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L-S ELECTRO-GALVANIZING COMPANY
CLEVELAND, OHIO

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SUMMARY

On August 30, 1993, the National Institute for Occupational Safety and Health (NIOSH) conducted an investigation at the L-S Electro-Galvanizing (L-SE) Company, located in Cleveland, Ohio. This investigation was performed in response to a request, which NIOSH received on July 8, 1993, for evaluation of occupational exposure to electric and magnetic fields among workers at the L-SE Company.

Since there are no Occupational Safety and Health Administration (OSHA) or NIOSH exposure criteria for either static magnetic or sub-radiofrequency electric and magnetic fields, the exposure criteria developed by the American Conference of Governmental Industrial Hygienists (ACGIH) was used for these agents. Static magnetic field (SMF) and sub-radiofrequency electric and magnetic field measurements were made at various company locations under normal work conditions. The SMF time-weighted average (TWA) was estimated to be less than 50 Gauss (G). The TWA SMF levels did not exceed the ACGIH Threshold Limit Value (TLV) of 600 G. Sub-radiofrequency electric and magnetic field levels ranged from 0.1 to 10 Volts per meter and 0.1 to 14 G, respectively. Sub-radiofrequency magnetic fields levels measured near a electrical sub-station door, outside the facility, did exceed the ACGIH TLV limit of 10 G, however, this measurement was not considered to be an occupational exposure at L-SE Company by the NIOSH investigators since workers are not normally found at this location.

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

KEYWORDS: SIC 3471 (electroplating, plating, polishing, anodizing, and coloring), EMF, Static Magnetic Fields, ELF, Electrogalvanizing.

BACKGROUND

The National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation concerning possible employee exposures to various frequencies of electromagnetic fields produced at the L-S Electro-Galvanizing (L-SE) Company located in Cleveland, Ohio. L-SE Company is a joint business venture between LTV Steel and Sumitofo Metal Industries, LTD of Japan which supplies high quality pure zinc and zinc nickel alloy plated steel for specialized automobile applications. The electrogalvanizing line used at L-SE Company has been in operation for about eight years and is divided into the following three sections: entry, process, and exit.

The entry section of the line is where steel coils are received into the facility, stored until processing, transferred to the electrogalvanizing line, unwound, welded to form a metal strip, and then precleaned to permit a good metal bond.

The process section is where the strip is thoroughly cleaned and levelled, plated with zinc alloy, painted and polished. This is the section where an electrical current (DC mode) is applied to the strip, in the presence of an appropriate electrolyte, to plate the steel. This particular evaluation dealt with evaluating occupational levels of electromagnetic fields produced by the plating system. Electrical power for the plating system comes from an electrical switching yard where alternating current (AC) at 11.5 kilovolts and 1000 amperes is rectified to 33,000 amperes and 42 volts direct current (DC).

The exit section is where the strip surface is inspected, test samples cut, welds and scrap are removed, and the coils rewound and removed.

Work is performed on the electrogalvanizing lines at the L-SE Company on a 24-hour operation using 14 workers divided among five crews. Only one or two workers per crew are involved directly with the electrolyte cells during the process section. Potential occupational exposure to SMF during operations is not continuous.

EVALUATION DESIGN AND METHODS

Emphasis was placed in this evaluation on documenting occupational levels of static magnetic and sub-radiofrequency electric and magnetic fields found at the electrogalvanizing facility at the L-SE Company. The evaluation was designed to survey actual worker exposures to both alternating and direct currents while they performed their work tasks at the L-SE Company. The limited number of measurements taken in and around the facility were not intended to represent an in-depth evaluation of the radiation fields at the site, but were rather intended to approximate occupational exposure levels on the days of measurement.

The following equipment was used to document levels of electromagnetic fields (ELF) produced at the L-SE Company:

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

- A Holaday model HI-3627 3-axis ELF magnetic field meter, capable of documenting sub-radiofrequency magnetic fields 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 Hz, and the dynamic range of the meter is from 0.2 mG to 20 G.

- A Holaday model HI-3550 magnetic field monitor, capable of documenting DC magnetic fields was used to measure static magnetic fields. This monitor is a lightweight battery operated personal magnetic field monitor using three-axis detection. The monitor can document both instantaneous and time-integrated field measurements. The measurement range is from 0.1 millitesla (mT) to 0.3 Tesla on a 3 second measurement update period. One mT is equivalent to 10,000 mG.

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

All measurements were taken during daylight hours and at positions considered to be typical of occupational exposure (one meter away and one meter from the floor). Where possible, at least two readings were taken at each measurement site with the equipment and the average reading recorded. All equipment used to document exposure to electric and magnetic fields had been calibrated within six months use either by NIOSH or their respective manufacturer.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed without experiencing adverse health effects. It is, however, important to note that not all exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity situation.

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects, even if the occupational exposures are controlled at the level set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus, potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information about chemical and physical agents become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH criteria documents and recommendations, (2) the ACGIH Threshold Limit Values (TLV), and (3) the U.S. Department of Labor, OSHA occupational health standards. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational diseases. In evaluating the exposure levels and the recommendations for reducing these levels found in these reports, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

Currently, there are no OSHA or NIOSH exposure criteria for either static magnetic or sub-radiofrequency electric and magnetic fields. Exposure criteria for these agents have been developed by ACGIH and are used in this evaluation.

