Environmental Field Surveys

**EMF RAPID PROGRAM
ENGINEERING PROJECT #3**

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**Prepared by
ENERTECH CONSULTANTS
17 Main Street
P.O.Box 770
Lee, Massachusetts 01238**

**Principal Investigator
Luciano E. Zaffanella**

**Prepared for
Lockheed Martin Energy Systems, Inc.
P.O.Box 2002
241 W. Tyrone Road, D104
Oak Ridge, Tennessee 37831-6501**

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CONTENTS

Section	Page
1 Introduction	1-1
2 Review of Environmental Field Surveys.....	2-1
Introduction	2-1
List of Environmental Field	2-1
Survey Review Format	2-2
Survey Review Summary	2-5
Conclusions from the Review of Past Surveys.....	2-10
3 Criteria for Environment Selection and Assessment of Survey Requirements	3-1
Criteria for Environment Selection	3-1
Assessment of Survey Requirements	3-5
4 Protocol for Environmental Field Surveys	4-1
Purpose of the Protocol	4-1
Information and Data to be Obtained	4-1
Team Members	4-4
Preparation Required at the Site	4-5
Instrumentation	4-5
Length of Work and Description of Each Day's Goal	4-6
File and Data Coding	4-6
Detailed Description of Tasks	4-6
Definitions	4-25
6 Data Management and Analysis	6-1
Introduction	6-1
Calculation of AC Field Components and AC and DC Field Spatial Relation	6-1
Calculation of the Distribution of RMS Field Values and Field Averages	6-5
7 Results	7-1
Introduction	7-1
Average Environmental Fields	7-1
Exposure by Person Type	7-11
Exposure by Source Type	7-19
Time Above a Field Threshold	7-21

Section	Page
DC Fields and Combination of AC and DC Fields	7-22
Harmonics	7-24
Polarization	7-29
Temporal Variations	7-30
Point Source Characterization	7-32
Magnetic Field Transients	7-36
References	7-42
8 Database	8-1
Introduction	8-1
Metadata	8-1
Data Products	8-3
Other Data	8-4
9 Conclusions	9-1
Appendix A - Statistical Distribution of Area Fields at All Surveyed Sites	A-1
Office Buildings	A-1
Office Building #1	A-1
Office Building #2	A-4
Office Building #3	A-7
Office Building #4	A-10
Schools.....	A-13
School #1	A-13
School #2	A-16
School #3	A-19
School #4	A-22
Hospitals	A-25
Hospital #1	A-25
Hospital #2	A-28
Hospital #3	A-31
Hospital #4	A-34
Machine Shops.....	A-37
Machine Shop #1	A-37
Machine Shop #2.....	A-40
Machine Shop #	A-43
Machine Shop 4	A-46
Grocery Stores	A-49
Grocery Store #1	A-49
Grocery Store #2	A-52

Section**Page**

Grocery Store #3	A-55
Grocery Store #4	A-58

Appendix B - Statistical Distribution of Area Fields, Fields at Exposure Points, and Combined Fields	B-1
---	------------

Appendix C - Magnetic Field Exposure by Type of People and Type of Source for All Surveyed Sites	C-1
---	------------

Appendix D - DC Fields, AC Field Harmonics and 60Hz Field Polarization for all Surveyed Sites	D-1
--	------------

Appendix E - Temporal Distribution Data	E-1
--	------------

Appendix F - Transient Survey Measuring System	F-1
---	------------

Appendix G - Waveshape Magnetic Field Transient Data	G-1
---	------------

Appendix H - Metadata File for the EMF Measurement Database.....	H-1
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Appendix I - Review of Past EMF Surveys	I-1
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SUMMARY

The EMF Research and Public Information Dissemination Program (RAPID) includes several engineering research in the area of exposure assessment and source characterization. RAPID engineering project #3: "Environmental Field Surveys" was performed to obtain information on the levels and characteristics of different environments, for which only limited data were available, especially in comparison to magnetic field data for the residential environment and for electric utility facilities, such as power lines and substations. This project was also to provide information on the contribution of various field sources in the surveyed environments.

Magnetic field surveys were performed at four sites for each of five environments: schools, hospitals, office buildings, machine shops, and grocery stores. Of the twenty sites surveyed, 11 were located in the San Francisco Bay Area and 9 in Massachusetts. The surveys used a protocol based on magnetic field measurements and observation of activity patterns, designed to provide estimates of magnetic field exposure by type of people and by type of sources. The magnetic field surveys conducted by this project produced a large amount of data which will form a part of the EMF measurement database

Field and exposure data were obtained separately for "area exposure" and "at exposure points". An exposure point is a location where persons engage in fixed, site specific activities near a local source that creates a significant increase in the area field. The area field is produced by "area sources", whose location and field distribution is in general not related to the location of the people in the area.

The area field distribution of a site, calculated weighing each area's field distribution by the time (person-minute) spent in the area, was not significantly different from the area field distribution obtained weighting each area by its surface area or giving to each area the same weight. Differences between weighting methods were less significant than differences between sites and between environments. Time Weighted Average Area (TWAA) field was found highest in grocery stores (1.93 mG average for the four sites), then in machine shops (1.42 mG), hospitals (1.27 mG), schools (0.83 mG), and office buildings (0.72 mG). The same ranking was obtained for the top 5th percentile of the area field distribution: 7.5 mG for grocery stores, 4.2 mG for machine shops, 3.7 mG for hospitals, 2.8 mG for schools, and 2.5 mG for office buildings. Differences between TWAA area fields obtained at different sites of the source environment were significant in comparison to differences between environments. In fact, the highest TWAA area field found in an office building (i.e. in the environment with the lowest average TWAA area field) was higher than the lowest average area field found in a grocery store (i.e. in the environment with the highest average TWAA area field).

Exposure at exposure points was characterized by defining a zone of activity (range of distances from a source), an exposure duration (person-minutes), and by determining, through measurements, the field at different distances from the source.

Time Weighted Average (TWA) fields, caused by the combination of area and point fields showed only a modest increase over TWAA fields for schools (from 0.8 to 0.9 mG), for hospitals (from 1.3 to 1.4 mG), and for office buildings (from 0.7 to 1.0 mG) and showed a strong increase for grocery stores (from 1.9 to 2.7 mG) and especially for machine shops (from 1.4 to 3.9 mG), indicating a large effect of local sources for these two environments.

Time weighted average field and time weighted field distribution was calculated separately for each group of people. In office buildings, secretarial and support staff had a greater exposure than professionals. In schools, teacher were slightly more exposed than students. Custodians and administrative staff were significantly more exposed than teachers and students. In hospitals, the medical staff and the maintenance staff were significantly more exposed than patients. Visitors were the least exposed. In machine shops welders had by far the largest exposure. In grocery stores clerks, cashiers, and butchers had much greater exposure than office staff and customers. Comparing groups of people across environments, it was found that welders in machine shops had the highest exposure, both in terms of TWA and of top 5th percentile were (TWA = 5.2 mG, top 5th percentile = 24.6 mG), followed by butchers in grocery stores (TWA = 4.1 mG, top 5th percentile = 12.8 mG) and clerks / cashiers in grocery stores (TWA = 4.0 mG, top 5th percentile = 11.9 mG). The groups with the lowest exposure were visitors in hospitals (TWA = 0.8 mG, top 5th percentile = 2.4 mG), students in schools (TWA = 0.9 mG, top 5th percentile = 2.9 mG), and professionals in office buildings (TWA = 0.9 mG, top 5th percentile = 2.6 mG). These data refer to the average person of a given type. Individual people may have higher or lower exposures and their exposure may vary significantly from day to day.

The relative contribution of each area source to area exposure was calculated. Net currents were the main contributor to area fields in schools, grocery stores, and hospitals. Office equipment was the main contributor to area fields in office buildings. Milling and welding equipment was the main contributor to area field in machine shops. Fluorescent lights were important contributions to area fields in grocery stores, office buildings, and hospitals. Electrical panels were an important contributor to area fields in machine shops. 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.

The percentage of total time spent above a field threshold was calculated for each type of persons, for different field thresholds (2, 5, 10, 20, and 40 mG). It was found, for instance, that clerks / cashiers in grocery stores had the highest percentage of time (56%) spent above 2 mG and that professional in office buildings had the lowest (14%).

Section 1

INTRODUCTION

1.0 INTRODUCTION

Increasing public concern about the question of possible harmful health effects from exposure to power frequency electric and magnetic fields (EMF) led the U.S. Congress to address this issue in the Energy Policy Act of 1992 (P.L. 102-486). Specifically, Section 2118, under Subtitle B, Title XXI, (42 USC 13478) authorizes the Secretary of Energy to establish a jointly funded (Federal and non-Federal sources) comprehensive program to:

- determine if exposure to electric and magnetic fields produced by the generation, transmission, and use of electric energy affects human health;
- carry out research, development, and demonstration of technologies to mitigate any adverse human health effects; and
- provide for the dissemination of EMF information to the public

In order to fulfill these legislated responsibilities, the EMF Research and Public Information Dissemination Program (RAPID) was established.

1.2 ENGINEERING RESEARCH ACTIVITIES

The *Research Agenda and Communication Plan* identifies the need for engineering research in four broad areas:

- Exposure Assessment and Source Characterization
- Quality assurance
- Field management
- Dosimetry

Exposure Assessment and Source Characterization

The objectives are to determine the range and typical characteristics of the electric and magnetic fields to which the general population and population subgroups are exposed.

To evaluate information about electric and magnetic field characteristics including field strength, frequency components, intermittency, coherence, transients and phase, as well as spatial and temporal distribution in relevant residential, workplace, and other environments.

To identify significant sources of EMF exposure, and use this information as input to support exposure assessment, risk assessment, communication, and the development of future field management strategies.

To evaluate instrumentation, and to develop techniques for measuring various types of electric and magnetic fields and techniques for assessing personal exposure.

An important goal of the EMF RAPID Program is to make significant contributions to the understanding of what kind of fields people are commonly exposed to in a variety of environments and from a variety of sources.

The implementation of engineering research for the EMF RAPID Program began in 1995 with the following five projects:

1. Development of recommendation for guidelines for field source measurement,
2. Development of recommendations for guidelines for environment-specific field measurement,
3. Environmental field surveys,
4. Development of recommendations for guidelines for Personal Exposure Measurement, and
5. Development of an EMF measurement Database.

1.3 PROJECT # 3: ENVIRONMENTAL FIELD SURVEYS

This report describes the performance and the results of Project # 3 "Environmental Field Surveys". There are many sources of magnetic fields in the environment. The most commonly discussed sources are from electric power lines and facilities. Important questions remain concerning which occupational and public groups are exposed to magnetic fields and at what level these exposures might be occurring. Some attention has been given to populations living near transmission line corridors, but only minimal regard to other magnetic field sources. Increasing public concern has been evident for magnetic fields in and around schools and in the work place. In New York State, California, and Canada various studies have been or are being conducted to characterize the EMF environment near and in schools. Most of the effort is concentrated on magnetic fields from utility owned transmission and distribution facilities. However, there are numerous other field sources present in the environment.

An objective of this project is to identify candidate environments and to conduct preliminary surveys in these environments. This information may also be used at a later date for further study of field sources, exposure assessments, and for developing options to mitigate fields. Another objective of this project is to provide information on contributions of field sources in the surveyed environments. Although not strictly a statistical report, this information will assist in future epidemiology studies and human risk assessments.

This project was conducted by Enertech Consultants from April 1995 to April 1996 as a subcontract from Lockheed Martin Energy System (LMES), Inc.. Dr. Paul Gailey of the Oak Ridge National Laboratory (ORNL) managed the project for LMES.

First a review of past environmental survey was conducted (see Section 2).

On the basis of this review and of discussions within the research team and between the research team and the staff of ORNL the environments to be surveyed during this project were identified (see Section 3).

A protocol designed to achieve the goals of the projects was prepared by Enertech and approved by ORNL (see Section 4).

The sites selected are listed in Section 5.

The methods of data management and analysis are described in Section 6.

The results obtained are described in Section 7.

The data produced by this project will be a part of the EMF Measurement Database. The structure and content of the data are described in Section 8.

The main conclusions of this Project are presented in Section 9.

This report is accompanied by several Appendices reporting the results obtained in detail.

Section 2

REVIEW OF ENVIRONMENTAL FIELD SURVEYS

2.1 INTRODUCTION

A preliminary review of existing EMF surveys was made to obtain background information which would be helpful in designing the survey protocols.

The review did not involve an exhausting search of existing publications. In planning the review the focus was kept on the issues that would influence the choice of environments to be surveyed and on the survey protocol adequate for that environment. These issues include:

- which environments were surveyed and why,
- what type of information was obtained: field levels, field characteristics, human exposure, source identification, source characterization, or other,
- what type of instrumentation and measuring technique was used,
- what protocol was used.

The review of past surveys summarized in this report is sufficient to draw conclusions on which to base recommendations for choice of environments and protocol.

2.2 LIST OF ENVIRONMENTAL FIELD

A list of articles and documents that describe EMF surveys is shown in Appendix I.

The documents are divided according to the type of environments surveyed. Even though the survey is not complete and additional relevant documents may be available, it is obvious that two environments have received the greatest attention: the residential environment, and the electric utility facility environment, as shown in the Table 2.1. Offices also have been looked at in several studies, but almost exclusively in relation to magnetic field from video display terminals (VDT).

Table 2.1 Number of Documents on EMF Surveys Divided by Environment

Type of Environment	Number of Documents (Appendix I)
Residential	37
Electric utility facilities	26
Offices	15
Schools	7
Transportation	5
Metal fabrication / welding shops	2
Hospitals	2
Machine shops	1
Agricultural	1
Shopping mall	1
Telephone facilities	1
Paper mills	1
Uranium enrichment industry	1

The residential environment has been surveyed extensively because some epidemiological studies have found an association between childhood cancer and proximity of residences to power lines.

The electric utility facilities have been extensively surveyed because the concerns about power frequency magnetic fields originated from studies of exposure near electric utility facilities, particularly power transmission and distribution lines, which may be responsible for some of the largest magnetic fields measured inside residences.

2.3 SURVEY REVIEW FORMAT

A review of the different documents was made following the format shown in the following example. The example shown below is the one with which the research team is most familiar.

Example Review of Environmental Surveys

Title

EPRI Survey of Residential Magnetic Field Sources - The 1000 Home Study

Period

1989 - 1990

Environment Types

Residences

Areas Surveyed

All rooms (Kitchens, Bedrooms, Living rooms, Bathrooms, Dining rooms, Family rooms, Halls),
Outdoor periphery,
Under power lines near residences,
Near electrical appliances.

Purpose of the Survey

Identification of all significant sources of 60 Hz magnetic fields in residences.
Estimation of the magnetic field levels caused by each source inside the residences.
Estimate, for each source, of the percentage of residences where magnetic fields exceed specified levels.
Determination of the relationship between magnetic field, source parameters, and source characteristics.
Characterization of field variations in space and time.
The survey was not intended to measure exposure of people to magnetic fields.

Instrumentation

Three-axis digital recorders for measurements of:
the rms value of the 60 Hz component,
the rms value of the third harmonic (180 Hz),
and the total harmonic field (100 Hz - 1 kHz).

Wheel for measurements of field versus distance.

Special device called "tracer load", to be inserted at a 120 V outlet, for measuring the contribution of house loads to the ground current, and to the residential fields caused by ground currents.

Clamp-on ammeters to measure the net current in the service drop.

Number of Sites

996 residences

Selection of Sites

Random selection from all residential customers of EPRI member utilities

Protocol

Especially designed for source identification and characterization by a crew of two operators for the measurements (one indoors and one outdoors) plus a utility representative who answered resident's questions and administered a questionnaire.

Two visits to the residence, the first lasting 1 1/2 hours to make measurements and install 24 hour recorders, and the second to retrieve the recorders.

Activities during the first visit included:

- Introduction of the measuring team.
- Documentation (questionnaire, photos and sketches) of residence and power lines.
- Automatic diagnostics with special instrumentation, including spot measurements at the center of each room.
- Detection of unusual wiring inside the residence.
- Installation of 24-hour recorders at 4 characteristic locations..
- Lateral profiles of neighboring transmission and distribution lines.
- Measurements of fields around the periphery of the residence.
- Magnetic field measurements made at 3 different distances from selected electrical appliances.

Data

Several analyses were made to obtain characteristic magnetic field quantities from the raw recorder data.

A comprehensive database was constructed containing up to 1400 variables per residence. The database contains information on the characteristics of the residence, characteristics of the power lines, spot measurements in each room of the residence, fields variations versus time over 24 hours, third harmonics, total harmonic contents, relative values of field components, field from electrical appliances, field around the periphery, etc. The data base can be used for statistical analyses and to determine the correlation between fields, residence characteristics, and power line characteristics.

Sources

The following sources were identified and characterized:

- Overhead power distribution lines (sources of highest average fields)
- Overhead power transmission lines (sources of highest average fields)
- Underground power distribution lines
- Residence grounding system (sources of the highest top 5% fields)
- Electrical appliances (sources of the highest maximum fields)
- Some multiple way switches and associated wiring.
- Grounding of sub-panels
- Wires for floor or ceiling heating

Reference

"Survey of Residential Magnetic Field Sources", EPRI Report TR-102759-
Volume 1 and Volume 2. September 1993

2.4 SURVEY REVIEW SUMMARY

Period

Magnetic field measurements and calculations date back several decades. However, the first systematic magnetic field measurements made for the purpose of assessing people exposure to magnetic field were performed during the 80s. Table 2.2 gives the number of magnetic field survey documents included in Appendix 1 published in each year.

Table 2.2 Year of Publication

<u>Year of publication</u>	<u>Number of documents</u>	<u>Year of publication</u>	<u>Number of documents</u>
1971	1	1988	8
1972-1981	1	1989	10
1982	3	1990	5
1983	5	1991	8
1984	1	1992	9
1985	1	1993	18
1986	2	1994	21
1987	6	1995	4

Purpose of the surveys

The purpose of most surveys was exposure assessment, either as a separate issue or in conjunction with epidemiological studies planned or in progress. The different purposes of the surveys described in the documents reviewed so far are listed in Table 2.3.

Table 2.3 Purpose of the Surveys

<u>Purpose of the survey</u>	<u>Number of reviewed documents</u>
Exposure assessment	15
Environment assessment (establish range of field levels)	8
Development and validation of analytical models for field calculations or exposure assessment.	9
Source identification	6
Create a database	5
Field management	3
Field or source characterization	2
Development of measurement guidelines	1

Number of sites

The number of sites varied from 1 to 2000 depending on the scope of the survey. On one end of this spectrum, two thousand transmission line right of ways were surveyed by the Tennessee Valley Authority to create a database for the transmission lines in their service area. On the other end, several documents describe surveys of one site only. The latter type of survey was made, for instance, when there were specific concerns for a specific site.

Site selection criteria

The sites in most surveys were selected on the basis of availability and convenience. Few surveys were made with a random selection process of the sites. Table 2.4 was constructed from the reviewed documents.

Table 2.4 Site Selection Criteria

<u>Site selection</u>	<u>Number of reviewed documents</u>
Selection on the basis of availability and convenience using volunteer sites and people	20
Sites selected to obtain a large spread of certain parameters (e.g. a large variety of equipment models, a large spread of line currents, several different construction types)	6
All available sites	4
A random sample of the available sites	1
Sites corresponding to cases and matched controls	1

Instrumentation

Most of the magnetic field surveys were performed using either a single axis or a three axis meter giving rms values. The three axis meter was in general a digital recorder, which in some surveys was used to measure personal exposure, or to obtain recordings of field versus time, or - in conjunction with a mapping wheel- field profiles or maps. Only in a few surveys information about harmonic content, particularly the third harmonic or the total harmonic distortion, is given. Surveys designed to verify models or characterize sources included also some current measurements. The DC field was rarely measured. Magnetic field transients were practically never measured.

The most thorough characterization of the magnetic field was made for the transportation system using a portable waveform capture system recorder, which allowed the assessment of the frequency spectrum from DC to about 3 kHz.

Table 2.5 summarizes the instrumentation employed.

Table 2.5 INSTRUMENTATION

<u>Instrumentation</u>	<u>Number of reviewed documents</u>
Rms meter with single axis probe	11
Rms digital recorder with 3 probes to measure 3 orthogonal field components	12
Harmonic measurements or frequency spectrum	4
Rms field profiles	6
Rms field mapping	4
Current measurements	6
Personal exposure meter	6
DC field measurements	0
Transient capturing system	1
Small probe	1

Although the review is partial, it is clear that past surveys were essentially surveys of the rms magnetic field made with either single-axis meters or 3-axis recorders.

Protocol

The most common component of the protocol of the reviewed surveys is the spot measurement of the magnetic field made with a single or a 3-axis meter. The measurement location was either specified (e.g. center of the room, near front door, etc.), measurements were made uniformly over the entire area, or measurements were made only in proximity of field sources. The survey review performed so far shows the protocol components listed in Table 2.6.

Table 2.6 Protocol

<u>Protocol component</u>	<u>Number of reviewed documents</u>
Spot measurements at specified points	13
Spot measurements uniformly distributed over an area	5
Spot measurements near field sources	7
Personal exposure	5
Field profiles	10
Field maps	2
Time recordings	7

In general measurements were made at locations where people exposure is likely to occur. This is obvious for personal exposure measurements, and was generally the case for measurements near the source or at specified points. For measurements at points uniformly distributed over an area or along a field profile, the point of measurements was generally chosen at one meter above ground.

Sources

The surveys identified a large number of magnetic field sources, which are listed below. Please note that the review is not complete and many more sources may be added to the current list.

Sources of magnetic fields in residential environments:

Overhead power distribution lines
Net currents in service drops and ground currents in the grounding system
Overhead power transmission lines
Some multiple-way switches and associated wiring
Wires for floor or ceiling heating
Rising cables of multi-story buildings
Grounding of subpanels
Underground power distribution lines
Electrical appliances including:

Electric blanket	Water beds	Refrigerator
Electric range	Television	Air conditioner (window unit)
Microwave oven	Clock - radio (analog)	Ceiling fan
Fluorescent light	Electric clothes dryer	Coffee maker
Aquarium	Baseboard heat	Toaster oven
Electric heater	Non-ceiling fan	Dishwasher
Can opener	Food processor / blender	Toaster

Sources of magnetic fields in electric utility facilities environments:

Overhead power transmission lines	Overhead power distribution lines
Underground power transmission lines	Underground power distribution lines
Substation high and low voltage buses	Transmission lines entering a substation
Distribution lines entering a substation	Air core reactors
Shunt reactors	Capacitor banks
Neutral and ground currents in substations	Currents induced in substation structures
Motors	Bus from generators
Generators and exciters in a generating station	Electrical panels

Sources of magnetic fields in offices :

Net currents in electrical wiring	Video display terminals
Back of computers	Electric typewriters
Currents in cable channels	Portable heaters
Switches and relays in electrical distribution room	Raceway from transformer to electrical distribution room
Fluorescent lights	Fans

Sources of magnetic fields in schools :

Net currents in electrical wiring (this type of source occurs in a variety of situations)	Transformers, switchgear, and main distribution panel
Distribution lines	Transmission lines
Fluorescent lights	Electrical typewriters
Video display terminals	Air conditioners
Aquariums	Vending machines
Electrical panels	Record players
Copiers	Overhead projectors
Shop machinery	Wire ways in or under the floors
Power feed cables	

Sources of magnetic fields in the transportation environment:

Current in the catenary/track circuit
Power cable beneath coach floor

Sources of magnetic fields in other environments :

Welding cables	Induction Heaters	Welding transformers
Soldering guns	Sputtering chamber	Welding gun
Rectifiers	Xenon arc lamps	Fork lift
Scissors lift	Oscilloscopes	He-Ne lasers
Pinball machines	Dispatcher radios	Incubators
Video games		

2.5 CONCLUSIONS FROM THE REVIEW OF PAST SURVEYS

The most common metric used in the past environmental surveys is the rms value of the magnetic field in the frequency range that includes the power frequency and its most significant harmonics. This choice was dictated by different reasons: availability of instrumentation, predominance of the power frequency field, results of epidemiological studies, and the need for practical protocols.

Availability of instrumentation.

When the first surveys were made the only meters available were of the single axis type and the operator either performed three separate measurements along three orthogonal axes or searched for the orientation of the probe that gave the maximum reading, which was called the "maximum field". Note that this is still an rms value; it is the rms value of the component of the magnetic field along the direction that gives the highest reading.

When three-axis meters were developed, they were used widely and the data were generally reported as the rms value of the "resultant" field, i.e. the meter performed internally the operation that the users of single axis meter had to perform manually: the square root of the sum of the squares of the rms values of the three orthogonal components.

It is noteworthy to observe that in the process of going from a single axis to a three axis meter the measurement of the maximum field was generally not made, because it became cumbersome and the common opinion was that the rms resultant was the quantity of interest. This situation generated some confusion that persists also today, since some guidelines recommend measuring the maximum field and this cannot be derived from the knowledge of the three orthogonal components. The maximum field could be anywhere between $(1/\sqrt{2})$ and 1.0 times the rms resultant. What generates this variability is the fact that the three orthogonal components may not be in phase. If they are in phase, as it happens, for instance, when the source of the field is a single current, the field maintains always the same direction in space and is said to be "linearly polarized", and the maximum field and the rms resultant coincide. In general, however, the field at the power frequency (and at its harmonics) describes an ellipse in space, and is said to be "elliptically polarized". The field polarization, defined as the ratio between minimum and maximum axis of the field ellipse, is the parameter that describes this particular feature of the magnetic field. Field polarization is rarely measured in surveys, and almost never described in the survey results. The instrumentation to measure polarization is now available (although more expensive and of less practical use than the three-axis field meters) and can be of practical use either alone or in conjunction with three-axes digital recorders.

Predominance of the power frequency field

Most surveys did not measure or did not report the harmonic content of the magnetic field. This is not only connected to the availability of instrumentation. In fact some three-axis digital recorders record also the total harmonic distortion, or the third and other predominant harmonics. Even when information about harmonics is collected, it is seldom reported. The report summaries are almost exclusively showing the rms field, and the main reason for that is that in most environments the harmonic distortion has little impact on the value of the rms field: with few exceptions the rms field is practically equal to the rms value of the power frequency field. For example, a 30 % harmonic distortion (which is a significant amount rarely exceeded) causes only a 4 % increase of the total rms value over the rms value of the fundamental power frequency component.

Recently, interest in obtaining information about harmonics has increased as a result of the emergence of resonance models and of data showing correlation between third harmonic and results of epidemiological results. Therefore, harmonic information is becoming desirable by itself, not because the harmonic content may affect the rms value of the field.

Results of epidemiological studies

All the epidemiological studies that have shown an association between magnetic field and some health outcome have used the rms value, obtained using single-axis or three-axis meters or through field calculations, as the measure of the magnetic field. This is a powerful reason for continuing the focus on rms measurements.

