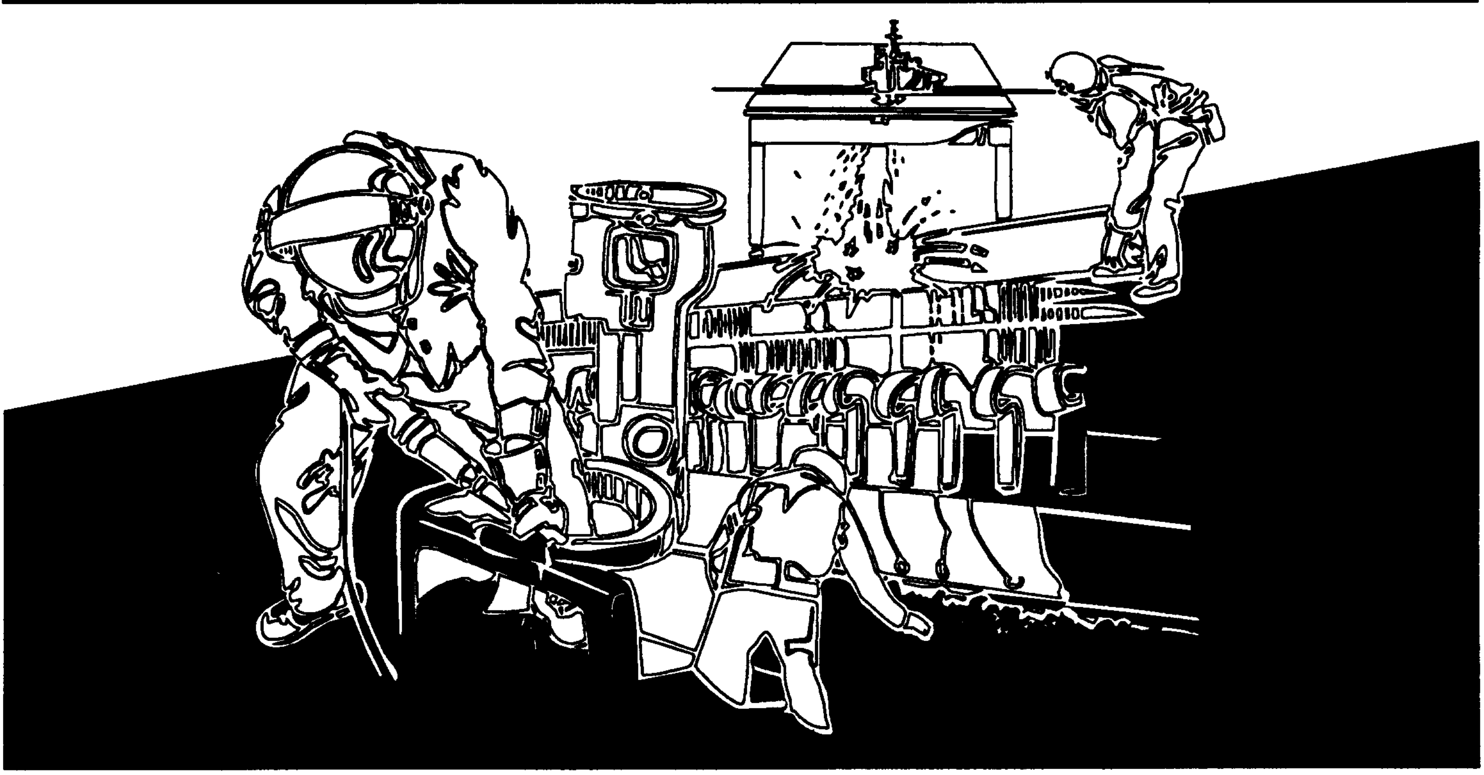
CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 93-0424-2486
CHICAGO TELEVISION STATIONS
CHICAGO, ILLINOIS



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 93-0424-2486
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I. SUMMARY

On December 14, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from three employees of WGN-television (TV) located in Chicago, Illinois. These employees were concerned about exposure to electromagnetic fields (EMF) emitted from television minicam viewfinders and its relationship to brain cancer. NIOSH subsequently received similar HHE requests from the International Brotherhood of Electrical Workers (IBEW) and the National Association of Broadcast Employees (NABET) for the ten Chicago-area TV stations they represent. On February 8, 1993, NIOSH investigators conducted an opening conference and initial site visit. Management representatives from six television stations, officials of the two requesting unions, and the employee requestors were present at this opening conference.

Sources of EMF exposure for camera operators included minicams, wireless headsets and microphones, car-mounted and portable two-way radios, electronic (ENG) and satellite (SNG) news gathering trucks and microwave communication equipment. NIOSH investigators, in cooperation with union, employee and management representatives, identified television stations that would provide the most representative sample of equipment and procedures used in the industry. EMF measurements were made at WGN-TV, WMAQ-TV, and WLS-TV on March 9-11, 1993, and June 8-11, 1993.

EMF emissions from studio and minicam cameras were below current occupational exposure limits for both ELF (extremely low frequency) and VLF (very low frequency) fields. Extremely low frequency (ELF) fields in studios, offices, and various work areas were also below these limits. However, degaussers, used to erase magnetic tape, were found to produce localized elevated ELF magnetic fields (1.6-5.6 Gauss at contact). Certain microwave communication equipment (minimacs) produced EMF levels in excess of occupational exposure limits especially if hand-held or used in restricted environments, such as helicopters. Emissions from two-way radios, used extensively by TV personnel, suggest that some EMF exposure exists; levels may vary depending on the antenna location and the radiated power. The possibility for exposure was greatest if the antenna was mounted on the trunk of the car. Personnel working in SNG and ENG trucks were not exposed to EMF levels in excess of occupational exposure limits. The only

possible exception would be if employees go on top of the ENG trucks during broadcasting, which would bring them close to the antenna.

In addition to EMF measurements, NIOSH investigators interviewed 48 employees at five stations: 36 minicam operators, 2 satellite transmission truck operators, and the remainder in various other jobs including editing and maintenance. The most prevalent health complaint reported among minicam operators was musculoskeletal problems. Twenty-two out of the 36 minicam operators (61%) reported disorders of the back, neck, arms, and legs.

Through review of union and management records and employee interviews, six cases of cancer (three lung cancers, one bone cancer, one oral cancer, and one brain cancer) were identified among ENG personnel since 1986.

The highest levels of EMF exposure were found in the hand-held and table mounted degaussers, two-way radios, and minimac equipment. Workers can be exposed to levels of microwave radiation from some of the minimacs that are above the current occupational exposure limit. Data from studies linking levels of EMF exposure to cancer are inconclusive at this time. However, the number and different types of identified cancers do not appear to be unusual for the number of workers at Chicago TV stations; the small number of cases makes it difficult to determine if they have a common cause. Additional recommendations to reduce occupational EMF exposure and improve worker safety are made in Section IX of this report.

KEYWORDS: SIC 4833 (television broadcasting stations), EMF, degausser, two-way radios, microwave radiation, ergonomics, television broadcasting

II. INTRODUCTION

On December 14, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from three employees who worked at the WGN-television (TV) station, located in Chicago, Illinois who were concerned about electromagnetic field (EMF) exposure from television minicams (portable television cameras). The WGN-TV employees were aware of two other non WGN-TV minicam operators who reportedly had been diagnosed with brain cancer and were concerned that the cancer might be related to occupational EMF exposure. NIOSH subsequently received similar requests for HHEs from the International Brotherhood of Electrical Workers (IBEW) and the National Association of Broadcast Employees (NABET) for the ten Chicago-area television (TV) stations whose employees they represent in the Chicago area.

NIOSH investigators conducted an opening conference and an initial site visit on February 8, 1993, with management representatives from six television stations, officials of the two requesting unions, and the employee requestors. NIOSH investigators, in cooperation with the two unions, employees, and management, identified television stations that would provide the most representative sample of equipment and procedures used by the stations. The stations selected for EMF measurement by NIOSH investigators, WGN-TV, WMAQ-TV, and WLS-TV, were visited on March 9-11, 1993, and June 8-11, 1993. In addition, employees were interviewed at all stations where measurements were made and additionally at WBBM-TV and WTTW-TV.

III. BACKGROUND

Since minicam operators were involved in many other aspects of the electronic news gathering (ENG) process, EMF from the minicams were only one source of employees' total exposure to EMF. Other sources of potential occupational EMF exposure cited at the opening conference were:

A. Wireless headsets and microphones. These devices are used for communication purposes among studio camera personnel and typically operate at frequencies between 180-210 MegaHertz (MHz) and 930-970 MHz with a power output less than 30-50 milliWatts (mW).

B. "Handy-talkies" (portable two-way radios). These radios are portable hand-held combination transmitting/receiving devices that operate in the frequency regions of 30-50, 140-170, or 400-510 MHz (depending on the particular model), with a power output between two and six watts.

Figure 1 shows a typical portable two-way radio that was measured at one of the facilities.

C. Vehicle-mounted two-way radios. These radios operate either at 160-166 MHz or 450-455 Mhz, with a radio frequency (RF) power output of up to 100 watts. The 160-166 MHz radios are usually installed in the cars and the 450-455 MHz radios are typically installed in the ENG trucks. Figure 2 shows a vehicle-mounted radio antenna.

D. Electronic news gathering (ENG) trucks. These trucks are essentially small field TV studios that contain a microwave transmitter (operating at a frequency of either 2, 7, or 13 GigaHertz [GHz]) that transmit signals to a fixed receiver, which in Chicago is located either at the Sears or Hancock building. The antenna for the truck transmitter can be elevated 40 to 50 feet for enhanced signal transmission to the receiver; the signal is then relayed to the television studio, either for editing or for broadcasting as a live shot. Additionally, the trucks carry radio equipment and their own electrical generators. The ENG trucks have been in use since 1976; Figure 3 shows a typical ENG truck.

E. Satellite news gathering (SNG) trucks. These trucks are used to transmit signals to a pre-designated satellite for relay to a land-based receiver and then directly back to the TV studio. The transmitter, shown in Figure 4, typically operates at a frequency of 14 GHz with a power output of approximately 300 watts per channel.

F. Degaussers. These are machines, either table-mounted or hand-held, used to demagnetize (erase) tape. A typical table-mounted type is shown in Figure 5 while Figure 6 shows a hand-held type.

G. Microwave communication devices (minimacs). These are portable microwave devices operating a 2, 7, 13, or 40 GHz used to transmit electronic signals either to a truck or TV studio. They are mounted on a tripod or pole or can be hand-held. Figure 7 shows a photograph of a typical minimac.

H. Cellular telephones. A cellular phone is a portable phone which, utilizing a vast network of "base stations" (fixed antennas), allows the user to make calls from virtually any location. The phones send and receive RF signals to and from the base station antennas. The TV broadcast facilities in this evaluation used a vehicle-mounted phone that is hard-wired to an antenna mounted on the roof, trunk, or rear window of the vehicle. They generally operate at 820-890 MHz at three watts.

The range of EMF frequencies produced by these sources in this evaluation extended from 60 Hertz (Hz) to 40 GHz and included exposures to ELF (extremely low frequency), VLF (very low frequency), RF (radio frequency) and microwave radiation. Job duties of studio personnel, including most camera operators may have brought them in contact with some or all of the above equipment. Most of the time, ENG personnel worked in the field and traveled by themselves or with a reporter; they would tape the shot and, if there was a deadline, travel in the ENG truck and transmit the tape back to the studio. If there was no urgent deadline, the camera operators would bring the tape to the studio or send it back by messenger. Live shots required two persons, one taping the shot and the other in the ENG truck. The amount of time the camera operators would spend taping varied according to the assignment. For example, sports coverage usually involved taping the whole game (possibly three hours), from which highlights would be taken; other assignments, such as a news report, might be substantially shorter. Often it is necessary to use minimacs to transmit signals from a building or helicopter to the receiver on the Sears or Hancock building. The need to rapidly communicate in the television industry means that workers can be exposed to radiation emitted from different types of two-way radios, cellular phones, or wireless microphones. Finally, the ability to erase tape with degaussers, so the tape can be reused, provides still another potential exposure scenario.

Some of the job titles of the several hundred television broadcasting personnel who may be exposed to EMF are engineers, editors, engineering technicians, news technicians, photojournalists, shooters, camera persons, and videographers. Some of the workers required to perform broadcasting duties are not employed full-time by television stations, but are hired on a part-time basis.

IV. METHODS

Emphasis was placed in this evaluation on both documenting typical occupational exposure levels to EMF over a wide range of frequencies as well as evaluating potential health effects to workers, both from EMF and other sources, at these television facilities.

A. EMF Measurements

The evaluation to determine EMF levels of electric and magnetic fields was designed to survey actual worker exposures to these fields during work tasks. The limited number of measurements taken in and around the various facilities were not intended to represent an in-depth evaluation of all EMF present at the site, but were rather intended to approximate occupational exposure levels on the days of evaluation. In most cases workers were exposed to a multitude of frequencies in the course of completing a particular job task. However, since it was not possible to measure all frequencies for every job each time, emphasis was placed on individually documenting each major EMF source.

The major EMF sources measured by the NIOSH investigators were studio and minicams, wireless headsets, "handy-talkies" (portable two-way radios), wireless microphones and head sets, car mounted two-way radios, ENG and SNG trucks, degaussers, and minimacs. No attempt was made to evaluate multiple exposure sources due to limitations in the monitoring equipment. In addition, EMF measurements were made in various studios to estimate the impact of transformers and studio lights. Extensive walk-around data was gathered at various selected sites for estimating area exposure to such sources as TV monitors, equipment racks, and video/audio electronic devices.

