TOPIC #11: OCCUPATIONAL AND NON-RESIDENTIAL EXPOSURES

SYNOPSIS

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Purpose

To summarize exposure levels in occupational and non-residential environments, and to identify high exposure groups or situations in these environments.

Summary

Risk assessments require knowledge of the exposures of affected populations to a particular agent or agents. This may be done by measuring exposures directly, but it is often done by extrapolating exposures based on prior knowledge of the dependence of exposure levels on activities, exposure sources, and environments. Computer models are often used. Characterizing EMF in occupational and non-residential environments is a key aspect of a risk assessment for EMF, whether measurements or extrapolations are used.

Many studies have measured EMF in occupational or other non-residential environments, most frequently at locations in the utility industry. Besides utility industry environments, other sites in which EMF exposure data have been collected include the electro-processing, communications, railroad, automobile, refinery, and semiconductor industries. Many of these, as well as studies in the utility industry, are reviewed by Bracken and Patterson (1996) with specific regard to the needs of epidemiology and risk assessment.

RAPID Engineering Projects #1, #2 and #4 developed guidelines for source, environment-specific, and personal-exposure magnetic-field measurements, respectively (Electric Research and Management, Inc. 1997; Magnetic Measurements, 1997; Bracken et al., 1997). All these guidelines apply to characterization of fields in occupational and non-residential settings. RAPID Engineering Project #3 (Zaffanella, 1996) was specifically designed to gather data at non-residential and non-utility sites, and included surveys in office buildings, schools, hospitals, machine shops, and grocery stores. RAPID Program Engineering Project #6 (Zaffanella and Kalton, 1998a; 1998b) surveyed the personal exposure of 1000 study participants from randomly selected households over a 24-hour period. Participants ranged in age from infants to retirees.

Data were analyzed for the entire 24 hours and for five separate activities—home not in bed, home in bed, at work, at school, and traveling.

A recently completed RAPID program study performed by NIOSH (Methner and Bowman, 1998) gathered field data at a variety of occupational locations using a "walkaround" survey method that was intended to collect data for assessing workers exposures. Sixty-two facilities were surveyed; the results are typical of those reported from other surveys. Magnetic-field data are highly skewed by a few, very high levels, and a log transformation does not produce normality. The geometric mean values ranged from 0.4 mG to 16.1 mG; 89 percent of the sites had geometric means below 4 mG. The investigators also used a statistic made up of the mean of the five highest values at each site to indicate the magnitude of the highest levels encountered and the potential for very high exposures. The sources producing high levels were predominantly electric motors, transformers, and electric furnaces.

The study also found that Standard Industrial Classification (SIC) codes were not good predictors of facilities having high EMF levels and that electric power consumption was a poor predictor of the average magnetic-field level at a facility. (The correlation was 0.68 for all 62 facilities but dropped to 0.11 when the facility with both the highest geometric mean and many electric furnaces was removed from the analysis.) Both of these results are in accordance with the view that high-level exposures occur essentially around localized high-magnitude sources, and that it is at the level of sources that data must be developed if distinctly different exposures are to be determined. The results of RAPID Engineering Project #1 on source characterization suggest that not just a generic source type, but individual sources could be important if a metric other than the time-weighted average were important.

Bracken and Patterson (1996) analyzed data for personal exposure in the electric utility industry. By job category, exposures ranged from an average of 2.2 mG for office workers to 10.4 mG for line workers. Their analysis suggests that, for utility workers, the greatest disaggregation possible may be only at the level of broad job categories, such as line worker, generation worker, and substation worker. Division into job titles within these broad categories does not produce differences in exposures.

RAPID # 3 (Zaffanella, 1996) performed environmental field surveys for four different sites at each of five different types of environments: schools, hospitals, grocery stores, office buildings, and machine shops. The average field levels ranged from a low of 0.53 mG at two of four schools to a high of 8.62 mG at one of the machine shops. There was overlap of the summary statistics for different sites among the different environments. The four sites of the grocery-store environment together had the highest average, but the machine-shop environment had the greatest range. The variability in these occupational and non-residential exposures is shown in Figure 11-1 taken from that study.

