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I. SUMMARY

In June 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Saint Louis Post-Dispatch (SLPD) in St. Louis, Missouri. Originating from the Newspaper Guild, the recognized representative of the editorial staff, the request indicated concern a possible excess number of brain tumors occurring in editorial staff members within the past 15 years. The request also concerned electromagnetic fields in the editorial office, and its possible relationship to the brain cancers. On December 14 and 15, 1993, NIOSH investigators conducted a site visit to the SLPD Building during which measurements of extremely low frequency (ELF) electric and magnetic fields in the building were made.

The medical evaluation focused on brain tumor case finding and verification. NIOSH investigators obtained death certificates, and insurance and medical records for individuals identified by management and employee representatives to have brain tumors and reviewed the employment histories of the cancer patients. There were initially seven individuals reported to have brain tumors. Records revealed, however, that three of the seven did not have primary brain tumors, but had cancers from other sites which had metastasized (spread) to the brain. One individual had initially been thought to have a brain tumor, but upon autopsy was found to have had an aneurysm. Two individuals had medically confirmed primary brain cancers of the astrocytoma cell type by tissue diagnosis. These individuals had been employed at the SLPD in the editorial room for 15 to 20 years and worked in the same office area for several years. Two current workers had been diagnosed with other tumors (meningioma and pituitary adenoma), but these tumors are not related to brain cancers of the astrocytoma type.

After a walk-through survey of the building, NIOSH investigators obtained and reviewed blueprints of the complete power distribution system for the fifth floor. No obvious unusual events or activities that would indicate the presence of a health hazard to office workers on the fifth floor were identified.

Exposure to sub-radiofrequency electric and magnetic fields, in the frequency range from 30 to 800 hertz (Hz), on the 5th floor ranged from 0.1 to 77.1 milligauss (mG) for the magnetic field and 1.9 to 3.9 volts/meters (V/m) for the electric field. There was little variation in field strength among the sites measured except in the central area of the fifth floor near the information desk where electric field levels were higher than other areas. The fields measured in the SLPD are relatively low, within the range of exposure levels in office settings previously reported by NIOSH and others, and are well below the current occupational exposure criteria levels of 25,000 V/m (electric density) and 10,000 mG (magnetic flux density).

The findings of this investigation provide no basis for concluding that the cases of brain cancer among SLPD editorial office employees are related to the physical environment of the SLPD Building. Although some studies suggest that brain cancer may be related to exposure to ELF electric and magnetic fields, the body of evidence is inconclusive. Moreover, the measurements made in this evaluation indicate that exposures to ELF fields in the SLPD are typical of modern office environments.

KEYWORD: SIC 2711 (Newspapers, Printing and Publishing), cancer, brain cancer, glioblastoma, ELF, E.M. radiation.

II. INTRODUCTION

In June 1993, NIOSH received a request for a health hazard evaluation at the Saint Louis Post-Dispatch (SLPD) Building in St. Louis, Missouri. The requestor, the Newspaper Guild (official representative of the newspaper editorial staff), indicated concern among the SLPD newspaper editorial staff about the safety of their work environment on the fifth floor of the building. The editorial staff were concerned about what appeared to be an unusual number of persons with brain tumors.

On December 14 and 15, 1993, NIOSH investigators conducted a site visit to the SLPD. The objectives of this survey were to: 1) determine whether comprehensive environmental or health studies were necessary, and 2) measure extremely low frequency (ELF), electric, and magnetic fields on the fifth floor of the building.

III. BACKGROUND

The six-story SLPD building, built in the 1950s, is located in central St. Louis. The fifth floor of the building covers 32,600 square feet and is currently occupied by the editorial staff of the newspaper, numbering around 255 people in 17 bureaus. The office area is a large open room, generally in the shape of a rectangle, with desks placed in clusters according to the news bureau (e.g., city, calendar, sports, etc.) to which the editorial staff is assigned.

The editorial staff duties include collecting and analyzing facts about news events through interview, investigation, or observation. They check reference sources for additional relevant facts and assemble (write) stories using ATEX or IBM-compatible personal computer terminals with specially designed computer keyboards (in addition to the standard QWERTY-configurated alphanumeric keys, there are additional editing and function keys). Editors also use these specially configurated keyboards to edit and correct news copy, write headlines, and set type electronically. Reporters can either spend significant time in the field or use the wire services, telephones, and library facilities in the building to gather and develop their stories. Also associated with the editorial staff are artists and photographers. The artists provide art-work services such as sketching, illustration, cartooning, and preparation of maps and graphs using drafting tables and computer graphics programs. Photographers use camera equipment to provide photographic coverage at events, supply all departments with photographic services, and have limited keying tasks at computer keyboards.