Epidemiological studies, however, have shown several inconsistencies. Some have shown that health outcomes are better associated with indirect field measurements (such as proximity to electrical installations) than with direct magnetic field measurements. This has fueled speculations that parameters other than the rms field value are responsible for the health outcome. Researchers have pointed on various occasions to: intensity of harmonics, direction of the field in space, direction of the field relative to the DC field, polarization, variations of the field with time (intermittency, coherence, window effects), and magnetic field transients. None of these parameters were measured, or if measured were not used to draw conclusions in epidemiological studies. All of these parameters can be measured with instrumentation available today, although the measurement protocol may become complex and cumbersome.

Protocol practicality

The way a survey is planned and executed depends not only on the quantities that one desires to collect, but also on practical considerations of logistics and cost. Some of these considerations may drive the choice of measurement protocol. For example, the EPRI 1000 home study was designed to obtain representative data on magnetic field sources in United States homes. A compromise had to be made between two conflicting requirements: a random selection of residences and a lengthy measurement campaign for each residence. The requirement to choose residences randomly resulted in imposing a time limit (one to one and one half hours) for the visit to each house. It was determined

that longer visits would severely limit the number and type of people willing to participate in the survey. As a result of the choice made, the refusal rate was acceptable and the data were considered representative. On the other hand, the time limit imposed a number of constraints on the number and type of measurements that could be made.

Source identification and characterization

Few studies have been specifically directed toward source identification and characterization. As a result there is the need for more information if such issues as risk assessment and magnetic field management need to be addressed.

Source identification and characterization in the residential environment has received most attention. Theoretical models of residential sources (electric blanket, power lines, net service drop and ground current) have been constructed and validated.

Source characterization has been particularly fruitful for the electric utility environment. The way transmission and distribution lines produce magnetic fields has been studied in great detail and new line designs to reduce fields have been proposed, as have schemes to reduce fields of existing constructions.

For other environments, however, source identification and characterization has been sketchy at best. For example, most of school surveys have been made in response to the perception that the field of nearby power line was responsible for high levels of exposure. In fact, the field from sources other than power lines was found in most cases to be the highest. On average, the field in schools was found to be significantly higher than in residences. However, there is no clear determination of the contribution of different sources and characterization of field sources as it may needed to take well reasoned policy actions. The same goes for other environments, where exposure to higher than residential field levels may exist for a great number of people. The information available is anecdotal and hardly useful, except for a preliminary assessment.

Section 3

CRITERIA FOR ENVIRONMENT SELECTION AND ASSESSMENT OF SURVEY REQUIREMENTS

3.1 CRITERIA FOR ENVIRONMENT SELECTION

It is important to obtain information on field levels and field sources in different environments in an effective and efficient way in order to contribute to the RAPID research program in a timely fashion. The needed approach is one that maximizes the usefulness of currently available information, avoids duplications, and provides results in stages with each stage immediately useful and providing data that are currently needed and can be easily included in the following stages.

The purpose of this project is to conduct "preliminary surveys", which may be expanded into more comprehensive surveys later if needed. For this reason the number of environments that will be surveyed in this project will be limited to those for which publicly available information is not adequate and that are of interest to epidemiology and public policy.

The RAPID Engineering program management has recommended the exclusion of **electric utility facilities** from this project, because (1) their field levels and source characteristics have already been widely studied and (2) research on exposure assessment, source characterization, and magnetic field management for electric utility facility is being made by other organization, particularly the Electric Power Research Institute (EPRI).

For similar reasons as stated above, the research team of this project recommended to exclude the residential environment, which has already been extensively studied, as indicated in the Section 2.

The **transportation environment** has also been extensively studied, although much less than the residential environment. The EMF characterization of the transportation environment is the object of research effort sponsored by the United States Department Of Transportation (DOT) under the leadership of the Transportation Research Board. Several studies have already been made to characterize EMF exposure aboard surface trains, subway vehicles, and in passenger stations. Good characterization of fields and field sources have been developed.

On the other hand, many other environments such as schools and commercial buildings have been studied to a much lesser extent, and in general only in regard to the possible proximity to overhead power lines. Seven different environment types were originally proposed for the purpose of conducting the RAPID Program's preliminary field surveys:

Schools, Offices, Grocery Stores, Shopping malls, Hospitals, Machine Shops, Metal Fabrication Shops where welding equipment is used.

The criteria used for the selection of the environment types are:

1. A potentially significant exposure to EMF may take place because of the large number of people and/or the significant amount of time people spend in that environment type.
2. A potentially significant exposure to EMF may take place because of unusually higher field levels or fields with unusual characteristics.
3. EMF exposure is of particular concern because of the population using the environment type. Concerns may rise, for example, because of results of past epidemiological studies, involvement in previous public debate or litigation, or because the people of that environment may be particularly sensitive (pregnant women, ill people, or people recovering from illness).
4. The environment type has not been previously studied in a comprehensive way, and information about sources and source characteristics is not sufficient for the purpose of exposure assessment, design and interpretation of epidemiological studies, risk assessment, and making decisions regarding field management.
5. The environment type is not systematically studied by another qualified organization, either in past studies or in studies now in progress..
6. Access to the sites of the selected environment type must be practical so that the preliminary surveys envisioned by the RAPID Program can be performed efficiently within the amount of efforts allocated to this project.
7. Information on the selected environment will help in the interpretation of existing and future epidemiological research.

Table 3.1 lists several environment types and scores each of them on the basis of the criteria discussed above.

Table 3.1 Environment Types and Criteria for Selection

Environment type	Large amount of people / time	Possible unusual fields	Population of concern	Insufficient previous studies	Not studied by other qualified organizations	Practical access to the sites	Helpful to epi studies
Residential	√		√			√	√
Schools	√		√	√	√		√
Hospitals	√	√	√	√	√		
Transportation vehicles and stations	√	√					
Industrial Settings							
Electric Utility Facilities	√	√				√	√
Machine shops	√	√		√	√	√	
Metal fabrication / welding shops		√		√	√	√	√
Aluminum smelters				√	√	√	√
Commercial Settings							
Office buildings	√		√	√	√	√	
Grocery stores	√			√	√	√	
Shopping malls	√			√	√	√	
Appliance stores				√	√	√	
Entertainment areas	√			√	√	√	

The scores from the above table indicates the following ranking for inclusion of different environment types in the surveys of this project:

1:	Schools
2, 3, 4, and 5:	Office buildings, Machine shops, Metal fabrication / welding shops, Aluminum smelters,
6, 7, 8, 9 and 10:	Residences, Hospitals, Grocery stores, Shopping malls, Entertainment centers

Enertech Consultants first recommended to ORNL to conduct field surveys in 7 of the above 9 environment types. This recommendation, however, was under the assumption that measurements of magnetic field transients were not to be performed. Magnetic field transient data are of great interest; however, their execution requires a significant effort. After discussion with ORNL magnetic field transient measurements were included in the protocol and five environments were selected for the survey. The number of sites per environment was set equal to four. The selected environments were:

- 1 - Schools
- 2 - Office buildings
- 3 - Machine shops, or Metal fabrication shops where welding equipment is used
- 4 - Hospitals
- 5 - Grocery Stores

The rationale for the proposed selection of environments is the following:

- Schools represent a particularly sensitive environment because of the results of some epidemiological studies showing a possible association between magnetic field and childhood cancer.
- Office buildings are an environment where a very large segment of the population spends a significant part of their lives. Office workers quite often include pregnant women.
- Machine shops represent a very common industrial environment with a large variety of possible sources of high and unusual fields. Metal fabrication shops where welding equipment is used represent an environment where high strength and unusual magnetic field sources may be present.
- Hospitals are a sensitive environment because of the presence of people who are sick or recuperating from sickness and may be more vulnerable to environmental stresses.

- Grocery stores are, among commercial sites, places with the largest number of people.

Shopping malls would have been an interesting environment because of the large number of people that work and visit there. They often include entertainment centers such as movie theaters and video arcades and fast food restaurants. However, the efforts to survey shopping malls would have been very large and might have required a reduction in efforts dedicated to the surveys of the other environments.

Aluminum smelters were not included in the recommended sites because it was thought that the work necessary to contact, and obtain the participation of suitable sites, and to perform the measurements at locations which are far from the locations of Enertech's offices would have exceeded the amount of efforts budgeted, unless the number of the other proposed environments or sites were considerably reduced.

3.2 ASSESSMENT OF SURVEY REQUIREMENTS

For each environment type the number of sites to be surveyed was set at four. This number was chosen because it was estimated that the project could be completed in 12 months and within the budgeted effort. It was also estimated that data from four sites for each environment would be sufficient for identification and characterization of the major environment-specific sources, determination of ranges of field levels, and information necessary for planning exhaustive surveys designed to obtain statistical results with preset accuracy targets.

The sites were to be chosen in a way to capture, to the extent allowed by the low number of sites, the effect of geographical and urban/suburban/rural diversities. To capture this diversity to the largest possible extent, measurements were to be performed in two areas with quite different climates. For each environment type two sites were to be chosen in Northern California (at driving distance from Enertech's Campbell office), and two sites in the Northeast United States (at driving distance from our office in Lee, Massachusetts). An environment "site" was defined as a complete architectural structure and associated areas that serve the purpose of the environment. For instance, a site for the study of the school environment is a school building, not just a classroom. A site for the office environment is an office building, not just an office or a floor.

It was intended to select sites with different characteristics, not only geographically, but also in terms of other parameters. As it turned out, recruitment of sites was very difficult and only a handful of sites for each environment was found that responded positively to the invitation to participate in the survey. Nevertheless sites of various ages (from a school a portion of which was built in 1895, to a five year old office building) were recruited.

Section 4

PROTOCOL FOR ENVIRONMENTAL FIELD SURVEYS

4.1 PURPOSE OF THE PROTOCOL

This protocol was developed for the environmental field surveys performed during the Engineering Project #3 of the EMF RAPID Program. The goal of this engineering project is to provide data for the assessment of exposure in different environments by type of people and by type of source.

It is hoped that this protocol will be useful also for those that will be engaged in future environmental field surveys having similar goals.

The purpose of this document is to provide clear instructions to the team of operators that will perform similar surveys and to provide a good reference to investigators that will use the survey results.

4.2 INFORMATION AND DATA TO BE OBTAINED

Two types of data are to be obtained: (1) data regarding strength and other characteristics of the magnetic field in different areas of a chosen environmental site and at different exposure points, and (2) data regarding people activities at the site. (For the definition of "environment", "site", "area", and "exposure point", see section 4.10).

Magnetic Field Data

The data of the survey will be contained in a database. The results will be presented in a number of summaries.

Area Data : The survey will provide the following data for each area of the site: magnetic field components and resultant at several points uniformly distributed over the area. The following data will be entered in the data base:

Number of measuring points

Area field r.m.s. average, $B_{a_{ave}}$, which is the average of the r.m.s. resultant magnetic fields in the frequency range from 40 Hz to 800 Hz measured at about 1 meter above the floor at several points uniformly distributed over the area surveyed.

Area field standard deviation, minimum, median, and maximum, $B_{A_{std.dev.}}$, $B_{A_{min}}$, $B_{A_{50}}$, $B_{A_{max}}$.

Magnetic field rms values corresponding to the following percentile levels: 1%, 5%, 10%, 25%, 50%, 75%, 90%, 95%, and 99%.

Temporal Field Variation Data. In some areas, a recorder will be placed at a secure location away from exposure points. This recorder will record the resultant rms magnetic field every 3 seconds. The following data will be placed in the data base:

start time (day, hour, min, and second) of the recordings
stop time (day, hour, min, and second) of the recordings
number of observations
average field during the recording period, $B_{24_{ave}}$
standard deviation, median, geometric mean and geometric standard deviation:
 $B_{24_{std.dev.}}$, $B_{24_{50}}$, $B_{24_{gm}}$, $B_{24_{gsd}}$
minimum, maximum: $B_{24_{min}}$, $B_{24_{max}}$
values corresponding to the following percentile levels: 1%, 5%, 10%, 25%, 50%, 75%, 90%, 95%, and 99%.

Simultaneous AC and DC measurements. Results of combined AC and DC measurements at up to 5 different points per area will be available. At each point the results will include: magnitude of the DC field, rms value and phase angle of the AC field (at 60 Hz and at each harmonic frequency up to 3000 Hz) parallel to the DC field, rms values and phase angles of the two orthogonal components of the AC field (at 60 Hz and at each harmonic frequency) that are perpendicular to the DC field. In addition, the value of the unperturbed DC field away from the site will be available. These data will be put in a data base from which different types of summaries may be produced. For example, the following summary quantities will describe some of the essential features of the AC and DC field combination, for all areas of the site combined.

- DC field distribution: average, standard deviation, minimum, median, and maximum.
- distribution of angles between the DC field vector and the major axis of the AC field.
- distribution of the values of polarization of the 60 Hz AC field.
- distribution of the rms values of the third harmonics (180 Hz) and of the fifth harmonics (300 Hz) of the AC field.

Source Data: For each measured field source of the site the following measurements are recommended:

Distance from the source surface	60 Hz						For all significant harmonics					
	X		Y		Z		X		Y		Z	
	mG	(°)	mG	(°)	mG	(°)	mG	(°)	mG	(°)	mG	(°)
D1 =	BX1	α X1	BY1	α Y1	BZ1	α Z1	Same type of data as for 60 Hz					
D2 =	BX2	α X2	BY2	α Y2	BZ2	α Z2						
D3 =	BX3	α X3	BY3	α Y3	BZ3	α Z3						

If measurements of phase angles are not possible, measurements of magnetic field magnitude should be made. If measurements at three points are not possible, measurements at a minimum of one point should be made.

For non-60 Hz field sources, the entire digitized waveshape of each field component and at each of three distances from the source surface will be available.

For each source the equivalent dipole moment magnitude (Am^2) at 60 Hz and at 180 Hz will be included in the database.

Peripheral Profile: The peripheral profile will be analyzed to help the operators identify the sources of field inside the site by determining the presence of net currents in water lines and in power lines connected to the building. These data will not be placed in the database.

Lateral Profile: The lateral profile of all power lines adjacent to the sites will be analyzed to determine the field values and the rate of field decay at the perimeter of the site. This will help the operators to determine if power lines are a source of field in the areas of the site.

Magnetic Field Transients: The following data summary will be provided:

- period of recording,
- number of transients recorded above an established threshold,
- maximum peak-to-peak amplitude of recorded transients in each of three orthogonal axes,
- waveshape of transients magnetic fields with the ten highest peak to peak amplitudes.

People Activity Data

All the people activity data obtained during the survey will be contained in a database. The results will be presented in a number of summaries. Two categories of people activity data are required: data about activity in each area and data about activity at specific locations (*exposure points*).

The activities in each area are defined by the following data:

person type (must be descriptive of the occupation of the person and of the work of the person at the site),

number of persons (a range of possible values),

time spent in the area (a range of possible values),

mobility, defined by the percentage of time people move in the area, while being at a fixed location within the area for the remaining time (a range of possible values).

The activity at each exposure point are defined by the following data:

field source name,

zone of activity, i.e. the space within the zone of influence in which the activity takes place (a range of possible distances from the source center),

type of persons active at the exposure point,

number of persons active at that location, either simultaneously or at different times (a range of possible values),

time of exposure (a range of possible values).

Exposure Data: Magnetic field measurements and activity data can be combined to provide the exposure data such as described in Section 6: "Data management and analysis", and presented in Section 7 "Results".

4.3 TEAM MEMBERS

The measuring team is composed of three well trained persons with an engineering background. They will be indicated hereafter as "operator # 1", "operator # 2", and "operator # 3". One of the operators is the team leader, who arranges the schedule and maintains communications with the site "contact person" (for the definition of site "contact person" see Section 4.4) . Two persons will be performing the measurements

associated with a systematic rms field survey and source identification and characterization, and the third person will be in charge of setting up the instrumentation for magnetic field transients, and making measurements external to the site if needed.

4.4 PREPARATION REQUIRED AT THE SITE

Measurements are performed at each site after all the arrangements with the owners or operators of the selected sites have been concluded, and the measurements have been scheduled. The owners or operators should designate a site "contact person", who is authorized to schedule the measurements and make all the logistical arrangements needed. A floor map of the site should be provided by the site contact person in advance of the measurements. An x-y coordinate system is overlaid to the map.

4.5 INSTRUMENTATION

Systematic Survey of Magnetic Fields in All Areas of the Site

The measurements of AC fields are performed using a portable digital recorder EMDEX II set to store in its memory the rms values of the magnetic field in the frequency range that includes the power frequency and its harmonics up to 800 Hz. The stored values are the field components along three orthogonal axes and the field resultant.

The recordings of temporal variations of the magnetic field are performed using EMDEX II recorders.

DC field measurements are made using a system composed of a DC probe added to a three-axis waveform capture instrument, the EMDEX WAVECORDER™ (this measurement system gives the magnitude of the DC field and the magnitudes of the AC field components parallel and perpendicular to the DC field).

Source identification and characterization

The source identification is performed using a survey meter EMDEX SNAP to locate the points of fields significantly higher than the average area field, and identify the equipment that produces those fields.

For each significant source the waveshape of the magnetic field will be captured using the EMDEX WAVECORDER™ waveform capture meter.

Peripheral and lateral profiles

The peripheral and lateral profiles are taken using a EMDEX II recorder with a special wheel that allows recordings of the distance traveled for each field measurement, which are made at a rate of one every 1.5 seconds.

Magnetic Field Transients

Transient magnetic fields are measured using the "EPRI Transient Survey Measurement System". This instrumentation consists of a system of antennas contained in an 18 inch cubical housing, a digital sampling oscilloscope, and a personal computer interfaced to the oscilloscope, and a digital audio tape disk drive. The system captures the transients within a frequency range of 5 kHz to 12 MHz that exceed a selected threshold. Simultaneous measurements with another set of probes captures the 40 Hz to 5 kHz components. A detailed description of the Transient Survey Measurement System is provided in EPRI report TR-104532, December 1994: "Survey Measurements and Experimental Studies of Residential Transients Magnetic Fields".

4.6 LENGTH OF WORK AND DESCRIPTION OF EACH DAY'S GOAL

Measurements at each site require two or three days depending on the complexity of the site. For sites with a large number of areas, such as large multi-floor sites, a few of many areas with similar functions are selected per floor or a few of many floors with similar function are selected and all the areas of those floors are surveyed. For an average two-day duration, the activities are divided among the two days as follows:

- the first day is dedicated to a systematic rms magnetic field strength survey, source identification and characterization, and placing of several 24-hour recorders and instrumentation for magnetic field transient recording;
- the second day is required for completing the survey and the source identification and characterization, and for the retrieval of the 24-hour recorders and of the magnetic field transient instrumentation.

If necessary measurements should continue for a third day, until completion.

4.7 FILE AND DATA CODING

The data of the survey will be contained in the *EMF Measurement Database*. The *metadata* which describe the organization of the data set and the *data products* that are included in the data set are presented in Section 8.

4.8 DETAILED DESCRIPTION OF TASKS

The protocol includes the work tasks described below in order of performance:

1. Meeting between the "measuring team leader" and the site "contact person". The purpose of the meeting is to make or review the schedule of the measurements in the different areas of the site. The contact person will review the rules about safety and

security of the site that the measuring team must follow. The contact person or another person designated by him should accompany the measuring team in the different areas. He or she should be authorized to enter in all the areas to be surveyed. He or she should be reasonably knowledgeable about the activities of the site, so that plausible answers can be provided to the questionnaire on people activities (see tasks 3 and 7).

2. Systematic survey of r.m.s. magnetic fields in all areas of the site. The purpose of this task is to obtain systematic data on the distribution of magnetic field rms values in the area surveyed, and to create field contour lines for the purpose of source identification. Measurements start at one area of the site and systematically continue until completion. Measurements are performed (by Operator # 1) using a portable digital recorder set to store in its memory the rms values of the magnetic field in the frequency range that includes the power frequency and its harmonics up to 800 Hz. The stored values are the field components along three orthogonal axes and the field resultant. The instrument is kept at constant orientation, so that its axes are always parallel to the reference axes x and y of the site and to the vertical (z axis). The measurements are executed every 1.5 seconds while the operator is slowly walking along a path chosen to cover uniformly the area to be measured. The instrument is kept at a height of about one meter above the floor. The measurements are taken without disruption of the activities in each area, and without waiting for an interruption of such activities, with the field sources in their normal operating condition. This measuring technique allows carrying the recorder over tables, chairs, and other objects that are lower than one meter.

Before the survey, the sketch of all areas are prepared on the basis of the site floor plan. At this stage, the sketch (see Figure 4.1) of an area shows only the general shape of the area, its orientation with respect to the x , y coordinate system chosen for the site, and its approximate dimensions, derived from the floor plan.

Approximate dimensions are sufficient for exposure assessment, as well as for source identification and characterization. In fact, it may be more convenient to prepare the area sketches all with the same proportions as those indicated in Figure 4.1, even though the actual area may have different shape. The "File Name" is the name assigned to the data file after downloading from the recorder. It should be in the form: X#_YYYY, where "X" is a letter that characterizes the type of environment (O for Office Building, G for Grocery Store, H for Hospital, M for Machine Shop, S for School), "#" is the site number (1 to 4 in this project), "YYYY" is a four letter identification of the area.

Envir. Type: School Area ID: Rm 23 Area Type: Classroom Date: 10/9 Operator: John Jones
File Name: SD - Rm 23

AREA ACTIVITY

Person <u>type</u>	Number <u>of persons</u>	Time <u>in area</u>	<u>Mobility</u>
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Main Area Field Source:

EXPOSURE POINTS

Field <u>Source</u>	Activity <u>Zone</u>	Person Type	
		(<u>N</u>) <u>time</u>	(<u>N</u>) <u>time</u>

4-9

Envir.Type: _____ Area ID Rm 25 Area Type _____ Date _____ Operator _____
 File Name SD - Rm 25

AREA ACTIVITY

Person type	Number of persons	Time in area	Mobility
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Main Area Field Source:

EXPOSURE POINTS

Field Source	Activity Zone	Person Type	
		() N time	() N time

103

X

201

Figure 4.3 - Area Sketch after Field Mapping (Irregular Path).

3. Questionnaire on people activities - Part I (Area activities). While Operator # 1 is making a measurement survey of the area, Operator # 2 and the Site Contact Person complete the part of the Questionnaire on People Activity that refers to the general activities in the area (*area activities*). The questions about area activities are indicated in the upper right corner of the Area Sketch.

Two categories of exposure are defined: general exposure in the area and exposure at specific locations (*exposure points*). Information about area exposure is recorded at this time, while information about exposure points is recorded later (after source identification).

The activities in each area are defined by: *person type*, *number of persons* and *time in the area*. These data are sufficient to assess exposure if the area field is relatively uniform. However, if the field is not uniform, another parameter may be needed, called *mobility*.

The *person type* must be descriptive of the occupation of the person and of the work of the person at the site. A list of person types is shown in Section 6.

The *number of persons* may be a specific number or a range of numbers if the number is not known exactly or if it varies from day to day.

The *time* spent in the area may be given in hr/day or in min/day or in % of an 8 hour day. When this time is transcribed into computer files, it should be expressed in minutes per day. Range of values may be given when the time spent in the area is not exactly known, or when the time varies from one person to another, or when the time varies from day to day. If not otherwise specified, it is assumed that time is spent in the area is an average for all the working days of the year. If this is not true, a note should be added, for example: "6 hr/day for 2 days/week", or "1 hr/day for 9 months a year".

Mobility is defined by the percentage of time people move in the area, while being at a fixed location within the area for the remaining time. If a person is mobile, but only in a portion of the area characterized by different field levels, the fact should be noted. Better yet, the area should be divided into two sections measured independently. For instance, an office/reception area may have different sources in the office section (monitors, typewriters, copier, etc) than in the reception section. If a certain type of persons (visitors) occupy only the reception section, they will not be subjected to the field of the sources in the office section, even though they may be 100% mobile.

If an area has different sections, each characterized by different activities and different magnetic fields, it is preferable to consider each section as a separate area. The extent by which this is done depends on the desired degree of detail. For instance, it is not generally desirable to divide a room into more than one area, unless both the activities and the field in the room are very non uniform. However, it may be advisable to divide a cafeteria into: dining area, serving area, and kitchen.

4. Field contour lines. An important goal of the survey is to identify the sources of the magnetic field in each area. Source identification may be an easy task in many cases. In other cases, however, the operator may need all the available tools at his or her disposal. If this is the case, immediately following the measurements in each area, the data of the recorder are processed (by Operator # 2) using a portable computer that will show on the screen the magnetic field contour lines. The portable computer is carried on a small dolly cart, which also carries the instrumentation for source characterization (see item 8) and for DC measurements (see item 12). These lines are created by an automated process (produced by commercially available instrumentation and software) that requires only a minimal amount of input from the operator. In fact, if the pattern of the measurement path is regular, only the type of pattern needs to be entered. The dimensions of the area are not important for the identification and characterization of sources and for exposure assessment. The type of pattern is indicated by a special code expressing the number of passes made parallel to each axis. For instance, the pattern of figure 4.2 is indicated by the notation: 4 y, meaning that the pattern starts from a point near the origin and in the y

direction, and that there are 4 full passes parallel to the y direction. Areas that do not lend themselves to this type of regular mapping require that the operator records the coordinates of all turning points. In the case of an irregular path, the dimensions of the area must be measured or estimated, and must be indicated on the Area Sketch (see example of Figure 4.3). For instance, the pattern of Figure 4.3 is indicated by the coordinates of each turning point as shown in the following table:

Table 4.1 Example of Coordinates of Turning Points for an Irregular Path

<u>Milestone</u> (#)	X (feet)	Y (feet)	<u>Milestone</u> (#)	X (feet)	Y (feet)
1	2	2	7	7	4
2	2	28	8	7	2
3	18	28	9	13	2
4	18	20	10	13	12
5	12	20	11	18	12
6	12	4	12	18	2

The field values recorded while the operator travels along a segment from one turning point to the next are assigned to points uniformly distributed along that segment. Turning points are recorded by pressing the event marker button of the recording instrument. The procedure gives reasonably accurate results for the purpose of identifying the origin of the field, provided the operator walks at a uniform speed between turning points. Using this procedure, 100 measuring points can be obtained in less than 3 minutes.

An example of contour lines is shown in Figure 4.4.

Figure 4.4 - Contour lines drawn after field mapping

5. Source identification. While Operator # 2 is developing the contour map, Operator # 1 performs a "visual survey of field sources". Operator # 1 uses a survey meter to determine whether there are sources of fields significantly higher than the average area field. If the source of the field is external to the area, the direction from which the field emanates is found (below the floor, on the other side of a wall, above the ceiling). For this purpose, measurements should be performed at different heights above ground (to determine whether the field source is below the floor or above the ceiling), and at different distances from walls (to determine whether the field source is on the other side of a wall).

Field sources and their location are marked on the Area Sketch. A field measurement at one foot from the surface of the source in the direction of possible people's activity space is made and the measured value is indicated on the sketch. The purpose of this measurement is to help formulate the source characterization plan (see item 6) and to obtain magnetic field data for sources without using the time consuming procedure described in item 8. The Area Sketch will look like the example of Figure 4.5.

Figure 4.5 Area Sketch after source identification by Operator # 1.