The following equipment was used to document the various types of EMF levels for this evaluation:

- 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 and the electrical frequency (as well as the waveforms) produced by such fields. The electric field strength was measured in units of Volts per meter (V/m) and the magnetic field strength was measured in units of Gauss (G) or milliGauss (mG) over the frequency range from 30 to 800 Hertz (Hz).

* A Holaday Industries, Inc. model HI-3627 3-axis ELF magnetic field meter was used to make isotropic measurements of the magnetic field in and around different workstations. The magnetic field is measured over the frequency region from 30 to 2000 Hertz (Hz) and the dynamic range of the instrument is from 0.2 mG to 20 G.

* Selected 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 region from

40 to 800 Hz. Measurements were made with this meter in both the walk-around and personal dosimetry modes.

* Holaday Industries, Inc. model 3637 3-axis VLF magnetic field meter was used to make isotropic measurements of the magnetic field in and around different workstations. The magnetic field is measured over the frequency region from 2 kiloHertz (kHz) to 400 kHz and the dynamic range of the instrument is 6 mG to 400 G when using special probe adapters.

* Holaday Industries, Inc. model HI-3603 VLF radiation survey meter was used to make measurements of the VLF electric fields around studio cameras and minicams. The electric field is measured over the frequency region from 2 to 300 kHz and the dynamic range of the meter covers 1 to 2000 V/m.

* Measurements of radio frequency radiation were made with a Holaday Model 3002 survey meter using two probes: a model STE for the electric (E) field and a model STH for the magnetic (H) field. The E-field probe is designed to cover the frequency range from 0.5 to 6000 MHz and measures the electric field strength in units of Volts squared per meter squared $(V/m)^2$. The lowest meter indicating level (LMIL) for this probe-meter combination system is 500 $(V/m)^2$. The H-field probe is designed to cover the frequency range from 5 to 300 MHz and measures the magnetic field strength in units of amperes squared per meter squared $(A/m)^2$. The LMIL for this probe-meter combination system is 0.005 $(A/m)^2$.

* Measurement of microwave (MW) radiation was performed with a Narda electromagnetic radiation monitor model 8616 connected to either a Narda magnetic field isotropic probel model 8633 (10 to 300 MHz) or an electric field isotropic probe model 8621B (0.3 to 40 GHz). Both field probes, when connected to the monitor, measure field intensities in milliWatts per square centimeter (mW/cm^2) over their respective frequency region. The LMIL is 0.05 mW/cm^2 for the 8616/8633 system and 0.01 mW/cm^2 for the 8616/8621B system.

* The frequency of most of the sources found in this evaluation were measured using an Optoelectronics Handi-Counter Model 3000 battery-powered frequency counter.

B. Medical Evaluation

The NIOSH medical evaluation consisted of employee, union, and management interviews at WBBM-TV, WLS-TV, and WMAQ-TV (network owned stations), WTTW-TV (a public broadcasting affiliate) and WGN-TV (an independent television station). Interviewed workers included all minicam operators available on the days of the evaluation or other workers selected by their union. In addition, we reviewed relevant employee records, and consulted with the company physician at WGN-TV. Cancer cases were ascertained through review of review of union and company records, interviews with union and company officials, and employee interviews. Since the ENG technology is relatively new, (within the last 20 years), long-term employees were able to remember and identify past employees who had worked with this technology and had cancer. During employee interviews, NIOSH medical investigators questioned employees about work procedures used at the different stations to evaluate the following: 1) their similarities between stations, 2) the existence of worst-case exposure scenarios, and 3) health effects that may be work-related.

V. EVALUATION CRITERIA

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

A. Sub-radio frequency electric and magnetic fields

The ACGIH has published threshold limit values (TLVs) for sub-radio frequency electric and magnetic fields (30 kiloHertz and below).[1] The TLV for magnetic fields (B) states "routine occupational exposure should not exceed:

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

where f is the frequency in Hertz." Conversely, the electric field (E) TLV states "occupational exposures should not exceed a field strength of 25 kiloVolts per meter (kV/m) from 0 to 100 Hz. For frequencies in the range of 100 Hz to 4 kHz, the TLV is given by:

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

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

This means, for example, that at 60 Hz, which is classified as 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 ELF E-field TLV is to minimize occupational hazards arising from spark discharge and contact current situations. The H-field TLV addresses induction of magnetophosphenes in the visual system and production of electric currents in the body.

B. Microwave and Radiofrequency Radiation

Many of the observed biological effects of exposure to MW and RF radiation can be attributed to a rise in body temperature. The heating effect of MW depends on the amount of energy absorbed by the body. The rate of absorption, denoted the specific absorption rate (SAR), is measured in watts per kilogram (W/kg) for the whole body or parts of the body. The SAR depends on many factors, such as the frequency and intensity of the radiation, size and shape of the exposed worker, and the worker's orientation in the radiation field.

The most influential standard for occupational exposure to MW radiation is the Institute of Electrical and Electronics Engineers (IEEE) standard published by the American National Standards Institute (ANSI) and known as ANSI C9S-1991.[2] The IEEE committee concluded that a SAR of 4 W/kg represents the threshold absorption level above which adverse health effects may arise as body temperature increases. A safety factor of ten was then added to give a SAR of 0.4 W/kg as the maximum permissible exposure, averaged over the entire body. The standard uses dosimetry measurements of MW radiation to calculate the power density limit necessary to achieve a SAR of 0.4 W/kg when averaged over a 0.1 hour period (see Table 1).

OSHA has a radiation protection guide (defined as the radiation level which should not be exceeded without careful considerations of the reasons for doing so) of 10 mW/cm^2 averaged over any possible 0.1 hour period.[3] This standard is applicable for far field measurements and is not useful in evaluating near field exposures which are of concern in this evaluation.

VI. RESULTS

Results are presented below in the following three major categories: 1) levels of EMF emitted from a number of sources, 2) analysis of medical interviews conducted with workers, and 3) major work practice issues that can affect workplace health and safety. The results are not separated by individual facilities, but have been combined to present a more representative overview of worker exposure and health problems at the evaluated television stations. Our results are specific to the measured equipment on the days of the evaluation; different equipment (although used for similar purposes) may produce different levels of EMF.

A. Electromagnetic Fields Measurements

1. Studio Cameras and Minicams

Two types of cameras are used by televisions stations, studio cameras and minicams. Most of the cameras are minicams and are used in field situations to record news. Fifteen percent of all cameras are studio cameras, also known as full-up cameras, that are used for news production purposes and taping shows in the studios. While the full-up cameras would only be found in the studios, the minicams might be found in trucks, cars, studios, and in the maintenance departments. Studio cameras, shown in Figure 8, were mounted on rollers for ease of movement in the studios, while the minicams (Figure 9), whose weight ranged from 20 to 30 pounds, were carried by news personnel.

Measurements of electromagnetic fields were made on various studio and minicam cameras and the results of these measurements are shown in Table 2. EMF assessments of these cameras were performed at the position where the worker was located for the majority of time when using the cameras. For the minicams the position would be at the viewfinder (the position where the eye is placed when the camera is used) and for the full-up cameras it would be at the eye position for workers who sat or stood. Table 2 shows that all positions measured produced exposure levels well below presently accepted occupational standards for both the VLF and ELF regions. On some minicams, both VLF and ELF electric and magnetic field measurements were made next to the electronic viewfinder, which is a small TV set located near the front of the camera. This position was chosen since it is where the electronic circuitry that operates the electronic viewfinder is located and may produce exposure to workers' hands when they operate the camera. Hand and arm levels were measured as high as 390 mG and

17 V/m. There was some dependency of EMF levels on age and condition of the minicams. The measurements indicate that magnetic field levels could be higher to the hands than those measured at the viewfinder position, but they were below ELF/VLF occupational exposure guideline levels.

2. *Walk-around EMF data*

a. Area surveys

There were numerous ELF and VLF sources throughout the three television facilities surveyed in this evaluation. Such sources included television monitors, videotape machines, video and audio console equipment racks, power supplies, small transformers, and studio lights. In general, the ELF electric and magnetic fields as measured in studios, editing rooms, and news rooms, typically ranged from 3 to 8 V/m and 2 to 5 mG. Studio magnetic field levels could be as high as 300 mG at locations near light control centers and small transformers. Measurements of magnetic fields in the hallways of the facilities ranged from 0.1 to 19 mG. It was also observed on the walk-around portion of the evaluation that VLF levels were smaller than ELF levels. Figures 10 and 11 show magnetic field levels, simultaneously measured at various distances from the floor in two different studios, using the EMDEX meter in a walk-around mode. These figures demonstrate that different parts of the body can receive different EMF exposures at the same time, perhaps from different sources (i.e., lighting near the ceiling or electric cables in the floor). Notice that the highest level was about 7 mG at a distance of 12 inches from the floor. It was also shown that the highest ELF exposure sources found at the stations were associated with table-mounted and hand-held degausser devices. These devices produced magnetic field levels at least ten times higher than any other source seen at the facilities.

b. EMDEX II results

Emdex II meters were worn by NIOSH personnel while making walk-around measurements. The data obtained from these results, shown in Table 3, were helpful in assessing the overall trend of occupational EMF levels, in the frequency region from 30 to 1000 Hz. Where possible, personal monitoring was performed on selected workers in the studio but not camera operators, since they were not available on the day of the evaluation. Figure 12 shows an EMDEX magnetic field time-intensity plot for a worker in one of the control rooms who is at a very close distance to various television monitors. The range of exposure for this worker ranged from 2.8 to 30.1 mG with an average of 12.2 mG. The three highest peaks occurred while the worker moved closer to the monitors for short periods of time, however the background level observed in the room was about 10 mG. The highest electric fields levels measured was 30 V/m. Figure 13 shows three time-intensity distributions from EMDEX meters worn by these workers which clearly depicts the magnitude of a degausser's magnetic field. All of the workers stood in the general vicinity of a degausser and received varying exposure levels at the same time (see Figure 13).

3. Degausser units

Nine tape degausser units were measured in this evaluation and the data for these measurements are shown in Table 4. Measurements with the EMDEX II meter clearly shows that these sources represent the highest ELF magnetic field-producing source found at the three sites on the days of measurements. NIOSH investigators found that, at contact, these devices can produce magnetic fields as high as 5.6 G. It should be noted that the particular version of the EMDEX II meter used by NIOSH for this evaluation is rated by its manufacturer to accurately read 3 G on any one coil, and the maximum level that can be theoretically documented with this meter is 5.2 G. This suggests that the real exposure levels are probably higher than reported in Table 4 when the worker is in contact with the unit since the measured exposure exceeded 5.2 G.

Degaussers were measured at each evaluated station and results were similar. While these sources can produce very high localized magnetic fields, the levels from the degaussers do drop off rapidly with distance from the source. Measurements made with EMDEX units located about ten feet from the unit showed average magnetic fields less than 2 to 4 mG. Moreover, these systems are not always in use. They are used infrequently as the need arises by workers. For example, Figure 15 shows the time intensity distribution of a EMDEX unit placed several feet from a degausser. Notice that after a six-hour time period the degausser system had been activated only six times. While the particular day that measurements were made may not represent typical use factors, it does suggest that magnetic field exposures must consider the time of use. Hence, it is suggested that occupational concern for these sources should be focussed upon reducing exposure for those times when workers are required to stand near such units and perform lengthy operations.

As part of this evaluation NIOSH investigators made a visit in June 1994, to a major manufacturer of commercial degausser systems to further investigate the levels of magnetic field produced by these units. Using a model similar to one measured in Chicago, it was shown that magnetic field levels from newer degausser models were about 30% less than those that had been measured on the same older model. In addition, the manufacturer demonstrated that further reductions, 78% at contact and 33% to 50% as one moved away from the degausser, were achieved by changing the cover material from aluminum to steel.

4. ENG and SNG Trucks

At the facilities evaluated there were a total of 15 ENG and 2 SNG trucks. Each of these trucks contain special equipment, capable of producing various EMF, used to process and transmit video information to either the studio or to an up-link satellite. The EMF producing equipment found on the trucks, such as two-way radios and cellular phones, will be discussed later in this evaluation. However, certain microwave radiation issues, that arise from using these trucks will be addressed here.

a. ENG Trucks

Typical microwave frequencies used on the trucks were either 2, 7, and 12 GigaHertz (GHz) sources operating at 5 to 12 W. Worker exposure to microwave was possible outside of the trucks if the transmitter was on when the antenna was being raised. All microwave radiation levels measured inside the trucks were below the LMIL of the meter used and therefore were not above occupational exposure limits. The highest emission levels measured from the 2 GHz source at a height of about 25 feet when the antenna was directed straight downward was 53 mW/cm^2. While this level exceeded the IEEE exposure limit of 6.7 mW/cm^2, it does not reflect realistic occupational exposure potential since no signal transmission to the studio would be possible. However, it does illustrate the need to insure proper orientation of the antenna before and after broadcasting activities.

However, occupational exposures can occur when: 1) broadcasting occurred at fixed field locations with workers stationed for extended periods of time on the truck top; 2) the antenna mast was not fully raised and the antenna was pointed downward, creating a possibility of having some "spill-over" of radiation onto the ground immediately around the truck. This "spill-over" effect was measured for one truck and found to be at a level of 13 mW/cm^2; and 3) during a news emergency situation where several ENG trucks from various news stations might be clustered together, which was not measured during this evaluation.

