TOPIC #1: THE RAPID ENGINEERING PROGRAM AND TECHNICAL PERSPECTIVES

SYNOPSIS[1]

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The RAPID Engineering Program

The RAPID Engineering Program supported eight projects to investigate the engineering aspects of EMF effects research. Brief summaries of these are provided below, followed by an evaluation of the RAPID Engineering Program. Enhanced Executive Summaries, including tables and figures to illustrate findings, appear in Appendix B.

RAPID #1: Development of Recommendations for Guidelines for Field Source Measurement

> The study constructed a set of characteristics for guiding and interpreting magnetic-field measurement studies and for focusing future field management; developed a systematic survey method to identify sources in order to correlate them with measurements made in other surveys/laboratory tests; and developed guidelines to measure field sources. Key to the effort was the development of a coding system to identify magnetic-field sources in appliances. They also developed guidelines for measuring magnetic fields *in situ* and appliances in a testing laboratory situation. Information on currently available equipment, and on the importance of pilot studies and detailed documentation steps, round out the work. (Electric Research and Management, Inc., 1997)

RAPID #2: Recommendations for Guidelines for Environment-specific Magnetic-field Measurements

> This project documented widely applicable methods for characterizing the magnetic fields in a given environment, recognizing the many sources co-existing within that space. The guidelines walk the investigator through the planning of a study, development of study structure and protocol, and execution and documentation. The guidelines are structured to produce a protocol that responds to specific site and project needs, one that will gather

[1] Material in the Dr. Gailey's synopsis/presentation that dealt with the expectations for the symposium itself is found in the Introduction to this report.

the most exposure-relevant information based on locations of people in relation to sources. (Bittner, 1997)

RAPID #3: Environmental Field Surveys

This project sought information on the levels and characteristics of different environments for which only limited data were available, especially for comparison with magnetic-field data for the residential environment and for electric utility facilities, such as power lines and substations. It also investigated the contribution of various field sources in the surveyed environments.

The protocol was based on magnetic-field measurements and observation of activity patterns to estimate magnetic-field exposure by type of people and by type of sources. Field and exposure data were obtained separately for area fields and exposure points at schools, hospitals, office buildings, machine shops, and grocery stores. Differences between average fields obtained at different sites in the same environment were significant in comparison to differences between environments. Main contributors to area fields were net currents, office equipment, and milling and welding equipment. Exposure by person type found that welders had the highest exposure, followed by some personnel in grocery stores. Power lines were, generally, a minor source of magnetic-field exposure. A significant percentage of exposure, however, was caused by sources that could not be identified. (Zaffanella, 1996)

RAPID#4: Recommendations for Guidelines for EMF Personal Exposure Measurements

This project developed recommended guidelines for PE measurement studies, to ensure reliable and comparable data across such studies. The flexible recommendations are intended to provide guidance for investigators with varied research objectives, rather than to dictate specific methodologies. The report presents general guidelines for planning a study, and specific guidelines for developing a detailed study design and protocols. Two pilot studies were carried out and are discussed as part of this RAPID project (one with high-school physics students, the other with employees at an electronic manufacturing plant). (Bracken et al., 1997)

RAPID #5: Development of an EMF Measurement Database

The primary goals for this project were (1) to develop a database structure that could accommodate the diversity of EMF data sets, (2) to provide guidance for production of future EMF data sets, and (3) to serve as an accessible repository of EMF measurement data. Among other objectives, the Database was to provide readily accessible, well-documented data; to facilitate communication among researchers; and to encourage additional analysis of existing data sets. Specifications and guidelines are available for researchers contributing data sets consisting of text, tabular, and graphic information describing their study and analysis of facts. Three data sets are currently available at the Web site (http://www.emf-data.org). More are anticipated. It is important to note that the

Web site exists as a clearinghouse only. Reports are not validated by the database organization. Inclusion in the Web site provides for no copyright restrictions or claims of ownership. (T. Dan Bracken, Inc., 1997; 1998)

RAPID #6: Survey of Personal Magnetic-field Exposure (Phase I) One Thousand People Personal Magnetic-field Exposure Survey (Phase II)

This project focused on characterizing personal magnetic-field exposure of the general population, by performing PE measurements for a random sample of the population. Phase I developed the survey methodology and collected initial data for 200 randomly selected adults. During Phase II, the investigators conducted a large-scale (1000-person) survey using the tested protocol. The protocols were implemented to complete collection of data for the 1000-person sample. The measurements for each subject were partitioned into the following categories: at home not in bed, at home in bed, at work, at school, during travel, and other. A variety of measures of the magnetic field were extracted for each subject and for each type of activity.

The following conclusions (and others) were drawn from the 1000-person sample.