6. Source characterization plan. When Operator # 1 has completed the identification of field sources and Operator # 2 has developed the contour lines, the two operators hold a "Source Identification Conference". The two operators compare their results, discuss which is the main source of the field in the area, and decide whether further investigation is needed. Further investigation may include tracing the path of net currents in and outside the area, looking in adjacent areas for the presence of sources whose influence extend to the surveyed area, and looking for the presence of power lines adjacent to the site. The main area field source is noted in the Area Sketch. Finally, the two operators agree on the sources whose field should be characterized. The result of the conference is the "Source Characterization Plan" for the area.

All significant sources of exposure should be included in the plan. In preparing the plan, the following criteria should be followed:

- The sources corresponding to the highest values of magnetic field obtained during the preliminary measurements should be included.
- The sources corresponding to the largest values of exposure (estimated by the operator after observing people activity patterns within the area during measurements) should be included in the plan.
- Measurements on identical sources should not be repeated (for instance, if a building has several air conditioning units of the same type, only one or two need to be measured). If an identical source was measured in a previous area, measurements need not be repeated. This situation should be noted on the sketch.
- The total number of sources included in the plan should not exceed the number of sources that an operator can measure within the budgeted time, which includes the time required for positioning of the instrument, taking measurements at three points, observing the waveshape, adjusting the instrument setting when needed, and transferring the data to a personal computer. A maximum of 50 sources could be characterized during the two day measurement period.

The sources that are included in the "source characterization plan" are marked with an asterisk on the Area Sketch. The preferential direction of the position of people away from the surface of the source should be marked with an arrow. The direction of measurements should coincide with the preferential direction. When there is no clear preferential direction there still should be one (for point sources) or more (for large sources) measurement directions and these should be marked with arrows on the area sketch. For each source and each direction of measurements, 3 measurements should be taken at three different distances from the source surface. The distances recommended are 6, 12, and 24 inches. For sources whose influence is clearly dominating a very large area, measurements should be made at wider intervals and the intervals should be noted on the Area Sketch, for example 12, 24, and 48 inches or 24, 48, and 96 inches.

The waveform record numbers should be written on the Area Sketch, near the asterisks (see Figure 4.6).

The candidate locations for recordings of temporal field variations of area fields should be selected and included in the source characterization plan. This selection should be made on the basis of (1) expected temporal variability of the source field (a source which is always "on" during the period of exposure is not a suitable candidate), and (2) practicality of locating the recorder in a convenient, safe, and secure position. In order to capture the temporal variability of the area field it is convenient to place a 24-hour recorder away from exposure points. A total of 3 to 5 recorders should be placed at locations in the various areas surveyed during the first day of measurements.

The points selected for the temporal field variation measurements are marked (with a clock) on the Area Sketch.

Figure 4.6 shows the Area Sketch after transcription of the "Area Activities" data, determination of the main area field source, selection of the sources to be characterized, and selection of sources for temporal field variation measurements.

Figure 4.6 Area Sketch after identification of sources to be characterized.

7. Questionnaire on people activities - Part II (Exposure points). While Operator # 1 is conducting source characterization measurements and placing the 24-hr recorders, Operator # 2 and the Site Contact Person complete the second part of the Questionnaire on People Activity that refers to the activities that take place at the exposure points. The questions are in the lower right corner of the Area Sketch and the answers are written directly on this sketch (see Figure 4.7).

An "exposure point" is the location where persons engage in fixed, site specific activities, e.g. sitting in front of a desktop computer or standing at a lathe in a machine shop, and where a local source creates a significant increase in the area field. If there is no local source, consideration of an exposure point is not necessary. Also, if there is a local source but no activity occurs there, consideration of that location is not necessary. An exposure point has a "zone of influence", which is the space in which the area field is affected by the local source.

For each exposure point the following data should be provided:

- "Field Source" name.
- "Zone of activity", which is the space within the zone of influence in which the activity takes place.

Simplification of the field measurement procedure requires substituting the concept of space with the concept of range of distances from the source. With this simplification, the zone of influence becomes a range of distances away from the surface of the source, in the direction toward the preferential position of the person or persons active near the source. This approach is suitable for sources characterized by relatively small dimensions and a clear position of the persons in relation to the source (e.g.: computer monitors).

If the source is relatively small, but the position of the persons in relation to the source is not clear (e.g. a slide projector), a range of distances should be given and the distances are interpreted as being equally likely in all the directions around the source. Measurements may still be performed in one direction only, in a way such that the field in all the other directions could be extrapolated.

If the source is relatively large and activities take place in different areas around the source (e.g. a large copier), the distances should be interpreted as distances from different points of the source surface and measurements should be preferably be performed in two or more directions away from different points of the source surface.

- "Type of persons" active at the exposure point.

- "Number of persons" active at that location, either simultaneously or at different times.
 - "Time" of exposure, i.e. the length of the period of activities at that exposure location. The time may be given in a number of ways:
 - hr/day = hour per day
 - min/day = minutes per day
 - % = percentage of the time spent in the area
 - occasional = something like 30 seconds to 2 minutes
 - WS = this is the workstation of the persons. The time persons spend at this location is indicated in the "Area Activity" questionnaire.
- For example if a person spends 6 hr/day in the area and has a mobility of 20 %, the time spent at his or her workstation is 4.8 hours. When the data are transcribed into computer files the time should be expressed in minutes per day.

Figure 4.7 Area Sketch after completion of part II of the questionnaire.

8. Source characterization. A detailed characterization of field sources is performed (by Operator # 1). The selected sources are those specified in the source characterization plan and indicated in the Area Sketch. For each source the waveshape of the magnetic field should be captured in at least three points within the zone of activity. The following protocol is specifically applicable to the EMDEX WAVECORDER™,

a waveform capture system commercially available through Enertech. The general approach, however, is valid for any waveform capture system.

Since the zone of activity may be different for each source, even if they are of the same type, the protocol should consist of measurements at predetermined points whose position is well defined in relation to the source surface (e.g.: 6", 1', and 2' from the surface).

The measurements should be performed along a straight line from the center of the source. Preferably, the measurement line should be either horizontal or vertical. The instrument should be oriented with its X axis pointed toward the center of the source.

The captured waveshape is used to provide the following data:

- 1) Fundamental frequency of the magnetic field.
The fundamental frequency is generally equal to the power frequency of 60 Hz. In some cases, however, the field has a frequency, f_d , different than 60 Hz. The waveshape then should be sampled for a period of time containing several 60 Hz cycles (e.g. 16 cycles).
- 2) R.m.s. values of the field strength along three orthogonal axes
- 3) Amplitude and phase angle for each axis and for all significant field components in the frequency spectrum from the fundamental frequency up to 3000 Hz.

Immediately after the waveshape is captured, it should be examined by the operator as it appears on the instrument screen. The operator should determine whether the waveshape fundamental frequency is 60 Hz or some other frequency. If the operator determines that the frequency is not 60 Hz, the instrument should be set to record for 16 60 Hz cycles (0.267 seconds) and a new recording should be made.

9. Temporal field variation recordings. Three to five recorders are placed near selected sources for measuring the temporal variations of their field. The instrument is set (by Operator # 1) to measure the field every 3 seconds. The location of the recorder should be noted on the Area Sketch (see Figure 4.7).
10. Simultaneous AC and DC field measurements. DC field measurements are made (by Operator # 2) at 5 points in each area (or in as many areas as possible). For a rectangular area, the measurements should be made at about 1 meter above ground near the center of the area and at 4 feet from each corner (or at the closest practical point) along the diagonals. The measurements are made with an instrument that gives the magnitude of the DC field and the magnitudes of the AC field components parallel and perpendicular to the DC field. This functionality is accomplished using a system composed of a DC probe added to a three-axis waveform capture instrument

and orienting the DC probe for maximum reading. The location of the measurement and value of the DC field are marked on the Area Sketch (see Figure 4.8).

Figure 4.8 Area Sketch after execution of the DC measurements.

In addition to performing DC measurements in all the areas of the site, DC field measurements are also performed (by Operator # 3) outside the site at sufficient distance from structures that may significantly perturb the earth magnetic field. This measurement will provide the reference DC field value from which it would be possible to derive the DC field attenuation caused by the building structure.

- Peripheral profile.** A peripheral profile is obtained (by Operator # 3) for each site. A peripheral profile consists of measurements of the magnetic field around the periphery of the site at a distance of 5-10 feet from the site borders (walls, or fences, or other demarcations). The peripheral profile is taken using a special wheel that allows precise recording of the distance traveled for each field measurement, which are made at a rate of one every 1.5 seconds. The purpose of these measurements is to assess the magnitude of the field caused by power lines near the site and to locate possible underground sources of magnetic field, which could be either power cables, current carrying water lines, or other current carrying conductors. An event marker is inserted in the data by the operator when passing near electrical equipment or underneath a power line or a service drop.

12. Lateral profile. For all power lines that produce a measurable magnetic field at the periphery of the area, a lateral profile is obtained (by Operator # 3). A lateral profile consists of measurements of magnetic field at different distances from the power line along a line extending up to or past the site being surveyed. The purpose of the lateral profile is to determine how much the power line field decays with distance, so that the contribution of the power line to the field measured inside the site can be estimated.
13. Magnetic field transients. Transient magnetic fields are measured using the "EPRI Transient Data Acquisition System" (described in the EPRI report TR-104532, December 1994: "Survey Measurements and Experimental Studies of Residential Transients Magnetic Fields").

The transient measuring system is installed (by Operator # 3) at a central location of each site, 20 or more feet away from electrical equipment and electrical wiring. The system should also be placed away from equipment that produces steady state high frequency fields, such as VDTs and fluorescent lights with electronic ballast.

The instrumentation is set to record transients with amplitude above a selected threshold. At first, the threshold will be adjusted to record repetitive transients or steady state high frequency fields that may be present at the site.

Then, the instrumentation will be set to record for a period of 24 hours (or for a work cycle). For the 24-hour measurements, the threshold will be set at 0.1 mG, for transients with frequencies of 100 kHz or greater, and at 0.4 mG for 10 kHz transients. These values correspond to the median values of the transient amplitudes recorded during the residential transient pilot study. In any case the threshold will be set above the level of repetitive transients and steady state high frequency background field that may be present at the site.

The data set acquired by the instrumentation system will be analyzed to provide a summary with the following data: period of recording, threshold, number of transients recorded above the threshold, statistics of peak to peak amplitudes for the transient magnetic fields recorded along three orthogonal axes. In addition, the waveshape of the transient magnetic fields with the ten highest peak to peak amplitudes will be given. For these transients the FFT amplitude in different frequency bins will be given (10 kHz - 100 kHz, 100 kHz - 1 MHz, 1 MHz - 10 MHz).

14. Instrumentation retrieval. The temporal field variation recorders will be retrieved (by Operator # 3) at the end of the second day of measurements, after at least 24 hours of recording, and their data should be downloaded to a PC. The transient instrumentation is retrieved (by Operator # 3) during the second day, after at least 24 hours of operation.

The following tables summarize the tasks and estimated average time of the protocol.

Table 4.2: Two day's tasks and estimated time

First day								
Time	8:30 - 8:45	8:45 - 9:15	9:15 - 9:45	9:45 - 10:15	10:15 - 10:45	10:45 - 12:00	13:00 - 14:45	14:45 - 17:00
operator #1	Task 1) Meeting with site "contact person"	Task 2/5/6/8/10) Systematic rms magnetic field strength survey, source identification and characterization: as many areas of the site as possible (for the details see table 2)						
operator #2	Task 1) Meeting with site "contact person"	Task 3/4/6/7/8b/9) Systematic rms magnetic field strength survey, source identification and characterization: as many areas of the site as possible (for the details see table 2)						
operator #3	Task 1) Meeting with site "contact person"	Task 11) Measure peripheral profile	Task 12) Measure lateral profile(s)	Task 12) Download profile data into PC, view and assess results	Task 10b) Perform DC measurements outdoor.	Task 13) Determine the appropriate location and install Transient Measurement System. Set trigger levels. Test system. Initiate temporal data collection.		Assist the other operators

Second day				
Time	8:30 - 12:00	13:00 - 15:00	15:00 - 16:00	16:00 - 17:00
operator #1	Task 2/5/6/8/10) Systematic rms magnetic field strength survey, source identification and characterization: as many areas of the site as possible (for the details see table 2)			
operator #2	Task 3/4/6/7/8b/9) Systematic rms magnetic field strength survey, source identification and characterization: as many areas of the site as possible (for the details see table 2)			
operator #3	Assist the other operators	Assist the other operators	Task 14) Retrieve 24-hr recorders and download data into PC	Task 14) Retrieve transient system

Table 4.3 Tasks and estimated average time for each area survey (Total average time per area: 17 minutes)*

Time (min)	Operator # 1	Operator # 2
1 2 3 4	Task 2) Area mapping with EMDEX II.	Task 3) Fill out Area Activity data sheet with help from Site Contact Person
5 6 7	Task 5) Source identification with EMDEX SNAP. Indicate sources on Area Sketch	Task 4) Download EMDEX II to PC and create field contour lines if necessary
8 9 10	Task 6) Source Id. Conference. Assess: Main Area Field Source and sources to be characterized.	Task 6) Source Id. Conference Select and mark sources for temporal recording.
11 12	Task 8) Source characterization with Wavecorder. Three points per source and per direction away from source.	Task 7) "Exposure Point" questionnaire with help from Site Contact Person
13 14	Task 8) Source characterization with Wavecorder.	Task 8b) Download Wavecorder data from previous area to PC
15 16 17	Task 9) Place temporal recorders	Task 10) AC + DC field measurements with WAVECORDER and DC probe

*Less time is required if there are no exposure point sources to characterize and if no temporal recorder is placed in the area.

4.9 DATA EXTRACTION AND EXPOSURE ANALYSIS

The results of the measurements and the answers to the questionnaire allow the calculation, for each area, of a number of exposure quantities. The method of calculation is based on simple assumptions and interpretations of both field and activity data. The data analysis is described in Section 6. The results obtained are described in Section 7. The data for the EMF Database are described in Section 8. The data collected may lend themselves to several types of analysis other than those described here.

The calculation of average exposure parameters is based on the following assumptions:

1. When a person is at an exposure point, the person is at a random location in the zone of activity, i.e. all points of the zone of activity are equally likely, or, put in another way, the person spends the same amount of time at each point of the zone of activity.
2. The temporal variability of area fields is much smaller than the spatial variability. This assumption was confirmed by the data (see Section 7).
3. The exposure parameters calculated are averages for categories of persons. Within the same category, some person may be more exposed than another.

The average exposure does not indicate possible differences between exposures of different persons, or differences in magnetic field to which the same person may be exposed during different parts of the day. The magnetic field measurements and the activity data from the questionnaire, however, provide information sufficient for estimates of exposure distributions. The method of calculation is indicated in section 6.

The method described in Section 6 estimates magnetic field exposure in terms of time weighted average field strength, and the strength is defined in terms of rms values. It is possible to use the data available in the database to estimate exposure in terms of other parameters as well.

Harmonics

Source characterization is performed with a wave capture instrument. Therefore, the same information available for 60 Hz is also available for the harmonics of 60 Hz, for instance for the 180 Hz component.

The area survey is performed with an rms instrument. Therefore no harmonic exposure data can be derived from the area mapping. However, wave capture measurements are performed at up to 5 locations in the area (at the area center and near four corners), away from exposure points. These measurements can be used to estimate the percentage of each harmonics in the area. The average percentage of harmonics, h , may be estimated using equation (18).

$$h = 100 \cdot \frac{\sum_{i=1}^5 H_i}{\sum_{i=1}^5 Brms_i} \quad (18)$$

where H_i are the harmonic fields (mG), and $Brms_i$ are the rms field values.

The harmonic exposure to area sources is then calculated multiplying the rms field exposure, calculated as indicated previously, by the harmonic percentage.

Field Thresholds

A potentially interesting parameter is the average field or the time above a threshold (or in a window of values). This parameter also can be derived from the measurements and the answers to the questionnaire and some calculations of this type are described in Section 6, and the results are shown in section 7

Intermittency

Intermittency need to be properly defined. In the EPRI Report TR-103328 (Dec. 1994), "Magnetic Field Management for Overhead Transmission Lines: A Primer", intermittency is defined as "a magnetic field event during which the rms value of the magnetic field has a significantly different value than before or after the event". The field variation that must be exceeded must be specified. For instance an intermittent may be defined every time there is a sudden field increase of more than 5 mG. The rate of

intermittency is the number of intermittents in an hour or in a day. It is assumed that the field variation occurs in a matter of cycles not seconds. Therefore, intermittents do not occur when a person is walking at a normal speed in regions where the field varies in space, but occurs only when a source field suddenly changes in time, as a result of insertions of loads. Information about intermittents is derived from the temporal recordings. Unfortunately these recordings were made only in few areas. The rate of recording (once every 3 seconds) is adequate to measure field variations caused by insertion of loads. For every temporal recorder placed at each site, the quantity to summarize is the rate of intermittency corresponding to different sudden field increases (e.g. : 1, 2, 5, 10, 20, and 50 mG). In areas where there are no sources of variable field, the intermittency will be zero. Sources with constant field when energized have an intermittency defined by the number of time per hour that the source is switched "on". Intermittency by person type may be derived only for those areas of the site in which there is no variable source (in which case the intermittency is zero) or in which a temporal recorder is used for each source of variable field.

Transients

The data set acquired by the transient instrumentation system will be analyzed to provide a summary with the following data:

Peak-to-peak amplitude, FFT amplitude in different frequency bins (10-100 kHz, 100 kHz-1 MHz, 1-10 MHz), of repetitive transients.

Period of recording, threshold, number of transients recorded above the threshold during a long-term (24-hour or work cycle) recording period.

Statistics (min, max, median, 10% level) of peak-to-peak amplitudes for the transient magnetic fields recorded along three orthogonal axes during the recording period.

Waveshape and FFT amplitude in different frequency bins (10-100 kHz, 100 kHz-1 MHz, 1-10 MHz) of the transient magnetic fields with the ten highest peak-to-peak amplitudes.

AC and DC Field Combination

For each area measurement results at up to 5 different points will be available. At each point the results will include: intensity of the DC field, intensity of the AC field (at 60 Hz and at different harmonic frequencies) parallel to the DC, intensity of the AC field (at 60 Hz and at different harmonic frequencies) perpendicular to the DC field, and value of the unperturbed DC field away from the site. These data will be put in a data base from which different types of summaries may be produced. For example, the following summary quantities will describe important features of the AC and DC field combination.

Exposure Data by Environment and by Site

Cross sites and cross environment comparisons are important for this survey. Therefore, a macro picture of the environmental fields is needed.

A macro picture of the environmental fields at each site is given by the "average environmental field", BE_i , to which persons of type i are exposed. This quantity is calculated as indicated in Section 6. Results are provided in section 8.

4.10 DEFINITIONS

Environment

"Environment" is defined as a place where activities of specific groups of people occur and which may be a source of characteristic exposure to EMF, by virtue of the type of electrical facilities and equipment typical of that place. For example, school buildings are a well defined environment where specific groups of people (students, teachers, school staff) spend significant amounts of time and where EMF may be produced by net currents in electrical conduits, power supply transformers and related switchgear, electrical panels, fluorescent lights, electrical equipment used by the students (video display monitors, audio-visual equipment, fish tanks, etc.), equipment used by the staff (video display monitors, copiers, and other equipment), nearby power lines, and other field sources.

Site

An environment "site" is defined as a complete architectural structure and associated areas that serve the purpose of the environment. For instance, a site for the study of the school environment is a school building, not just a classroom. A site for the office environment is an office building, not just an office or a floor.

Area

Each environment site is divided into different "areas". An area is defined on the basis that the people that occupy that area are a well defined group, or the activities that take place in that area are well defined. If the field characteristics vary significantly within an area, it may be useful to subdivide the area into smaller areas.

Exposure Areas and Exposure Points

We will distinguish between "exposure areas", and "exposure points". An *exposure area* is an area of a site where there is a significant field originating from sources other than local sources. In general, it will not be possible to know in advance whether the field from non local sources is significant. Therefore, the protocol requires mapping the field in all areas by making measurements uniformly distributed over the area. An *exposure point* is the location where persons engage in fixed, site specific activities, e.g. sitting in front of a desktop computer or standing at a lathe in a machine shop, or where a local source creates a significant increase in the area field. If there is no local source, consideration of an exposure point is not necessary. Also, if there is a local source but no activity occurs there, consideration of that location is not necessary. An exposure point has a "zone of influence", which is the space in which the area field is affected by the local source.

Section 5

SITES SURVEYED

The original plan for recruitment of sites to be surveyed anticipated some sort of random selection among a number of potentially available sites. However, contacts with school organizations, hospital organizations, and individual site owners and operators were not very fruitful. Only a handful of sites were eventually available for selection.

The goal was to survey two sites for each environment in California and two sites in Massachusetts. However, a number of factors intervened to change the planned geographical subdivision of sites. The recruitment of hospitals was relatively successful in California, while difficulties were anticipated in Massachusetts. Therefore, it was decided to survey all four hospitals in California. On the other hand, only one grocery store could be recruited in California. Therefore, the other three were recruited in Massachusetts. In Massachusetts, only one machine shop could be recruited. The other three, therefore, were surveyed in California.

The reluctance of site owners and operators to participate in the magnetic field surveys of DOE RAPID research program was ascribed to (1) lack of motivation and incentives and (2) fear that an EMF survey would reveal situations that would alarm people at the site or would require costly mitigation efforts.

The surveys were first performed in California. Eleven sites were surveyed during the period September - December 1995:

- 2 Office Buildings
- 2 Schools
- 4 Hospitals
- 2 Machine Shops
- 1 Grocery Store

The instrumentation was then shipped to Massachusetts where eight sites were surveyed in the period January - March 1996:

- 2 Office Buildings
- 2 Schools
- 1 Machine Shop
- 3 Grocery Stores

The final site, a Machine Shop, was measured in California during April 1996.

One of the sites, identified in this report as Machine Shop #1, was surveyed also by another team as a part of RAPID Engineering Project #2: "Development of recommendations for guidelines for Environment-Specific Field Measurements". The two surveys took place on different days and were performed by different people and instrumentation. The protocols for the two surveys were developed independently. A

comparison between individual data was not made, except for one of the data that could be easily be extracted from the two surveys: the average area field, e.g. the average of all the average fields of the surveyed areas. The average area fields determined by the two surveys showed an excellent agreement: 1.35 mG measured by Project #2 and 1.38 mG measured by Project #3.

Description of the Sites

The agreement with the site owners and operators was that the sites would not be identified by name. A characterization of the sites is given in table 5.1.

Table 5.1 Site Data

Environment	Site (#)	Location	Survey Date	Number of Areas Surveyed	Surface Area Surveyed (square ft)	Time Surveyed (person · minute)
Office Building	1	Palo Alto, CA	Nov 95	224	48,330	111,200
	2	San Francisco, CA	Dec 95	85	21,100	33,600
	3	Boston, MA	Jan 96	69	20,200	40,200
	4	Boston, MA	Jan 96	79	60,200	71,600
School	1	(K-5) Santa Clara, CA	Nov 95	42	70,000	197,100
	2	(K-6) Campbell, CA	Nov 95	31	39,400	109,100
	3	(K-12) Western Massachusetts	Jan 96	72	61,700	276,800
	4	(K-5) Western Massachusetts	Feb 96	54	52,300	287,500
Hospital	1	San Jose, CA	Sept 95	80	30,200	207,400
	2	San Francisco Peninsula Area	Oct 95	71	39,900	233,400
	3	San Jose, CA	Nov 95	74	74,700	426,600
	4	Santa Clara, CA	Dec 95	178	71,700	447,600
Machine Shop	1	Hayward, CA	Sept 95	14	75,700	45,200
	2	Freemont, CA	Nov 95	22	31,800	33,500
	3	Western Massachusetts	Mar 96	4	1,500	1,900
	4	Oakland, CA	Apr 96	9	16,800	4,600
Grocery Store	1	San Jose, CA	Dec 95	9	5,300	95,200
	2	Western Mass	Feb 96	28	20,000	52,200
	3	Western Mass.	Mar 96	23	14,900	43,900
	4	Western Mass.	Mar 96	14	6,800	7,800

Section 6

DATA MANAGEMENT AND ANALYSIS

6.1 INTRODUCTION

This Section describes how the data generated as a result of the magnetic field surveys were managed and analyzed. The results of the data analysis are summarized in Section 7. Section 8 describes how the data were organized for use in a database.

The measurements were performed by a three person team at each site. The data obtained at the site consisted of measurements with digital recorders and data sheets filled out by the operators. The data from the digital recorders were downloaded into a PC. The data from the data sheets were manually entered into computer files.

Digital recorder and manually entered data were used in conjunction with computer program specially designed for this project to create data tables for the database and for the summary results presented in Section 7. The following calculations were performed:

- Calculation of the AC field components and of the spatial relation between AC and DC fields.
- Calculation of the distribution of rms magnetic field values for each site without weights, weighted by surface area, and weighted by time in each area. Calculation of the distribution of field values for all person types together and for each person type separately. Calculation of the distribution of magnetic field values for all area sources together and for each area source separately. Calculation of the distribution of field values for area sources and point sources separately and in combination. Calculation of time above given field values.

6.2 CALCULATION OF AC FIELD COMPONENTS AND AC AND DC FIELD SPATIAL RELATION

The measurements that are the basis for these calculations were performed with a single axis DC meter and a three axis waveshape capturing instrument. The measurements were made at a height of about one meter above the floor generally at five locations in the area surveyed: at about four feet from each corner and near the center of the area. The number of locations sometime was less than five, because of some loss of data or because the area was small. The DC meter probe axis and the X axis of the AC meter coincided. The operator rotated the DC meter probe until the highest DC field reading was obtained, at which point the DC field was read and the AC waveshape was captured.

The DC field readings and the AC waveshape identifications were entered in a file such as the example file shown in Table 6.1. These files were named ACDCX#.inp, where X# is the identification of the site (e.g. ACDCG1.inp is the file for Grocery store # 1). The file contains one line of data for each area in which the AC/DC measurements were made. The first line of the file contains the Site Identification (G1), the value of the unperturbed geomagnetic field (497 mG), the number of floors (1), the number of areas in which AC/DC measurements were made (9), and the building material (Stucco & Steel). Each line after the header lines is a line of data that indicates in how many points the measurements were made and, for each point, gives the file and wave identification of the AC wave measured at the point and the value of the DC field in mG.

Table 6.1 Example of ACDC Input File with DC Field and AC Waveshape Data Recorded by the Operator.