The radiating power associated with these antenna systems were low. Hence, standing in front of these antennas might create more immediate concern for loss of data transmission than immediate biological effects from radiation exposure. For example, one of the ENG trucks tested had the capability of transmitting both 2 and 7 GHz signals simultaneously at 12 W each. Measurements were made with these two systems in an active mode at eight feet from the truck. A level of 2 mW/cm^2 was recorded when the antennas were all the way down, which is below the occupational guideline. Whenever the antenna is carried facing the ground or truck and then has power applied to it upon arrival at a site, the possibility exists for occupational exposure either directly to workers on the ground, on top of the truck, or potentially to the driver. NIOSH investigators suggested that the trucks contain some type of warning lights on the inside and outside of the truck to warn workers that the truck was transmitting.

The ENG trucks have been designed by the various TV facilities for certain unique purposes and therefore will differ in content and type of equipment used. The ENG trucks also differ slightly on operating frequencies, and are operated by different workers. In fact, we were told that sometimes the truck workers may include temporary day-hires. This difference in trucks may result in different operating procedures for each truck. For example, the direction the antenna faces while moving or while in storage may be different for two different trucks owned by the same station. Other observations that may impact worker's safety and health are noted under the work practice section.

b. SNG Trucks

The two SNG trucks seen in this evaluation operated at 13 GHz and at a power level of 300 and 500 W. In general, there were two or three workers assigned to the truck for operational purposes. The operator of the SNG truck must have clearance from the satellite prior to transmitting microwave signals. No workers were seen on top of the SNG trucks during operation, and measurements made on the inside of both trucks were below the LMIL.

5. *MINIMACS (Portable hand-held microwave equipment)*

Some minimacs measured in this evaluation emitted 20 mW/cm^2 from the tip of their antenna. While this level is twice the level of the IEEE exposure standard for the frequency of the minimacs, it is unlikely that a worker would intentionally stand in front of the antenna for any extended period of time since this would cause signal disruption requiring the antenna to be moved. However, microwave emission levels of 7 mW/cm^2 were found along the length of the antenna and also to the side and behind the device. NIOSH investigators were informed that some workers would hold minimacs in their hands while transmitting signals from a helicopter. While measurements were not performed on a helicopter during this evaluation, workers reported that continuous adjustment and movement of the minicams was necessary to keep it aligned with the receiver. This movement would not only potentially expose the pilot, but the holder of the minimacs, camera operator, and any passengers as well.

6. *Wireless Headsets/Microphones*

A total of six wireless headsets were measured during this evaluation. The range of frequencies measured was from 181 to 560 MHz and the highest E-field level documented was less than 3×10^3 $(V/m)^2$ and the highest magnetic field level was 0.02 $(A/m)^2$ at contact with a headset transmitter. These devices are normally worn on the body, particularly in the waist area. This maximum measured level is below the IEEE occupational guideline value of 3.77 x 103 $(V/m)^2$.

7. *Two-way Radios*

There were over 25 cars containing two-way radios at the three facilities evaluated. They typically operate either near 160 MHz or 450 MHz and can have a RF power output of up to 100 watts. The

160 MHz radios are usually found in cars while the 450 MHz radios are portable. Workers informed the NIOSH investigators that operating power levels were increasing since cars were travelling further from the studios to get stories and higher power levels were necessary to relay news information. Another factor mentioned several times was the presence of the cellular phones as a possible alternative communication source for the radios. In fact, most of the cars had both radio and cellular phone antennas mounted normally on the rear trunk or roof.

An 18 inch long antenna for the car radio was mounted either on top of or on the rear of the radio-equipped cars, (possibly on the center of the rear trunk, on one of the rear sides). NIOSH investigators were informed that generally there were only two riders in the cars and they rode in the front seat. Occupational exposure to EMF emitted by vehicle-mounted radios could occur if:

a) a worker was in the back seat of the car and radiation was transmitted from the antenna through the rear window,

b) when a worker was positioned near the antenna outside of the car and another worker operated the radio, and

c) if the rear trunk was open while transmitting. The antenna then would be even closer to the rear seat area creating a higher potential for exposure to car occupants, particularly rear seat occupants.

The location of the antenna and its proximity to the workers controls the exposure potential to radio frequency radiation produced by the radios. Measurements indicated that these levels could be quite high depending on: the wattage associated with the radio, its frequency, and the length of time workers were exposed.

Every one of the facilities evaluated indicated that the radios were not used continuously. In fact, at one facility NIOSH investigators monitored the time usage and found that the maximum cumulative time of use never exceed two hours per day per vehicle on the vehicles measured. Furthermore, even during this two-hour period of time the radio was not constantly transmitting. Based on selected measurements and interviews with several workers it was found that during typical six-minute intervals, transmission might occur a total of approximately 40 seconds. This represents a 0.1 duty factor value.

Occupational radiation measurements were made at the facilities on both portable and vehicle-mounted two-way radios operating in the frequency region between 161 to 166 MHz and 450 to 455 MHz at various power levels. Most of these measurements were made at a distance of three feet from the radio antenna. However, a few measurements were made at other locations or distances deemed by the NIOSH investigators to be occupationally relevant.

The maximum electric and magnetic field strength levels measured at three feet from two-way radio antennas, operating in the 161 to 166 MHz region, was 1×10^4 $(V/m)^2$ and 0.01 $(A/m)^2$, respectively. Applying the 0.10 duty factor produces corrected radiation exposure levels that are below the IEEE exposure guidelines for this frequency (see Table 1).

The highest power density level measured at three feet from radio antennas operating in the 450-455 MHz region was 5 mW/cm^2. Applying the duty factor produces a corrected exposure which is also below the IEEE guidelines value of 1.5 mW/cm^2 for this region.

Selected measurements were made at four inches from the trunk-mounted antennas for the 161-166 MHz two-way radios operating at 100 watts. These measurements were in excess of the IEEE guideline values even after duty factor corrections are applied. While workers can be found in the vicinity of the trunk in the course of their work, they are not normally there for long periods of time while the radio is on.

Transmitting with the trunk raised will produce about a ten-fold increase in EMF levels at the rear window (and subsequent increased exposure to a rear seat passenger), compared to levels obtained with the trunk closed. However, NIOSH investigators were informed by both workers and management that the presence of a rear seat passenger was rare. Front seat exposure, to both the driver and the passenger were at levels below the IEEE standard for both frequency regions in all two-way radios measured.

Both the ENG/SNG trucks also could contain mounted radios. In that case, the antennas would be located on the truck top and in general would not constitute a problem except for those situations where the worker would have to work on top of the truck.

During the evaluation of two-way radios, several trucks were observed that had Citizen Band (CB) radios and antennas installed. These radios emit radiation at 27.12 MHz and apparently were still being used for TV station-truck communication purposes. Measurements were taken at 12 inches from the CB antenna and levels of 5×10^5 $(V/m)^2$ and 0.16 $(A/m)^2$ were recorded. The electric field level exceeds the IEEE guideline values, even with the duty factor correction considered. The antenna was located near the driver door and therefore does represent a potential exposure source when the driver stood on the running board and used the CB radio.

8. Cellular Telephones

Measurements made at several vehicle-mounted rear cellular phone antennas gave power density levels of 1.9 mW/cm^2 at distances of six inches from the antenna. This level is below the IEEE guideline values and furthermore, these levels continued to drop the further away measurements were made from the antenna. Moreover, levels did not remain constant at the maximum measured value. As soon as the telephone call was picked up by the base station the levels also dropped. Perhaps the levels decreased due to minimal power requirements necessary to connect calls in an area having many base stations. Had measurement been conducted far away from a metropolitan area, the power levels necessary to make a connection may have been much higher.

All measurement levels in the vehicle from the cellular phone antenna were below the LMIL. The only exception to this finding were small leakage levels found in those cars containing rear window-mounted and roof-mounted antennas.

B. Medical Evaluation

The observed and reported work practices and reported health problems were similar at each of the visited stations, so the results were combined. NIOSH investigators interviewed a total of 48 employees at five stations: 36 minicam operators, 2 satellite transmission truck operators, and the remainder in various other jobs, including editing and maintenance.

The most prevalent category of health effects reported by minicam operators was musculoskeletal problems related to the weight of the camera and associated equipment. Twenty-two of the 36 interviewed minicam operators (61%) reported disorders of the back, neck, arms, and legs, including, what was called by one operator, "cameraman's shoulder." Several minicam operators reported that, at times, they would have to carry all their equipment from the truck to the news site in one trip. This practice was necessary because of time constraints and because the equipment is expensive and cannot be left unattended. The weight of the camera and its associated equipment could exceed 80 pounds and be difficult to carry.

Six cases of cancer were identified among ENG personnel since 1986 from review of union records and employee interviews: one brain tumor (glioblastoma), one bone cancer, one mouth cancer, and three cases of lung cancer. One of the initially reported brain cancers was found to be a lung cancer that had metastasized (spread) to the brain.

C. Work Practices

During worker interviews and field observations the following health and safety issues were noted:

1. Employees reported that the microwave transmitter switch on trucks is often, inadvertently, left on when employees leave the trucks. Employees sometimes use the circuit breakers to turn off all power on the trucks, rather than just switch off the transmitter. When this is done, power will be restored to the transmitter when the circuit breaker is turned back on even though the antenna may be pointed in an improper direction (at the truck or in the area directly in front of the truck), possibly exposing employees to microwave radiation. There is no interlock for the antenna to prevent it from transmitting before it is aimed, nor is there any light outside the truck that would indicate whether or not the transmitter is on. Workers reported that this inadvertent transmission would also occur when the transmitters were left on and the trucks were connected to an AC power source in the garage. This same finding of the need to install an interlock on the ENG truck to eliminate microwave radiation was reported in a previous NIOSH evaluation at another TV broadcasting facility.[4]

2. Minicam operators reported that they sometime might be at the scene of an emergency, such as a fire or a chemical spill, before the police. When emergency personnel would arrive, they would be wearing respiratory protective devices while the camera operators would not be wearing any. They also expressed the opinion that dispatchers would not fully inform them of the nature of the emergency they were being

asked to tape. Management representatives said, however, that field crews were provided with all available and current information.

3. Minicam operators reported that, at times, it would be necessary to tape from on top of the ENG trucks. The absence of platform guard rails on top of the ENG trucks is a safety hazard that creates the potential for slips and falls when workers are required to be on top of the truck.

4. There was no standard operating procedures (SOPs) for truck operation or training programs for operators of ENG trucks, particularly for the day-hires, concerning the proper use of ENG transmission trucks. Policies varied station to station, with some stations not assigning day-hires to the ENG trucks by themselves, others only assigning individuals who had previously worked full-time at the station, and still others assigning employees to the ENG trucks who only had a cursory orientation by an experienced operator. Most minicam operators felt that a training manual concerning use of the trucks would be helpful. The NIOSH investigators believe there exists a need for the facilities to develop a complete set of standard operating procedures (SOPs) for use with the trucks.

5. There exists the possibility of raising the transmission mast, particularly at night, into energized power lines. It was not clear to the NIOSH investigators how or if the trucks were properly electrically grounded during broadcast time periods.

6. The exhaust pipe for the generator is located near where the worker is required to stand when outside the truck and workers reported that inhalation of exhaust emissions from the generators on the ENG trucks was possible.

7. At one facility, automatically controlled cameras (robo-cams) were in use (Figure 14). These cameras were remotely controlled by workers located on another floor. The use of such techniques may lead to unforeseen unintentional injuries unless special precautions are taken.

8. Some of the small tape edit rooms were stacked with equipment racks in and around walkways. Not only was it difficult to move around these rooms, but ventilation may be inadequate based on the number of workers and the equipment demands in the space. Of particular interest in this regard were maintenance/repair areas that performed

limited welding/brazing operations in areas that were not originally designed for such activities.

VII. DISCUSSION

A. Measured EMF Levels

1. Studio Cameras and Minicams

Several issues effecting potential occupational exposure from the EMF fields produced by the cameras need to be discussed. First, the occupational EMF levels produced at a cameraman's typical working distance, from either the studio cameras or minicams, were all below current EMF guideline values. Second, ELF magnetic fields were approximately an order of magnitude higher than VLF magnetic fields while the electric field levels were about the same. Third, the occupational magnetic field levels did not vary greatly among the various camera makes. Fourth, magnetic field levels measured on minicams at the hand and finger locations, near the viewfinder, could be about ten times higher than those measured at the worker's eye but were still below occupational exposure guideline levels. Fifth, some worker exposure from television monitors and cameras can occur in the maintenance/repair shops. However, these levels would average about 5 to 8 mG on a time-weighted basis and appeared to be no higher than those that have previously been reported by NIOSH in a similar environment.[5]

2. ELF Measurements made in Studios and on Degaussers

Occupational ELF levels in the studio ranged widely due to such factors as worker location from sources, length of time near sources, and the type of work being performed. For example, ELF magnetic field levels at contact (i.e., finger and wrist exposures), with a single TV monitor could produce 35 mG, while at two to three feet away from the monitor (a typical worker distance), the magnetic field level could decrease by about an order of magnitude to about 4 mG. However, if a worker was to view several monitors that are grouped closely together at the same time (a common practice at television stations), there is a potential for higher exposure levels at close distance.

However, it was clearly demonstrated that the various degausser units, either hand-held or table-mounted, were the dominant sources of ELF exposures at the TV stations evaluated. While it was not possible to accurately measure the magnetic field levels in contact with the degausser due to meter limitations, measurements made at a degausser manufacturer on similar units seen at the TV stations suggest that contact levels do not exceed occupational guideline levels of 10 G. Moreover, a magnetic field measurement made at contact is much higher than levels a worker encounters at a distance of two to three feet away. The NIOSH investigators do not believe workers stand at contact with the degausser surface for extended periods of time, but rather stand two to three feet away during the degaussing period. In fact, Figure 15 suggests that workers may use a degausser for only a few times per day and each time is of a short duration, i.e., less than 30 seconds. However, if workers are requested to degauss, say 100 tapes, the exposure potential may be elevated and safety personnel may wish to consider other techniques.

