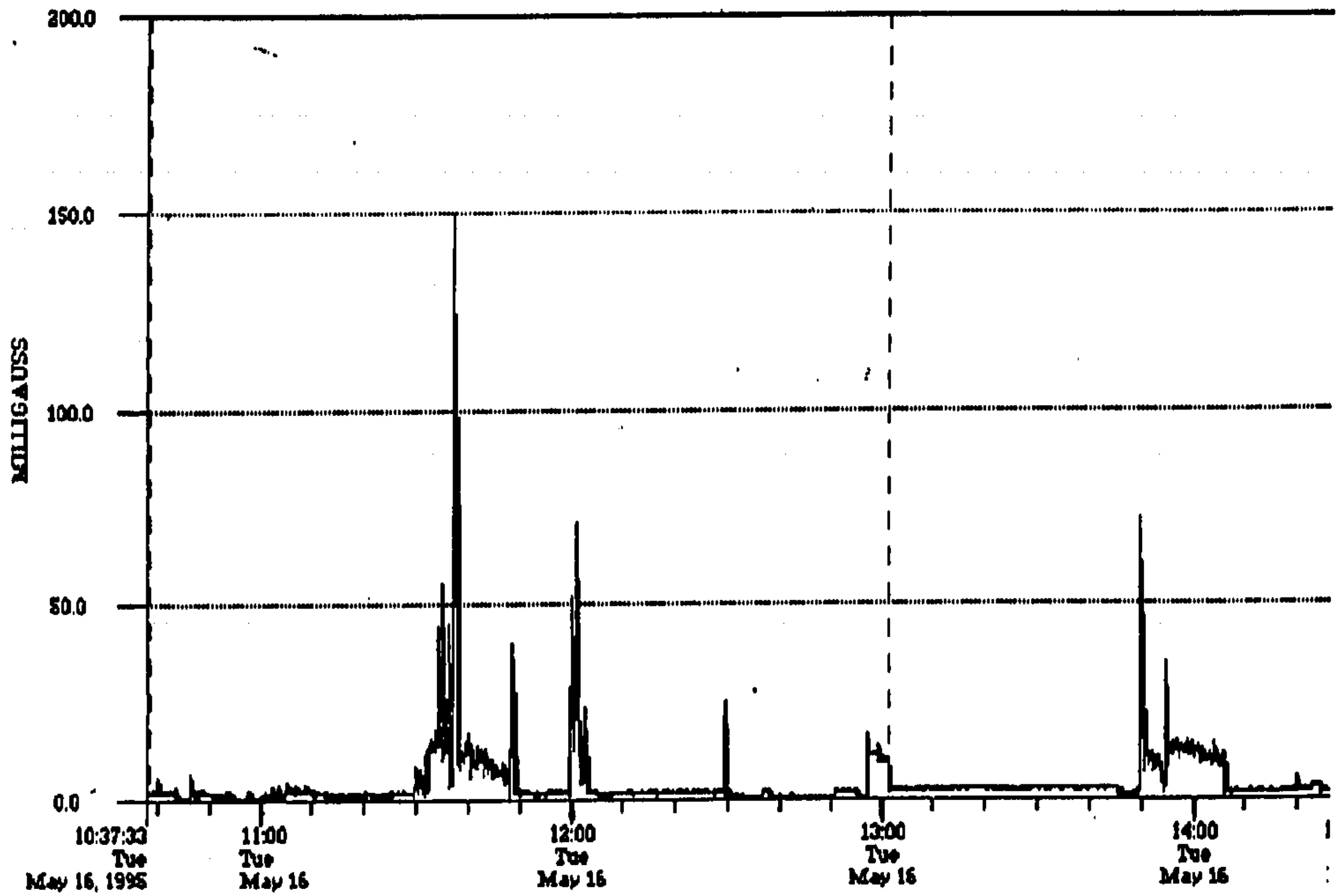

Figure 3. Time–magnetic field intensity relationship for second worker in room A. The high peaks (i.e., >50 mG) were also clearly associated with standing next to filing cabinet.