1. The distribution of the average fields during a 24-hour period for the population of the U.S. is estimated to be log-normal, with a geometric mean of 0.90 milligauss (mG) (95% CI from 0.85 to 0.96 mG) and a geometric standard deviation equal to 2.17 (95% CI from 2.08 to 2.27).
2. About 26% of the people spend more than one hour in fields greater than 4 mG, and about 9% of the people spend more than one hour at fields greater than 8 mG. About 2% of the people experience at least one gauss (1000 mG) during a 24-hour period.
3. The largest average fields (experienced by a few percentage of the people) were recorded during the period “at work.” The lowest average fields were recorded during the period “at home, in bed.”
4. Very little difference in 24-hour average magnetic field was found between men and women. The largest geometric mean among age groups was found for working-age people (geometric mean: 0.97 mG), followed by retirement-age people (0.83 mG), school-age children (0.78 mG), and pre-school children (0.59 mG). Little difference was found among different regions of the U.S.
5. The lowest exposure at home was measured for people living in mobile homes, followed by single-family residences. Duplex and apartments correspond to the largest exposures. The highest exposures at home are in smaller houses and in houses with metallic rather than plastic pipes. (Zaffanella and Kalton, 1998a;1998b)

RAPID #7: Development of Field Exposure Prediction Models

Project #7 developed a general model that combines time/activity pattern information with PE, area, and/or magnetic-field source information to estimate personal exposure of individuals or groups. Questionnaires specifically targeted time/activity information germane to environments, EMF exposure components, and presence or use of appliances and tools. The model defines classes of subjects by age and by rural/urban exposures.

Computational models address three field parameters requiring different computational algorithms: time-weighted-average field (TWA), peak field estimates and harmonic field exposures. Input parameters to the model accommodate either point or statistical distributions for input parameters of field level or time in activity. Final report is in preparation. Preliminary information is available in Rankin and Bracken (1997).

RAPID #8: Evaluation of Field-reduction Technologies

This project evaluated field-reduction methods for a variety of magnetic-field sources (including transmission lines, distribution lines, substations, building wiring, appliances and machinery, and transportation systems). Five methods were evaluated: (1) minimizing magnetic fields when current-carrying conductors are matched with appropriate return conductors, (2) placing opposing current pairs as close together as possible, (3) splitting currents, (4) decreasing magnetic fields via distance from the sources, and (5) reducing current and thus reducing magnetic fields. Lifetime costs estimates were developed for reducing magnetic fields from six source types. The relative cost depends strongly on the source type and the selected field criterion. (Johnson and Gauger, 1997)

Related Studies

The RAPID engineering program sponsored several studies that took advantage of ongoing related research in other agencies. These were directed primarily at characterizing exposures in various environments, and included the following:

- The University of Bristol study: Assessment of Human Exposure to Magnetic fields Produced by Domestic Appliances (Kaune et al., 1996);
- The National Institute for Occupation Safety and Health study: Hazard Surveillance for Workplace Magnetic Fields: I. Walkaround Sampling Method for Measuring Ambient Field Magnitude II. Field Characteristics from Waveform Measurements (Methner and Bowman, 1998);
- The University of Southern California study: Preliminary Investigation into EMF Exposures Resulting from the Use of Home Sewing Machines (Sobel and Davanipour, 1996);
- The University of Washington study: Characterization of Exposures to ELF Magnetic Fields in the Office Environment (Yost and Hogue, 1995); and

- The U.S. Department of Transportation study: Survey and Assessment of Electric and Magnetic Field (EMF) Public Exposure in the Transportation Environment (Electric Research and Management Inc., 1997).

RAPID Engineering Program Evaluation

The RAPID engineering studies aimed to summarize and synthesize existing knowledge to enable researchers to focus the technology on important questions.[2] The result is a broader approach to research than has previously been available and a series of guidelines that can be widely used to produce research that is consistent and comparable.

The eight projects and five related studies succeeded in generating and testing tools to develop consistent methodologies for measuring, characterizing, and recording magnetic fields, and in gathering significant new information on sources, environments, and personal exposure. Their results fall into four general categories:

1. Technologies to measure and characterize magnetic fields (RAPID Projects #1, 2, 4, and 7);
2. Information on types and extent of human exposure in residential and occupational settings (RAPID Projects #3 and 6);
3. Techniques to manage exposure/mitigate the fields (RAPID Project #8); and
4. Dissemination of information (RAPID Project #5).

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[2] Note that none of these studies directly addressed *risk*. A true approach to risk assessment cannot be undertaken unless those investigating the biology of effects can identify consistent adverse effects. Only then could biological and engineering studies be used to determine levels of risk and ways to reduce them.

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