RAPID #6 (Zaffanella and Kalton, 1998a; 1998b) collected personal exposure data for 24 hours for each of 1000 participants. The data were estimated to be log-normal, with geometric mean of 0.90 mG and geometric standard deviation (GSD) of 2.17 for the 24-hour averages. Participants noted the periods spent at work, school, and travel; the field levels during these activities were analyzed. The geometric mean at work was 1.09 mG (GSD=2.49). Service occupations had the highest mean (1.75 mG), followed by electrical occupations (1.17 mG). Lowest were farming, forestry, and fishing (0.51 mG). The geometric mean during travel was 0.99 mG (GSD=1.96), and the value at school was 0.69 mG (GSD=2.06). For “at home, not in bed, the geometric mean was 0.80 mG (GSD=2.52); for in bed the geometric mean was 0.52 mG (GSD=3.52).

Yost et al. (1997) have developed a preliminary JEM for magnetic-field exposure based on the Standard Occupational Classification (SOC80, 1990). The major group JEM assigns a geometric mean and other statistics of the average daily mean exposure for each of 44 general (two-digit) occupational codes based on exposure measurements from five studies. The distribution of exposures across occupational codes indicates that, for most (34 out of 44), the geometric mean of average daily exposures 2 mG or less. Although the results are based on limited measurements and are subject to the uncertainties associated with aggregating over many job titles, they are consistent with the surveys that indicate most occupational exposures are not substantially different from exposures at home or in other non-residential environments.

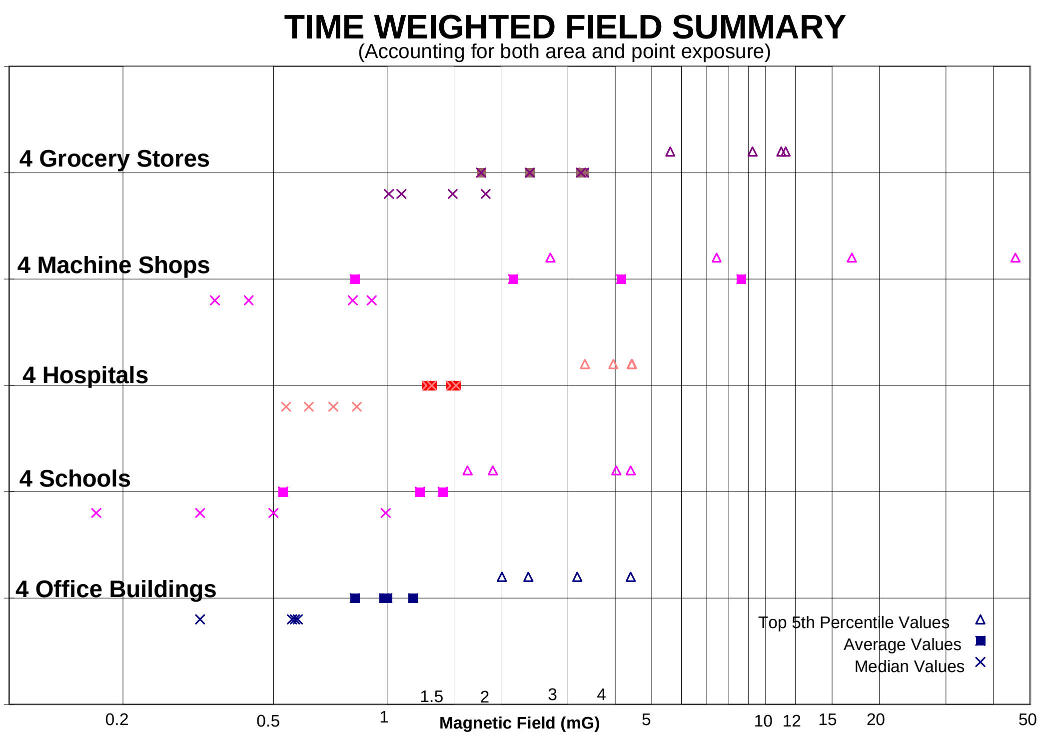

Figure 11-1. Summary of time-weighted fields in all surveyed sites. From: RAPID Engineering Project #3 (Zaffanella, 1996)