G1 497 1 9 Stucco & Steel													
		Number											
Area #	Floor #	Wave Filename	of points	Wave #	DC mG	Wave #	DC mG	Wave #	DC mG	Wave #	DC mG	Wave #	DC mG
1	1	G1_DC_01. WCD	5	1	521	2	395	3	474	4	484	5	463
2	1	G1_DC_01. WCD	5	11	511	12	524	13	390	14	497	15	488
3	1	G1_DC_01. WCD	5	6	475	7	540	8	491	9	551	10	520
4	1	G1_DC_02. WCD	5	6	463	7	375	8	437	9	544	10	417
5	1	G1_DC_02. WCD	5	1	467	2	469	3	517	4	426	5	475
7	1	G1_DC_02. WCD	5	11	261	12	347	13	359	14	267	15	341
8	1	G1_DC_03. WCD	5	1	355	2	357	3	430	4	446	5	433
9	1	G1_DC_03. WCD	5	6	397	7	467	8	452	9	413	10	446

The ACDCX#.inp file is used as a input of an ad hoc program (named PROCESS) that:

1. Retrieves the digitized wave record. The data consist of two 60 Hz cycles sampled at a rate of 15.36 kHz. The three components along the X, Y, and Z axis of the instrument (EMDEX Wavecorder™) are sampled simultaneously. The X axis is parallel to the DC field probe, which is being aligned by the operator in the direction of the DC field (maximum reading).
2. Makes a Fourier analysis of each of the three field components on the basis of a period of a 30 Hz wave. The analysis is made up to a frequency of 3 kHz. If the field is periodic at 60 Hz, the frequency components at 30 Hz and multiples of 30 Hz, which are not also multiples of 60 Hz, should be close to zero. When the field significantly departs from a periodic function at 60 Hz, the ratio between 30 Hz and 60 Hz components is significantly greater than zero (as a practical rule of thumb:

greater than 0.1). The 30 Hz to 60 Hz ratio is calculated and used as an index of 60 Hz periodicity.

3. Calculates the maximum and minimum axes of the field ellipse for selected frequencies. Calculates the polarization, defined as the ratio between the minor and the major axis of the field ellipse, for all frequency components.
4. Calculates the rms value of the AC field component perpendicular to the DC field. The component parallel to the DC field is the X component.
5. Calculates the angle in space between the major axis of the field ellipse and the direction of the DC field. These calculations are made for the 60 Hz, 180 Hz, and 300 Hz field components.

The output of the program PROCESS is a file named ACDCX#.out. The data in this file are a part of the database of this project. A partial example of ACDC output file is shown in Table 6.2. For convenience of space, this table reports only the 60 Hz data. The actual files contains also the 180 Hz data, the 300 Hz data, the frequency and amplitude of the largest harmonics (other than 180 and 300 Hz), and the ratio between 30 Hz and 60 Hz components.

The data from the ACDC output files were used to generate graphical representation of the results. The summary results are shown in Section 7. The results for all sites are shown in Appendix D. The type of graphs that were generated are:

1. Statistical distribution of the DC magnetic field values compared with the unperturbed geomagnetic field of a site.
2. Polarization of the 60 Hz magnetic field versus the 60 Hz rms value for each site.
3. Rms value of the third and fifth harmonics of 60 Hz versus the rms value of the 60 Hz component.
4. Space angle between the major axis of the AC field ellipse and the direction of the DC field.

Table 6.2 Example of ACDC Output File Containing the Processed Information on AC Harmonics and Polarization and the Relative Angle between AC and DC Fields.

Rec	X60	X60 Angle	Y60	Y60 Angle	Z60	Z60 Angle	B Max	AC-DC Angle	B Perp.	Polarization
#	(mG)	(degree)	(mG)	(degree)	(mG)	(degree)	(mG)	(degree)	(mG)	(%)
1	1.05	112	1.13	103	0.05	-119	1.54	47	1.13	8
2	0.09	177	0.16	-15	0.13	7	0.22	65	0.2	17
3	0.16	-85	0.34	169	0.05	88	0.34	80	0.34	48
4	0.3	162	0.28	-43	0.01	23	0.4	43	0.28	22
5	0.2	-93	0.13	-48	0.03	-153	0.22	29	0.13	38
6	0.14	157	0.12	-82	0.03	-113	0.16	37	0.12	58
7	0.35	-164	0.59	-124	0.17	138	0.65	63	0.59	40
8	0.94	-99	1.52	104	0.39	21	1.76	59	1.52	28
9	0.16	41	0.15	34	0.07	-24	0.22	43	0.15	29
10	0.32	178	0.47	28	0	-25	0.55	57	0.47	24
11	0.29	60	0.13	-137	0.04	-107	0.32	24	0.13	11
12	0.11	145	0.08	45	0.04	-8	0.12	26	0.09	68
13	0.11	-57	0.38	-149	0.09	-146	0.39	90	0.39	27
14	0.25	-149	0.09	5	0.01	-9	0.27	19	0.09	15
15	0.28	52	0.19	-131	0.03	122	0.34	34	0.19	9
16	0.21	-160	0.34	-172	0.12	-144	0.41	60	0.36	15
17	9.66	97	4.79	101	1.37	176	10.78	26	4.8	13
18	8.1	-135	4.54	-137	1.3	-57	9.28	29	4.54	14
19	0.69	-105	1.93	-124	0.54	-49	2.05	71	1.94	27
20	0.65	97	2.43	28	0.59	120	2.44	84	2.43	34
21	0.41	-177	0.32	-171	0.05	94	0.52	38	0.32	10
22	0.25	49	0.13	-173	0.1	-119	0.29	29	0.15	30
23	0.15	-27	0.7	-159	0.11	-87	0.7	82	0.7	21
24	0.16	-116	0.25	144	0.05	-143	0.25	81	0.25	63
25	0.16	141	0.13	-103	0.05	132	0.18	34	0.13	57
26	4.97	61	3.57	73	0.47	162	6.08	36	3.57	12
27	3.29	157	1.37	156	0.12	-96	3.57	23	1.37	3
28	4.24	83	1.88	97	0.25	-179	4.62	23	1.88	11
29	7.43	142	3.39	160	0.49	-126	8.11	24	3.39	14
30	5.08	76	2.73	86	0.24	179	5.75	28	2.73	8
31	7.71	173	4.96	174	0.68	-105	9.17	33	4.97	7
32	2.21	49	1	63	0.29	143	2.41	24	1	15
33	2.06	-83	2.23	-85	0.14	2	3.04	47	2.23	5
34	13.05	166	7.57	161	0.56	-111	15.08	30	7.57	5
35	6.2	-110	3	-107	0.4	-22	6.89	26	3	6

6.3 CALCULATION OF THE DISTRIBUTION OF RMS FIELD VALUES AND FIELD AVERAGES

The objective of these calculations were the determination, for each surveyed site, of the following exposure quantities:

- Average area fields (i.e. fields generated by area sources, excluding the field at exposure point). Several types of averages were considered depending on how the different areas of the site were weighted: a straight average of the average field in each area, an average obtained by giving to each area a weight proportional to its surface area, and an average obtained by giving to each area a weight proportional to the total time (person-minute) spent by all types of persons in one day in each area.
- Cumulative distribution of area fields: field values not exceeded for 1%, 5%, 10%, 25%, 50%, 75%, 90%, 95%, and 99% of the time. Three cumulative distributions were considered: all areas with the same weight, areas weighted by surface area, and areas weighted by total time.
- Time spent by all types of person considered together in each of 30 area field bins set in a geometric progression from 0.1 to 500 mG.
- Time spent by each separate type of person in each of 30 area field bins set in a geometric progression from 0.1 to 500 mG.
- Time spent by all types of persons, considering each type of area source separately, in each of 30 area field bins set in a geometric progression from 0.1 to 500 mG.
- Time spent by each separate type of persons and for each separate type of area source, in each of 30 area field bins set in a geometric progression from 0.1 to 500 mG.
- Total exposure (mG-person-minute) and time weighted field (mG) for all types of persons and all area sources, for each person type and all area sources, for all person types and each area source, and for each person type and area source type.
- Contribution of each area source to the time weighted average exposure calculated for each type of person.
- Time spent by all types of person at exposure points in each of 30 field bins set in a geometric progression from 0.1 to 500 mG.
- Time spent by each types of person at exposure points in each of 30 field bins set in a geometric progression from 0.1 to 500 mG.
- Time spent by all types of person in each of 30 field bins set in a geometric progression from 0.1 to 500 mG, when considering the combined contribution to the field by area sources and by the sources at exposure points.
- Contribution of field at exposure point to the total time weighted average exposure calculated for each type of person.
- Time spent above a given threshold of field (combined area and exposure point field) by all types of people and separately by each type of people. The following thresholds were considered: 1, 2, 5, 10, 20, and 40 mG.

The calculations required creating the files described in the following. Most of these files are a part of the database of this project.

List of Person Types and Area Types

Table 6.3 Person and Area Types for Machine Shops

	Person Types
1	Machinist / Fitter
2	Welder
3	Engineer / Inspector
4	Assembler / Shipper / Maintenance Staff
5	Office Staff
	Area Types
1	Machining
2	Administration
3	Shipping
4	Engineering
5	Production / Assembly

Table 6.4 Person and Area Types for Grocery Stores

	Person Types
1	Clerk / Cashier
2	Butcher / Assistant
3	Office Staff
4	Customer
	Area Types
1	Customer Access Area
2	Butchers / Clerk / Staff Area
3	Office Staff Area

Table 6.5 Person and Area Types for Hospitals

	Person Types
1	Patient
2	Medical Staff
3	Visitor
4	Maintenance Staff
	Area Types
1	Patient Room
2	Examination Room
3	Nurse's Station / Staff Area
4	Public Facility
5	Administration Office
6	Laboratory

Table 6.6 Person and Area Types for Office Buildings

	Person Types
1	General Staff / Secretary / Support Staff
2	Professionals (Engineers, Managers, etc..)
3	Maintenance Staff
4	Visitors
	Area Types
1	Lobby or other Public Area
2	General Staff Area
3	Private Office

Table 6.7 Person and Area Types for Schools

	Person Types
1	Teacher
2	Student
3	Custodian
4	Administrative Staff
5	Volunteer Parent
	Area Types
1	Classroom
2	Cafeteria / Kitchen / Auditorium
3	Main Office (Student Area)
4	Administration (Staff Area)
5	Library / Learning Center

List of Area Source Type

Table 6.8 Area Sources

1	Transmission Line	15	Underground Distribution
2	Distribution Line	16	Appliances
3	Power Supply Cable to Building	17	Source Unknown (Background Field)
4	Main Distribution Panel	18	x-ray or Lab Equipment
5	Net Current in Electrical Conduits	19	Headwall Panel
6	Electrical Panel	20	Area source unknown (Masked by Point Sources)
7	Air Conditioners	21	Vending Machines
8	Fluorescent Lights	22	Power Cable Shaft
9	Multiple Way Switch	23	Control Panel
10	Transformer	24	Power Supply Cables
11	Office Equipment	25	Merchandising Equipment
12	Power Cable Trays	26	Milling Equipment (Lathe, Mill, Drill press, Etc..)
13	Source Unknown (Low Field)	27	Welding Equipment and Cables
14	Source Unknown		

List of Exposure Point Source Type

Table 6.9 Point Sources

1	Computer Monitor	37	Tape Duplicator
2	Computer Monitor	38	Switchboard / Control Panel
3	Computer Monitor	39	Electrical Panel
4	Copier	40	Distribution Panel
5	Clock	41	Printer
6	Clock Radio	42	Computer Camera
7	Plug-in Transformer	43	Enlarger
8	Fluorescent Desk Light	44	Charger
9	Fluorescent Light (Ceiling	45	Fax Machine
10	Typewriter	46	Video Projector
11	TV	47	Mainframe
12	Overhead Projector	48	Uninterruptable Power Supply
13	Media Board	49	Computer
14	Adding Machine / Cash Register / Check Out Counter	50	Security Equipment
15	Toaster Oven	51	Slide Projector
16	Range	52	Micro Fiche Reader
17	Portable Space Heater	53	Pencil Sharpener
18	Portable Fan	54	Timer Switch
19	Scanner	55	Animated Figurines
20	Aquarium Pump	56	Dictaphone
21	Incubator	57	CD - ROM
22	Vending Machine	58	Headwall Panel
23	Food Warmer	59	Monitoring Equipment
24	Refrigerator	60	Motorized Bed
25	Dish Washer	61	Air Conditioner
26	Light Box	62	Milling Machine
27	Microwave Oven	63	Saw
28	Heating Unit (Fixed)	64	Lathe
29	Dry Type Transformer	65	Grinder
30	Sewing Machine	66	Precision Equipment
31	Coke Machine	67	Drill Press
32	Ditto Machine	68	Welder
33	Laboratory Equipment	69	Belt Sander
34	Coffee Machine	70	Air Compressor
35	Tape Player	71	Pipe Threader
36	Laminating Machine		

Map File

The MAP file contains the data describing the spatial distribution of the rms magnetic field in each area. It is the result of mapping the area with an EMDEX II as described in the protocol. After downloading the EMDEX data to a PC, and after analyzing the data with the software provided for the EMDEX II (EMCALC 95), one MAP file is created for each site. An example of MAP file is shown in Table 6.3. Because of the large number of fields in this file, Table 6.3 is divided in two parts.

Table 6.10 Example of MAP File (Part 1)

Area (#)	Area Name	Floor	EMDEX Filename	Surface Area (ft ²)	% of Area Surveyed	# of Observ	Average (mG)	St. Dev. (mG)	Geo Mean (mG)	Geo St. Dev.
1	Frozen Foods/Stock Section	1	G1FROZ_ D.MDX	750	100	71	1	1.06	0.717	2.063
2	Produce Section	1	G1PROD_ D.MDX	600	100	66	1.53	0.93	1.243	1.993
3	Check- Out/Cashiers Area	1	G1CASH_ D.MDX	1125	100	136	1.4	3.51	0.523	3.133
4	Butcher Area	1	G1BUTC_ D.MDX	1750	100	119	5.61	5.44	3.549	2.655
5	Meat Counter Area	1	G1CNTR_ D.MDX	600	100	83	1.47	1.37	1.035	2.224
6	Walk-In Freezer	1	G1FREZ_ D.MDX	144	100	24	2.87	0.88	2.751	1.346
7	Produce Freezer	1	G1PFRZ_ D.MDX	144	100	29	6.84	2.96	6.131	1.653
8	Stock Room	1	G1STCK_ D.MDX	144	100	28	5.98	3.48	5.044	1.825
9	Office	1	G1OFFI_D .MDX	72	100	25	5.51	3.07	4.799	1.7

Continues: Table 6.10 Example of MAP File (Part 2)

Area #	Min (mG)	1% (mG)	5% (mG)	10% (mG)	25% (mG)	50% (mG)	75% (mG)	90% (mG)	95% (mG)	99% (mG)	Max (mG)
1	0.29	0.29	0.37	0.38	0.43	0.54	0.93	2.81	3.82	4.89	4.89
2	0.26	0.26	0.36	0.47	0.74	1.48	2.13	2.76	3.41	3.82	3.82
3	0.01	0.11	0.14	0.23	0.31	0.38	0.64	2.83	7.18	17.89	29.70
4	0.84	0.88	0.98	1.08	1.29	3.74	7.66	15.71	18.49	20.49	20.70
5	0.34	0.34	0.37	0.47	0.58	0.77	1.91	4.22	4.33	4.52	4.52
6	1.86	1.86	1.86	1.93	2.09	2.61	3.86	4.23	4.37	4.46	4.46
7	1.96	1.96	2.49	2.77	4.26	6.99	9.44	10.48	11.09	11.23	11.23
8	2.08	2.08	2.22	2.32	2.79	4.74	10.21	11.18	11.26	11.64	11.64
9	2.17	2.17	2.64	2.67	2.89	4.14	8.53	10.76	11.49	11.69	11.69

Area Activity File

The data are entered in this file manually from the answers to the area activity questionnaire described in the protocol. An example of area activity file is given in Table 6.4. This file has one line of records for each area surveyed. There is one area activity file for each site. For each of up to five types of persons the following information is contained in the activity file: range of number of persons that may occupy the area in one day, range of time (in minutes) that persons of this type may stay in the area, range of mobility (see protocol for definition) that a person of this type may have in the area. For convenience the example of Table 6.4 contains only the data for person type 1.

Table 6.11 Example of Area Activity File

Area (#)	Area Name	EMDEX Filename	Area Type	Person Type 1					
				Number		Time (min)		Mobility (%)	
				Min	Max	Min	Max	Min	Max
1	Frozen Foods/Stock Section	G1FROZ_D.MDX	1	2	5	12	30	90	100
2	Produce Section	G1PROD_D.MDX	1	2	3	240	360	80	100
3	Checkout/Cashier Area	G1cash_D.MDX	1	2	5	360	480	20	40
4	Butcher Area	G1BUTC_D.MDX	2	0	0	0	0	0	0
5	Meat Counter Area	G1CNTR_D.MDX	1	0	0	0	0	0	0
6	Walk-In Freezer	G1FREZ_D.MDX	2	0	0	0	0	0	0
7	Produce Freezer	G1PFRZ_D.MDX	2	2	3	60	120	80	100
8	Stock Room	G1STCK_D.MDX	2	1	2	180	240	80	90
9	Office	G1OFFI_D.MDX	3	2	3	6	12	5	10

Main Area Source File

For each area, this file simply contains the type number corresponding to the area source that has been determined by the operators to be the most significant contributor to the field in the area surveyed. There is one main area source file for each site.

Exposure Point Activity File

The data are entered in this file manually from the answers to the exposure point activity questionnaire described in the protocol. An example of exposure point activity file is given in Table 6.5. This file has one line of records for each area surveyed. There is one exposure point activity file for each site. The file contains for each exposure point the following information: type number of the source at the exposure point, range of distances from the source when person are at the exposure location, measurement method used to characterize the field of the source at the exposure point, number of the data set where the field information is contained in another file (Source Characterization File). For each of up to two types of persons the following information is contained in the exposure point activity file: range of number of persons that may be at the exposure point during one day, range of time (in minutes) that persons of this type may stay at the

exposure point. For convenience the example of Table 6.4 contains only the data for only one type of person per source.

Table 6.12 Example of Exposure Point Activity File

Source		Activity Zone		Person	Number of Persons		Time of Exposure		Source Charact.		Source
Area	Type	Min	Max	Type	Min	Max	Min	Max	ID	Method	Dataset
(#)	(#)	(Feet)	(Feet)	(#)			(Min/Day)	(Min/Day)	(#)	(#)	(#)
1	24	2	4	4	100	200	1	5	1	1	1
2	24	2	4	1	2	3	60	180	2	1	8
2	26	3	6	1	2	3	180	300	3	1	10
3	69	1	3	1	1	1	360	480	4	1	4
3	14	1	5	1	1	1	360	480	5	1	5
3	69	1	3	1	1	1	360	480	6	1	6
3	14	1	5	1	1	1	360	480	7	1	7
4	24	2	5	2	3	6	240	360	8	1	12
4	63	2	5	2	3	6	240	360	9	1	11
4	70	2	5	2	1	2	120	240	10	1	13
4	70	2	5	2	1	2	120	240	11	1	15
4	71	2	4	2	2	6	20	30	12	1	14
5	24	2	4	2	2	6	240	360	13	1	2
5	69	2	5	2	2	6	240	360	14	1	3
5	24	2	4	2	2	6	240	360	15	1	9
7	24	0	4	1	2	3	60	120	16	4	2
8	39	2	6	1	1	2	180	240	17	3	1
9	39	3	6	1	2	3	10	20	18	3	2

Source Characterization File. Method 1

Source characterization measurements were performed with any one of three different methods. The preferred method (method 1) consisted in waveshape capture measurements along three orthogonal axes at three points on a straight line at different distances from the source surface. In addition to the three orthogonal components of the magnetic fields, the waveshape of the power supply was also captured in order to provide a signal to which the phase angles of the magnetic field waveshape could be referenced. The measured waveshape identification number and the distances from the source surface at which the measurements were made were recorded by the operator in the data sheet and then transcribed in files such as that shown in the example of Table 6.13. This is a one line table for each measured point source. It contains the source identification number, the source name, the Wavecorder™ file name, and wave identification numbers and distances from the source surface for all three measuring points.

Table 6.13 Source Data Transcribed by the Operator

Source ID #	Source Name	Wave File Name	1 st Point		2nd Point		3rd Point	
			Wave (#)	Distance (m)	Wave (#)	Distance (m)	Wave (#)	Distance (m)
1	Freezer	g1_src01.wcd	1	-0.152	2	-0.305	3	-0.61

The characterization of a source field is based on waveshape capture. It requires a Fourier spectrum analysis of the captured waves identified in data such as those of Table 6.13. This analysis is performed with the specialized software of the Wavecorder™. An example of a summary FFT table obtained with this software is shown in Table 6.14. Each FFT table refers to one measuring point (1st, 2nd, or 3rd measuring point). For convenience the example in Table 6.14 shows results up to 540 Hz. However, actual summary tables contain data up to 3000 Hz.

Table 6.14 Summary FFT Table

Frequency (Hz)	X rms (mG)	X angle (degree)	Y rms (mG)	Y angle (degree)	Z rms (mG)	Z angle (degree)
30	0.06	190.14	0.13	203.24	0.06	-3.35
60	4.37	200.31	14.71	219.62	5.68	6.74
90	0.02	-47.24	0.11	21.96	0.05	177.39
120	0.08	-54.9	0.58	240.2	0.23	226.34
150	0.06	246.5	0.11	-42.94	0.05	127.2
180	2.87	255.24	4.65	-66.99	1.76	111.46
210	0.08	69.53	0.12	93.88	0.04	-78.41
240	0.05	73.55	0.39	242.75	0.22	248.08
270	0.01	84.76	0.05	24.17	0.02	124.12
300	0.58	249.26	1.42	-61.05	0.62	117.49
330	0.05	64.45	0.1	96.93	0.04	-79.65
360	0.06	68.13	0.12	258.26	0.12	259.12
390	0.02	54.26	0.07	70.27	0.01	260.01
420	0.09	-19.27	0.36	22.86	0.15	217.02
450	0.02	100.69	0.04	99.73	0.01	-17.73
480	0.01	67.13	0.03	-5.5	0.03	-53.57
510	0.01	94.04	0.04	84.73	0.01	-9.88
540	0.02	258.75	0.1	9.01	0.02	158.58

An intermediate file was created for each source measured using method 1. This file is named X#S#.sdc, where X# is the site identification number (e.g. G1 for Grocery store #1) and S# is the progressive source number. The .sdc file contains information such as: the amplitude of the 30 Hz component, the amplitude and phase angle of the 60 Hz and 180 Hz components at the three measuring points, the coordinates of the three measuring points, the coordinates of the measuring probes of the instrument, and the range of coordinates estimated for the dipole center. All the coordinates are referred to a point on the surface of the source. The probe coordinates are relative to the center front of the instrument. An example of this file is shown in Table 6.15.

Table 6. 15 Data Required for Calculation of Dipole Moment and Field at Different Distances from the Source Surface

	(mG)	(mG)	(mG)			
Magnitude of 30 Hz X,Y,Z components at 1st meas. point	0.06	0.13	0.06			
Magnitude of 30 Hz X,Y,Z components at 2nd meas. point	0.01	0.02	0.03			
Magnitude of 30 Hz X,Y,Z components at 3rd meas. point	0	0.04	0.01			
		Phase		Phase		Phase
	(mG)	(degree)	(mG)	(degree)	(mG)	(degree)
1st Point - X,Y,Z data at 60 Hz	4.37	17.46	14.71	36.77	5.68	-176.11
2nd Point - X,Y,Z data at 60 Hz	0.33	-153.1	3.06	-152.36	2.59	-175.78
3rd Point - X,Y,Z data at 60 Hz	0.17	135.2	3.3	-65.22	0.59	-78.31
1st Point - X,Y,Z data at 180 Hz	2.87	72.39	4.65	-249.84	1.76	-71.39
2nd Point - X,Y,Z data at 180 Hz	1.18	-115.1	0.73	-291.03	1	-265.74
3rd Point - X,Y,Z data at 180 Hz	0.62	130.83	0.88	-44.05	0.57	-43.47
	X (m)	Y(m)	Z (m)			
1st Meas. Point - Coordinates	-0.152	0	0			
2nd Meas. Point - Coordinates	-0.305	0	0			
3rd Meas. Point - Coordinates	-0.61	0	0			
X Probe - Relative Coordinates	-0.032	-0.04	0			
Y Probe - Relative Coordinates	-0.007	-0.01	0			
Z Probe - Relative Coordinates	-0.026	-0.058	0			
Min. Coordinates of Dipole	0	-0.3	-0.3			
Max. Coordinates of Dipole	0.6	0.3	0.3			

The data contained in the .sdc files were used as the input to a computer program named MYFIRST, which calculates the center and the value of the magnetic field dipole moment. The calculations are based on the paper "Magnetic Field Characterization of Electrical Appliances as Point Sources Through in Situ Measurements" (Paper 96 WM 345-4 PWRD, presented at the 1996 IEEE/PES Winter Power Meeting, Jan. 96, Baltimore, MD. To be published in the IEEE Transactions on Power Delivery). The program places the dipole moment at a location within the dipole moment range and calculates the three orthogonal components of the dipole moment in magnitude and phase angle that give magnetic field values that best fit the measured values (field magnitude and phase angle measured by three probes at three different instrument locations, for a total of 18 measured quantities). The program then changes the location of dipole moment within its estimated range until the location that minimizes the differences between measured and calculated values is found.

The output of the computer program MYFIRST is the Source Characterization File. Source Characterization Files are included in the database. They contain the calculated fields at 60 Hz and at 180 Hz at 13 different distances from the source surface, from zero to 1.83 meters (6 feet), the coordinates of the dipole moment of the source, the dipole moment magnitude and real and imaginary components both at 60 Hz and 180 Hz, and the ratio between the 30 Hz and the 60 Hz rms components measured near the source (as

a rule of thumb when this ratio exceeds 10% the field is not periodic at 60 Hz). Some of this information is shown in the example of Table 6.16.

Table 6.16 Example of Source Characterization File - Method 1 (Part 1)

Source ID	Source Name	Point #1 Distance (m)	Point #1 Field (mG)	Point #2 Distance (m)	Point #2 Field (mG)	etc (m)	etc (mG)	Point #13 Distance (m)	Point #13 Field (mG)
1	Freezer	0	2132	-0.15	24.79			-1.83	0.02
2	Food Display	0	1.87	-0.15	1.13			-1.83	0.04
3	Electronic Scale	0	8.9	-0.15	6.43			-1.83	0.04
4	Electronic Scale	0	239	-0.15	12.52			-1.83	0.02
5	Cash Register	0	12	-0.15	7.29			-1.83	0.03
6	Electronic Scale	0	535	-0.15	64.99			-1.83	0.05
7	Cash Register	0	38	-0.15	6.47			-1.83	0.01
8	Refrig. Unit	0	5.0	-0.15	2.91			-1.83	0.09
9	Display Counter	0	7.3	-0.15	4.24			-1.83	0.14
10	Lighting System	0	5.8	-0.15	3.23			-1.83	0.1
11	Bone Cutter	0	1.65	-0.15	1.53			-1.83	0.02
12	Display Counter	0	14.1	-0.15	8.68			-1.83	0.36
13	Meat Slicer	0	14.2	-0.15	4.67			-1.83	0.01
14	Heat Sealing Machine	0	13.8	-0.15	8.38			-1.83	0.33
15	Meat Slicer	0	296	-0.15	25.48			-1.83	0.06

Continues: Table 6.16 Example of Source Characterization File - Method 1 (Part 2)

Source ID	60 Hz Dipole (Am ²)	180 Hz Dipole (Am ²)	30/60 Ratio (%)
1	7.96E-02	4.27E-02	0.95
2	5.04E-01	5.99E-03	1.27
3	1.35E-01	7.13E-03	0.4
4	1.31E-01	2.04E-02	1.22
5	1.99E-01	1.40E-02	0.94
6	2.05E-01	1.58E-01	1.14
7	4.18E-02	1.27E-01	0.84
8	9.86E-01	4.39E-03	1.41
9	1.73E+00	2.69E-03	1.01
10	1.10E+00	6.74E-02	1.03
11	1.01E-01	6.89E-03	55.93
12	3.17E+00	2.21E-02	0.6
13	5.91E-02	4.82E-01	7.55
14	3.76E+00	1.01E-02	0.75
15	3.24E-01	2.05E-02	13.22

Source Characterization File. Method 2

Source characterization measurements could not be with method 1 when a reference voltage signal was not available. In these cases the field wave was captured at one to three points at different distances from the source, the Fourier analysis of each wave was performed, the rms value of the 60 Hz component was calculated and a Source Characterization file was created. An example of this file is shown in Table 6.17. The file contains: the data set identification number, the distances from the source surface at which measurements were made, and the calculated rms value of the 60 Hz field.