All levels of ELF fields measured on walk-around surveys and near degaussers, inside the three selected facilities, on the days of measurements, were within the range of exposure levels in office and small industrial settings previously reported by NIOSH, and are below current occupational exposure criteria.

3. Cellular Phones

Public interest has recently been focused on whether the use of cellular phones is related to development of brain cancer.[6] The closeness of the skull and brain to hand-held units, (which contain an active telephone antenna) during use has obviously contributed to this concern. At this point in time, there is no conclusive answer to this concern since only a small number of biological studies at these frequencies have even investigated cancer as an endpoint.[7,8] These studies are not conclusive in either substantiating or rejecting the validity of this possible health concern. Although rigorous scientific evidence of health effects, notably brain cancer, from exposure to microwave radiation from cellular telephones as used in the TV broadcasting industry does not exist, the NIOSH investigators believe it would be judicious to maintain exposure levels as low as possible until the safety from such exposures has been determined.[6]

4. Two-Way Radios

Occupational exposure to EMF emitted by two-way radios depend primarily upon the amount of time spent using the radios, location of the worker relative to the antenna, and operating power level of the radio. While measurements made in this evaluation do indicate that exposure to radio antennas can occur to TV personnel, there is some question as to whether or not these levels are above accepted exposure levels. Routine two-way land-mobile communications should involve transmission times of only a few seconds at a time.[9] Another important factor is the power levels used by the radio. This evaluation found that the levels were increasing as the news coverage area expanded. In addition, when several two-way radios are used simultaneously at the same site, as might occur with a news story involving disasters or major crimes, the potential for exceeding occupational exposure levels increases.

The location of the antenna on the vehicle is still another important parameter affecting occupational exposure. If the radio antenna is located on the center of the rear trunk (typical for high wattage radio units) there exists a possibility for exposure to rear seat riders from transmission through the rear window. NIOSH investigators believe that the use of a metallic screen mounted in the rear window may reduce transmission of RF energy through the rear window. If, however, the antenna is roof-mounted then exposure to riders in the vehicle should be low. The exception to this is when the radio is used when standing outside the vehicle and talking on the outstretched radio mike. In that scenario, and with high power units, exposure potential to the head increases. These findings were recently supported in a study by the EPA.[10]

Data obtained in this evaluation generally supports that under conditions of normal use (which includes portions of intermittent use [duty factor]) and appropriate power levels, the use of two-way radios can be considered safe for workers. However, some mobile transmitters can be operated at high intensity power levels (100 watt output power) for which prolonged exposure near the antenna could exceed the IEEE guideline values.

While some general measurements were made on two-way radios at the three facilities evaluated, the NIOSH investigators did not believe it was necessary to conduct extensive measurements since this had already been performed by other investigators. The measurements that were performed generally supported the range of results found in these other reports.[11,12] These other measurements indicate, as this evaluation also showed, that EMF levels both inside and outside of vehicles can vary as a function of power levels, location of antennas, make and model of vehicle, operational frequency, time of use, and nature of work. In addition, it was found that as frequency is increased the EMF levels tended to decrease.

The following presents a number of approaches that two-way radio users might use to reduce their exposure potential:

a. Transmission using hand-held radios should be kept as short as possible. Workers should try to maximize the distance hand-held radios are held from their head.

b. Use lowest power setting necessary to carry out communication.

c. EMF measurements should be made on various two-way radios on a regular basis to insure compliance with appropriate FCC regulations.

d. Workers need to be educated about not standing close to any transmitting antenna while it is active.

e. Operators and users of two-way radios should adhere to the safety precautions recommended by manufacturers of such systems.

5. *Minimacs*

Based on the measurements made in this evaluation it is strongly recommended that the policy of holding these devices in hands or laps be immediately discontinued and other holding or mounting techniques be used. Facilities need to acquire a microwave radiation detector that can monitor the output of these devices to ensure compliance with appropriate occupational exposure guideline levels.

6. *Other Sources*

Measurements made in both SNG and ENG trucks did not indicate any exposure to workers inside the truck during broadcast periods. Exposure outside the trucks was possible when workers were on top of the trucks performing various tasks while the antenna is active. Workers indicated to the NIOSH investigators that access to the transmission area of the antenna was sometimes not secured. While workers are aware of this situation and are not exposed in this manner, it was reported by workers that children were observed climbing on the SNG trucks, particularly when used outside major sporting events. In addition to safety hazards (falls) these children could potentially be exposed to microwave radiation. The development of SOPs, as suggested earlier, should also address such issues.

B. Ergonomic Hazards

The following potential ergonomic problems were noted during the evaluation: a) the lack of glare screens for high reflectance situations seen in the news room; b) the presence of small mirrors next to video display terminals, which can create glare problems; c) lack of adjustable chairs and workstations in some edit rooms; d) fixed-height work stations that do not accommodate workers of different sizes; e) poor equipment layout in many rooms, requiring awkward reaches for many job duties; f) the lack of foot rests for use by short workers; g) the lack of wrist supports for keyboards; and, h) seat height of edit room chairs that did not permit users to move freely around work tables without hitting their knees on an under-table mounted TV set holders. NIOSH recently evaluated some of these problems found at another TV station.[13]

Other authors have reported disorders of the shoulders that may be relevant to what minicam operators reported to us. Feldman reported weakness and pain in letter carriers, who carry their load directly on the shoulder.[14] Working at the shoulder level has been associated with increased reporting of rotator cuff tendinitis, with a calculated odds ratio from pooled study data of 11.[15] Brachial plexus neuritis (neurovascular compression syndrome) involves compression of the brachial plexus and is characterized by numbness in the fingers, a weak pulse in the wrist, and a "pins and needle" sensation in the hands.[16]

Several workers expressed concern about the minicam operator often being the only person dispatched to cover a story. In that situation the camera operator becomes a "one-man band" and has to address all situations that can arise. Workers believe this type of increased work demand may result in increased job injuries. For example, these operators may have to walk backwards during filming and, if alone, would be unaware of any hazards that might exist behind them, such as icy pavements or a curb.

C. EMF Health effects

Health effects from the different parts of the electro-magnetic spectrum are different and will be discussed separately. For fields in the ELF range, most of the health concerns have centered around the development of cancer. In the VLF range up to 1 MHz (but particularly up to 100 KHz with respect to the nervous system) the concern is centered around induced currents and their biologic effects;[17] above 1 MHz the concern is predominantly thermal injury. Health effects that may occur from exposure to a mixed field, as may be found at television stations, are not known and have not been studied.

Health risks from exposure to ELF fields are not clear at this time. For example, one study shows an increased risk of leukemia to children in Sweden[18] while another shows no effect to children in Finland.[19] The study of Swedish children, however, did not show an increased risk of all cancer. A NIOSH workshop on the health effects of exposure to electromagnetic fields found "uncertainty about the relationship between exposures to electromagnetic fields and health outcomes."[20] Occupational studies are similarly conflicting. Some studies report an elevated risk of some forms of cancer (particularly leukemia and brain cancer) in some, but not all, worker groups with possible exposure to high electromagnetic field levels.[21] Other studies do not report a similar elevated risk.[22]

Many of the biological effects seen from exposure to microwave radiation are a response to a rise in body or partial-body temperature.[23] Exposure to very high levels of microwave radiation can adversely affect a worker's health. Human and animal studies indicate that this type of radiation can cause harmful biological effects due to excessive heating of body tissues. MW radiation can penetrate the body and cause heating of internal tissues. The body's heat sensors are located in the skin and do not readily sense heat deep within the body. Therefore, workers may absorb large amounts of radiation without being immediately aware of the presence of such energy. There have been reports that personnel exposed to MW fields from radar equipment, MW heaters and sealers, and radio/TV towers have experienced a warming sensation some time after being exposed.[24,25]

Studies of human health effects caused by low-level microwave radiation exposure have been inconclusive. Lilienfeld et al.[26] examined cancer in employees stationed in the United States Embassy in Moscow who were exposed to microwave radiation. No increased overall or disease specific mortality was evident when compared to State Department workers at other embassies. In another study, United States Navy radar personnel were divided into high and low radar exposure groups. In the high exposure group, there were statistically non-significant elevated rates of cancers of the respiratory tract, digestive system and leukemias.[27] When the high exposure group was further divided to distinguish between those most highly exposed, a statistically significant excess of lung cancers was evident. Smoking history was not available so it was possible that the excess lung cancers were due to increased smoking in the most highly exposed group.

Thomas et al. looked at mortality rates from brain cancer among workers exposed to microwave and radio frequency radiation. They found an excess risk among men who had been employed in the design, manufacture, installation and maintenance of electronic or electrical equipment (relative risk = 2.3), but did not find an excess risk in men exposed to MW/RF radiation in other jobs.[28] They determined that these data suggested that exposure to MW/RF radiation may not, at least by itself, be responsible for the excess cancers in the studied groups. In addition, the amount of MW/RF radiation could not be quantified by the researchers; therefore actual MW/RF exposure, if any, is not known. It appears that the exposure for many of the occupations included in the study was to ELF fields, not to microwave radiation. Interest in health effects from police-operated radar equipment has increased due to reports (usually in the popular and trade press) of cancer, most notably testicular and brain cancer occurring in police officers who had previously used the units.[29] A cluster of testicular cancer has been reported among radar-using police officers in one police department.[30]

Although the IEEE standard for occupational exposure to MW/RF is based mainly on thermal effects, the standard acknowledges the possibility of non-thermal effects of exposure to microwave radiation. The IEEE chose not to incorporate this data in its determination of an exposure guideline and offered the reason that "the biological significance of non-thermal interactions has not yet resulted in any meaningful basis for alteration of the standard."

D. Electromagnetic Interference (EMI)

Various electronic devices can be susceptible to electromagnetic interference if they are not designed to be protected against it. Common sources of EMI include cellular phones, mobile communications equipment such as two-way radios, radio and TV transmitters, amateur and CB radio transmitters. In recent years, the FDA has issued a number of alerts regarding EMI with wheelchairs, medical breathing monitors, pacemakers, gas monitors, and electrosurgical knives. Recently, the Netherlands healthcare inspectorate banned the use of mobile telephones in hospitals and nursing homes in order to minimize the potential for EMI problems.[31]

As the power levels of two-way radios increase in the broadcast news business, one can conceive an emergency situation where the fire department hazardous materials response teams radios are interfering with the police portable radios that are blocking reception of paramedic electrocardiogram radio monitors, which in turn are interfering with the TV broadcast vehicles containing two-way radios. Workers need to be reminded that EMI not only can degrade overall performance of communication systems, but can represent environmental and occupational safety concerns.

E. NIOSH and the IEEE Standard

In 1993, the Federal Communication Commission (FCC) proposed to update and modify its RF regulation by adopting new guidelines for evaluating occupational and environmental effects of RF radiation. These new guidelines had just been developed by the IEEE and were known as IEEE C95.1-1991 and covered the frequency range from 3 kHz to 300 GHz. At the request of the FCC, NIOSH was asked to submit formal comments to the FCC addressing its opinion as to the merits of that proposal. The NIOSH investigators believe the formal comments of NIOSH about this standard has applicability to the evaluation, and therefore, a copy of the comments are included as Appendix A in this report.

VIII. CONCLUSIONS

In performing this evaluation data was obtained at three typical modern mid-western television stations which included interviews with more than 40 workers, observations of workers as they performed their various duties, hundreds of occupational EMF measurements taken on a multitude of various EMF emitting devices that produce EMF at different frequencies, and discussions with various union and management groups.

NIOSH investigators identified areas with potentially excessive exposure to ELF, VLF, RF or microwave (radar) radiation. Workers at these sites are potentially exposed to all of these fields either individually or, possibly, at the same time. High levels of EMF were found with use of the tape degaussers, hand-held microwaves, and two-way (car mounted) radios.

Health effects, including the development of cancer from EMF exposure, are unclear at this time, and no definitive conclusions can be drawn between EMF exposure and cancer in this group of workers. The number and types of identified cancers do not appear to be unusual for the number of workers involved in ENG in Chicago. The small number of cases of any one particular cancer type makes it difficult to determine if they have a common cause. Musculoskeletal problems that employees felt was related to the weight of the camera and associated equipment appears to be prevalent among minicam operators.

IX. RECOMMENDATIONS

Based upon the information obtained in this evaluation, we conclude that there is a need for both management and unions at the various TV stations in the Chicago area to revise and strengthen basic safety and health practices and reduce exposures to EMF. Recommendations to achieve that end include:

A. The degaussing machine should be relocated to an area where fewer people would be exposed to its emissions. If possible, a method to mechanically load tapes into the machine without having an operator stand next to it should be developed.

B. An interlock should be installed to prevent the microwave transmitter on the trucks from transmitting until the antenna is in the proper position. Lights should be installed both on the antenna and the outside of the truck to indicate when the unit is transmitting.

C. Exposure of employees to EMF resulting from the use of the high power radio transmitter found in the automobiles should be addressed. Suggestions include: 1) relocating the antenna to the roof, 2) lowering the output power, 3) increasing shielding, and 4) using alternative methods of communication, such as cellular phones.

D. Cellular telephone antennas mounted on the rear window should be relocated from the window to another outside placement to minimize exposure to electromagnetic radiation in the rear seat. Measurements should be made to insure roof-mounted systems do not emit RF radiation into the vehicle.

