TOPIC #7: SOURCE AND ENVIRONMENT CHARACTERIZATION

SYNOPSIS

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Purpose

To summarize the state of knowledge and technology for characterizing EMF from specific sources and in 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 exposure sources and of environmental levels of the agent. Computer models are often used. Characterizing EMF from individual sources and in definable environments is a key aspect of any risk assessment for EMF, whether measurements or extrapolations are used.

Exposures to environmental agents can usually be measured as scalar quantities. Toxic chemicals (which can be characterized by simple, slowly varying concentrations by mass or volume) are an example. EMF, on the other hand, are not simple scalars but vectors that can occur over a range of frequencies with continuous variation in time and space. That by itself would make their characterization a challenging task. Additionally, however, no parameter of environmental EMF is clearly biologically active in producing adverse health effects, so there is no biological guidance to help bound the task.

Sources

The recently completed RAPID Engineering Project #1 (Electric Research and Management, Inc., 1997) investigated the problem of EMF source measurement and characterization and prepared guidelines for characterizing sources of EMF. The Project began by reviewing the complexity of characterizing sources; then worked out methods for reducing data-collection requirements and for cataloging sources; and finished by developing and applying source-measurement protocols.

The problem is to prune a potentially very large number of data points—the three-component field vector measured along three orthogonal axes with the source at the origin, at a frequency twice the EMF frequency of interest—without losing information that could be important to a risk assessment.

RAPID #1 concluded as follows:

- Sampling that covers a frequency range of 3 Hz - 3 kHz is adequate.
- An adequate sampling period is the inverse of the power frequency. This is based on the repetitive nature of operating sources.
- Transient characteristics may be captured with high-speed sampling that is initiated as required.
- The number of spatial data points can be reduced by applying mathematical models of field spatial dependence. This conclusion relies on modeling a source as a point dipole moment from an infinitely small coil and using the dipole to reconstruct the field. The dipole is determined by fitting measurement data to the model.

Dipole moments were calculated in RAPID Project #3 (Enertech, 1996) for selected sources in office buildings, schools, machine shops, and grocery stores, using the method described by Zaffanella et al. (1997). Values ranged from a little below 1 $A{\cdot}m^2$ for a cassette radio to above 50 $A{\cdot}m^2$ for a transformer in a machine shop. An analogous approach using spherical and cylindrical dipoles to describe fields from multiple sources in an environment has been described by Olsen and Lyon (1996).

Instruments are available to collect data of increasing complexity through the requirements identified in RAPID #1, above. By category, these include the following

- survey meters for one- or three-axis, narrow-band or broad-band, rms measurements;
- similar instruments that record the field data and perhaps time and location data;
- one- or three-axis wave-capture recorders that are able to collect data as specified above;
- multi-sensor three-axis wave-capture recorders; and
- transient capture recorders.

While most field attributes can be defined with existing equipment, problems remain in the areas of field continuity, or coherence, and the complementary idea of “intermittency,” which arises from an interruption in coherence.

RAPID #1 identified the following field attributes as being important for characterizing a field source:

- some measure of magnitude
- frequency
- spatial dependence

- temporal operating conditions, and
- if possible, polarization.

The degree of sophistication of the instruments used will determine the complexity of the data obtained on these attributes. RAPID #1 used and recommends a wave-capture system; however there are available, simpler technologies that can collect much information on these attributes. Again, the fact that the biologically active field component or components, if any, are unknown makes the choice somewhat arbitrary at this time.

EMF produced by appliances, tools, and sources found in the occupational environment have been characterized as part of RAPID Projects #1 and 3 as well as in other studies [see, e.g., Gauger (1985), Mader and Peralta (1992)]. The results indicate the variability that occurs not only between different groups of sources, as between a kitchen mixer and a paint sprayer, but also between different sources in the same group. Appliances may produce highly localized fields on the order of tens of gauss, with considerable field strength in harmonics of the fundamental power frequency. RAPID #1 recommends a four-digit source classification system to categorize sources. The intent is to be able to catalog source data to guide future surveys or provide input for epidemiologic studies. The first digit of the classification system indicates the order of magnitude of the field at 30 cm from the source; the second digit indicates the dominant frequency; the third is an indication of the variability from steady-state operation of the source; the fourth describes spatial attenuation and polarization. The data necessary to complete the four-digit classification do not require a wave-capture measurement system.

Environments

Fields have also been characterized by levels over an area in different environments. RAPID Project #2 (Bittner, 1997) identified seventy-five different studies in which area source measurements were performed. It also developed guidelines for measuring EMF in different environments. Just as source characterization requires measurement of many parameters of the field, so also does environmental area characterization. A recurring caution of the RAPID #2 report is that magnetic-field characteristics cannot be properly described by a single measurement or series of measurements. Rather, "Many factors, including the physical parameters of the environment; the location and operation of sources; the activity patterns of the occupants; and the spatial, temporal, frequency, and other parameters of the magnetic fields together paint a picture that characterizes magnetic-field exposure" (Bittner, 1997:3-1). Items requiring planning include the following:

- source identification
- activity-pattern data collection
- non-magnetic-field data
- micro-environment identification
- selection of points for measurement

- magnetic-field data collection.

RAPID #3 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 study presented rms area field distributions for each site in three ways: as an average of area fields at different locations, as average area fields at different locations weighted by surface area, and as average area fields at different locations weighted by the time that people spent in the locations. It was found that the differences produced by the different weighting methods were not as significant as the differences between sites and between environments. The order of TWA area field levels (from highest to lowest) was grocery stores, machine shops, hospitals, and schools, and office buildings. However, the highest average in one of the office buildings was higher than the lowest average found in a grocery store, demonstrating the variability that occurs within an environment type and the potential difficulty in trying to categorize environments into those having distinctly different field levels. This result is reinforced by similar results pointed out by others (e.g., Bracken and Patterson, 1996) regarding the high variability that occurs when data are categorized by job task or job category.

Conclusions

- There are simple and complex methods for characterizing fields from sources. The choice depends on the purpose of the measurements.
- Sources can be characterized using a complex set of measurements as was done in RAPID #1. The technology exists to do this. However, the data will likely need to be reduced to a few values, and the source classification system proposed in RAPID #1 does not require such a complex set of measurements.
- Sources can also be characterized with a few measurements and a computational algorithm (based on the dipole moment), based on knowledge of sources.
- The methods and technology exist to perform environmental surveys. At present, no method of presenting area source measurements clearly defines different environments.

Implications for Risk Assessment

The development of guidelines for source characterization is an important step towards a common database of comparable measurements.

While there is no guarantee that an important health effects parameter of EMF is not missed by the techniques of the guidelines, they reflect the present state of knowledge, and the technology exists to apply them.

The variability of fields within and among source types or groups will make any large-scale exposure assessment difficult. The variability is much more complex than just differences in a TWA, for example. More work is necessary to develop methods to account for this and to rationalize exposures.

The variability of TWA area measurements of fields will make a large-scale exposure assessment difficult. Variability may be as great between different sites of the same type of exposure environment as between different exposure environments.

Remaining Questions

1. What is the likelihood that an important parameter of EMF is not being captured by the procedures developed in RAPID #1?
2. Is it feasible to develop a catalog of source characterizations that can be used for risk assessment?
3. Can the source characterization guidelines be simplified?
4. Is it possible to present area source data in a way that reduces the variability within an environment type?

References

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