Table 6.17 Example of Source Characterization file - Method 2

Data Set (#)	Distance (m)	Field (mG)	Distance (m)	Field (mG)	Distance (m)	Field (mG)
1	-0.152	241	-0.305	72.7	-0.457	27.8
2	-0.152	63	-0.305	20.4	-0.457	9.7
3	-0.152	11.9	-0.305	5.8	-0.457	3.6
4	-0.152	14.7	-0.305	7.1	-0.457	4

Source Characterization File. Method 3

Source characterization measurements often consisted of spot measurements made using a survey magnetic field meter only at one distance from the source surface. This method of measurements was used when it was necessary to minimize the disruption of the work of people at exposure points. In these cases, the field rms value was read directly from the digital display of the instrument and recorded in the data sheet. The data were subsequently transcribed in Source Characterization files, such as that shown in the example of Table 6.18. The file contains: the data set identification number, the distances from the source surface at which measurements were made, and the calculated rms value of the 60 Hz field.

Table 17 Example of Source Characterization file - Method 2

Data Set (#)	Field (mG)	Distance (m)
1	1.7	2
2	3.7	1
3	1.2	1
4	10	2
5	1.4	1
6	2.3	1
7	0.7	1

Calculation of Exposure Quantities

The calculation of exposure quantities was performed for each site separately using the computer program QWINTTEST, developed with the specific purpose of analyzing the data of this project and provide summary tables with the most important exposure quantities. The outline of the calculations is described in the following.

The computer program QWINTWEST reads the input files previously described: the MAP file containing the statistical distribution of the field in each area of the site; the Area Activity File containing information on the type, number, and time of people in each area; the Main Area Source file with the identification of the area source most responsible for the field in each area; the Exposure Point Activity file containing information on the type, number, and time of people at each exposure point; the Source Characterization files containing information about the field of point sources.

The program calculates for each surveyed area the fraction of measurements in each of 30 field bins obtained by dividing the interval between 0.01 and 500 mG in geometric progression.

The fraction of measurements in each bin are added for all surveyed areas and the fraction of measurement in each field bin is calculated for the entire site. The addition is made in three ways: a straight addition (implying that each area has the same weight), an addition weighted by the surface of each area, and an addition weighted by the time spent in each area. The time spent in each area is calculate by multiplying the number of persons in the area by the time spent in the area. The result is expressed in person-minute. Since the area activity questionnaire gives ranges of values the program first calculates the average number of people and the average time in the area.

Once the distribution of field fraction in each bin is calculated, the cumulative distribution and the statistical parameters of the distribution can be calculated, such as: average field, different percentile levels, percentage of measurements above specified field values.

Calculation of area field distribution, average area field, and total exposure (mG-person-minute) are made for all type of people combined, for each type of people separately, for all area sources combined, for each area source separately, and for each type of person and area source separately. The contribution of each area source to the total exposure of each type of people is calculated.

The field at each exposure point is calculated for different distances from the source. For sources characterized using method 1 the field at different distances is directly provided by the Source Characterization file. For sources characterized using method 2 or method 3, the field at different distances is obtained by interpolating or extrapolating the field values contained in the Source Characterization file. In all cases the field is assumed to be equivalent of that produced by a point source, e.g. the field is assumed to vary inversely with the third power of the distance from a point.

The activity zone and the time spent at exposure points are obtained from the Exposure Point Activity file. The location of people is assumed to be uniformly distributed in the activity zone during the time at exposure point. Knowing the field at different points of

the activity zone, the time spent at the exposure point is calculated for each field bin. The field distribution at each exposure point is constructed and then the field distribution at all exposure points is calculated. Calculations are made for all types of person combined, and for each type of person separately.

The field distribution for the combination of area field and field at exposure points is calculated as follows. The previously calculated area and exposure point field distributions are ideal distributions in the sense that area fields are assumed to be unaffected by field at exposure points and field at exposure points is calculated extrapolating the field measured near the source assuming that the background field is zero. In practical situations neither of the two assumptions is true. Even though the operator tried to measure area fields without being close to point sources and even though the field from point sources decays rapidly, area field measurements are affected by point sources in areas where the point source density is very high, such as offices crowded with office equipment, or machine shops crowded with machinery. The time spent at exposure points was subtracted from the time spent in the area to obtain the time in the area away from exposure point. The area field exposure distribution (mG-person-minute in each field bin) away from exposure points was calculated. The field at exposure point was calculated by combining the field caused by the point source with the area field considered as a background. The combination was considered as the sum of two vectors with random relative phase angle. The combined field was calculated as the square root of the sum of the squares of a field randomly extracted from the distribution at exposure points calculated as previously discussed (without consideration of area field) and a field randomly extracted from the area field distribution.

The contribution of the field at exposure point to the total time weighted average was calculated for all person types combined and for each person type separately.

The time spent above a given threshold (1, 2, 5, 10, 20, and 40 mG) of combined area and exposure point field was calculated for all person types combined, and for each person type separately.

The output of the program QWINTTEST is a file named OUTX#.dat (X# is the site ID), which contains the data that were used to describe the results in the form of the tables and graphs of Section 7 and Appendices A, B, and C.

Section 7

RESULTS

7.1 INTRODUCTION

This Section describes the results obtained during the field surveys conducted in different environments. The surveys were conducted at four sites for each of five different environments: schools, office buildings, hospitals, grocery stores, and machine shops.

The most important results are summarized in this Section. More detailed results are reported in Appendix A: "Statistical Distribution of Area Fields at All Surveyed Sites", Appendix B: "Statistical Distribution of Area Fields, Fields at Exposure Points, and Combined Fields", Appendix C: "Magnetic Field Exposure by Type of People and Type of Source for all Surveyed Sites", Appendix D: "DC Fields, AC Field Harmonics, and 60 Hz Field Polarization for All Measured Sites", and Appendix E "Temporal Distribution Data".

All the data used to generate the summary results presented in this Section are contained in tables (ASCII files) that can be used to create a database as described in Section 8. Ad hoc computer programs were used for the analysis of the raw data to create additional tables, which can also be a part of the database.

7.2 AVERAGE ENVIRONMENTAL FIELDS

The survey protocol was developed with the purpose of obtaining data for two different types of exposure: exposure to area sources and exposure at exposure points.

Exposure to magnetic field may occur as a result of being in an area where the field is caused by sources whose location and geometry is generally not related to the location of the people who occupy the area. People may be considered to have a random location within the area. The magnetic field values obtained during the systematic "magnetic field mapping" of the area and the answers to the "area activity questionnaire" provide the field values and the exposure time used to calculate exposure to area fields.

At an exposure point a significant amount of magnetic field exposure takes place, independently of the area field, by virtue of the presence of a local field source and of the activity of persons occurring near this source. The "source characterization measurements" and the answers to the "exposure point questionnaire" provide the field values and the exposure time used to calculate exposure at exposure points.

Average Area Fields

The average value and the distribution of the rms magnetic field was calculated for each surveyed area of each site. The overall site average field and the overall distribution of magnetic field in each site were calculated in three different ways:

1. Each area was given the same weight.
2. Each area was given a weight proportional to its surface area.
3. Each area was given a weight proportional to the exposure time: number of persons multiplied by the number of minutes per day in the area.

Examples of results. For each site, the results were described in tables and graphs of the type shown in the examples of Table 7.1, Figures 7.1, and Figure 7.2. Table 7.1 reports results for School #3. Figure 7.1 reports the distribution of area field for School #3. The range of field values from 0.01 to 500 mG was divided in 30 bins in a geometric progression as shown in Table 7.1. Figure 7.2 reports the cumulative distribution of area fields.

The results and graphs for all surveyed sites are shown in Appendix A.

Table 7.1 Example of Average Area Fields and Area Field Distribution (School #3)

Average area fields		
w/o weights	weighted by ft²	weighted by person-hour
-----	-----	-----
0.48 mG	0.48 mG	0.45 mG

Minimum and maximum measured area fields

0.01 mG 76.5 mG

Field cumulative distribution:

Percentile	field	field	field
level	w/o weights	weighted by ft²	weighted by person-hours
1	0.01	0.01	0.01
5	0.01	0.01	0.01
10	0.01	0.01	0.01
25	0.09	0.07	0.03
50	0.18	0.20	0.16
75	0.50	0.54	0.45
90	1.09	1.05	1.02
95	1.81	1.57	1.65
99	3.21	4.37	3.20

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin	From	To	W/o weights	Weighted by	Weighted by	Time
(#)	(mG)	(mG)	(fraction)	ft ² (fraction)	person-hour (fraction)	in bin (person-min)
1	0.010	0.014	0.177	0.184	0.220	60811
2	0.014	0.021	0.015	0.015	0.017	4795
3	0.021	0.030	0.015	0.015	0.017	4795
4	0.030	0.042	0.015	0.015	0.017	4795
5	0.042	0.061	0.015	0.015	0.017	4795
6	0.061	0.087	0.015	0.015	0.017	4795
7	0.087	0.125	0.107	0.083	0.101	28027
8	0.125	0.179	0.152	0.135	0.136	37647
9	0.179	0.257	0.095	0.093	0.091	25249
10	0.257	0.368	0.080	0.084	0.075	20843
11	0.368	0.528	0.081	0.093	0.077	21254
12	0.528	0.758	0.077	0.092	0.073	20322
13	0.758	1.087	0.058	0.069	0.049	13577
14	1.087	1.559	0.040	0.042	0.037	10379
15	1.559	2.236	0.025	0.023	0.024	6649
16	2.236	3.207	0.016	0.012	0.014	3921
17	3.207	4.600	0.009	0.007	0.007	2002
18	4.600	6.598	0.006	0.005	0.005	1261
19	6.598	9.463	0.002	0.002	0.001	310
20	9.463	13.572	0.001	0.001	0.001	224
21	13.572	19.466	0.001	0.001	0.000	112
22	19.466	27.920	0.000	0.000	0.000	92
23	27.920	40.045	0.000	0.000	0.000	78
24	40.045	57.435	0.000	0.000	0.000	39
25	57.435	82.377	0.000	0.000	0.000	33
26	82.377	118.152	0.000	0.000	0.000	0
27	118.152	169.462	0.000	0.000	0.000	0
28	169.462	243.055	0.000	0.000	0.000	0
29	243.055	348.608	0.000	0.000	0.000	0
30	348.608	500.000	0.000	0.000	0.000	0
TOTAL			1.00	1.00	1.00	276805

Time Above Field Values

Total time = 276805
 Time above 1 mG = 28241
 Time above 2 mG = 10129
 Time above 5 mG = 1858
 Time above 10 mG = 544

Figure 7.1 Example of Distribution of Area Fields in 30 Bins in Geometric progression from 0.01 to 500 mG.

Figure 7.2 Example of Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Summary of Area Fields. The average area fields, median area fields, and the fields exceeded in 5% of the measurements (top 5th percentile) are shown in Table 7.2 for all sites. The data of Table 7.2 are shown in Figure 7.3.

The environments listed in Table 7.2 are in ascending order of time weighted averages:

Office buildings: 0.72 mG
 Schools: 0.83 mG
 Hospitals: 1.27 mG
 Machine shops: 1.43 mG
 Grocery stores: 1.93 mG

Table 7.2 Area Field Summary

	<u>AVERAGE</u>			<u>MEDIAN</u>			<u>TOP 5th PERCENTILE</u>		
	No Weight (mG)	Surface Area (mG)	Exp. Time (mG)	No Weight (mG)	Surface Area (mG)	Exp. Time (mG)	No Weight (mG)	Surface Area (mG)	Exp. Time (mG)
Office Building									
#1	1.18	1.08	1.11	0.55	0.52	0.54	3.91	3.98	4.26
#2	0.83	0.82	0.86	0.48	0.54	0.49	2.64	2.22	2.74
#3	0.58	0.65	0.61	0.38	0.38	0.42	1.82	2.14	1.89
#4	<u>0.53</u>	<u>0.52</u>	<u>0.31</u>	<u>0.17</u>	<u>0.24</u>	<u>0.16</u>	<u>0.94</u>	<u>1.69</u>	<u>1.01</u>
Averages	0.78	0.77	0.72	0.40	0.42	0.40	2.32	2.51	2.48
School									
#1	0.71	0.51	0.48	0.33	0.24	0.29	3.44	1.97	1.47
#2	1.07	1.21	1.01	0.67	0.67	0.44	3.44	3.96	3.88
#3	0.48	0.48	0.45	0.18	0.20	0.16	1.81	1.57	1.65
#4	<u>1.40</u>	<u>1.48</u>	<u>1.37</u>	<u>0.97</u>	<u>0.93</u>	<u>0.97</u>	<u>4.42</u>	<u>4.98</u>	<u>4.30</u>
Averages	0.92	0.92	0.83	0.54	0.51	0.47	3.28	3.12	2.83
Hospital									
#1	1.36	1.07	1.43	0.56	0.50	0.79	5.49	3.24	4.42
#2	1.15	1.12	1.20	0.61	0.52	0.60	3.83	4.13	4.03
#3	2.41	1.60	1.22	0.41	0.37	0.42	3.34	4.77	2.96
#4	<u>1.17</u>	<u>1.40</u>	<u>1.24</u>	<u>0.54</u>	<u>0.55</u>	<u>0.52</u>	<u>3.22</u>	<u>3.68</u>	<u>3.21</u>
Averages	1.52	1.30	1.27	0.53	0.49	0.58	3.97	3.96	3.67
Machine Shop									
#1	1.38	1.04	1.62	0.36	0.22	0.37	5.27	3.06	5.13
#2	0.59	0.90	0.75	0.29	0.32	0.31	1.89	2.31	2.49
#3	0.86	0.87	0.88	0.74	0.75	0.77	1.46	1.53	1.52
#4	<u>3.11</u>	<u>1.64</u>	<u>2.42</u>	<u>0.75</u>	<u>0.66</u>	<u>0.63</u>	<u>8.86</u>	<u>4.25</u>	<u>7.69</u>
Averages	1.49	1.11	1.42	0.54	0.49	0.52	4.37	2.79	4.21
Grocery Store									
#1	3.58	3.19	2.12	2.51	1.43	0.78	12.04	13.34	9.02
#2	2.03	1.94	1.86	1.14	1.10	0.96	7.03	6.50	7.14
#3	2.81	3.07	2.67	1.53	1.46	1.35	10.31	11.87	10.36
#4	<u>1.15</u>	<u>1.21</u>	<u>1.05</u>	<u>0.90</u>	<u>0.82</u>	<u>0.67</u>	<u>3.19</u>	<u>3.59</u>	<u>3.30</u>
Averages	2.39	2.35	1.93	1.52	1.20	0.94	8.14	8.82	7.46

TIME WEIGHTED AREA FIELD SUMMARY

(Without consideration of exposure points)

Figure 7.3 Summary of Time Weighted Area Fields for All Surveyed Sites.

Average Field at Exposure Points. The field at exposure points is the combination of the field caused by a local source and the field caused by area sources. The average field at exposure points in ideal situations without area sources may be different than the field in actual situations. The protocol required to perform field special measurements near the local field sources responsible for the field at exposure points. Generally, the measured field values of local sources were much larger than the background field caused by area sources.

The values of the field at all the locations of the "activity zone" were extrapolated from the field values measured close to the source. Three different methods of extrapolations were used depending on the type of measurements performed.

The preferred method of measurements was the three-point source characterization method described in Reference 7.1. This method requires measuring the magnetic field waveshape along three orthogonal axes at three different distances from the surface of the source plus a reference voltage signal. With this method, it is possible to determine the location and value of the equivalent magnetic dipole of the source. The field at all points of the activity zone can be calculated knowing location and value of the magnetic dipole.

An alternative method of measurements at exposure points consisted of measuring the magnetic field waveshape along three orthogonal axes at three points, but without the reference voltage signal. This method was applied when the reference voltage signal could

not be easily obtained. The field at different distances was calculated as if the field were generated by a point source located inside the source along the line of the measuring points so that the field varied inversely to the third power of the distance from the source.

At some exposure point, waveshape recording would have been too intrusive and time consuming. In these cases, a spot measurement of the field at one single distance was performed. The field at all the other distances of the activity zone was calculated by assuming that the field was produced by a point source located 0.15 cm inside the surface of the source.

By combining the field measurement results and the exposure point questionnaire, the ideal (without area source background) distribution of magnetic fields at exposure points was calculated. An example of such a distribution is shown in the third column of Table 7.3. The table uses the same field bins as those of Table 7.1.

Table 7.3 Example of Distribution of Area Field, Field at Exposure Points, and Combined Area and Point Field (School #3). (The data are in person-minute)

Bin (#)	Area (ideal)	Area (w/o exp. points)	Exp. Point (ideal)	Exp. Point (with area bkgnd)	Total Exposure
1	60811	58388	0	0	58388
2	4795	4543	0	0	4543
3	4795	4543	0	0	4543
4	4795	4543	128	10	4553
5	4795	4543	1548	139	4682
6	4795	4543	2056	223	4767
7	28027	25673	2778	451	26124
8	37647	34406	4333	1215	35622
9	25249	22964	4150	2216	25180
10	20843	18561	3861	2829	21390
11	21254	17120	3693	3991	21111
12	20322	15731	3432	5262	20993
13	13577	9243	3004	6016	15259
14	10379	6918	1545	5042	1377
19	310	253	121	180	433
20	224	180	81	126	306
21	112	104	85	93	197
22	92	90	87	89	179
23	78	76	22	24	100
24	39	39	27	27	66
25	33	33	15	15	48
26	0	0	9	9	9
27	0	0	13	13	13
28	0	0	10	10	10
29	0	0	0	0	0

Combined Area and Exposure Point Field Distribution. An example of the combined field distribution that takes into account of both area and point field sources is shown in the last column of Table 7.3. The second column of the table shows the area field distribution as if point sources were not present. The data in this column coincide with those of the last column of Table 7.1. The third column of table 7.3 shows the time in each bin calculated by subtracting the time at exposure points from the time in each area. The fourth column shows the exposure data at exposure point as if there were no area field. The fifth column reports the distribution of field values at exposure points calculated taking into account the background area field. For this calculation the area field and the field at exposure points were combined in a random fashion, by assuming that to each exposure point field could correspond any randomly chosen area field with a randomly chosen relative phase angle. Finally, the last column of the table shows the combined area and exposure point time for each bin, obtained by adding the values of the third column to those of the fifth column.

The distribution of area fields, fields at exposure points, and combined (area and exposure point) fields are shown in curves such as those of Figures 7.4 and 7.5, which apply to School #3. Figure 7.4 reports the total time (person-min) in each field bin. Figure 7.5 reports the total time weighted field (mG-person-min) in each bin. This example shows that the field at exposure points has little effect on the overall distribution, except for the highest field bins.

Similar graphs for all surveyed sites are shown in Appendix B.

DISTRIBUTION OF EXPOSURE TO AREA AND TO LOCAL SOURCES

Figure 7.4 Example of Time Distribution for Area Fields, Fields at Exposure Points, and Combined Fields (School #3).

DISTRIBUTION OF EXPOSURE TO AREA AND TO LOCAL SOURCES

Figure 7.5 Example of Exposure Distribution for Area Fields, Fields at Exposure Points, and Combined Fields (School #3).

Summary of Combined (Area and Exposure Point) Fields. The time weighted average area fields and area and exposure point fields are shown in Table 7.4 for all sites. Also reported are the median fields, and the fields exceeded in 5% of the measurements (top 5th percentile). The combined time weighted averages for the different environments are:

Office buildings: 0.99 mG
 Schools: 0.92 mG
 Hospitals: 1.39 mG
 Machine shops: 3.94 mG
 Grocery stores: 2.68 mG

The data of Table 7.4 are shown in Figure 7.6.

Table 7.4 Time Weighted Field Summary

	<u>AVERAGE</u>		<u>MEDIAN</u>		<u>TOP 5th PERCENTILE</u>	
	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)
Office Building						
#1	1.11	1.17	0.54	0.57	4.26	4.40
#2	0.86	0.98	0.49	0.56	2.74	3.18
#3	0.61	0.82	0.42	0.58	1.89	2.36
#4	<u>0.31</u>	<u>1.00</u>	<u>0.16</u>	<u>0.32</u>	<u>1.01</u>	<u>2.01</u>
Averages	<u>0.72</u>	<u>0.99</u>	<u>0.40</u>	<u>0.51</u>	<u>2.48</u>	<u>2.99</u>
School						
#1	0.48	0.53	0.29	0.32	1.47	1.63
#2	1.01	1.22	0.44	0.50	3.88	4.03
#3	0.45	0.53	0.16	0.17	1.65	1.90
#4	<u>1.37</u>	<u>1.40</u>	<u>0.97</u>	<u>0.99</u>	<u>4.30</u>	<u>4.40</u>
Averages	<u>0.83</u>	<u>0.92</u>	<u>0.47</u>	<u>0.62</u>	<u>2.83</u>	<u>2.99</u>
Hospital						
#1	1.43	1.47	0.79	0.83	4.42	4.44
#2	1.20	1.27	0.60	0.72	4.03	4.42
#3	1.22	1.52	0.42	0.54	2.96	3.96
#4	<u>1.24</u>	<u>1.31</u>	<u>0.52</u>	<u>0.62</u>	<u>3.21</u>	<u>3.33</u>
Averages	<u>1.27</u>	<u>1.39</u>	<u>0.58</u>	<u>0.68</u>	<u>3.67</u>	<u>4.04</u>
Machine Shop						
#1	1.62	2.15	0.37	0.43	5.13	7.42
#2	0.75	0.82	0.31	0.35	2.49	2.70
#3	0.88	8.62	0.77	0.91	1.52	45.8
#4	<u>2.42</u>	<u>4.15</u>	<u>0.63</u>	<u>0.81</u>	<u>7.69</u>	<u>16.9</u>
Averages	<u>1.42</u>	<u>3.94</u>	<u>0.52</u>	<u>0.63</u>	<u>4.21</u>	<u>18.2</u>
Grocery Store						
#1	2.12	2.38	0.78	1.09	9.02	9.24
#2	1.86	3.31	0.96	1.49	7.14	11.0
#3	2.67	3.25	1.35	1.82	10.36	11.3
#4	<u>1.05</u>	<u>1.77</u>	<u>0.67</u>	<u>1.01</u>	<u>3.30</u>	<u>5.60</u>
Averages	<u>1.93</u>	<u>2.68</u>	<u>0.94</u>	<u>1.35</u>	<u>7.46</u>	<u>9.29</u>

Figure 7.6 Summary of Time Weighted Fields for All Surveyed Sites (Accounting for both Area and Point Sources).

7.3 EXPOSURE BY PERSON TYPE

The magnetic field exposure data presented in section 7.1 refer to all types of people that occupy the surveyed areas of each site. The data were also elaborated for each person type separately. Graphical representation similar to that of Figure 7.2 can be presented for each category of person of each site. An example is shown in Figure 7.7, which shows the time weighted distribution of area fields for different categories of people included in the survey of school #3. Similar figures for all sites are presented in Appendix C.

Calculations were performed not only for exposure to area sources but also for the combined exposure to area and point sources. The results are shown in Table 7.5. Data are presented in terms of time weighted averages, median, and top 5th percentile value, for each site of each environment, for exposure to area sources and for combined exposure to area and point sources.

Figure 7.7 Example of Distribution of Area Field for Different Categories of People of a Site.