E. Portable microwave transmitters should not be hand-held and should not be used where the opportunity exists to irradiate other personnel, such as helicopter pilots. Although NIOSH investigators did not examine the use of microwave transmitters in helicopters, it would be prudent to locate transmitting antennas on helicopters outside of passenger areas, with the antennas oriented in a way that would preclude unintentional exposure to the occupants of the helicopter.

F. To prevent accidentally exposing other employees, or other people surrounding the transmission trucks, to microwave radiation, transmission truck operators should raise the masts for the microwave antennas above surrounding trucks before transmitting.

G. Management and unions should jointly develop, written standard operating procedures (SOPs) that cover the proper and safe operation of all communication and transmission equipment. A formalized training program, using those SOPs, should be developed for operators of communication and transmission equipment.

H. Television stations should work with minicam manufacturers to develop engineering controls to reduce load-bearing shoulder weight associated with minicams. A lighter camera is one possibility. Alternatively, the minicam could be mounted on a quick-release tripod or a light weight waist-supported platform could be developed.

I. Management at TV stations should consider purchasing appropriate microwave and radio frequency radiation monitoring equipment to assist in measuring EMF exposures associated with various sources, especially during maintenance/repair operations.

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4. IBEW-Chicago
5. NABET-Chicago

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1
RF AND MICROWAVE IEEE OCCUPATIONAL EXPOSURE GUIDELINES
HETA 93-0424-
Chicago Television Stations

frequency range (MHz)	electric field strength $(V/m)^2$	magnetic field strength $(A/m)^2$	power density E-field/H-field (mW/cm^2)
	377,000	26,600	
0.1-3	377,000	$(16.3/f)^2$	
3-30	$(1842/f)^2$	$(16.3/f)^2$	
30-100	3770	$(16.3/f)^2$	
100-300	3770	0.027	1.0
300-3000			f/300
3000-15,000			10
15,000-300,000			10

f = frequency in MHz
MHz = MegaHertz
V/m = Volts per meter
A/m = Amps per meter
mW/cm^2 = milliWatts per square centimeter

TABLE 2
EMF MEASUREMENTS MADE AT EYEPIECE ON VARIOUS TV STUDIO AND MINICAMERAS
HETA 93-0424-
Chicago Television Stations

Camera Make	Number Measured	Maximum ELF Field Electric (V/m)	Maximum ELF Field Magnetic (mG)	Maximum VLF Field Electric (V/m)	Maximum VLF Field Magnetic (mG)
Hyper Had	1	19.1	17.0	0.3	< 1
Ikegami HK322	9	8.5	24.0	9.3	1.2
Ikegami HK323	2	4.1	24.0	4.2	2
Ikegami HL790	2	3.2	17.0	0.4	< 1
Ikegami HL55	1	4.7	11.2	14.7	< 1
NEC SP3A	1	35.0	12.5	10.7	< 1
Panasonic AQ20	2	4.5	8.1	4.8	< 1
Sony Betacam BBW300	2	3.5	19.0	0.4	< 1
Sony Betacam SP	2	1.9	19.0	0.2	< 1
Sony BVP3	1	3.3	7.2	2.7	< 1
Sony BVP5	3	3.3	17.2	0.4	< 1
Sony BVP7	2	3.3	14.0	0.4	< 1
Sony BVV5	1	3.4	16.0	0.4	1
	29	1.9-19.1	7.2-24	0.2-14.7	<1-2

mG = milliGauss
V/m = Volts per meter

TABLE 3
PERSONAL MAGNETIC FIELD LEVELS (milliGauss) MEASURED AT TV STATIONS
WITH EMDEX METERS (all at 1.5 seconds)
HETA 93-0424-
Chicago Television Stations

Worker Identification	Minimum	Maximum	Mean	Std Dev.	Median	Geo Mean	Std Dev.
A	0.2	1370	21.96	99.09	1.3	1.75	4.74
B	0.1	96.9	3.00	7.48	1.3	1.36	2.83
C	0.2	114.1	2.40	7.07	1.0	1.15	2.57
D	0.1	433	5.10	17.99	1.3	1.45	3.54
E	2.8	30.1	12.17	3.37	12.9	11.59	1.40
F	0.1	2407	39.3	206.81	1.1	1.59	4.65
G	0.3	3306	38.6	251.98	1.1	1.44	3.89
H	0.3	743	4.2	19.84	1.3	1.30	2.96
I	0.3	481	6.2	32.46	1.1	1.37	3.16

TABLE 4
MAXIMUM MAGNETIC FIELD LEVELS AS A FUNCTION OF DISTANCE FROM VARIOUS DEGAUSSER UNITS USING AN EMDEX METER
HETA 93-0424-
Chicago Television Stations

Degausser Type	Maximum Magnetic Field Level in Gauss (G) at various distances			
	Contact	1 foot	2 foot	3 foot
Data Security MP-14, T	-	1.1	-	
Data Security MP-14, T	5.6	3.3	0.75	-
Garner 270, T	5.6	1.5	-	0.64
Garner 4000, T	1.2	2.5	-	0.07
Unknown, HH	5.6	0.16	0.03	-
Han-D-Mag, HH	5.6	0.44	0.07	-
ITC ESL-IV, T	5.0	-	-	-
Lauderdale, T	5.0	-	-	-
Unknown, T	5.6	0.2	0.23	0.11

T = Table-mounted
HH = Hand-held

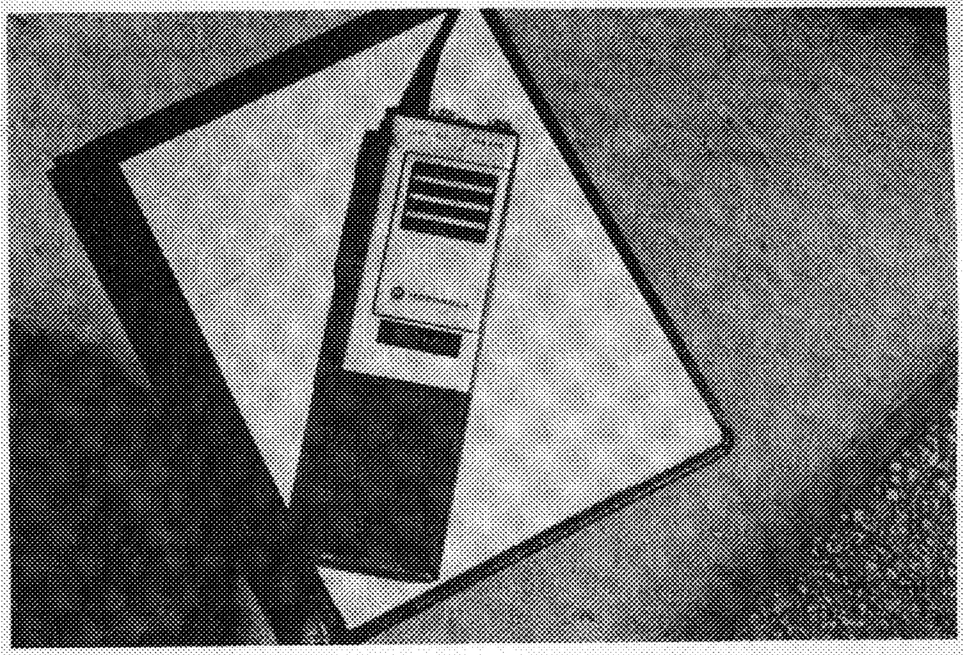

Figure 1. Typical portable (hand-held) two-way radio used for communication at television stations. The radio operates at 5 watts with a frequency of 455 MHz.

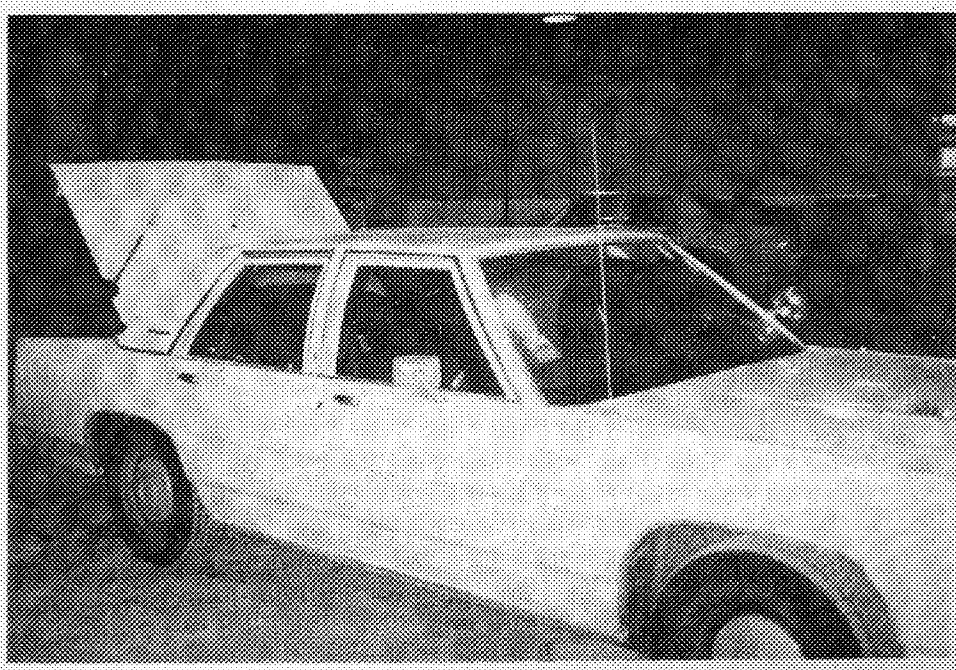

Figure 2. Vehicle with two antennas on trunk. Notice relationship of antenna to rear window when the trunk is opened.

(a)

(b)

Figure 3. Typical ENG truck with its 2 GHz antenna in (a) travel mode and (b) full extension mode.

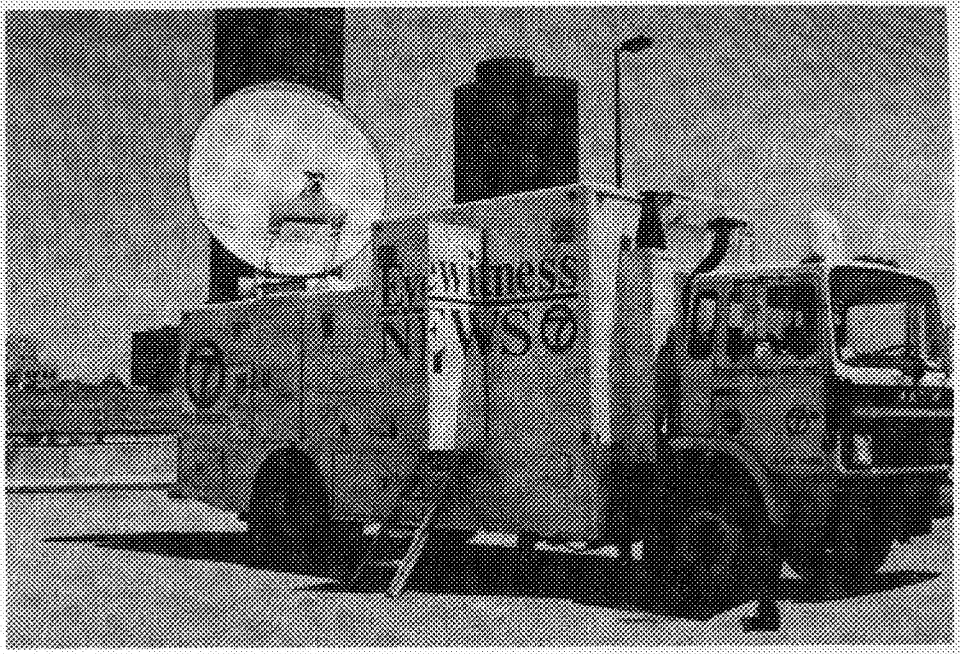

Figure 4. Typical SNG truck with its 300 watt/channel antenna that transmits at 14 GHz.

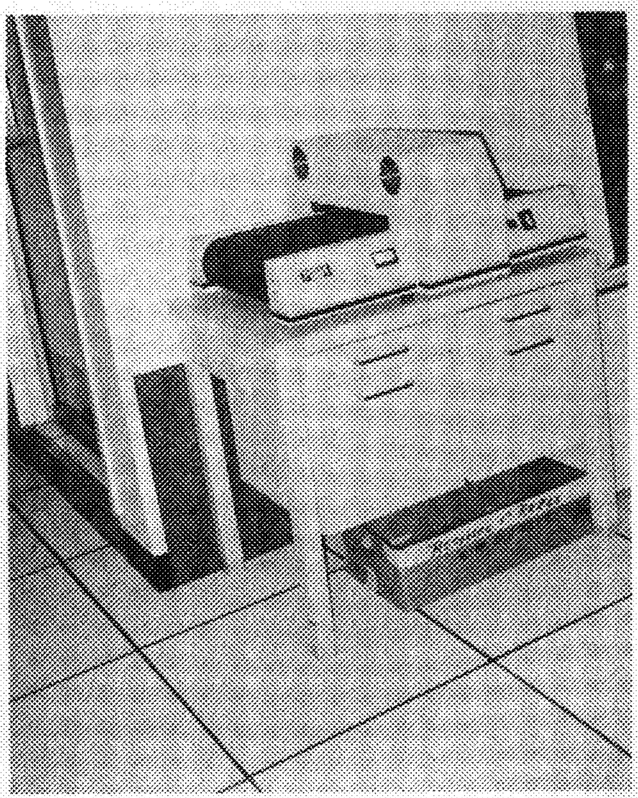

Figure 5. Typical table-mounted degausser used at television stations.