V. EVALUATION CRITERIA

A. Sub-Radiofrequency Electric and Magnetic Fields

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.[6] The present TLV for magnetic fields (B_{TLV}) states "routine occupational exposure should not exceed:

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

where f is the frequency in hertz." One millitesla (mT) equals 10 Gauss. Conversely, the electric field TLV states "occupational exposures should not

exceed a field strength of 25 kV/m from 0 to 100 hertz (Hz). For frequencies in the range of 100 Hz to 4 kHz, the TLV is given by:

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

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

This means, for example, at 60 Hz, which is classified as extremely low frequency (ELF), the electric field intensity TLV is 25,000 volts per meter (V/m) and the magnetic flux density TLV is 1 mT or 10,000 milligauss. 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 body currents. Prevention of cancer is not a basis for either of these TLVs because exposure has not been conclusively linked to cancer.

B. Brain Cancer

Brain cancer occurrence is a relatively rare event. There are about 17,000 new primary brain cancers a year in the United States, accounting for approximately 1.2% of primary cancers. The age-adjusted annual death rate for brain cancer between 1985 and 1987 was 4.9 deaths per 100,000 males and 3.9 deaths per 100,000 females.[1] Estimated rates of brain cancer in the United States increase with increasing age up to age 75; age-adjusted rates show an increase of 28 percent between 1973 and 1987.* The causes for these increases are not fully understood, but include the following:

- Better diagnostic techniques, such as computerized axial tomography scanning (CT-scan) and magnetic resonance imaging (MRI). These make diagnosis much less difficult than in the past.
- Increased incidence of metastatic brain tumors, (spread of malignant cancer cells from other tissues) which are frequently mistaken for primary brain tumors.
- Better access to medical care, especially in some white-collar occupational groups in metropolitan areas, compared to blue-collar or rural populations.
- Other factors, such as infectious (e.g., human immunodeficiency virus [HIV]), occupational, or environmental causes, may also account for some of this increase.

1. Brain Tumors and Different Cell Types

When discussing tumors of the brain, it is important to consider the type of cell from which these tumors arise. There is good evidence that various cell types of

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Estimated rates are based on data from the Surveillance, Epidemiology and End Results Program, Division of Cancer Prevention and Control, National Cancer Institute and are made available through the Information Resources Management Office of the Centers for Disease Control.

brain tumors reveal sufficiently distinct epidemiologic patterns to be considered as separate diseases. The following summary of brain tumor cell types adapted from a recent review on brain tumors from *CA*, a Journal of the American Cancer Society[2] may be useful:

Neurons are the cells that transmit signals within the brain and throughout the spinal cord. They are the most common cells in the brain; they do not replicate. Therefore, they have little potential for neoplastic or cancerous changes that result in tumor growth.

Glial cells are the supporting cells of the brain. They provide structural and metabolic functions of the brain, including protecting the neurons and assuring their nourishment and electrochemical stability. Glial cells give rise to a variety of tumors, each capable of behaving in a benign or malignant fashion. Gliomas account for about 60 percent of primary brain tumors. The most common forms are the astrocytoma, the oligodendroglioma, and the malignant glioblastoma multiform.

The brain and spinal cord are surrounded by a series of protective coverings, the **meninges**, which are responsible for maintaining the cerebrospinal fluid pathways around the brain and the spinal cord. Tumors which arise from the meninges, called meningiomas, are common, and are almost always benign. These tumors usually put pressure on the brain which results in symptoms, or they produce a reaction (irritation or edema) in brain adjacent to the tumor. Meningiomas account for about 20 percent of adult primary brain tumors. They occur in specific areas of the brain and the majority are surgically curable. There are several case reports that meningiomas have occurred at sites of previous trauma resulting from injury or surgical procedures. However, other studies have not found this relationship.

The cranial nerves (the nerves which originate in the brain and serve the head and neck) generally require a nerve sheath. These **nerve sheaths** may also give rise to tumors, called schwannomas (they arise from the **Schwann cells** of the sheath.) They are almost always benign. Symptoms from these tumors are related to the specific nerve involved, or result from compression of the adjacent brain tissue. The most common type are the vestibular, formerly called acoustic neuroma. These tumors cause hearing loss as the earliest symptom. Schwannomas account for about two percent of adult brain tumors.