Table 7.5 Time Weighted Field by Category of People

Office Buildings	<u>AVERAGE</u>		<u>MEDIAN</u>		<u>TOP 5TH PERCENTILE</u>	
	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)
General staff / secretary / support staff Office Building						
#1	1.39	1.58	0.70	0.76	5.86	6.31
#2	0.91	1.11	0.41	0.51	3.79	4.42
#3	0.59	0.92	0.42	0.71	1.81	2.14
#4	<u>0.30</u>	<u>0.93</u>	<u>0.16</u>	<u>0.36</u>	<u>1.00</u>	<u>1.93</u>
Averages	0.80	1.14	0.42	0.59	3.12	3.70
Professional (Engineers, manager, etc.) Office Building						
#1	0.99	1.00	0.50	0.50	3.79	3.79
#2	0.80	0.82	0.64	0.65	2.14	2.14
#3	0.61	0.81	0.42	0.57	1.87	2.37
#4	<u>0.31</u>	<u>1.14</u>	<u>0.17</u>	<u>0.25</u>	<u>0.97</u>	<u>2.19</u>
Averages	0.68	0.94	0.43	0.49	2.19	2.62
Maintenance staff Office Building						
#1	1.07	1.08	0.53	0.54	3.90	3.90
#2	0.80	1.04	0.50	0.65	2.21	3.71
#3						
#4						
Averages	0.94	1.06	0.52	0.60	3.06	3.81
Visitors Office Building						
#1						
#2	0.72	0.72	0.57	0.57	2.10	2.10
#3						
#4						

Continues: Table 7.5 Time Weighted Field by Category of People

Schools	<u>AVERAGE</u>		<u>MEDIAN</u>		<u>TOP 5TH PERCENTILE</u>	
	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)
Teacher School						
#1	0.48	0.52	0.30	0.33	1.50	1.69
#2	1.01	1.36	0.49	0.60	3.72	4.38
#3	0.49	0.57	0.16	0.17	1.85	2.09
#4	<u>1.61</u>	<u>1.65</u>	<u>1.16</u>	<u>1.18</u>	<u>4.82</u>	<u>5.07</u>
Averages	<u>0.90</u>	<u>1.03</u>	<u>0.53</u>	<u>0.57</u>	<u>2.97</u>	<u>3.31</u>
Student School						
#1	0.44	0.48	0.29	0.32	1.39	1.49
#2	1.00	1.20	0.42	0.48	3.90	4.01
#3	0.41	0.49	0.16	0.17	1.51	1.70
#4	<u>1.34</u>	<u>1.36</u>	<u>0.92</u>	<u>0.95</u>	<u>4.18</u>	<u>4.22</u>
Averages	<u>0.80</u>	<u>0.88</u>	<u>0.45</u>	<u>0.48</u>	<u>2.75</u>	<u>2.86</u>
Custodian School						
#1	0.92	1.21	0.33	0.42	4.34	5.97
#2	1.22	1.22	0.78	0.78	3.87	3.77
#3	1.41	1.45	0.36	0.38	4.13	4.22
#4	<u>2.52</u>	<u>2.52</u>	<u>2.20</u>	<u>2.20</u>	<u>5.50</u>	<u>5.50</u>
Averages	<u>1.52</u>	<u>1.60</u>	<u>0.92</u>	<u>0.95</u>	<u>4.46</u>	<u>4.89</u>
Administrative staff School						
#1	1.45	1.77	0.45	0.70	6.71	7.53
#2	1.48	1.48	1.20	1.24	3.77	3.96
#3	0.93	1.19	0.30	0.42	4.54	5.23
#4	<u>2.52</u>	<u>2.72</u>	<u>2.16</u>	<u>2.83</u>	<u>5.61</u>	<u>10.9</u>
Averages	<u>1.60</u>	<u>1.79</u>	<u>1.03</u>	<u>1.30</u>	<u>5.16</u>	<u>6.91</u>
Volunteer parent School						
#1	0.53	0.62	0.25	0.30	2.03	2.54
#2						
#3						
#4						
Averages						

Continues: Table 7.5 Time Weighted Field by Category of People

Hospitals	<u>AVERAGE</u>		<u>MEDIAN</u>		<u>TOP 5TH PERCENTILE</u>	
	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)
Patient Hospital						
#1	1.58	1.64	0.79	0.82	5.88	5.94
#2	0.68	0.86	0.38	0.54	2.20	2.98
#3	0.71	0.79	0.41	0.48	2.30	2.48
#4	<u>0.97</u>	<u>1.04</u>	<u>0.54</u>	<u>0.63</u>	<u>2.96</u>	<u>3.02</u>
Averages	0.99	1.08	0.53	0.62	3.34	3.61
Medical staff Hospital						
#1	1.50	1.53	0.84	0.89	4.50	4.53
#2	1.33	1.37	0.68	0.79	4.32	4.76
#3	2.02	2.66	0.41	0.70	4.21	8.60
#4	<u>1.69</u>	<u>1.75</u>	<u>0.61</u>	<u>0.69</u>	<u>4.23</u>	<u>4.30</u>
Averages	1.64	1.83	0.64	0.77	4.32	5.55
Visitor Hospital						
#1	0.84	0.87	0.63	0.66	2.21	2.22
#2	0.58	0.66	0.38	0.49	1.52	1.75
#3	0.82	0.89	0.46	0.53	2.90	2.95
#4	<u>0.78</u>	<u>0.87</u>	<u>0.40</u>	<u>0.50</u>	<u>2.60</u>	<u>2.71</u>
Averages	0.76	0.82	0.47	0.55	2.31	2.41
Maintenance staff Hospital						
#1						
#2						
#3	1.58	2.10	0.45	0.76	5.26	7.94
#4	<u>1.42</u>	<u>1.52</u>	<u>0.55</u>	<u>0.68</u>	<u>3.51</u>	<u>3.89</u>
Averages	1.50	1.81	0.50	0.72	4.39	5.92

Continues: Table 7.5 Time Weighted Field by Category of People

Machine Shops	<u>AVERAGE</u>		<u>MEDIAN</u>		<u>TOP 5TH PERCENTILE</u>	
	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)
Machinist / fitter Machine Shop						
#1	1.50	1.91	0.25	0.32	5.70	5.70
#2	0.76	0.86	0.31	0.35	2.84	3.16
#3						
#4	<u>1.70</u>	<u>2.61</u>	<u>0.65</u>	<u>0.46</u>	<u>4.83</u>	<u>9.13</u>
Averages	<u>1.32</u>	<u>1.79</u>	<u>0.34</u>	<u>0.38</u>	<u>4.46</u>	<u>6.00</u>
Welder Machine Shop						
#1	1.89	4.68	0.49	0.68	5.78	22.6
#2	0.93	0.97	0.35	0.37	3.19	3.36
#3	0.88	8.62	0.77	0.91	1.52	45.6
#4	<u>2.90</u>	<u>6.42</u>	<u>0.65</u>	<u>2.32</u>	<u>12.9</u>	<u>26.7</u>
Averages	<u>0.93</u>	<u>5.17</u>	<u>0.57</u>	<u>1.07</u>	<u>5.85</u>	<u>24.6</u>
Engineer/ inspector Machine Shop						
#1	1.82	2.21	1.55	1.62	4.42	4.66
#2	0.49	0.59	0.26	0.35	1.45	1.70
#3						
#4	<u>2.64</u>	<u>3.21</u>	<u>0.98</u>	<u>1.01</u>	<u>4.76</u>	<u>9.07</u>
Averages	<u>1.65</u>	<u>2.00</u>	<u>0.93</u>	<u>0.99</u>	<u>3.54</u>	<u>5.14</u>
Assembler/ shipper/ maint. staff Machine Shop						
#1	2.63	2.63	0.26	0.26	6.65	6.65
#2	0.87	0.87	0.31	0.31	0.83	0.83
#3						
#4	<u>2.76</u>	<u>3.95</u>	<u>0.67</u>	<u>0.89</u>	<u>7.60</u>	<u>11.8</u>
Averages	<u>2.09</u>	<u>2.48</u>	<u>0.41</u>	<u>0.49</u>	<u>5.03</u>	<u>6.43</u>
Office staff Machine Shop						
#1	0.61	0.62	0.36	0.38	1.76	1.76
#2	0.69	0.81	0.33	0.37	1.85	2.03
#3						
#4	<u>2.48</u>	<u>3.92</u>	<u>1.08</u>	<u>1.22</u>	<u>4.05</u>	<u>10.2</u>
Averages	<u>1.26</u>	<u>1.78</u>	<u>0.59</u>	<u>0.66</u>	<u>2.55</u>	<u>4.66</u>

Continues: Table 7.5 Time Weighted Field by Category of People

Grocery Store	<u>AVERAGE</u>		<u>MEDIAN</u>		<u>TOP 5TH PERCENTILE</u>	
	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)	Area (mG)	Area and Exposure Points (mG)
Clerk / cashier Grocery Store						
#1	2.44	3.05	0.88	1.63	10.9	11.1
#2	2.65	4.46	1.03	3.59	8.62	9.56
#3	3.86	5.67	1.71	4.28	14.4	15.7
#4	<u>0.54</u>	<u>2.77</u>	<u>0.40</u>	<u>1.33</u>	<u>1.28</u>	<u>11.1</u>
Averages	2.37	3.99	1.00	2.71	8.80	11.9
Butcher / assistant Grocery Store						
#1	5.68	6.02	3.56	3.52	18.2	18.2
#2	1.43	1.57	1.03	1.13	3.99	4.14
#3	6.77	6.77	3.20	3.20	25.2	25.2
#4	<u>1.87</u>	<u>1.87</u>	<u>1.60</u>	<u>1.60</u>	<u>3.85</u>	<u>3.85</u>
Averages	3.94	4.06	2.35	2.36	12.8	12.8
Office staff Grocery Store						
#1	5.67	5.75	4.37	4.44	12.5	12.5
#2	1.96	2.13	1.36	1.46	6.77	6.82
#3	2.02	2.02	1.32	1.32	6.96	6.96
#4	<u>1.09</u>	<u>1.19</u>	<u>1.04</u>	<u>1.12</u>	<u>1.80</u>	<u>2.08</u>
Averages	2.69	2.77	2.02	2.09	7.01	7.09
Customer Grocery Store						
#1	1.42	1.65	0.65	0.83	4.30	4.52
#2	1.51	3.12	0.83	1.12	3.93	13.50
#3	2.31	2.55	1.25	1.45	8.59	8.79
#4	<u>1.07</u>	<u>1.41</u>	<u>0.67</u>	<u>0.82</u>	<u>3.33</u>	<u>4.14</u>
Averages	1.58	2.18	0.85	1.06	5.04	7.74

From table 7.5 it is possible to derive a ranking of different categories of people in the surveyed environments in terms of time weighted average magnetic fields, that account for the total exposure to area and point sources. The results are shown in Table 7.6.

Table 7.6 Ranking of Categories of People on the Basis of Time Weighted Average (TWA) Magnetic Fields

<u>Category of People</u>	<u>Environment</u>	<u>TWA (mG)</u>	<u>Top 5th Percentile</u>
Welder	Machine shop	5.17	24.6
Butcher / Assistant	Grocery store	4.06	12.8
Clerk / Cashier	Grocery store	3.99	11.9
Office staff	Grocery store	2.77	7.09
Assembler / Shipper/ Maintenance staff	Machine shop	2.48	6.43
Customer	Grocery store	2.18	7.74
Engineer / Inspector	Machine shop	2.00	5.14
Medical staff	Hospital	1.83	5.55
Maintenance staff	Hospital	1.81	5.92
Machinist / Fitter	Machine shop	1.79	6.00
Administrative staff	School	1.79	6.91
Office staff	Machine shop	1.78	4.66
Custodian	School	1.60	4.89
General, Secretarial, and support staff	Office building	1.14	3.70
Patient	Hospital	1.08	3.61
Maintenance staff	Office building	1.06	3.81
Teacher	School	1.03	3.31
Professional	Office building	0.94	2.62
Student	School	0.88	2.86
Visitor	Hospital	0.82	2.41

7.4 EXPOSURE BY SOURCE TYPE

Area Sources

The area source that was judged by the operators to be the main contributor to the field in an area, exclusive of the sources at exposure points, is called the "main area source". The magnetic field weighted by exposure time was analyzed also in terms of main area sources. The results for each area are presented as shown in the example graph of Figure 7.8, which shows the time (mG-person) in each field bin for each main area source.

Graphs like those of figure 7.8 provide a visual indication of the relative contribution of different area sources to magnetic field exposure. Similar graphs for all surveyed sites are presented in Appendix C. In addition, the results were analyzed with the purpose of calculating the relative contribution of each area source to the magnetic field exposure in different environments. The calculations were performed as follows. The total exposure (mG-person-min) corresponding to each area source was calculated for each of the four sites surveyed for each environment and was expressed in percentage of the total exposure caused by all area sources. The results of the four sites weighted by the time weighted average field of the site (shown in Table 7.2) were then combined to obtain the results applicable to each environment. The results are shown in Table 7.7.

Figure 7.8 Example of Time in Each Field Bin for Different Area Sources and for All Sources Combined.

Table 7.7 Relative Contribution of Area Sources to Magnetic Field Exposure

Area Source	Schools	Grocery	Office	Hospitals	Machine
(Description)	(%)	Stores	Buildings	(%)	Shops
Power Lines	1.8	18.0	6.1	0.0	0.0
Power supply cables	2.1	0.0	2.6	2.9	0.0
Electrical panels	2.4	2.5	3.0	9.4	21.6
Net Currents	53.9	38.8	2.9	20.6	6.6
Air Conditioners	0.8	0.0	0.0	0.5	0.0
Fluorescent Lights	0.1	27.2	19.4	13.5	11.0
Transformers	0.0	0.0	0.0	0.9	21.9
Office Equipment, Appliances	14.6	0.6	33.8	13.1	8.2
Unknown	24.4	6.1	31.1	29.5	3.2
Laboratory equipment	0.0	0.0	0.0	9.6	0.0
Vending Machines	0.0	0.0	1.1	0.1	0.0
Merchandising Equipment	0.0	6.8	0.0	0.0	0.0
Milling and Welding Equipment	0.0	0.0	0.0	0.0	27.4
	100.0	100.0	100.0	100.0	100.0

Field at Exposure Points

The field at exposure points was calculated separately and then combined with the area field, giving results as those shown in Figures 7.4 and 7.5. The relative importance of area and point sources is also expressed by the results presented in Table 7.5.

7.5 TIME ABOVE A FIELD THRESHOLD

The measurement results can be analyzed to provide quantities other than the time weighted average fields. One such quantity is the time spent above a field threshold. The results obtained for different types of people in different environments are shown in Table 7.8. The time spent above a given field threshold is expressed as a percentage of the total time spent in the environment. Calculations of these percentages were made for the four sites of each environment and then these were averaged to obtain the results applicable to the environment.

Table 7.8 Time Above a Field Threshold (Percentage of the total time. Average for all the sites of the same environment)

	Time Above 2 mG	Time Above 5 mG	Time Above 10 mG	Time Above 20 mG	Time Above 40 mG
Office Building					
General staff / secretary / support staff	17.7	4.8	1.8	0.31	0.10
Professional	14.4	2.9	0.90	0.33	0.16
Maintenance staff	24.9	7.2	3.6	2.1	0.01
Visitors	29.4	7.9	4.5	3.1	0.05
Schools					
Teacher	29.1	10.0	2.7	0.46	0.08
Student	25.3	7.4	1.9	0.41	0.07
Custodian	41.6	16.7	6.6	0.88	0.39
Administrative staff	57.1	27.0	11.2	2.3	0.14
Hospital					
Patient	31.5	7.2	2.7	0.83	0.21
Medical staff	41.1	16.1	5.3	2.0	0.69
Visitor	24.4	5.1	1.0	0.22	0.03
Maintenance staff	33.4	10.5	4.7	1.9	0.7
Machine Shop					
Machinist / fitter	22.0	11.7	5.4	2.5	1.2
Welder	42.7	25.1	17.3	10.8	5.0
Engineer / inspector	43.4	16.6	4.8	2.0	0.86
Assembler / shipper / maintenance staff	26.8	14.6	7.9	3.8	1.7
Office staff	30.7	8.5	4.4	2.1	0.72
Grocery Stores					
Clerk / cashier	55.5	28.4	8.9	0.60	0.11
Butcher / assistant	46.8	16.2	9.0	4.6	0.00
Office staff	40.0	14.8	4.5	0.06	0.00
Customer	28.8	9.2	3.2	0.79	0.11

7.6 DC FIELDS AND COMBINATION OF AC AND DC FIELDS

The distribution of DC field measurements at each site is presented in graphs such as that shown in the example of Figure 7.9. Similar graphs for all the sites surveyed are presented in Appendix D. In all cases there is a wide dispersion of DC magnetic field values.

The angle between DC and AC field was calculated and plotted versus the AC field magnitude. Two examples are shown in Figure 7.10 (for a machine shop) and 7.11 (for a hospital). In both cases the distribution of these angles was found to be not significantly different from a random distribution of angles between two vectors in space. No other similar graphs are presented for the remaining environments.

Figure 7.9 Example of Distribution of DC Field Measured in Different Areas of a Site (School #3).

Figure 7.10 Example of Distribution of the Angle Between the DC Field Vector and the Major Axis of the AC Field Ellipse (Metal Shop #1).

Figure 7.11 Example of Distribution of the Angle Between the DC Field Vector and the Major Axis of the AC Field Ellipse (Hospital #1).

7.7 HARMONICS

The waveshape of the magnetic field was recorded at one to five points in different areas of the site. From these data the amplitude of the third (180 Hz) and fifth (300 Hz) harmonics were extracted and presented as in the example of Figure 7.12. The third and fifth harmonics were the most significant harmonics of 60 Hz present in the area field. The data for all the other sites are reported in Appendix D.

Figure 7.12 Example of Third and Fifth Harmonic Field Values Plotted versus the 60 Hz Field Value (School #3).

The results of the harmonic analyses were pooled for each environment. Figure 7.13 shows the third and fifth harmonic rms field values versus the 60 Hz rms field value for all schools. Each point of the curve represent a moving average. This figure indicates that the third harmonic in the school environment is between 20% and 50 % with a slight tendency of reduction for higher field values. The fifth harmonic percentage has a marked tendency to decrease for increasing field values, going from about 10% for 60 Hz fields of 0.2 mG to about 3% for fields of 8 mG.

Figure 7.14 shows the third and fifth harmonic rms field values versus the 60 Hz rms field value for all hospitals. This figure indicates that the percentage of third harmonic in the hospital environment has a tendency to decrease for increasing field values from about 30% to less than 10% going from 60 Hz fields of 0.1 mG to about 4 mG, with an

upturn for fields greater than 4 mG. The fifth harmonic percentage has a tendency to decrease for increasing field values, going from about 10% for 60 Hz fields of 0.2 mG to about 3% for fields of 4 mG.

Figure 7.15 shows the third and fifth harmonic rms field values versus the 60 Hz rms field value for all grocery stores. This figure indicates that the percentage of third harmonic in the grocery store environment has a tendency to decrease for increasing field values from about 30% to less than 10% going from 60 Hz fields of 0.2 mG to about 10 mG. The fifth harmonic percentage shows a slight decrease for increasing field values, going from about 5-10% for 60 Hz fields of 0.2 mG to 2-3% for fields of 10 mG. .

Figure 7.16 shows the third and fifth harmonic rms field values versus the 60 Hz rms field value for all office buildings. This figure indicates that the percentage of third harmonic in the office building environment has a tendency to decrease for increasing field values from about 30% to less than 10% going from 60 Hz fields of 0.1 mG to 4 mG. The fifth harmonic percentage has a tendency to decrease for increasing field values, going from about 10% for 60 Hz fields of 0.2 mG to about 2% for fields of 4 mG.

Figure 7.17 shows the third and fifth harmonic rms field values versus the 60 Hz rms field value for all machine shops. This figure indicates that the percentage of third harmonic in the machine shop environment has a tendency to decrease for increasing field values from about 30% to less than 10% going from 60 Hz fields of 0.1 mG to about 8 mG. The fifth harmonic percentage remains at the 3-4 % level for 60 Hz fields between 0.7 and 7 mG.

Figure 7.13 Third and Fifth Harmonic RMS Value versus 60 Hz RMS Value. All Measurements in Schools Combined.

Figure 7.14 Third and Fifth Harmonic RMS Value versus 60 Hz RMS Value. All Measurements in Hospitals Combined.

Figure 7.15 Third and Fifth Harmonic RMS Value versus 60 Hz RMS Value. All Measurements in Grocery Stores Combined.

Figure 7.16 Third and Fifth Harmonic RMS Value versus 60 Hz RMS Value. All Measurements in Office Buildings Combined.

Figure 7.17 Third and Fifth Harmonic RMS Value versus 60 Hz RMS Value. All Measurements in Machine Shops Combined.

7.8 POLARIZATION

The polarization of the 60 Hz magnetic field, expressed as the ratio between the minor and the major axis of the 60 Hz field ellipse, was calculated from the waveshape recordings at each site. An example of the graphical representation of the results is shown in figure 7.18. Similar figures for all the other sites are presented in Appendix D. The figures show that the polarization decreases as the magnitude of the 60 Hz field increases. This is shown more clearly in Figure 7.19, in which the results for all schools are combined and where a moving average of a few polarization values is shown. A similar behavior was found for all the environments surveyed.

Figure 7.18 Example of Polarization of the 60 Hz Field Measured at a Site (School #3).

Figure 7.19 Polarization versus RMS Value of 60 Hz Magnetic Field. Results for All Schools Combined.

7.9 TEMPORAL VARIATIONS

Temporal variations of area fields were recorded by leaving a few recorders at fixed locations for periods of time ranging from a few hours to more than 24 hours. The data were analyzed by selecting the periods of time during which the site was occupied and the normal site activities took place. The detailed statistics of the temporal distributions are presented in Appendix E. Of particular interest is the geometric standard deviation of the temporal distribution of the magnetic field values. The geometric standard deviation of the temporal distribution obtained from each temporal recording were calculated and a geometric average was calculated for each site. The results are presented in Table 7.9.

The geometric standard deviation of the temporal distribution is compared in Table 7.10 with the geometric standard deviation of the spatial field distribution obtained through area mapping and with the geometric standard deviation of the combined spatial-temporal distribution. The geometric standard deviation of the combined spatial-temporal distribution was calculated assuming that the temporal and spatial distributions are independent and are log-normal. Calculations were performed using the following equation:

$$(\log(GSD_{s-t}))^2 = (\log(GSD_s))^2 + (\log(GSD_t))^2$$

where GSD_{s-t} is the geometric standard deviation of the spatial-temporal field distribution, GSD_s is the geometric standard deviation of the spatial field distribution, and GSD_t is the geometric standard deviation of the temporal field distribution.

As shown in Table 7.10, in the great majority of the cases the geometric standard deviation of the spatial-temporal distribution is close to that of the spatial distribution. This means that an accurate knowledge of the temporal distribution adds little to the accuracy of exposure calculations. The importance of temporal variation is further reduced if the field at exposure points is considered together with the area field when constructing the overall field distribution as shown in section 7.1.

Table 7.9 Geometric Standard Deviation of the Temporal Field Distribution

Environment	Site #1	Site #2	Site #3	Site #4
Office Building	1.10	1.11	1.10	1.06
School	1.28	1.35	1.21	1.24
Hospital	1.13	1.45	1.47	1.27
Machine Shop	1.54	1.19	1.30	1.34
Grocery stores	1.23	---	1.03	---

Table 7.10 Geometric Standard Deviation of the Spatial (S), Temporal (T), and Spatial-Temporal (S-T) Distributions of Area Fields

	Site #1			Site #2			Site #3			Site #4		
	S	T	S-T	S	T	S-T	S	T	S-T	S	T	S-T
Office Building	3.16	1.10	3.18	4.24	1.11	4.26	2.84	1.10	2.85	7.91	1.06	7.92
School	2.69	1.28	2.77	3.11	1.35	3.23	11.4	1.21	11.5	3.31	1.24	3.38
Hospital	3.47	1.13	3.49	3.26	1.45	3.45	4.12	1.47	4.34	3.24	1.27	3.32
Machine Shop	3.83	1.54	4.10	2.30	1.19	2.34	1.46	1.30	1.58	2.91	1.34	3.03
Grocery Store	4.05	1.23	4.11	4.12	—	—	3.34	1.03	3.34	2.18	—	—

7.10 POINT SOURCE CHARACTERIZATION

The preferred method to characterize point sources was the three-point waveshape capture method described in Reference 7.1. The results of these measurements include the estimate of the magnitude of the magnetic field dipole of the source, expressed in $A \cdot m^2$. The field at a distance R (expressed in meter) from a dipole with magnitude M has a value which is between M/R^3 and $2M/R^3$, the exact value depending on the relative orientation of the dipole moment. For instance, if the dipole moment is equal to $4 A \cdot m^2$, the magnetic field at 0.5 m from the dipole moment (located inside the source) is between 32 and 64 mG. Thus, the dipole moment is a useful quantity for assessing the field of point sources. The values of dipole moments calculated for the sources measured in each environment are presented in Table 7.11. Only the ten highest dipole value sources are listed for each environment. Also listed is the ratio between the 30 Hz and the 60 Hz component that are calculated performing a Fourier analysis on the basis of a 30 Hz period. A value of this parameter larger than 10% indicates that the waveshape has significant components which are not 60 Hz or multiples of 60 Hz.

**Table 7.11 Dipole Moment of Point Sources Measured During the Survey
(Ten Highest Values for Each Environment)**

Site	Office Buildings	Dipole Moment (60Hz)	Dipole Moment (180Hz)	30/60 Hz @ Point #1
	Source Name	($A \cdot m^2$)	($A \cdot m^2$)	(%)
1	UPS	4.75E+00	1.20E-01	0.9
4	UPS	4.30E+00	5.91E-01	0.77
4	Fan	3.34E+00	6.03E-02	0.97
1	Slide Projector	3.20E+00	1.21E-01	1.01
1	Refrigerator	1.78E+00	1.47E-02	0.51
1	Refrigerator	1.41E+00	7.74E-04	0.61
2	Pencil Sharpener	1.36E+00	3.39E-02	1.24
1	Copier (Idle)	1.10E+00		
1	Postage Scale	9.10E-01	3.55E-02	1.59
1	Copy Machine	8.95E-01	5.49E-02	0.7
1	Cassette Radio	7.90E-01	2.26E-03	3.96

Site	Schools	Dipole Moment (60Hz)	Dipole Moment (180Hz)	30/60 Hz @ Point #1
	Source Name	($A \cdot m^2$)	($A \cdot m^2$)	(%)
2	Pencil Sharpener	1.43E+01	2.15E-01	0.95
2	Timer	8.14E+00	1.95E-02	0.49
3	Aquarium Pump	5.64E+00	9.99E-03	0.52
2	Pencil Sharpener	5.33E+00	2.73E-01	0.45
2	Elevator Panel	5.07E+00	1.47E-02	1.19
4	Pencil Sharpener	4.92E+00	3.92E-01	1.11
3	Fluorescent Light	4.60E+00	1.17E-01	0.56
2	Fluorescent Light	4.24E+00	2.44E-02	1.02
4	Refrigerator	2.58E+00	1.60E-02	0.76
1	OH Projector	2.40E+00	7.03E-02	0.56

Hospitals		Dipole Moment (60Hz) (Am^2)	Dipole Moment (180Hz) (Am^2)	30/60 Hz @ Point #1 (%)
Site	Source Name			
4	UPS	1.51E+01	1.57E-01	1.06
3	Incubator	7.65E+00	7.25E-02	1.09
1	X Ray Machine			
	Power Supply	7.33E+00	2.09E-02	0.86
1	X Ray Machine			
	Power Supply	5.96E+00	3.41E-02	1.04
1	X Ray Viewer	5.23E+00	1.82E-01	0.6
2	Lab Freezer	4.56E+00	1.13E-02	0.66
2	Vending Machine	3.95E+00	2.06E-02	0.55
4	X Ray Machine			
	Power Supply	3.93E+00	2.39E-02	0.85
3	Refrigeration Unit	3.72E+00	2.63E-02	0.53
2	Analysis Machine	3.60E+00	1.12E-02	2.73

Machine Shops		Dipole Moment (60Hz) (Am^2)	Dipole Moment (180Hz) (Am^2)	30/60 Hz @ Point #1 (%)
Site	Source Name			
4	Transformer	5.19E+01	6.36E-02	0.74
1	Welder	1.06E+01	4.55E-01	0.77
	Power Supply			
1	11 kW Motor	1.02E+01	5.14E+00	2.76
1	Welder	6.11E+00	5.14E-01	4.9
	Power Supply			
3	Grinder	4.01E+00	1.26E-01	0.86
3	Air Compressor	3.93E+00	1.76E-02	4
1	Ohio Mill Motor	2.76E+00	1.21E-02	4.68
3	Drill Press	2.40E+00	1.49E-02	0.95
2	Precision	2.08E+00	1.30E-02	1.94
	Measuring Instrum.			
2	Belt Sander	1.96E+00	2.44E-02	6.32

Grocery Stores		Dipole Moment (60Hz) (Am^2)	Dipole Moment (180Hz) (Am^2)	30/60 Hz @ Point #1 (%)
Site	Source Name			
2	Refrigerator	8.03E+00	2.64E-02	0.51
3	Regulator	5.99E+00	3.68E-01	0.47
2	Refrigerator	4.18E+00	4.06E-02	0.81
1	Heat Sealing Machine	3.76E+00	1.01E-02	0.75
1	Display Counter	3.17E+00	2.21E-02	0.6
	Lights			
1	Display Counter	1.73E+00	2.69E-03	1.01
	Lights			
2	Fluorescent Lights	1.56E+00	1.93E-02	0.89
3	Register	1.23E+00	3.77E-02	0.99
1	OH Lighting System	1.10E+00	6.74E-02	1.03
2	Check out counter	1.07E+00	8.35E-02	0.97

Most of the point sources measured have a magnetic field which is periodic at 60 Hz and thus contains only 60 Hz and its harmonics. The magnetic field of computer monitors has a period which may be different from 60 Hz. An example of monitor field waveshape is shown in Figure 7.20. The field produced by welding machines and cables was often different from 60 Hz. Measurements of these fields were made by capturing the waveshape for several 60 Hz periods. Examples of such waveshapes are shown in Figures 7.21, 7.22, and 7.23.