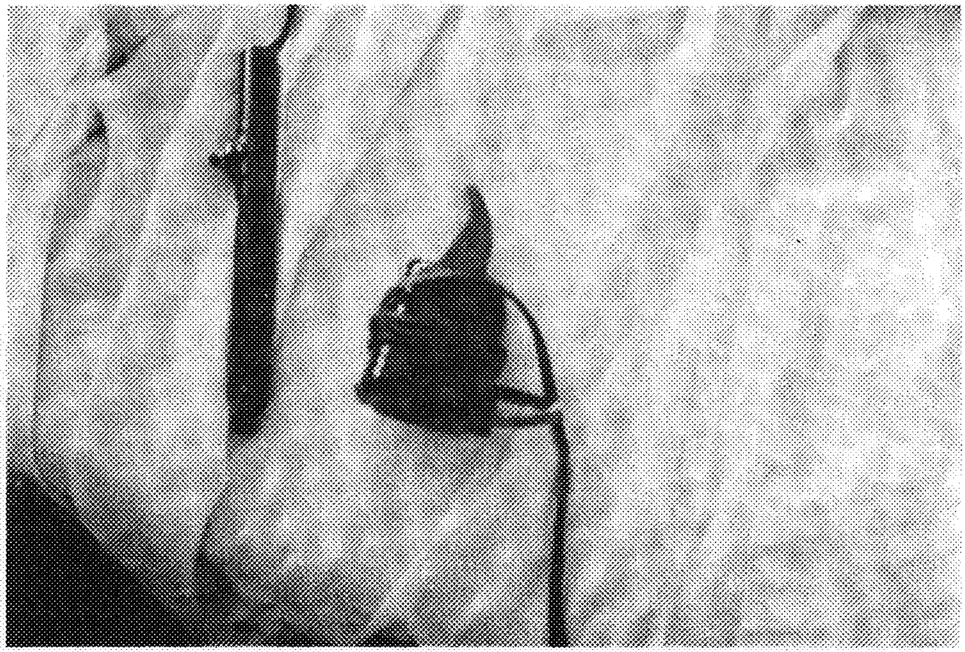

Figure 6. Two typical hand-held degaussers used at television broadcasting stations.

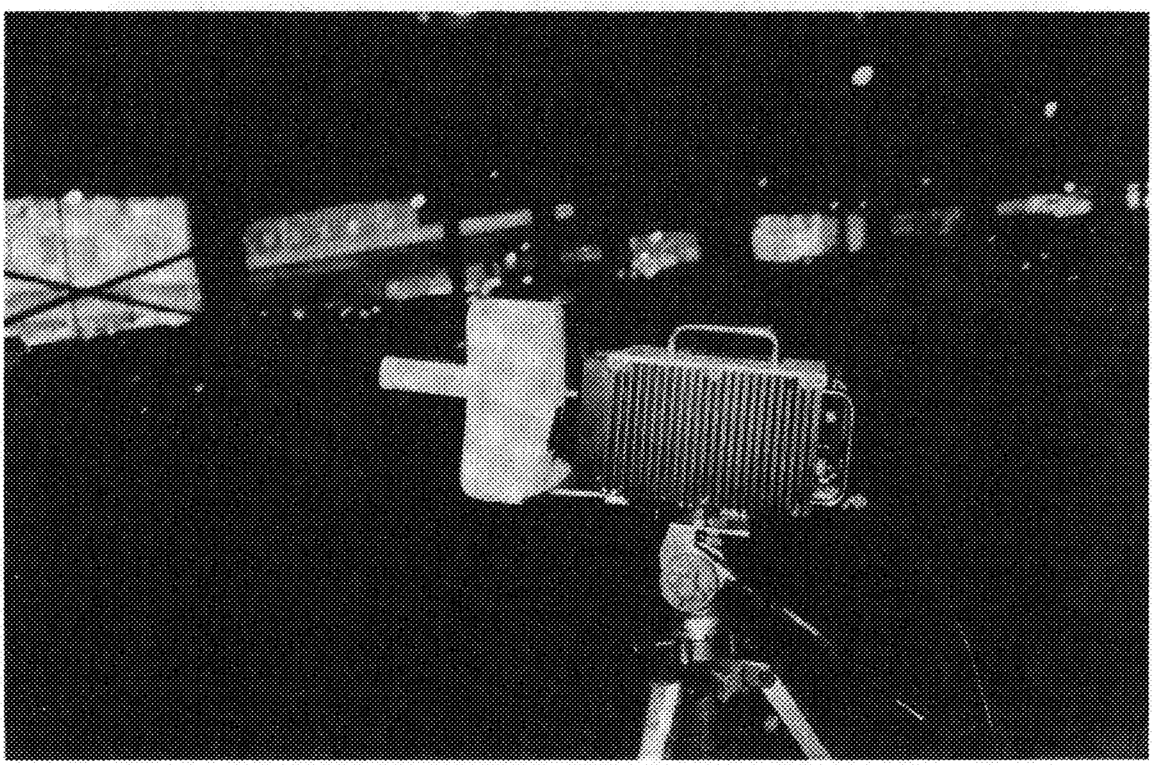

Figure 7. A 3 watt portable microwave transmitter (minimac) operating at 7 Ghz.

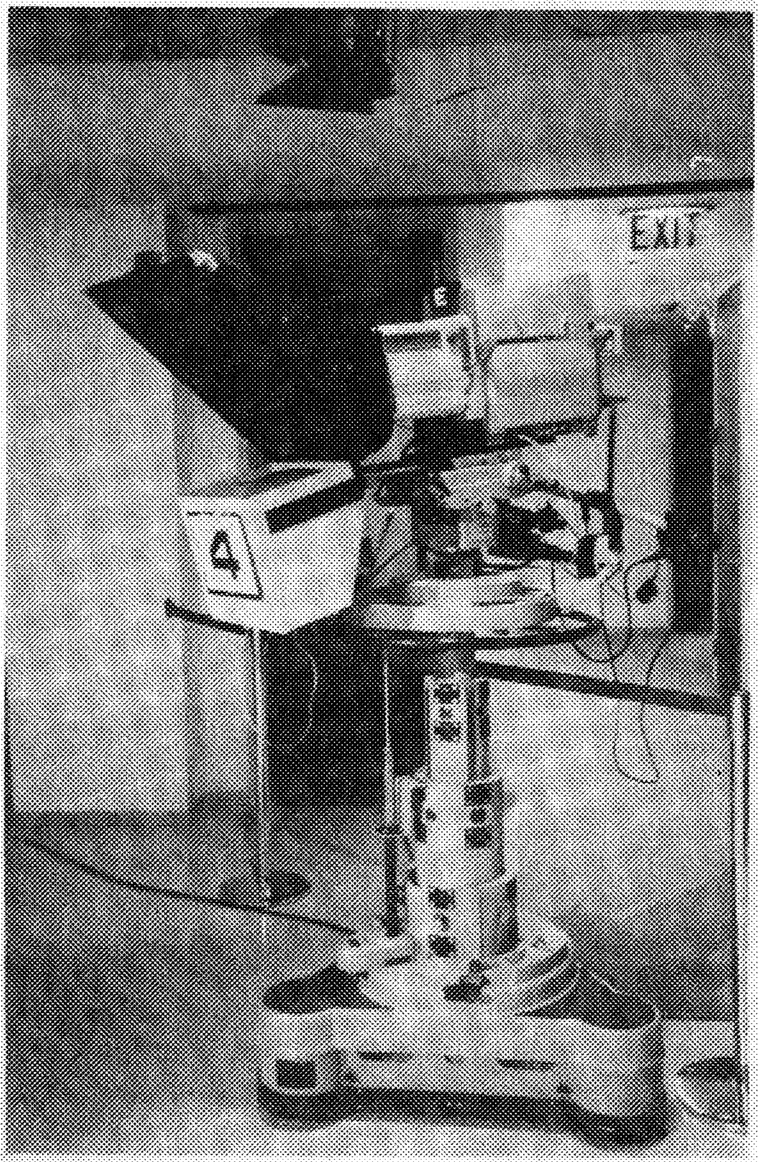

Figure 8. Typical studio camera on rollers.

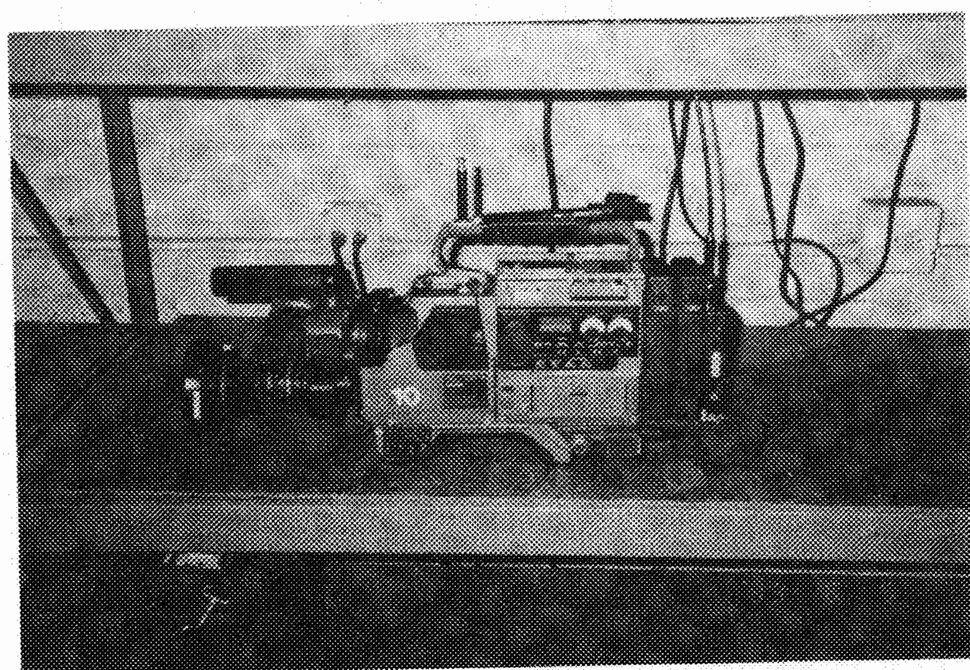

Figure 9. Typical minicam.

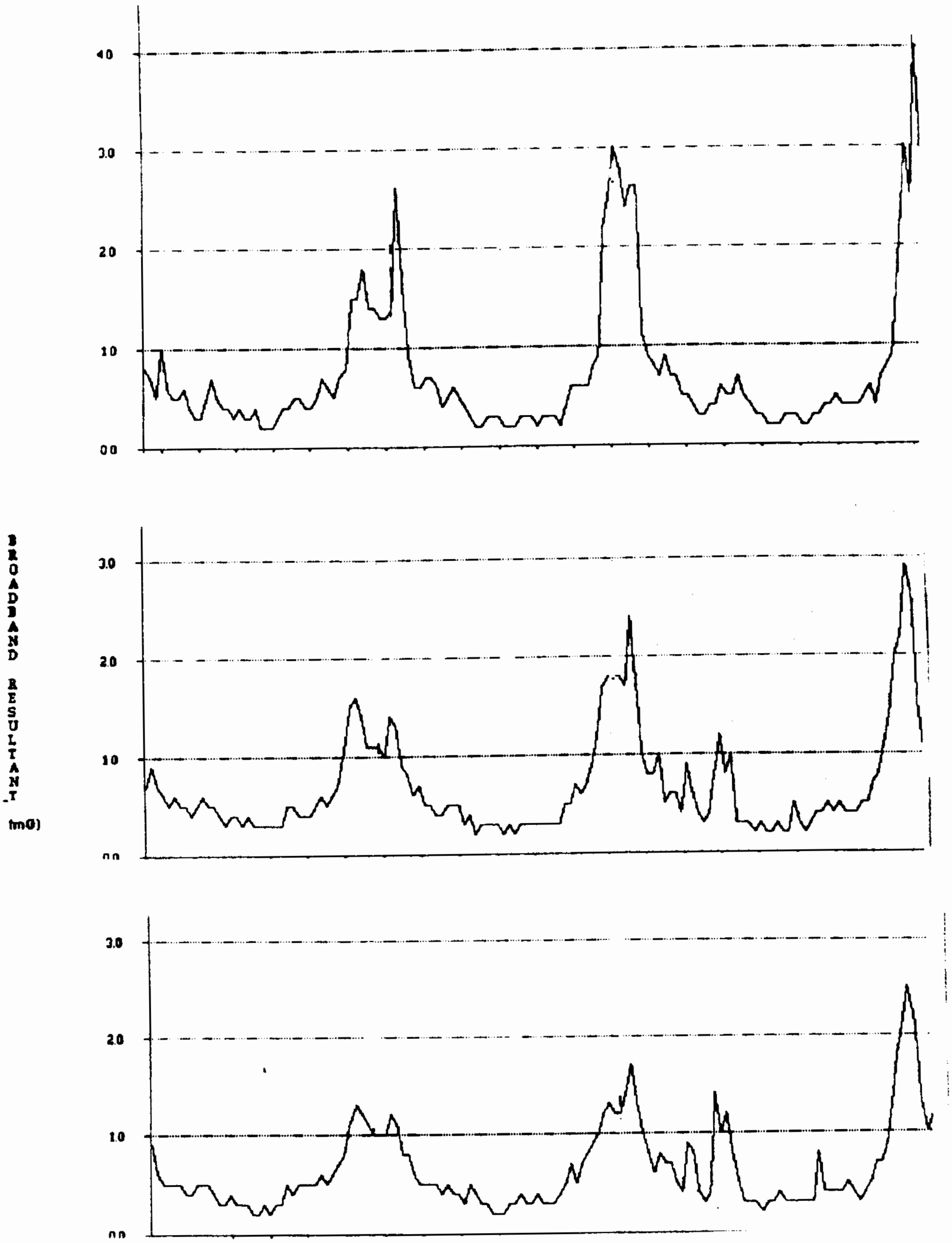

Figure 10. Emdex measurements made in television studio "x" on March 9, 1993, at three different distances from the floor. Measurements were made at the same time.