Tumors of the lymphatic system, lymphomas, account for 2 percent of tumors found in the region of the brain, but are generally not considered primary brain tumors.

The other 10 percent of brain tumors are from **primitive stem cells** or **embryonic cells** that have not followed the usual paths of cell migration during formation of the nervous system in the fetus. Examples of these types of tumors include craniopharyngiomas and dermoid or epidermoid cysts.

Tumors of the pituitary gland are usually included in the discussions of brain tumors, but they are not primary brain tumors. They are tumors of the endocrine (glandular) system. Tumors of the pituitary, because of their location, may affect the brain and the optic nerves by compressing those structures adjacent to the pituitary at the base of the brain.

2. Metastatic Cancer Spread to the Brain

As more patients with primary cancers of various kinds (e.g., lung cancer, breast cancer) are being successfully treated, more patients are living long enough for their cancers to spread from one part of the body to another; that is, they develop "metastases". Because most cancers can spread though cancer cells carried

through the blood (blood-borne metastases), it is not surprising that the brain is a frequent site of metastases. The brain receives 20 percent of the blood flow of the heart, and the arteries within the brain have a "no-outlet" pattern (called end-artery pattern) that can trap cancer cells, which then multiply and form a metastatic deposit. The brain is also protected by a very efficient filtering system, the blood brain barrier (BBB), which can filter out certain chemotherapy agents. The chemotherapy agents may be effective throughout the rest of the body (systemically) but do not penetrate the BBB; this allows time for growth of malignant cells in the brain. For example, women with breast cancer who receive adjuvant (auxiliary) chemotherapy to kill systemic micrometastases are more likely to have recurrences of their breast cancer in the brain than women who do not receive such therapy.[3]

3. Occupational Exposure and Brain Tumors

Numerous epidemiologic studies have shown a relationship between brain cancer and exposure to chemicals in specific industries. These industries include the rubber industry, oil refineries, and various chemical industries such as polyvinyl chloride production, which share common exposures to organic solvents, lubricating oil, acrylonitrile, vinyl chloride, formaldehyde, polycyclic aromatic hydrocarbons, and phenolic compounds.[4] Other industries and occupations found to have elevated risks include agricultural crop production, printing and publishing, and many professional occupations such as engineers, lawyers and judges, and banking/finance managers.[3,5]

Attention also has been focused on reports of elevated brain cancer risk among workers in various electrical occupations that suggest a link between brain cancer and exposure to electromagnetic fields (EMF). In a January 1991 workshop sponsored by NIOSH, the epidemiologic information on the health effects of electric and magnetic fields on workers was reviewed.[6] For brain cancer, two types of studies provide important evidence. Among the case-control studies reviewed, most show elevated risks for electrical-related occupations, but assess exposure only indirectly. Among the cohort studies of electrical workers, risks are elevated, but many are not statistically significant despite large sample sizes and long observation periods. Other reviewers have noted further limitations to previous investigations, including the possibility that the observed effects may be due to other exposures present in the industries and occupations that have been studied or that non-occupational risk factors for brain cancer were not adequately considered.[7] Currently, the general consensus is that the evidence for a carcinogenic effect of exposure to EMF is suggestive for brain cancer but not conclusive.

Factors such as smoking or alcohol consumption have shown variable association with brain tumors.

V. METHODS

An initial site visit to the SLPD building was made on December 14 and 15, 1993. On December 14, an afternoon walk-through inspection of the fifth floor was conducted, preliminary measurements of ELF were made, and plans for systematic measurements were made for the following day.

On December 15, 1993, an opening conference was held with representatives of the Newspaper Guild and the management of SLPD. During this meeting, there were concerns raised about the perceived brain cancer cluster as well as the types and measurements of electromagnetic fields present on the fifth floor. A discussion was held concerning the HHE request, and an overview of 1) cancer clusters, and 2) brain cancers and their occupational epidemiology was given by NIOSH investigators. Following the meeting, an inspection of the fifth floor as well as the fourth and sixth floors, was conducted to check for EMF sources. NIOSH investigators looked for conditions or circumstances atypical of general office environments that might present a hazard or could possibly be related to brain cancers. The inspection focused on offices and open areas on the fifth floor of the building. Confidential interviews were held with employees of the fifth floor to obtain information concerning the HHE topics. The day's activities and preliminary observations were summarized in a closing conference.

NIOSH investigators obtained death certificates and insurance and medical records relevant to persons with brain cancer identified by the SLPD and the Newspaper Guild. NIOSH investigators also reviewed blueprints of the complete power distribution system for the fifth floor and reduced-scale floor plans showing the possible location of power cables.