Conclusions

Taken together, the results of both the recent studies on occupational and non-residential exposures described above, as well as those of past studies, lead to the following conclusions.

- High exposures in occupational and other non-residential environments result from localized, high-magnitude sources. The variety and variability of these sources make generalizations tenuous.

- Routine exposures to electric fields above levels found in common indoor and outdoor environments are limited to a few occupational categories in the electric-utility industry. These are transmission line workers and transmission substation workers. Others may receive incidental exposures to higher-than-common electric fields when walking under high-voltage transmission lines.

- Routine exposures to magnetic fields above levels found in common indoor and outdoor environments occur for many more occupational categories. These include electric-utility personnel whose work takes place in or very near to electric generation, substation, transmission and distribution facilities; electric welders; employees who work in close proximity to high-current ac equipment such as electric furnaces, production-line demagnetizers, electric motors, and train engines.

- TWA exposures for most occupations are less than 2 mG and not substantially different from residential and non-residential exposures.

- On average, occupational exposures tend to be higher than residential exposures and result in employed persons generally having higher exposures than unemployed or retired persons. However, there are occupations where occupational exposures are less than residential exposures. Depending on the job category, occupational exposure can contribute a substantial portion of total exposure, even though time at work is typically about 25 percent of total time.

- With a few exceptions, exposures above 1 G are rare, infrequent, and of short duration among workers, even in the most highly exposed jobs. Exceptions are performing maintenance tasks very close to energized electrical transmission and distribution conductors, and operating certain high-current equipment such as electric train engines, production de-magnetizers, and electric furnaces.

- Relatively high exposures in non-residential settings have been found to occur in grocery stores and locations with specific sources. However, there are no non-residential environments, except those near electric transmission and distribution lines, that can be routinely characterized as high exposure areas.

- Schools, in general, appear to have lower exposures than residences based on the results of RAPID #6 and other studies. Exceptions may be schools near transmission facilities.

The most common sources of higher field exposures in schools are electric supply facilities and small localized sources such as appliances and audio-visual equipment. Fields from both of these types of sources are very localized.

- Exposures to magnetic-field transients, while potentially important, have not been so well characterized as those to other field attributes.

Implications for Risk Assessment

Occupational categories among electric-utility workers with relatively high EMF exposures have been identified (and have been the most studied). If other occupational groups with such common exposures across employers and geographic regions cannot be identified, risk assessments may require PE data.

In general, residential exposure is the most significant contributor to total exposure because of time spent in the home. However, activities with specific sources or in specific environments with high fields at work or in other locations can affect both average and peak exposures. These must be accounted for in performing risk assessments.

Occupational exposures are generally not substantially different from those in residential and non-residential environments, making identification of high-exposure groups outside a limited number of specific job categories problematic.

Average field levels in occupational settings are not predicted by either SIC code or electricity use in the environments studied. The apparent predominance of local sources in affecting average field levels as well as PE in occupational settings may make risk assessments dependent on PE data or at least on explicit source data.

Remaining Questions

1. Can high-exposure (or otherwise distinct) occupations or groups (using a measure related to potential adverse health effects) be uniquely identified?

2. What sophistication in data collection should be used to gather future data on occupational and non-residential exposures?

3. Should data collection in occupational and non-residential environments proceed without knowledge of a health-related exposure metric?

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