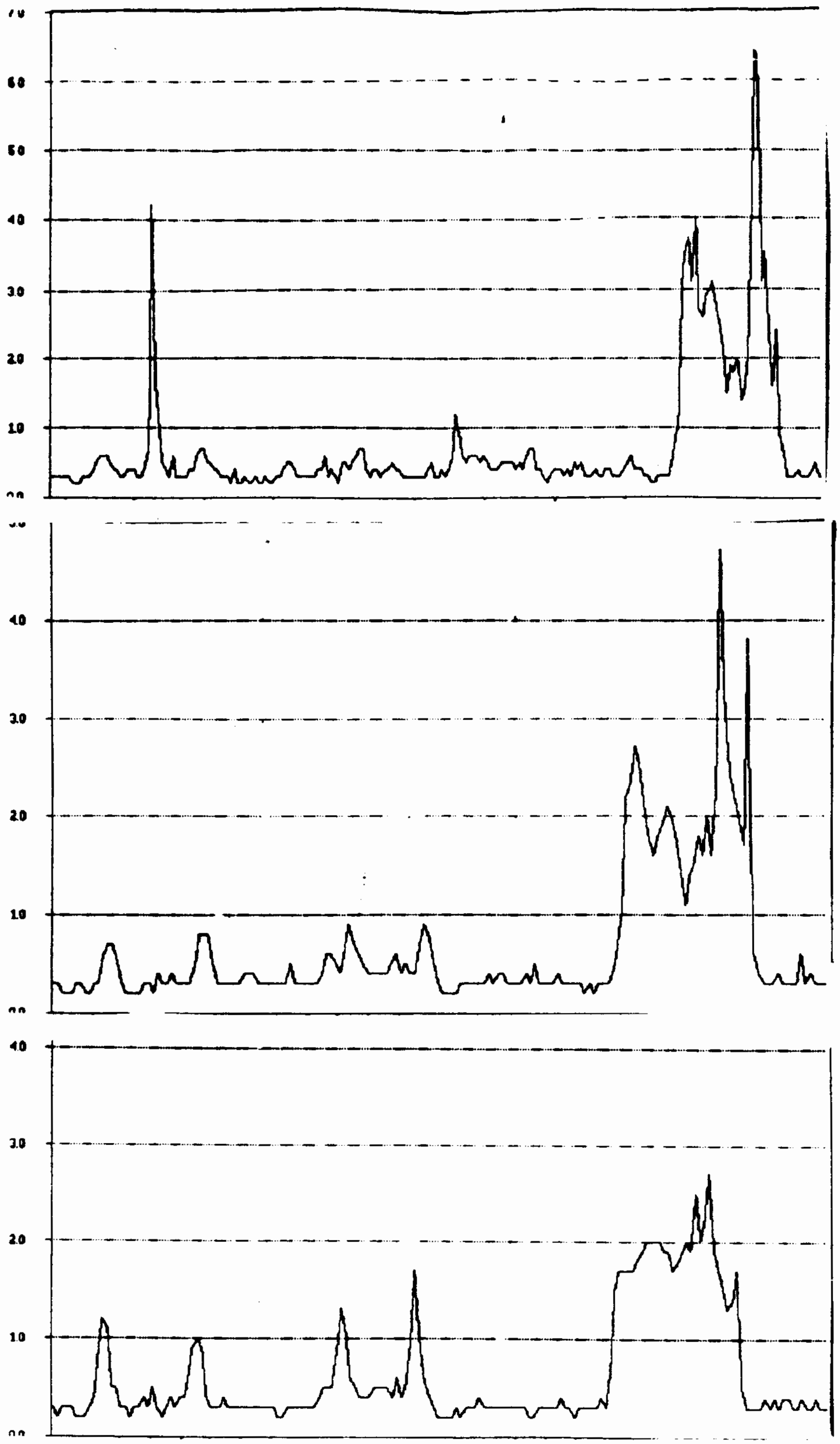

Figure 11. Emdex measurements made in television studio "y" on March 9, 1993, at three different distances from the floor. Measurements were made at the same time.

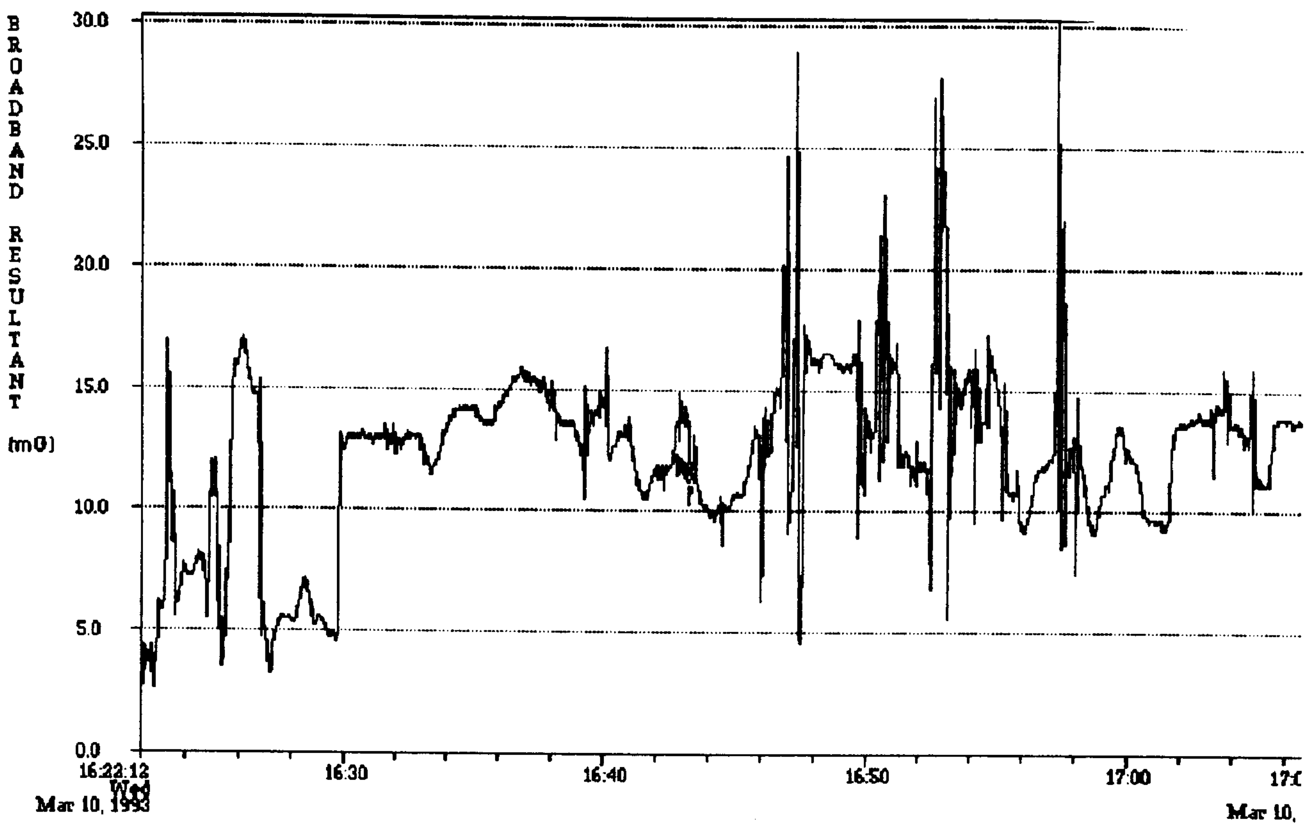

Figure 12. Emdex time-intensity plot for worker performing activities in control room.

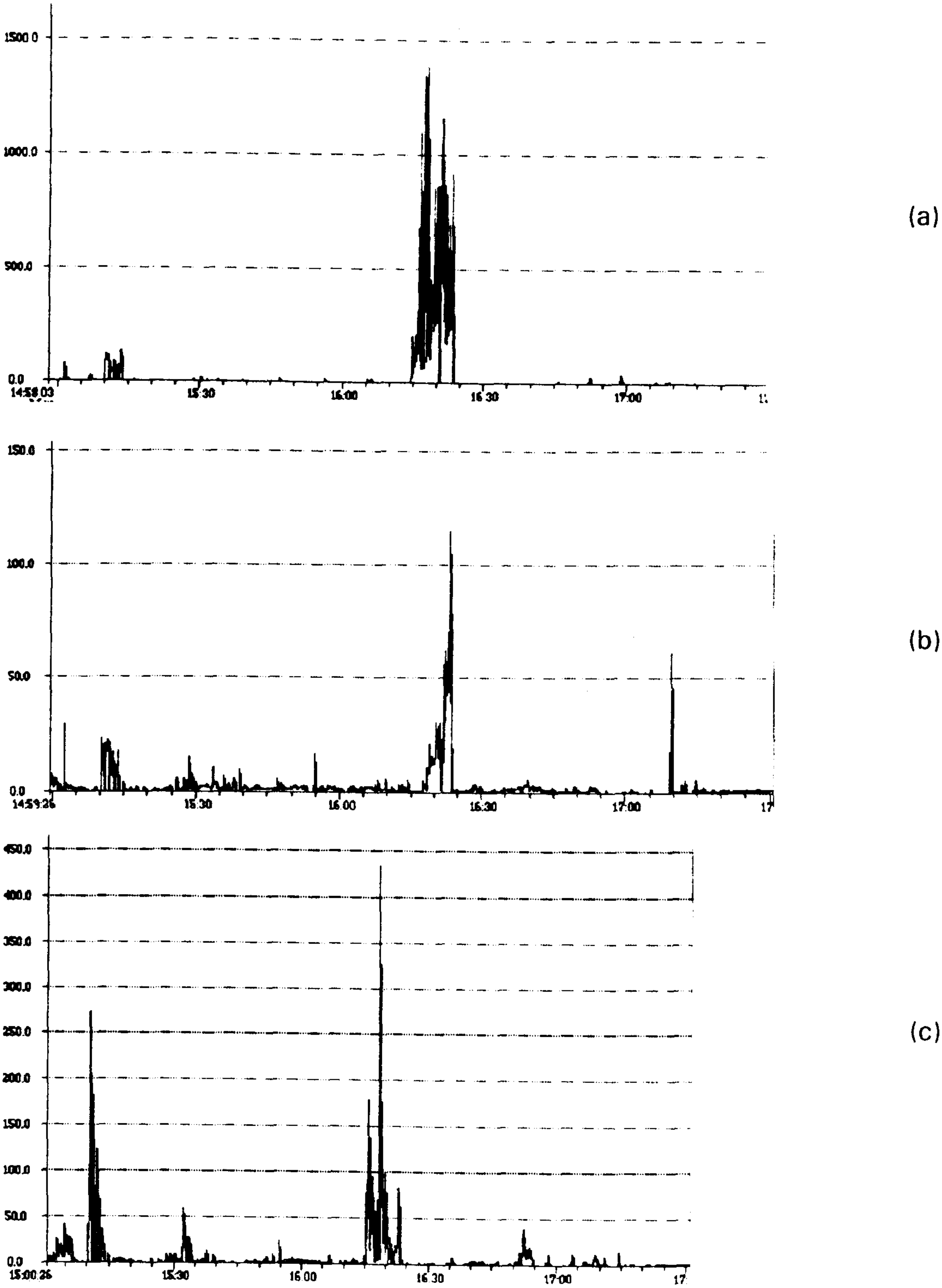

Figure 13. Magnetic field measurements from the same degausser unit as a function of the distance from the unit: (a) contact with unit; (b) 3 feet away; (c) 5 feet away.

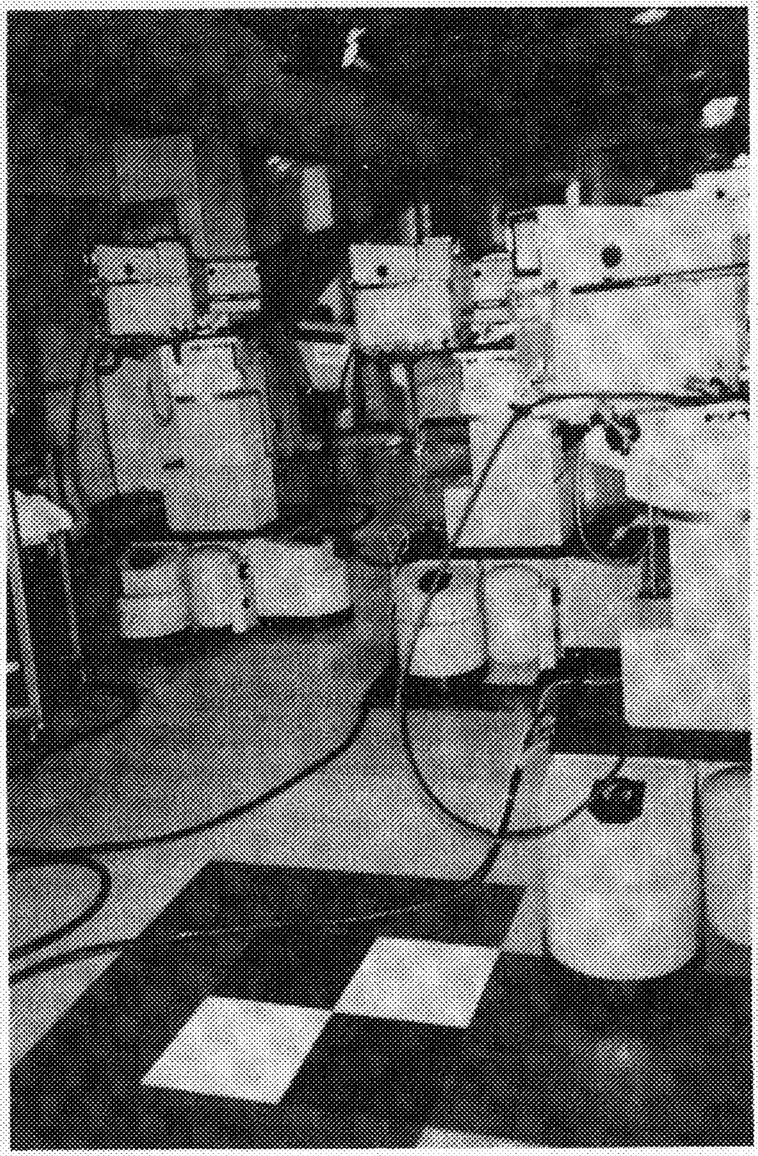

Figure 14. Robotic cameras.