Figure 7.20 Example of waveshape of magnetic field measured near a computer monitor. The horizontal axis shows the time in units of 65 μ s. The entire frame is 1/30th of a second, i.e. two 60 Hz cycles.

Figure 7.21 Example of waveshape of magnetic field measured near a welder during welding operations in Machine Shop #1. The horizontal axis shows the time in units of $65 \mu\text{s}$. The entire frame is $4/30^{\text{th}}$ of a second, i.e. sixteen 60 Hz cycles.

Figure 7.22 Example of waveshape of magnetic field measured near a welder during welding operations in Machine Shop #3. The horizontal axis shows the time in units of $65 \mu\text{s}$. The entire frame is $4/30^{\text{th}}$ of a second, i.e. sixteen 60 Hz cycles.

Figure 7.23 Example of waveshape of magnetic field measured near a welder during welding operations in Machine Shop #4. The horizontal axis shows the time in units of 65 μ s. The entire frame is 4/30th of a second, i.e. sixteen 60 Hz cycles.

7.11 MAGNETIC FIELD TRANSIENTS

Number of Recorded Transients

There were a total of 16,789 transient events that triggered the system during the DOE Rapid Project. Of these, 9290 data records met the recording criteria and were stored to memory. With 6 waveform files per data record, the acquired database comprises a total of 55,740 waveforms. In terms of computer memory this equates to approximately 2.8 gigabytes of information. Table 7.12 summarizes the number of triggers and the number of records obtained at each site over the respective 24-hour measurement intervals.

Waveform Analysis/Feature Extraction

Waveform analysis and feature extraction were performed using the internal digital signal processing functions of the LeCroy 7200. This was accomplished under the auspices of several computer programs running on the personal computer. These programs controlled all data processing input/output functions such as waveform transfer between the PC and the LeCroy 7200 and for parameter extraction and storage to reduced data files.

The data analysis computer programs include routines to extract parameters of the raw transient waveforms in both the time and frequency domains. Features such as trigger time, maximum, peak-to-peak, mean, and RMS amplitudes were extracted.

Frequency domain analyses were performed using the LeCroy 7200 Fast Fourier Transform (FFT) with a Blackman-Harris window and DC suppression applied to the waveforms. For the upper bandwidth channels this analysis had a resolution of 5 kHz. The FFT of the background signal traces was subtracted from the FFT of the transient waveforms in an attempt to separate the transient frequency information from the background frequency information. Extracted features included the maximum component amplitude and frequency in 3 decade frequency bins: 10 - 100 kHz, 100 kHz - 1 MHz, and 1 - 10 MHz. Since the analyses were performed on raw data, the extracted amplitudes are expressed in volts.

Table 7.12 Summary of total number of triggers and records per site

Data ID	Site Type	Recording Duration (Hrs : Min)	Total # of Transients Detected	Total # of Transients Recorded	Detection Threshold (mG)
0926	H1	27:00	1142	1086	0.02
1002	H2	26:15	80	79	0.01
1145	H3	45:21	49	42	0.01
1204	H4	11:07	2946	1399	0.05
0929	M1	27:31	332	274	0.05
1120	M2	18:02	3328	1399	0.01
0320	M3	25:08	129	122	0.05
0404	M4	24:04	299	251	0.05
1101	S1	25:01	623	509	0.01
1106	S2	24:10	1014	828	0.01
0206	S3	24:15	23	18	0.01
0118	S4	23:34	172	130	0.01
1129	O1	20:18	4595	1399	0.01
1220	O2	28:03	118	85	0.01
0122	O3	22:39	80	74	0.01
0123	O4	22:02	209	193	0.01
*	G1	*	*	*	*
0130	G2	19:32	876	797	0.01
0226	G3	24:03	774	605	0.05
*	G4	*	*	*	*

* No transients measured at these location due to lack of available space.

Statistical Analysis

Statistical analyses and exploratory data analysis were performed on the data using Intercooled STATA, (ISTATA) a statistical analysis software package. The reduced extracted feature data files for 18 sites were imported into the ISTATA environment, where a subset of the extracted feature data was prepared and saved for analysis. Calibration constants were applied to the data to convert voltage values to magnetic flux densities. The constants used in this conversion are listed in Table 7.13.

Table 7.13 Signal channel calibration conversion constants

SIGNAL CHANNEL	CALIBRATION CONVERSION CONSTANT
Bxf	0.25 mG/V
Byf	0.25 mG/V
Bzf	0.25 mG/V
Bxs	23 mG/V
Bys	23 mG/V
Bzs	23 mG/V

Figure 7.24 shows the number of transients recorded at each measurement location type. These curves represent the total number of transients recorded at each location type divided by the number of locations measured. This format was chosen to normalize the Grocery Store data which was obtained at only two of the four measurement locations due to a lack of physical space to install the equipment. In all cases, the maximum peak to peak value on a single high frequency channel axis was used to compile the summaries. Machine shops, as a group had the largest number of transients measured above 0.2 mG. Hospitals and schools had very few transients measured above 0.3 mG.

Figure 7.24 Average number of transients exceeding a given value for each environment surveyed.

Figures 7.25 through 7.29 present more detailed measurement summaries for each of the five types of sites measured. Figure 7.25 shows the number of transients recorded at each hospital that exceeded a given value. Hospitals H1 and H2 had a large number of transients between 0.1 and 0.2 mG, but no transient above 0.35 mG was recorded.

Figure 7.26 shows the number of transients recorded at each machine shop that exceeded a given value. All four machine shops had a large number of transients above 0.2 mG. Machine shop M4 had more than 100 transients recorded above 0.25 mG.

Figure 7.27 shows the number of transients recorded at each school that exceeded a given value. The majority of recorded transients for the schools were below 0.25 mG. While school S3 had less than 20 total recorded transients, most of those were above 0.25 mG.

Figure 7.28 shows the number of transients recorded at each office building that exceeded a given value. Office buildings O1, O3, and O4 followed similar patterns in the number of transients above 0.1 mG. Office building O2 had significantly more transients recorded between approximately 0.1 mG and 0.5 mG.

Figure 7.29 shows the number of transients recorded the two different grocery stores where it was physically practical to install the transient recording system. Grocery store G2 had significantly more recorded transients than G3 below 0.2 mG. For G3, more transients in the 0.2 mG to 0.4 mG range were recorded.

Figure 7.25 Number of transients exceeding a given value for all measured hospitals.

Figure 7.26 Number of transients exceeding a given value for all measured machine shops.

Figure 7.27 Number of transients exceeding a given value for all measured schools.

Figure

7.28 Number of transients exceeding a given value for all measured office buildings.

Figure

7.29 Number of transients exceeding a given value for all measured grocery stores.

In an environment with a significant number of repetitive transients above the normal system trigger threshold, the system trigger level must be increased to avoid filling the available waveform storage space with a number of similar transients. As shown back in Table 7.12, the repetitive transient rejection algorithm discarded a large number of repetitive transients in an effort to minimize system deadtime. Even though for hospital H4, machine shop M2, and office building O1, the algorithm discarded over 6600 transient events, the system recording limit of 1399 events was reached.

The transient measurement protocol anticipated recording repetitive transients at the trigger level of 0.01 mG . For some site, however, the system trigger level had to be increased to provide for capturing transient events above the repetitive level.

As shown in Table 7.12, six sites required raising the trigger threshold above 0.01 mG. For these six locations, the normal system trigger level would have allowed too many events of low amplitude to be captured causing excessive system deadtime and exceeding the available storage space. However, in all six cases, the signals which necessitated raising the trigger threshold were not repetitive transients but were actually a wide range of signals with various amplitude and frequency characteristics

The top ten largest peak to peak transients for each measurement location are included in Appendix G. This appendix also includes tables for each transient event which describe the frequency components for each high frequency channel axis.

7.12 REFERENCES

7.1 L.E.Zaffanella, T.P.Sullivan, I. Visintainer, "Magnetic Field Characterization of Electrical Appliances as Point Sources Through in Situ Measurements" Paper 96 WM 345-4 PWRD, presented at the 1996 IEEE/PES Winter Power Meeting, Jan. 96, Baltimore, MD. To be published in the IEEE Transactions on Power Delivery.

Section 8

DATABASE

8.1 INTRODUCTION

This Section describes the data set generated as a result of the environmental magnetic field surveys performed during EMF RAPID Engineering Project 3 "Environmental Field surveys". The management and analysis of the data are described in Section 6.

The data set produced by this project is intended to be included in the *EMF Measurement Database* developed by the U.S. Department of Energy (DOE). DOE's EMF Measurement Database consists of a *database index* and a *database repository*. For each data set, the index contains the *metadata* (i.e. data about data), which describe the nature and organization of the data set. The repository contains the *data products* of the data set.

The metadata file and the data product files resulting from this project are described in this Section.

8.2 METADATA

The metadata of the data set of the EMF RAPID Engineering Project 3: "Environmental Field Surveys" consists of four parts: data set reference, data set description, data model, and data product description. A metadata file using the Standardized Generalized Markup Language (SGML) was prepared. This file is listed in Appendix H.

The data model used is described by the *entity-relationship diagram* (ER diagram) of Figure 8.1.

Figure 8.1 Entity - Relationship Diagram

8.3 DATA PRODUCTS

The following data products are available from this project:

(One) Site File. This file contains general characteristics of all the sites tested.

(One) Area Type File. This file contains the description of different types of areas for each environment.

(One) Person Type File. This file contains the description of different types of persons for each environment.

(One) Area Source Type File. This file contains the description of different types of area sources.

(One) Point Source Type File. This file contains the description of different types of sources at exposure points.

(Twenty) ACDC Measurement Files. These files contain the description of the summary results of the simultaneous AC and DC measurements performed in different areas of each site.

(Twenty) MAP Files. These files contain the statistical summaries of the rms field values measured in all areas of each site.

(Twenty) Area Activity Files. These files contain the information obtained from the area activity questionnaire for all areas of each site.

(Twenty) Main Area Source Files. These files contain the identification of the area source responsible for the area field, for all areas of each site.

(Twenty) Exposure Point Activity Files. These files contain the information obtained from the exposure point activity questionnaire, for all areas of each site.

(Twenty) Source Characterization (Method 1) Files. These files contain the information about the field at different distances from sources characterized through measurements using method 1. For all source of each site.

(Seven) Source Characterization (Method 2) Files. These files contain the information about the field at different distances from sources characterized through measurements using method 2. For all sources of each site, except those sites in which characterization method 2 was not used.

(Nineteen) Source Characterization (Method 3) Files. These files contain the information about the field at different distances from sources characterized

through measurements using method 3. For all sources of each site, except those sites in which characterization method 3 was not used.

(Twenty) Wave Files. These files contain information about the waveshape records for source characterization.

(One) Temporal Data File. This file contains the statistical summary of the results of EMDEX II recorders left at fixed location over periods of time.

(Eighteen) Transient Data Set Information Files. These files contain information on number, times of occurrence, peak-to-peak values, and frequency of magnetic field transients for all the transients measured at each site. Measurements at two sites were not made because of lack of a suitable location for the transient instrumentation.

8.3 OTHER DATA

The EMDEX files containing the temporal data may be of further interest should some aspect of the temporal variations other than those used for the conclusions of this report be considered important. These files are available, although they have not been included in the database.

The Wavecorder files obtained during source characterization and the description of their structure are also available, although they have not been included in the database. The source field waveshape may be of further interest beyond what was used to derive the conclusions of this report.

Section 9

CONCLUSIONS

Preliminary magnetic field surveys were conducted in five different environments: schools, hospitals, office buildings, machine shops, and grocery stores. The first objective of this project was to obtain information on the levels and characteristics of these environments, for which only limited data were available, especially in comparison to magnetic field data for the residential environment and for electric utility facilities (power lines and substations). The second objective of this project was to provide information on the contribution of various field sources in the surveyed environments. The information obtained by this project would also be useful for further studies of field sources, exposure assessment, and for developing options to mitigate fields.

Magnetic field surveys were performed at four sites for each of the five selected environments. Of the twenty sites surveyed, 11 were located in the San Francisco Bay Area and 9 in Massachusetts. The sites were selected from a convenience sample, the main criteria for the selection being the adequacy of the site for the purpose for the survey and the willingness of the site owners or operators to participate in the study.

A magnetic field site survey protocol based on magnetic field measurements and observation of activity patterns was developed. The protocol combines the requirement of efficiency and minimal disruption of site activities with the need to obtain estimates of magnetic field exposure by type of people and by type of sources.

The magnetic field surveys conducted by this project produced a large amount of data which will form a part of the EMF database. A detailed analysis of the data was performed as a part of this project with the following conclusions:

- 1- Field and exposure data could be obtained separately for "area exposure" and "at exposure points". An exposure point is a location where persons engage in fixed, site specific activities (e.g. sitting in front of a desktop computer or standing at a lathe in a machine shop) near a local source that creates a significant increase in the area field. The area field is produced by "area sources", whose location and field distribution is in general not related to the location of the people in the area. Example of area sources are power lines, net currents in electrical conduits, and distributed fluorescent lights on the ceiling.
- 2- The area field distribution of a site, calculated weighing each area's field distribution by the time (person-minute) spent in the area, was not significantly different from the area field distribution obtained weighting each area by its surface area or giving to each area the same weight. Differences between weighting methods are less significant than differences between sites and between environments.

- 3- Time Weighted Average Area (TWAA) field was found highest in grocery stores (1.93 mG average for the four sites), then in machine shops (1.42 mG), hospitals (1.27 mG), schools (0.83 mG), and office buildings (0.72 mG). The same ranking was obtained for the top 5th percentile of the area field distribution: 7.5 mG for grocery stores, 4.2 mG for machine shops, 3.7 mG for hospitals, 2.8 mG for schools, and 2.5 mG for office buildings.
- 4- Differences between TWAA area fields obtained at different sites of the source environment were significant in comparison to differences between environments. In fact, the highest TWAA area field found in an office building (i.e. in the environment with the lowest average TWAA area field) was higher than the lowest average area field found in a grocery store (i.e. in the environment with the highest average TWAA area field).
- 5- Exposure at exposure points can be characterized by defining a zone of activity (range of distances from a source), an exposure duration (person-minutes), and by determining, through measurements, the field at different distances from the source.
- 6- Time Weighted Average (TWA) fields, caused by the combination of area and point fields showed only a modest increase over TWAA fields for schools (from 0.8 to 0.9 mG), for hospitals (from 1.3 to 1.4 mG), and for office buildings (from 0.7 to 1.0 mG) and showed a strong increase for grocery stores (from 1.9 to 2.7 mG) and especially for machine shops (from 1.4 to 3.9 mG), indicating a large effect of local sources for these two environments.
- 7- Time weighted average field and time weighted field distribution was calculated separately for each group of people. The following observations were made:
 - In office buildings, secretarial and support staff had a greater exposure than professionals.
 - In schools, teacher were slightly more exposed than students. Custodians and administrative staff were significantly more exposed than teachers and students.
 - In hospitals, the medical staff and the maintenance staff were significantly more exposed than patients. Visitors were the least exposed.
 - In machine shops welders had by far the largest exposure.
 - In grocery stores clerks, cashiers, and butchers had much greater exposure than office staff and customers.

8- Comparing groups of people across environments, the following observations were made:

- The groups with the highest time weighted exposure, both in terms of TWA and of top 5th percentile were welders in machine shops (TWA = 5.2 mG, top 5th percentile = 24.6 mG), followed by butchers in grocery stores (TWA = 4.1 mG, top 5th percentile = 12.8 mG) and clerks / cashiers in grocery stores (TWA = 4.0 mG, top 5th percentile = 11.9 mG),
- The groups with the lowest time weighted exposure were visitors in hospitals (TWA = 0.8 mG, top 5th percentile = 2.4 mG), students in schools (TWA = 0.9 mG, top 5th percentile = 2.9 mG), and professionals in office buildings (TWA = 0.9 mG, top 5th percentile = 2.6 mG). These data refer to the average person of a given type. Individual people may have higher or lower exposures and their exposure may vary significantly from day to day.

9- The operators were well trained technical people conducting the survey using specialized techniques. They identified most of the area sources responsible for the largest contribution to area field in each area. Time weighted average area fields and time weighted area field distribution were calculated separately for each area source. The relative contribution of each area source to area exposure was calculated. The following observations were made:

- Net currents were the main contributor to area fields in schools, grocery stores, and hospitals.
- Office equipment was the main contributor to area fields in office buildings.
- Milling and welding equipment was the main contributor to area field in machine shops.
- Fluorescent lights were important contributions to area fields in grocery stores, office buildings, and hospitals.
- Electrical panels were an important contributor to area fields in machine shops.
- 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.

10- The percentage of total time spent above a field threshold was calculated for each type of persons, for different field thresholds (2, 5, 10, 20, and 40 mG). It was found, for instance, that clerks / cashiers in grocery stores had the highest percentage of time (56%) spent above 2 mG and that professional in office buildings had the lowest (14%).

11- The magnitude of the DC magnetic field varies greatly from one location to another of the source site. Distribution of DC magnetic field values were provided for each

site. The median values of these distributions are lower than the value of the unperturbed geomagnetic field.

12- The angle between the DC field vector and the direction of the major axis of the 60 Hz field ellipse appears to be random.

13- The waveshape of area fields and of fields from point sources was systematically captured. Amplitude of harmonics and field polarization were calculated. The following observations were made regarding the harmonic content of area fields:

- The most significant harmonics in the area fields were the third (180 Hz) and the fifth (300 Hz).

Environmental Field Surveys

Volume 2: Appendices A,B,C,D,E,F

**EMF RAPID PROGRAM
ENGINEERING PROJECT #3**

Prepared by
ENERTECH CONSULTANTS
17 Main Street
P.O.Box 770
Lee, Massachusetts 01238

Principal Investigator
Luciano E. Zaffanella

Prepared for
Lockheed Martin Energy Systems, Inc.
P.O.Box 2002
241 W. Tyrone Road, D104
Oak Ridge, Tennessee 37831-6501

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CONTENTS

Section	Page
Appendix A - Statistical Distribution of Area Fields at All Surveyed Sites	A-1
Office Building #1	A-1
Office Building #2	A-4
Office Building #3	A-7
Office Building #4	A-10
School #1	A-13
School #2	A-16
School #3	A-19
School #4	A-22
Hospital #1	A-25
Hospital #2	A-28
Hospital #3	A-31
Hospital #4	A-34
Machine Shop #1	A-37
Machine Shop #2.....	A-40
Machine Shop #	A-43
Machine Shop 4	A-46
Grocery Store #1	A-49
Grocery Store #2	A-52
Grocery Store #3	A-55
Grocery Store #4	A-58
 Appendix B - Statistical Distribution of Area Fields, Fields at Exposure Points, and Combined Fields	 B-1
 Appendix C - Magnetic Field Exposure by Type of People and Type of Source for All Surveyed Sites	 C-1
 Appendix D - DC Fields, AC Field Harmonics and 60Hz Field Polarization for all Surveyed Sites	 D-1
 Appendix E - Temporal Distribution Data	 E-1
 Appendix F - Transient Survey Measuring System	 F-1

APPENDIX A

STATISTICAL DISTRIBUTION OF AREA FIELDS AT ALL SURVEYED SITES

OFFICE BUILDINGS

Office Building #1

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
1.18 mG	1.08 mG	1.11 Mg

Minimum and maximum measured area fields

0.01 mG 32.5 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.1	0.02	0.01
5	0.16	0.13	0.12
10	0.2	0.18	0.17
25	0.31	0.28	0.28
50	0.55	0.52	0.54
75	1.1	1.07	1.07
90	2.44	2.45	2.55
95	3.91	3.98	4.26
99	6.6	9.14	6.53

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.003	0.009	0.013	1401
2	0.014	0.021	0	0.001	0.002	174
3	0.021	0.03	0	0.001	0.002	174
4	0.03	0.042	0	0.001	0.002	174
5	0.042	0.061	0	0.001	0.002	174
6	0.061	0.087	0	0.001	0.002	174
7	0.087	0.125	0.012	0.027	0.034	3750
8	0.125	0.179	0.052	0.06	0.061	6815
9	0.179	0.257	0.12	0.121	0.109	12089
10	0.257	0.368	0.14	0.139	0.127	14136
11	0.368	0.528	0.157	0.15	0.142	15802
12	0.528	0.758	0.153	0.142	0.162	17965
13	0.758	1.087	0.109	0.103	0.1	11087
14	1.087	1.559	0.088	0.082	0.075	8389
15	1.559	2.236	0.055	0.054	0.057	6347
16	2.236	3.207	0.043	0.041	0.04	4476
17	3.207	4.6	0.032	0.032	0.03	3315
18	4.6	6.598	0.017	0.017	0.019	2166
19	6.598	9.463	0.009	0.009	0.015	1672
20	9.463	13.572	0.005	0.005	0.004	493
21	13.572	19.466	0.002	0.003	0.003	335
22	19.466	27.92	0	0.001	0.001	60
23	27.92	40.045	0	0.001	0	37
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	111205

Time Above Field Values

Total time = 111205
 Time above 1 mG = 29853
 Time above 2 mG = 14517
 Time above 5 mG = 4261

Time above 10 mG = 849

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Office Building #2

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
0.83 mG	0.82 mG	0.86 mG

Minimum and maximum measured area fields

0.01 mG 16.8 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.01	0.01	0.01
5	0.01	0.01	0.01
10	0.09	0.09	0.08
25	0.18	0.2	0.17
50	0.48	0.54	0.49
75	0.99	1.03	1.01
90	1.73	1.77	1.84
95	2.64	2.22	2.74
99	6.6	6.15	6.57

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.068	0.063	0.074	2503
2	0.014	0.021	0.005	0.005	0.006	188
3	0.021	0.03	0.005	0.005	0.006	188
4	0.03	0.042	0.005	0.005	0.006	188
5	0.042	0.061	0.005	0.005	0.006	188
6	0.061	0.087	0.005	0.005	0.006	188
7	0.087	0.125	0.075	0.067	0.073	2457
8	0.125	0.179	0.076	0.08	0.08	2699
9	0.179	0.257	0.06	0.052	0.055	1854
10	0.257	0.368	0.1	0.093	0.098	3300
11	0.368	0.528	0.128	0.108	0.117	3936
12	0.528	0.758	0.126	0.158	0.131	4422
13	0.758	1.087	0.113	0.125	0.117	3942
14	1.087	1.559	0.102	0.104	0.097	3274
15	1.559	2.236	0.056	0.075	0.065	2170
16	2.236	3.207	0.018	0.024	0.023	764
17	3.207	4.6	0.014	0.009	0.015	520
18	4.6	6.598	0.01	0.006	0.01	344
19	6.598	9.463	0.007	0.004	0.007	238
20	9.463	13.572	0.005	0.004	0.005	182
21	13.572	19.466	0.001	0.001	0.001	25
22	19.466	27.92	0	0	0	0
23	27.92	40.045	0	0	0	0
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	33630

Time Above Field Values

Total time = 33630
 Time above 1 mG = 8428
 Time above 2 mG = 2744
 Time above 5 mG = 709

Time above 10 mG =

179

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Office Building #3

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
0.58 mG	0.65 mG	0.61 mG

Minimum and maximum measured area fields

0.01 mG 16 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.01	0.01	0.09
5	0.12	0.11	0.13
10	0.15	0.15	0.17
25	0.23	0.23	0.25
50	0.38	0.38	0.42
75	0.67	0.72	0.72
90	1.22	1.43	1.29
95	1.82	2.14	1.89
99	2.24	4.14	2.19

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.015	0.022	0.006	244
2	0.014	0.021	0.001	0.002	0.001	24
3	0.021	0.03	0.001	0.002	0.001	24
4	0.03	0.042	0.001	0.002	0.001	24
5	0.042	0.061	0.001	0.002	0.001	24
6	0.061	0.087	0.001	0.002	0.001	24
7	0.087	0.125	0.034	0.035	0.028	1133
8	0.125	0.179	0.09	0.09	0.081	3259
9	0.179	0.257	0.157	0.157	0.135	5432
10	0.257	0.368	0.187	0.172	0.189	7613
11	0.368	0.528	0.182	0.165	0.188	7569
12	0.528	0.758	0.124	0.117	0.14	5621
13	0.758	1.087	0.089	0.088	0.104	4198
14	1.087	1.559	0.052	0.061	0.057	2278
15	1.559	2.236	0.033	0.039	0.036	1454
16	2.236	3.207	0.021	0.028	0.024	965
17	3.207	4.6	0.004	0.01	0.004	142
18	4.6	6.598	0.002	0.003	0.003	101
19	6.598	9.463	0.002	0.003	0.001	43
20	9.463	13.572	0	0	0	3
21	13.572	19.466	0	0.001	0	4
22	19.466	27.92	0	0	0	0
23	27.92	40.045	0	0	0	0
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	40181

Time Above Field Values

Total time = 40181
 Time above 1 mG = 5960
 Time above 2 mG = 1708
 Time above 5 mG = 127
 Time above 10 mG = 6

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Office Building #4

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
0.53 mG	0.52 mG	0.31 mG

Minimum and maximum measured area fields

0.01 mG	16.7 mG
---------	---------

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.01	0.01	0.01
5	0.01	0.01	0.01
10	0.01	0.04	0.01
25	0.11	0.14	0.1
50	0.17	0.24	0.16
75	0.29	0.49	0.3
90	0.59	0.97	0.8
95	0.94	1.69	1.01
99	2.24	6.77	3.21

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.101	0.074	0.13	9318
2	0.014	0.021	0.01	0.008	0.014	1002
3	0.021	0.03	0.01	0.008	0.014	997
4	0.03	0.042	0.01	0.008	0.014	997
5	0.042	0.061	0.01	0.008	0.014	997
6	0.061	0.087	0.01	0.008	0.014	997
7	0.087	0.125	0.168	0.1	0.156	11184
8	0.125	0.179	0.226	0.156	0.2	14342
9	0.179	0.257	0.178	0.159	0.159	11407
10	0.257	0.368	0.087	0.127	0.084	5989
11	0.368	0.528	0.081	0.124	0.063	4510
12	0.528	0.758	0.039	0.084	0.028	2037
13	0.758	1.087	0.04	0.055	0.077	5488
14	1.087	1.559	0.012	0.025	0.012	824
15	1.559	2.236	0.008	0.023	0.008	593
16	2.236	3.207	0.003	0.01	0.003	226
17	3.207	4.6	0.002	0.006	0.002	164
18	4.6	6.598	0.002	0.005	0.002	152
19	6.598	9.463	0.001	0.005	0.001	70
20	9.463	13.572	0.001	0.005	0.001	65
21	13.572	19.466	0.001	0	0.001	41
22	19.466	27.92	0	0	0	0
23	27.92	40.045	0	0	0	0
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	71627