This evaluation was designed to assess occupational exposure to sub-radiofrequency fields of SLPD fifth floor workers during a typical 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 at the facility, but are intended to estimate occupational exposure levels on the days of measurements.

The following equipment was used in this evaluation:

P 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 milligauss (mG) in the frequency range from 30 to 800 Hz.

P 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 (B) was measured in mG over the frequency range from 30 to 800 Hz.

In performing this evaluation, the NIOSH investigators obtained data from (a) a sample of fixed locations on the fifth floor, and (b) on a sample of employees working on the fifth floor.

VI. RESULTS

A. Cancer Occurrence

The investigation revealed that three of the seven deceased employees identified by management and union representatives as having brain tumors did not have primary brain tumors; rather, they had cancers from other sites (e.g., prostate and two lung cancers) which had spread to the brain. One individual had initially been thought to have a brain tumor but upon autopsy was found to have had an aneurysm. Two had medically confirmed primary brain cancers of the astrocytoma cell-type by tissue diagnosis. These individuals had been employed at the SLPD in the editorial room for over 20 years and worked in the same office area for several years. One deceased worker's medical records and next-of-kin were not located, so tissue verification of the tumor could not be obtained. Information from the death certificate listed the cause of death as brain tumor; this employee had worked as an outside salesperson.

Two current employees have been diagnosed with other tumors (meningioma and pituitary adenoma) in the past 10 years, but these tumors are not related to brain tumors of the astrocytoma type.

B. Electric and Magnetic Field Exposure in the Building

1. Zone Measurements

Levels of ELF electric and magnetic fields were measured by dividing the fifth floor office area into 24 smaller equal-sized rectangular zones. Five magnetic field measurements were obtained in each zone (at the four midpoints of the sides of the rectangles and at the center) at both floor level and at a height of 8-feet. These five measurements were averaged to give a representative value for each of the zones. The magnetic field level as measured anywhere in the small zones ranged from 0.3 to 30 mG at the floor and from 0.2 to 12 mG at 8 feet off the floor. Highest average magnetic field measurements were in the middle of the news room and lowest at the extreme ends in all zones, regardless of the height of the measurement. The magnetic field levels at the floor were generally higher than those at the ceiling of the same zone. These two findings suggest that the highest magnetic field levels are at floor in the middle of the news room. Electric field measurements were made only at the center of each zone; their values ranged from 1.9 to 3.9 V/m.

Magnetic field spot measurements made on the floor across the middle zone gave a maximum of 38 mG. While such levels are not extremely large, it was apparent that the source of these levels extended across the width of the entire 5th floor and was in many places the dominant source of the ELF fields.

2. Personnel Measurements

Workers from each of the six end zones and the three middle zones (total of 9) were selected to wear EMDEX meters for approximately two hours to assess personal exposure patterns. The results of that effort indicated that the average magnetic field in the six end zones ranged from 0.88 to 1.90 mG, and the three

middle zones from 3.23 to 9.79 mG. These results are consistent with the zone measurements and indicate that workers in the middle of the fifth floor are exposed to slightly higher magnetic field levels apparently due to electric sources presently located under the raised floor. It was not possible to identify the nature of the source from the electric plans since they had not been updated. The NIOSH investigators believe that the source was from an unmarked conduit that was visible under the raised floor, but could also have been an electrical conduit or wire located further below the original floor. In fact, at some areas on the west side of the floor, levels as high as 134 mG were found when meters were placed in contact with the original floor. Workers, however, do not come into contact with the original floor, as a floor platform has been built upon the existing floor. The SLPD building engineers mentioned that the source might even be associated with the computer center (located on the fourth floor) wiring circuit that could be located under the original fifth floor. However, a tour of the fourth floor did not reveal any information that would support that finding. Time did not permit NIOSH investigators to further pursue a positive identification of the source.

3. Other Observations

Sources of ELF field exposure were prevalent throughout the Fifth floor of the SLPD and included the items listed below.

humidifiers	fluorescent lamps
wall and desk clocks	AM/FM radios
computer printers	battery chargers
microwave ovens	view boxes
illustrator's waxers	coffee pots
water dispensers	photocopy machines
television sets	video display terminals
FAX machines	refrigerators
electric typewriters	power strips
electric pencil sharpeners	wall and desk fans
data-link components	dictaphones
data switch boxes	Christmas lights
video/audio cassette recorders	

The above list of sources can produce ELF levels ranging from 2-20 volts per meter and magnetic field levels from .1 to 1200 mG. Many of these items, such as video display terminals 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 in the office. Electromagnetic field strength decreases in proportion to 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.