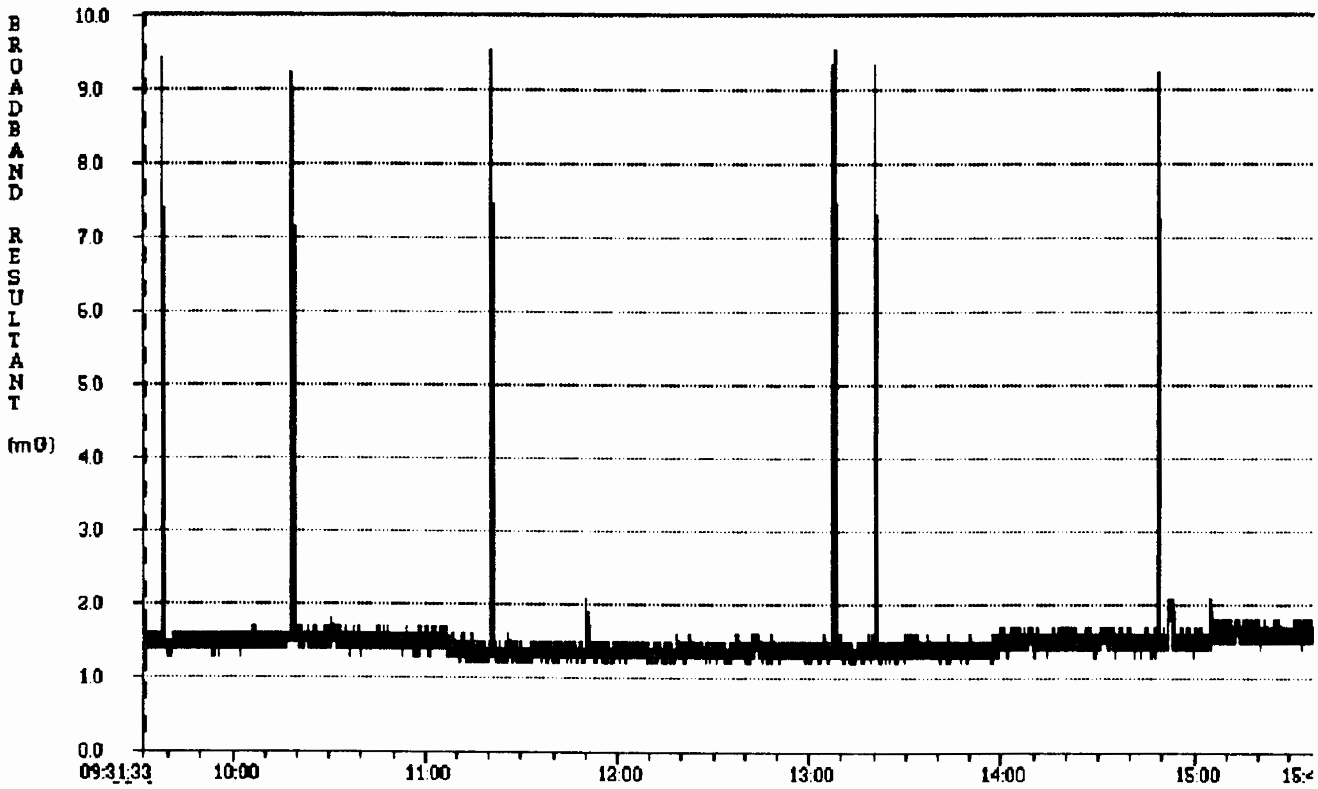

Figure 15. Use of Emdex time-intensity graph to determine degausser on-time use factor for a six-hour time period. The six major peaks represent degausser on-time.

Figure 16. Studio control room. Note the large number of television sets in the room.

Appendix A

NIOSH

Comments to FCC

COMMENTS OF THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH ON THE FEDERAL COMMUNICATIONS COMMISSION PROPOSED RULE ON RADIOFREQUENCY RADIATION EXPOSURE GUIDELINES

47 CFR Part 1
ET Docket No. 93-62

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

1/11/94

The National Institute for Occupational Safety and Health (NIOSH) supports the Federal Communications Commission (FCC) in its effort to update the guidelines for evaluating the occupational and environmental effects of radiofrequency (RF) radiation.

The FCC proposes to modify its RF regulations by adopting new guidelines that have been developed by the Institute of Electrical and Electronic Engineers (IEEE) and published by the American National Standards Institute (ANSI). These guidelines have been designated IEEE C95.1-1991 by IEEE and ANSI/IEEE C95.1-1992 by ANSI. The frequency range covered by the FCC guidelines is from 3 kHz to 300 GHz.

While the maximum permissible exposure levels defined by ANSI/IEEE C95.1-1992 are similar to those defined by other related publications [NCRP 1986; WHO 1993], NIOSH is concerned about the lack of participation by experts with a public health perspective in the IEEE RF standards setting process. For example, epidemiology studies were categorically rejected as not useful in the process of setting the ANSI/IEEE C95.1-1992 limits. This lack of public health perspective creates a weakness in the ANSI/IEEE C95.1-1992 standard that should be acknowledged by the FCC in adopting these guidelines for regulating occupational and environmental exposures to RF radiation.

GENERAL COMMENTS

The provision of a two-tier standard based on "controlled" versus "uncontrolled" environments is problematic. The designation of controlled versus uncontrolled depends, in part, on the worker's knowledge of both the exposure level and the related health effects. It is extremely difficult to assess the level of a worker's "knowledge" and it is especially so when the standard does not provide any guidance on training programs or worker notification procedures. Therefore, the conservative public health approach would be to adopt only the more restrictive "uncontrolled environment" limits for all exposed workers and the general public.

The exposure levels that would be set by the standard are based on only one dominant mechanism -- adverse health effects caused by body heating. Nonthermal biological health effects have been reported in some studies and research continues in this area [NCRP 1986; WHO 1993]. The standard should note that other health effects may be associated with RF exposure and that exposure should be minimized to the extent possible.

In general, the standard provides minimal guidance on control measures, appropriate medical surveillance, training, or hazard communication.

SPECIFIC COMMENTS

Specific comments on various sections of the proposed standard to improve worker protection are as follows. The item number and the page number refer to the FCC notice of proposed rulemaking.

Page 6, Item 12

Regarding the definition of uncontrolled environment, which states that "there are no expectations that the exposure levels may exceed...", these "expectations" need to be based on some measurements or calculations of anticipated personal exposures. They should not be defined merely by presumption or past history, in view of the more restrictive guidelines (proposed) to be used from the ANSI/IEEE C95.1-1992.

Page 6, Item 13

The more "conservative approach" (i.e., one set of exposure limits) is appropriate, particularly with respect to general public exposure. Thus, if there is any question about exposure category (controlled versus uncontrolled), the uncontrolled criteria should be applied.

Page 8, Item 17

NIOSH agrees with the overall approach to hand-held portable devices. However, NIOSH questions whether it is possible or practical to ensure that "the radiating structure," which can include not only the whip antenna but in some cases the body of the cellular phone, is not within 2.5 cm of the body (e.g., head). If this spacing cannot be assured, exclusions based on radiated power should not be used. Thus, all cellular phones, with a "radiating structure" in the handset should require specific absorption rate (SAR) determinations to demonstrate compliance with the exclusion guidelines. Proof of such determinations should be submitted as part of the equipment authorization process.

Page 9, Item 20

The current categorical exclusions (i.e., for cellular phones and two-way radios) are not consistent with provisions of the ANSI/IEEE C95.1-1992 guidelines, and should not be carried over without new justification. The current FCC exclusions are based on the 1982 ANSI guidelines, and the FCC acknowledges that the 1992 ANSI/IEEE guidelines are more restrictive.

Page 10, Item 21

Categorical exclusions should be limited to situations where there is no possibility of excessive worker (as well as general public) exposure. However, it is not necessary to limit categorical exclusions to situations where field strengths will never be exceeded. If SAR or induced current maximum permissible exposures (MPEs) can be met (see ANSI/IEEE C95.1-1992, 4.2.1), field strengths can be exceeded. It is important to monitor the relative location of workers to the antenna/radiating structures.

If FCC intends to adopt the newer 1992 guidelines and carry over the old FCC categorical exclusions, an explanation should be provided of the basis for continuing use of the old exclusions that are no longer supported by the ANSI guidelines.

Certification of procedures, to preclude working near antennas, would be a protective approach. Careful determination of the worker's location, relative to antennas or metallic structures with RF current flow, is essential before meaningful SAR or current determinations can be made.

Evaluating exposure of workers within a few feet of a transmitting antenna must include determinations of SAR as well as induced and contact current in the body. Workers in these situations are receiving coupled exposures that cannot be evaluated using field strength measurements alone. It is critical to carefully determine where the workers are located, relative to the RF antenna or other metallic structure with current flow. The SAR and induced current determinations are explained in the ANSI/IEEE C95.1-1992 guidelines (see pages 13-14, 18-19 of these guidelines).

Page 10, Item 22

Induced body current could be measured for stations operating at and below 100 MHz. A frequency-tunable field intensity meter (e.g., Potomac® FIM-71) could be used to measure the induced current at and below 100 MHz. On the other hand, equipment and research are only available for the measurement of contact current up to 30 MHz. Stuchly et al. [1991] specified circuitry for a human equivalent impedance operable only up to 30 MHz and the Narda 8870 contact current meter only operates up to 30 MHz. A human equivalent impedance for 30 to 100 MHz should be developed, along with a practical contact current meter for 30 to 100 MHz. When developed, the frequency-tunable field strength meter could be used to determine the contact current flowing through this human equivalent impedance.

Regarding the split of the FM frequency band, induced current measurements should be required for up to 108 MHz, even though these frequencies are not included in the ANSI/IEEE C95.1-1992 guidelines. These frequencies could be measured with the same technology used at 100 MHz, if the instruments were properly calibrated.

Page 11, Item 24

The FCC has proposed using the more conservative approach (guidelines for "uncontrolled environment") when an area of uncertain definition exists. NIOSH agrees with this approach. If such a rationale were followed in this case, the lower limits of NCRP (see section 17.4 of NCRP [1986]) or WHO [1993] would be more conservative at the frequency ranges where such differences exist. However, these differences are not as important for the FCC-licensed sources of RF radiation as the inclusion of the induced current restrictions, which are not found in the NCRP guidelines.

Page 12, Item 25

The NCRP guidance states "If the carrier frequency is modulated at a depth of 50 percent or greater at frequencies between 3 and 100 Hz, the exposure criteria for the general population shall also apply to occupational exposures." There are data from in vitro and in vivo research noting effects under these conditions although the implications for risk to human health are not clear. It has been shown that modulation of this type (extremely low frequency, or ELF modulation) exists on amateur radio, microwave ovens, AM and FM radio, television, air traffic control radars, and LORAN. Further, RF sources have power supplies that are fed by 60 Hz power mains. The amount of ELF amplitude modulation (ripple) on the RF carrier depends on the quality or completeness of filtering on the power supplies. Thus, it follows that many, if not most signals from RF sources will have measurable ELF amplitude modulation. Before making ELF amplitude modulation restrictions, it may be useful to determine the depth or amount of ELF amplitude modulation in other common RF sources and the ease of making these measurements. The cost and reliability of such measurements is not clear.

Page 13, Item 27

The Commission should require more complete documentation or evidence from applicants who claim compliance with environmental RF radiation guidelines. The documentation should include laboratory data with calculations or measurements to support the claim. The data should be provided in a form suitable for scientific review, with sufficient detail to critique the method used to establish that data.

Pages 13-14, Item 28

The ANSI/IEEE C95.3-1992 guidelines for measurement procedures are appropriate for showing compliance.

Page 14, Item 29

Notes on specific types of equipment have been made elsewhere in these comments. In addition, the measurement guidelines set forth in IEEE C95.3-1991 are also relevant here. NIOSH was a participant in the development of C95.3 recommendations.

REFERENCES

NCRP [1986]. Biological effects and exposure criteria for radiofrequency electromagnetic fields. Bethesda, MD: National Council on Radiation Protection and Measurements, NCRP Report No. 86.

Stuchly MA, Kozlowski JA, Symons S, Lecuyer DW [1991]. Measurements of contact currents in radiofrequency fields. Health Physics 60(4):547-557.

WHO [1993]. Electromagnetic fields (300 Hz to 300 GHz). Geneva, Switzerland: World Health Organization, Environmental Health Criteria 137.

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