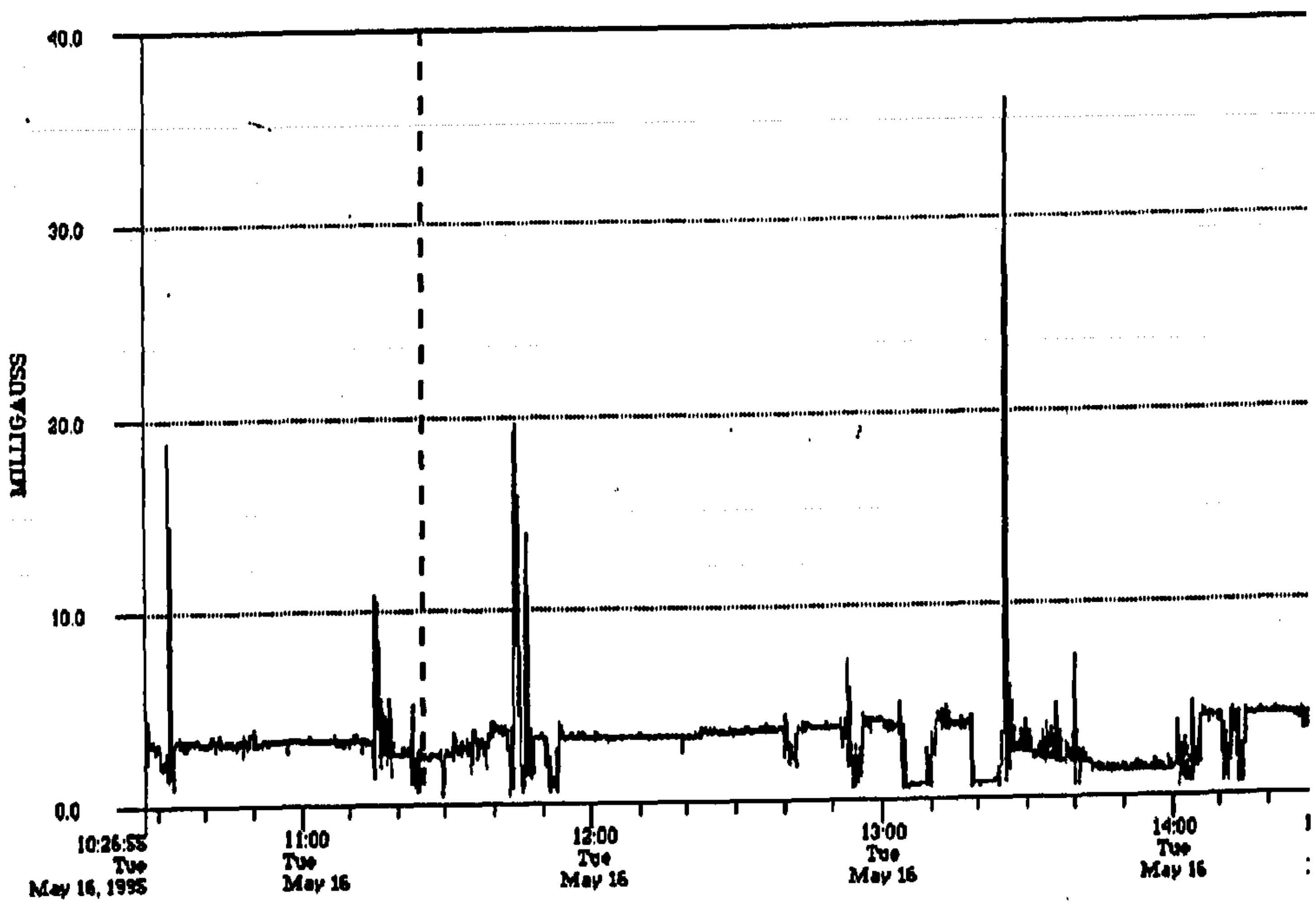

Figure 4. Time–magnetic field intensity relationship for supervisor who works in another room. The high peak around 1:30 resulted from entering room A and standing near same filing cabinet mentioned in Figures 2 & 3.

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