VII. DISCUSSION AND CONCLUSIONS

Cancer is a group of diseases that share a common feature, the uncontrolled growth and spread of abnormal cells. Cancer is common in the United States. About one in three

people will eventually develop cancer. One of every five deaths is from cancer. Among adults, cancer occurs more frequently among men than among women, and the rate of occurrence increases with increasing age.[2]

Cancers often appear to occur in clusters. Cases that are close together in time or space (for example, a neighborhood or workplace) may have a shared cause or may represent the coincidental occurrence of unrelated causes. The number of cases may seem high, particularly among the small group of people who have something in common with the cases, such as working in the same building. Even if the number of cases represents a statistically significant excess, this may not indicate a causal link to the workplace environment. When a small number of cases occurs it usually is difficult to determine whether they have a common cause. This is especially true for cancer cases that occur among workers in non-industrial settings, where a biologically significant exposure may be difficult to identify.

In this investigation at the SLPD there were two, possibly three cases of related primary brain cancer. No further information was obtained about the one individual who worked only part-time in the building as a sales representative, although the death certificate listed "brain tumor" as the primary cause of his death. Only two were confirmed to have a malignant tumor of the same cell type. When evaluating the role of exposure to hazardous agents in the development of cancer, investigators usually consider only malignant, **primary** tumors; other tumors may represent different pathophysiologic processes. Investigators also take into account the **type** of cell that has become cancerous, as different cell types are affected by different exposures and have different susceptibility to become cancerous. The occurrence of the cases in which the brain was the primary cancer site could be either a coincidental occurrence or the result of exposure to the same (occupational or non-occupational) chemical, physical or biological agent.

Questions were raised about other suspected or potential workplace exposures during our investigation. NIOSH investigators did not identify any obvious unusual events or activities that would indicate the presence of a health hazard to office workers at the SLPD. The particulate residue detected on many air supply diffusers and surrounding areas is commonly observed in many office environments with HVAC systems. These particles, possibly carbonaceous (soot) in origin, may have come from the air supply or from the office area, possibly adhering to the ceiling and diffuser area due to electrostatic charges.
Lead in drinking water may be a health hazard depending on the extent of exposure, but lead has not been shown to be a cause of brain cancer. Asbestos also has not been shown to be a cause of brain cancer. Due to the low concentrations, small volumes, and limited use of the photocopy cleaning and bonding materials, exposures to these substances is minimal and, therefore, could not plausibly explain the multiple cases of brain cancer (even if they, or similar chemicals, were used in the same manner years ago).

All levels of ELF measured inside the building are relatively low, within the range of exposure levels in office settings previously reported by NIOSH, and are well below current occupational exposure criteria. Although employees may be concerned about levels of exposure below the established criteria, there is currently no conclusive evidence to show that chronic exposure to ELF fields causes adverse human health effects. It should be noted, however, that the health effects related to ELF fields may be linked to many variables, of which field strength is only one. Therefore,

depending on these variables, weaker electric or magnetic fields are not necessarily safer than stronger fields.

Based on the information discussed above, it appears unlikely that the cases of brain cancer among SLPD staff are related to the physical environment of the SLPD. Although some studies suggest that brain cancer may be related to exposure to ELF electric and magnetic fields, the body of evidence is inconclusive. Moreover, the measurements made in this evaluation indicate that exposures to ELF fields in the SLPD are typical of modern office environments.

VIII. RECOMMENDATIONS

Although the levels of ELF electric and magnetic fields measured in the SLPD are relatively low, exposure of building occupants could be reduced. Management of the SLPD indicated that older video display terminals were being replaced by newer, state-of-the art equipment that minimizes electric and magnetic field output. Continuation of these efforts is appropriate. While the source of the ELF fields discovered in the middle of the floor could not be resolved during our visit, management and workers may want to resolve that issue by having an electrical contractor trace the line to its source. Once the nature of the source has been determined, possible solutions about reducing exposures may be available, such as moving the line or rearranging some of the work areas.

There is a high level of concern and anxiety among building occupants as a result of recent conflicting reports of this perceived excess of cancers, which have apparently resulted from miscommunication between the Newspaper Guild and the SLPD management. It appears that some of this anxiety could be reduced by improved communication.

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HEALTH HAZARD EVALUATION REPORT

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