A. Static Magnetic Fields[1-3]

In general, there are two conditions for magnetic field exposures which need to be understood. Exposures can occur either from a steady or time-varying field exposure. In a steady magnetic field, the flux does not change with time and will not cause current to flow in a fixed object. In a time-varying field, the magnetic flux passing through a surface changes with time and can induce an electrical current flow in conductive objects. Both types of fields create different biological effects.

Exposure to static magnetic fields has been linked to slight increases in blood pressures, alternation in operation of artificial cardiac pacemakers, movement of implanted metal objects, rotation of sickle cells, and influencing the length of the circadian cycle. Many scientists believe that the effect of static magnetic fields are very subtle and may not represent a particularly hazardous exposure. There have been no official occupational health limits set for static magnetic fields. The Stanford Linear Accelerator Center proposed, in 1971, values of 2,000 to 20,000 G (depending on exposure time and the area of the body) for an upper limit based on lack of complaints. In 1979, the Department of Energy, based on known biological effects that had been reported, established a level of 20,000 G. The only other limit for this type of exposure has been proposed by ACGIH in 1987. The TLV for static magnetic fields states, "Routine occupational exposures should not exceed 600 G whole body or 6,000 G to the extremities on a daily, time-weighted average basis. A flux density of 20,000 G is recommended as a ceiling value."

B. Sub-Radiofrequency Electric and Magnetic Fields[4]

The ACGIH has published TLVs for sub-radiofrequency electric and magnetic fields. The TLV for magnetic fields (B_{TLV}) states "routine occupational exposure should not exceed:

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

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

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

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

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

The basis of the 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 induced currents in the body.

RESULTS AND DISCUSSION

Table 1 shows the maximum EMF levels measured at the L-SE Company on the days of measurement as a function of location, intensity, field, and presence of worker. The highest SMF level measured was 152 G at the rear of the rectification unit. As a result of SMF measurements made at various locations in the facility and the estimated time spent at these locations, it was estimated by the NIOSH investigators that the SMF TWA level was less than 50 G and can be compared to TLV criteria of 600 G.

The maximum ELF magnetic field level found inside the facility was 6.5 G at the rectification unit while the highest level found outside was 14 G at the open doors leading to the sub-station. The maximum electric field level documented was 10 V/m under the power lines leading to the sub-station.

Sub-radiofrequency magnetic field waveforms were analyzed at several different facility locations during operation of the electrogalvanizing line. The magnetic field waveforms, as captured by the Holaday meter and displayed on a digital oscilloscope, were generally found to be of the normal 60 Hz sinusoidal pattern.

CONCLUSIONS

The highest SMF measured at the facility was 152 G, and that occurred at the rear of the lower rectification unit. This particular measurement could be of occupational significance to electrical maintenance workers, however during these evaluations no L-SE Company workers were observed in the area where this measurement was performed. The SMF TWA was estimated to be less than 50 G. The maximum ELF magnetic field measured on the days of evaluation, inside the facility, was 6.5 G at the lower rectification area. The maximum ELF magnetic field measured outside the facility was 14 G and that occurred at the door leading to the sub-station unit. This level exceeds the ACGIH TLV criteria of 10 G and hence workers who are in this location for an extended time could receive an exposure which is of occupational importance. However, NIOSH investigators did not observe workers in this area for any length of time. Finally, the highest ELF electric field measured was 10 V/m underneath the power cables.

Based on the data collected in this evaluation, and comparison with current occupational criteria, the NIOSH investigators concluded that no health hazard existed on the days of measurement from exposure to electric and magnetic fields found at the facility. While sub-radiofrequency magnetic field levels at the door leading to the sub-station did exceed the ACGIH TLV, it was not considered to be of major occupational exposure since workers were not seen at this location.

RECOMMENDATIONS

The following recommendations are offered to reduce potentially significant occupational exposures and safety risks at the L-SE Company facility.

1. L-SE Company should consider purchasing appropriate static magnetic and sub-radiofrequency electric and magnetic field monitoring instruments to monitor levels of electric and magnetic field produced on the plant property.

2. The safety office should consider posting various areas within the facilities with signs indicating levels of fields, need to remove various metal objects and perhaps credit cards, and warnings for workers with metallic implants.

3. It is suggested that the doors leading into the sub-station facility be kept locked in order to minimize exposure to ELF magnetic fields that can be above the TLV.

REFERENCES

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1. L-SE Company
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Table 1

Magnetic Field Measurements as a Function of Different Locations, Intensity, Field, and Presence of Workers

L-S Electro-Galvanizing Company
Cleveland, Ohio
August 29-30, 1993
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Source Type	Source Location	Worker Present	Field	Field Strength Level (G)
Power Cable	Outside	No	AC	0.10 - 0.17
Electrical Sub-Station	Outside	No	AC	12 - 14
Collector Rings	Inside Dip Tanks	Yes	DC	27 - 140
Area	Catwalk Dip Tanks	Yes	DC	2 - 3
Rectification Units	Rectifier Room (Top)	Yes	AC DC	2 - 4.6 70 - 152
Walk-Around Room	Rectifier Room (Lower)	Yes	AC DC	0.04 - 0.25 1 - 2
Work Station	E & I Lab Rectifier (Lower)	Yes	AC DC	0.04 - 0.07 1.2 - 10
Rectifier Panel	Rectifier Room (Lower)	No	AC DC	16 > 4* 9.4 > 0.9*

* = Measurement made at contact with source and 3 feet away