Time Above Field Values

Total time = 71627
 Time above 1 mG = 3405
 Time above 2 mG = 902
 Time above 5 mG = 294
 Time above 10 mG = 96

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

SCHOOLS

School #1

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
0.71 mG	0.51 mG	0.48 mG

Minimum and maximum measured area fields

0.01 mG 13.1 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.01	0.01	0.01
5	0.09	0.01	0.11
10	0.13	0.01	0.13
25	0.19	0.14	0.19
50	0.33	0.24	0.29
75	0.67	0.43	0.47
90	2.05	1.04	0.98
95	3.44	1.97	1.47
99	6.6	5.58	3.2

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.041	0.116	0.018	3515
2	0.014	0.021	0.002	0.005	0.002	336
3	0.021	0.03	0.002	0.005	0.002	336
4	0.03	0.042	0.002	0.005	0.002	336
5	0.042	0.061	0.002	0.005	0.002	336
6	0.061	0.087	0.002	0.005	0.002	336
7	0.087	0.125	0.048	0.07	0.046	9049
8	0.125	0.179	0.126	0.155	0.157	30869
9	0.179	0.257	0.16	0.167	0.201	39536
10	0.257	0.368	0.183	0.166	0.221	43585
11	0.368	0.528	0.141	0.116	0.158	31136
12	0.528	0.758	0.066	0.049	0.058	11527
13	0.758	1.087	0.054	0.039	0.048	9543
14	1.087	1.559	0.046	0.032	0.042	8354
15	1.559	2.236	0.037	0.02	0.021	4120
16	2.236	3.207	0.034	0.015	0.008	1556
17	3.207	4.6	0.034	0.014	0.005	1067
18	4.6	6.598	0.01	0.007	0.006	1135
19	6.598	9.463	0.008	0.004	0.001	265
20	9.463	13.572	0.004	0.002	0.001	115
21	13.572	19.466	0	0	0	0
22	19.466	27.92	0	0	0	0
23	27.92	40.045	0	0	0	0
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	197055

Time Above Field Values

Total time	=	197055
Time above 1 mG	=	18819
Time above 2 mG	=	5413
Time above 5 mG	=	1253
Time above 10 mG	=	98

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

School #2

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
1.07 mG	1.21 mG	1.01 mG

Minimum and maximum measured area fields

0.01 mG 20.2 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.1	0.08	0.09
5	0.14	0.13	0.13
10	0.18	0.17	0.16
25	0.27	0.26	0.23
50	0.67	0.67	0.44
75	1.42	1.79	1.15
90	2.38	3	2.61
95	3.44	3.96	3.88
99	4.6	6.06	4.54

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.003	0.006	0.002	262
2	0.014	0.021	0	0.001	0.001	57
3	0.021	0.03	0	0.001	0.001	57
4	0.03	0.042	0	0.001	0.001	57
5	0.042	0.061	0	0.001	0.001	57
6	0.061	0.087	0	0.001	0.001	57
7	0.087	0.125	0.025	0.028	0.028	3089
8	0.125	0.179	0.074	0.08	0.092	10029
9	0.179	0.257	0.134	0.13	0.196	21347
10	0.257	0.368	0.083	0.091	0.118	12880
11	0.368	0.528	0.111	0.105	0.139	15220
12	0.528	0.758	0.114	0.087	0.087	9466
13	0.758	1.087	0.125	0.091	0.075	8207
14	1.087	1.559	0.112	0.086	0.077	8424
15	1.559	2.236	0.11	0.119	0.064	6940
16	2.236	3.207	0.052	0.091	0.049	5327
17	3.207	4.6	0.036	0.057	0.042	4548
18	4.6	6.598	0.014	0.019	0.019	2049
19	6.598	9.463	0.002	0.002	0.004	384
20	9.463	13.572	0.002	0.002	0.004	394
21	13.572	19.466	0.001	0.001	0.002	179
22	19.466	27.92	0	0	0.001	106
23	27.92	40.045	0	0	0	0
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	109136

Time Above Field Values

Total time = 109136
 Time above 1 mG = 30249
 Time above 2 mG = 15134
 Time above 5 mG = 2638
 Time above 10 mG = 619

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

School #3

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
0.48 mG	0.48 mG	0.45 mG

Minimum and maximum measured area fields

0.01 mG 76.5 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.01	0.01	0.01
5	0.01	0.01	0.01
10	0.01	0.01	0.01
25	0.09	0.07	0.03
50	0.18	0.2	0.16
75	0.5	0.54	0.45
90	1.09	1.05	1.02
95	1.81	1.57	1.65
99	3.21	4.37	3.2

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.177	0.184	0.22	60811
2	0.014	0.021	0.015	0.015	0.017	4795
3	0.021	0.03	0.015	0.015	0.017	4795
4	0.03	0.042	0.015	0.015	0.017	4795
5	0.042	0.061	0.015	0.015	0.017	4795
6	0.061	0.087	0.015	0.015	0.017	4795
7	0.087	0.125	0.107	0.083	0.101	28027
8	0.125	0.179	0.152	0.135	0.136	37647
9	0.179	0.257	0.095	0.093	0.091	25249
10	0.257	0.368	0.08	0.084	0.075	20843
11	0.368	0.528	0.081	0.093	0.077	21254
12	0.528	0.758	0.077	0.092	0.073	20322
13	0.758	1.087	0.058	0.069	0.049	13577
14	1.087	1.559	0.04	0.042	0.037	10379
15	1.559	2.236	0.025	0.023	0.024	6649
16	2.236	3.207	0.016	0.012	0.014	3921
17	3.207	4.6	0.009	0.007	0.007	2002
18	4.6	6.598	0.006	0.005	0.005	1261
19	6.598	9.463	0.002	0.002	0.001	310
20	9.463	13.572	0.001	0.001	0.001	224
21	13.572	19.466	0.001	0.001	0	112
22	19.466	27.92	0	0	0	92
23	27.92	40.045	0	0	0	78
24	40.045	57.435	0	0	0	39
25	57.435	82.377	0	0	0	33
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	276805

Time Above Field Values

Total time =	276805
Time above 1 mG =	28241
Time above 2 mG =	10129
Time above 5 mG =	1858
Time above 10 mG =	544

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

School #4

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
1.4 mG	1.48 mG	1.37 mG

Minimum and maximum measured area fields

0.01 mG 17.3 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.01	0.02	0.01
5	0.13	0.13	0.13
10	0.18	0.19	0.16
25	0.38	0.36	0.32
50	0.97	0.93	0.97
75	1.88	1.93	1.81
90	3.11	3.38	2.95
95	4.42	4.98	4.3
99	6.6	8.99	6.56

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.011	0.01	0.012	3457
2	0.014	0.021	0.001	0.001	0.002	462
3	0.021	0.03	0.001	0.001	0.002	462
4	0.03	0.042	0.001	0.001	0.002	462
5	0.042	0.061	0.001	0.001	0.002	462
6	0.061	0.087	0.001	0.001	0.002	462
7	0.087	0.125	0.028	0.025	0.025	7186
8	0.125	0.179	0.058	0.05	0.081	23410
9	0.179	0.257	0.072	0.102	0.08	22963
10	0.257	0.368	0.071	0.063	0.076	21821
11	0.368	0.528	0.068	0.065	0.064	18497
12	0.528	0.758	0.113	0.121	0.096	27643
13	0.758	1.087	0.11	0.112	0.091	26067
14	1.087	1.559	0.148	0.128	0.163	46773
15	1.559	2.236	0.134	0.125	0.143	41093
16	2.236	3.207	0.087	0.087	0.083	23979
17	3.207	4.6	0.047	0.05	0.035	10165
18	4.6	6.598	0.026	0.032	0.023	6475
19	6.598	9.463	0.013	0.017	0.013	3720
20	9.463	13.572	0.004	0.006	0.006	1761
21	13.572	19.466	0.001	0.001	0.001	202
22	19.466	27.92	0	0	0	0
23	27.92	40.045	0	0	0	0
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	287519

Time Above Field Values

Total time = 287519
 Time above 1 mG = 140196
 Time above 2 mG = 59014
 Time above 5 mG = 10661
 Time above 10 mG = 1693

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

HOSPITALS

Hospital #1

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
1.36 mG	1.07 mG	1.43 mG

Minimum and maximum measured area fields

0.01 mG 87.1 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.09	0.09	0.1
5	0.14	0.13	0.14
10	0.18	0.17	0.18
25	0.29	0.27	0.33
50	0.56	0.5	0.79
75	1.4	1.08	2.12
90	3	2.31	3.3
95	5.49	3.24	4.42
99	13.57	10.56	4.52

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.004	0.004	0.002	435
2	0.014	0.021	0.001	0.001	0	60
3	0.021	0.03	0.001	0.001	0	60
4	0.03	0.042	0.001	0.001	0	60
5	0.042	0.061	0.001	0.001	0	60
6	0.061	0.087	0.001	0.001	0	60
7	0.087	0.125	0.026	0.028	0.021	4409
8	0.125	0.179	0.062	0.086	0.07	14609
9	0.179	0.257	0.108	0.114	0.08	16547
10	0.257	0.368	0.158	0.164	0.118	24500
11	0.368	0.528	0.125	0.122	0.103	21416
12	0.528	0.758	0.101	0.126	0.095	19723
13	0.758	1.087	0.101	0.104	0.091	18918
14	1.087	1.559	0.091	0.085	0.082	16918
15	1.559	2.236	0.074	0.059	0.104	21500
16	2.236	3.207	0.059	0.053	0.128	26520
17	3.207	4.6	0.03	0.021	0.062	12913
18	4.6	6.598	0.017	0.011	0.032	6622
19	6.598	9.463	0.019	0.007	0.005	990
20	9.463	13.572	0.01	0.005	0.002	509
21	13.572	19.466	0.009	0.004	0.002	332
22	19.466	27.92	0.002	0.002	0.001	189
23	27.92	40.045	0	0	0	18
24	40.045	57.435	0	0	0	17
25	57.435	82.377	0	0	0	3
26	82.377	118.152	0	0	0	1
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	207390

Time Above Field Values

Total time = 207390
 Time above 1 mG = 90906
 Time above 2 mG = 54764
 Time above 5 mG = 7149
 Time above 10 mG = 990

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Hospital #2

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
1.15 mG	1.12 mG	1.2 mG

Minimum and maximum measured area fields

0.01 mG 29.7 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.1	0.09	0.09
5	0.15	0.13	0.14
10	0.19	0.16	0.18
25	0.33	0.27	0.31
50	0.61	0.52	0.6
75	1.3	1.16	1.35
90	2.49	2.6	2.6
95	3.83	4.13	4.03
99	9.46	9.39	9.45

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.003	0.004	0.003	729
2	0.014	0.021	0	0.001	0.001	151
3	0.021	0.03	0	0.001	0.001	151
4	0.03	0.042	0	0.001	0.001	151
5	0.042	0.061	0	0.001	0.001	151
6	0.061	0.087	0	0.001	0.001	151
7	0.087	0.125	0.017	0.027	0.019	4422
8	0.125	0.179	0.062	0.096	0.069	16020
9	0.179	0.257	0.089	0.098	0.094	22017
10	0.257	0.368	0.122	0.134	0.128	29946
11	0.368	0.528	0.151	0.139	0.146	34073
12	0.528	0.758	0.143	0.132	0.127	29619
13	0.758	1.087	0.114	0.101	0.107	24928
14	1.087	1.559	0.105	0.086	0.098	22765
15	1.559	2.236	0.078	0.061	0.088	20484
16	2.236	3.207	0.049	0.045	0.049	11464
17	3.207	4.6	0.03	0.033	0.032	7570
18	4.6	6.598	0.015	0.017	0.016	3651
19	6.598	9.463	0.009	0.012	0.009	2193
20	9.463	13.572	0.006	0.005	0.006	1330
21	13.572	19.466	0.002	0.003	0.004	888
22	19.466	27.92	0.002	0.001	0.002	489
23	27.92	40.045	0	0	0	41
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	233385

Time Above Field Values

Total time = 233385
 Time above 1 mG = 76640
 Time above 2 mG = 33964
 Time above 5 mG = 7748
 Time above 10 mG = 2544

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Hospital #3

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
2.41 mG	1.6 mG	1.22 mG

Minimum and maximum measured area fields

0.01 mG 2228.8 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.01	0.01	0.01
5	0.02	0.02	0.04
10	0.1	0.1	0.11
25	0.18	0.18	0.21
50	0.41	0.37	0.42
75	0.94	0.92	0.91
90	1.92	2.1	1.86
95	3.34	4.77	2.96
99	13.57	21.63	9.45

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.048	0.047	0.037	15932
2	0.014	0.021	0.005	0.005	0.004	1903
3	0.021	0.03	0.005	0.005	0.004	1903
4	0.03	0.042	0.005	0.005	0.004	1903
5	0.042	0.061	0.005	0.005	0.004	1903
6	0.061	0.087	0.005	0.005	0.004	1903
7	0.087	0.125	0.085	0.075	0.059	25133
8	0.125	0.179	0.094	0.104	0.086	36517
9	0.179	0.257	0.105	0.123	0.11	47118
10	0.257	0.368	0.117	0.124	0.141	59961
11	0.368	0.528	0.108	0.107	0.132	56123
12	0.528	0.758	0.117	0.099	0.124	52954
13	0.758	1.087	0.093	0.086	0.083	35543
14	1.087	1.559	0.084	0.073	0.083	35362
15	1.559	2.236	0.047	0.043	0.052	21989
16	2.236	3.207	0.027	0.026	0.029	12249
17	3.207	4.6	0.013	0.015	0.015	6584
18	4.6	6.598	0.008	0.01	0.009	3872
19	6.598	9.463	0.01	0.013	0.006	2550
20	9.463	13.572	0.008	0.01	0.003	1456
21	13.572	19.466	0.005	0.007	0.002	848
22	19.466	27.92	0.003	0.004	0.001	562
23	27.92	40.045	0.003	0.004	0.001	571
24	40.045	57.435	0.001	0.001	0.001	245
25	57.435	82.377	0	0	0	109
26	82.377	118.152	0	0	0	109
27	118.152	169.462	0	0	0	109
28	169.462	243.055	0	0	0	109
29	243.055	348.608	0	0	0	109
30	348.608	500	0	0	0	109
TOTAL			1	1	1	426611

Time Above Field Values

Total time = 426611
 Time above 1 mG = 95159
 Time above 2 mG = 36392
 Time above 5 mG = 9861
 Time above 10 mG = 4111

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Hospital #4

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
1.17 mG	1.4 mG	1.24 mG

Minimum and maximum measured area fields

0.01 mG 328 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.09	0.02	0.01
5	0.13	0.12	0.11
10	0.17	0.16	0.15
25	0.3	0.28	0.26
50	0.54	0.55	0.52
75	1.05	1.09	1.06
90	2.1	2.19	2.1
95	3.22	3.68	3.21
99	9.46	11.93	9.45

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.005	0.01	0.015	6934
2	0.014	0.021	0	0.001	0.002	683
3	0.021	0.03	0	0.001	0.002	683
4	0.03	0.042	0	0.001	0.002	683
5	0.042	0.061	0	0.001	0.002	683
6	0.061	0.087	0	0.001	0.002	683
7	0.087	0.125	0.034	0.037	0.04	17944
8	0.125	0.179	0.073	0.076	0.083	37294
9	0.179	0.257	0.087	0.096	0.104	46403
10	0.257	0.368	0.137	0.126	0.118	52882
11	0.368	0.528	0.153	0.137	0.136	60785
12	0.528	0.758	0.14	0.128	0.136	61033
13	0.758	1.087	0.132	0.132	0.119	53250
14	1.087	1.559	0.092	0.095	0.095	42303
15	1.559	2.236	0.056	0.06	0.057	25680
16	2.236	3.207	0.039	0.038	0.039	17297
17	3.207	4.6	0.019	0.022	0.018	8249
18	4.6	6.598	0.012	0.013	0.011	4814
19	6.598	9.463	0.008	0.009	0.008	3576
20	9.463	13.572	0.006	0.006	0.005	2315
21	13.572	19.466	0.002	0.002	0.003	1314
22	19.466	27.92	0.001	0.001	0.001	502
23	27.92	40.045	0.001	0.001	0.001	436
24	40.045	57.435	0.001	0.001	0.001	508
25	57.435	82.377	0	0	0	206
26	82.377	118.152	0	0	0	49
27	118.152	169.462	0	0	0	48
28	169.462	243.055	0	0	0	80
29	243.055	348.608	0	0	0	108
30	348.608	500	0	0	0	0
TOTAL			1	1	1	447621

Time Above Field Values

Total time = 447621
 Time above 1 mG = 119799
 Time above 2 mG = 47446
 Time above 5 mG = 12842
 Time above 10 mG = 5211

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

MACHINE SHOPS

Machine Shop #1

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
1.38 mG	1.04 mG	1.62 mG

Minimum and maximum measured area fields

0.01 mG 141 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.01	0.01	0.01
5	0.04	0.01	0.1
10	0.13	0.01	0.13
25	0.18	0.11	0.19
50	0.36	0.22	0.37
75	1.39	0.51	1.01
90	3.71	1.63	2.91
95	5.27	3.06	5.13
99	9.46	11.95	13.58

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0.035	0.125	0.021	598
2	0.014	0.021	0.005	0.017	0.004	105
3	0.021	0.03	0.005	0.017	0.004	105
4	0.03	0.042	0.005	0.017	0.004	105
5	0.042	0.061	0.005	0.017	0.004	105
6	0.061	0.087	0.005	0.017	0.004	105
7	0.087	0.125	0.033	0.06	0.038	1052
8	0.125	0.179	0.151	0.163	0.151	4201
9	0.179	0.257	0.152	0.138	0.12	3353
10	0.257	0.368	0.116	0.114	0.148	4114
11	0.368	0.528	0.065	0.075	0.103	2859
12	0.528	0.758	0.064	0.049	0.085	2381
13	0.758	1.087	0.067	0.047	0.084	2343
14	1.087	1.559	0.065	0.042	0.059	1655
15	1.559	2.236	0.059	0.034	0.046	1296
16	2.236	3.207	0.049	0.023	0.037	1033
17	3.207	4.6	0.055	0.016	0.031	872
18	4.6	6.598	0.045	0.013	0.027	763
19	6.598	9.463	0.01	0.005	0.01	285
20	9.463	13.572	0.003	0.004	0.006	175
21	13.572	19.466	0.003	0.003	0.005	139
22	19.466	27.92	0.001	0.001	0.002	67
23	27.92	40.045	0.001	0.001	0.001	30
24	40.045	57.435	0.001	0.001	0.001	30
25	57.435	82.377	0.001	0.001	0.001	30
26	82.377	118.152	0.001	0.001	0.001	30
27	118.152	169.462	0.001	0.001	0.002	51
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	27881

Time Above Field Values

Total time = 27881
 Time above 1 mG = 6996
 Time above 2 mG = 3904
 Time above 5 mG = 1422
 Time above 10 mG = 524
 A-38

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Machine Shop #2

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
0.59 mG	0.9 mG	0.75 mG

Minimum and maximum measured area fields

0.11 mG 64.9 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.13	0.13	0.13
5	0.16	0.17	0.16
10	0.18	0.19	0.19
25	0.22	0.23	0.23
50	0.29	0.32	0.31
75	0.39	0.47	0.48
90	0.86	1.08	1.34
95	1.89	2.31	2.49
99	4.6	9.89	6.53

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0	0	0	0
2	0.014	0.021	0	0	0	0
3	0.021	0.03	0	0	0	0
4	0.03	0.042	0	0	0	0
5	0.042	0.061	0	0	0	0
6	0.061	0.087	0	0	0	0
7	0.087	0.125	0	0.002	0.002	51
8	0.125	0.179	0.075	0.058	0.073	2447
9	0.179	0.257	0.338	0.281	0.284	9533
10	0.257	0.368	0.323	0.303	0.301	10100
11	0.368	0.528	0.116	0.163	0.128	4287
12	0.528	0.758	0.04	0.056	0.054	1804
13	0.758	1.087	0.026	0.037	0.04	1331
14	1.087	1.559	0.021	0.031	0.035	1177
15	1.559	2.236	0.021	0.017	0.029	979
16	2.236	3.207	0.013	0.014	0.018	618
17	3.207	4.6	0.01	0.019	0.019	631
18	4.6	6.598	0.007	0.006	0.006	211
19	6.598	9.463	0.004	0.003	0.004	130
20	9.463	13.572	0.001	0.002	0.002	83
21	13.572	19.466	0.001	0.002	0.002	80
22	19.466	27.92	0.001	0.002	0.001	44
23	27.92	40.045	0	0.001	0	9
24	40.045	57.435	0	0.001	0	9
25	57.435	82.377	0	0.003	0.001	24
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1.00	1.00	1.00	33548

Time Above Field Values

Total time = 33548
 Time above 1 mG = 4302
 Time above 2 mG = 2142
 Time above 5 mG = 541
 Time above 10 mG = 235
 A-41

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Machine Shop #3

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
0.86 mG	0.87 mG	0.88 mG

Minimum and maximum measured area fields

0.42 mG 7 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.39	0.39	0.39
5	0.47	0.47	0.49
10	0.54	0.54	0.55
25	0.62	0.62	0.63
50	0.74	0.75	0.77
75	0.95	0.97	0.98
90	1.09	1.21	1.22
95	1.46	1.53	1.52
99	2.24	3.14	2.16

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0	0	0	0
2	0.014	0.021	0	0	0	0
3	0.021	0.03	0	0	0	0
4	0.03	0.042	0	0	0	0
5	0.042	0.061	0	0	0	0
6	0.061	0.087	0	0	0	0
7	0.087	0.125	0	0	0	0
8	0.125	0.179	0	0	0	0
9	0.179	0.257	0	0	0	0
10	0.257	0.368	0	0	0	0
11	0.368	0.528	0.075	0.081	0.067	128
12	0.528	0.758	0.457	0.436	0.423	812
13	0.758	1.087	0.368	0.364	0.388	745
14	1.087	1.559	0.062	0.074	0.078	150
15	1.559	2.236	0.015	0.018	0.019	36
16	2.236	3.207	0.015	0.018	0.019	36
17	3.207	4.6	0.002	0.003	0.002	4
18	4.6	6.598	0.002	0.003	0.002	4
19	6.598	9.463	0.003	0.003	0.003	5
20	9.463	13.572	0	0	0	0
21	13.572	19.466	0	0	0	0
22	19.466	27.92	0	0	0	0
23	27.92	40.045	0	0	0	0
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	1920

Time Above Field Values

Total time =	1920
Time above 1 mG =	407
Time above 2 mG =	60
Time above 5 mG =	8
Time above 10 mG =	0

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Machine Shop #4

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
3.11 mG	1.64 mG	2.42 mG

Minimum and maximum measured area fields

0.26 mG 126.5 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.27	0.26	0.26
5	0.3	0.29	0.29
10	0.34	0.33	0.32
25	0.48	0.45	0.42
50	0.75	0.66	0.63
75	1.59	1.08	1.37
90	4.24	2.56	3.83
95	8.86	4.25	7.69
99	82.38	18.29	40.05

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0	0	0	0
2	0.014	0.021	0	0	0	0
3	0.021	0.03	0	0	0	0
4	0.03	0.042	0	0	0	0
5	0.042	0.061	0	0	0	0
6	0.061	0.087	0	0	0	0
7	0.087	0.125	0	0	0	0
8	0.125	0.179	0	0	0	0
9	0.179	0.257	0	0	0	0
10	0.257	0.368	0.129	0.147	0.16	744
11	0.368	0.528	0.171	0.213	0.253	1175
12	0.528	0.758	0.197	0.249	0.15	696
13	0.758	1.087	0.137	0.146	0.104	481
14	1.087	1.559	0.104	0.098	0.087	401
15	1.559	2.236	0.058	0.037	0.052	242
16	2.236	3.207	0.053	0.034	0.039	182
17	3.207	4.6	0.053	0.037	0.038	176
18	4.6	6.598	0.027	0.011	0.023	107
19	6.598	9.463	0.011	0.007	0.01	46
20	9.463	13.572	0.01	0.007	0.011	50
21	13.572	19.466	0.008	0.007	0.013	58
22	19.466	27.92	0.006	0.003	0.006	28
23	27.92	40.045	0.004	0.001	0.002	9
24	40.045	57.435	0.004	0.001	0.002	9
25	57.435	82.377	0.005	0.001	0.003	13
26	82.377	118.152	0.009	0.002	0.006	27
27	118.152	169.462	0.001	0.001	0	1
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	4638

Time Above Field Values

Total time = 4638
 Time above 1 mG = 1460
 Time above 2 mG = 780
 Time above 5 mG = 322
 Time above 10 mG = 186

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

GROCERY STORES

Grocery Store #1

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
3.58 mG	3.19 mG	2.12 mG

Minimum and maximum measured area fields

0.01 mG 29.7 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.19	0.15	0.12
5	0.33	0.28	0.24
10	0.42	0.35	0.29
25	0.81	0.55	0.43
50	2.51	1.43	0.78
75	4.56	3.83	2.31
90	9.71	8.99	4.56
95	12.04	13.34	9.02
99	13.57	20.68	13.47

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0	0	0.001	25
2	0.014	0.021	0	0	0.001	25
3	0.021	0.03	0	0	0.001	25
4	0.03	0.042	0	0	0.001	25
5	0.042	0.061	0	0	0.001	25
6	0.061	0.087	0	0	0.001	25
7	0.087	0.125	0.002	0.005	0.008	366
8	0.125	0.179	0.005	0.009	0.015	687
9	0.179	0.257	0.009	0.018	0.031	1376
10	0.257	0.368	0.051	0.083	0.136	6098
11	0.368	0.528	0.092	0.124	0.141	6358
12	0.528	0.758	0.08	0.097	0.161	7236
13	0.758	1.087	0.055	0.085	0.081	3630
14	1.087	1.559	0.058	0.105	0.088	3938
15	1.559	2.236	0.103	0.091	0.081	3640
16	2.236	3.207	0.154	0.09	0.071	3171
17	3.207	4.6	0.144	0.093	0.087	3919
18	4.6	6.598	0.066	0.058	0.028	1253
19	6.598	9.463	0.074	0.048	0.023	1035
20	9.463	13.572	0.088	0.045	0.021	956
21	13.572	19.466	0.013	0.036	0.018	817
22	19.466	27.92	0.004	0.011	0.007	294
23	27.92	40.045	0	0	0	20
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	44946

Time Above Field Values

Total time =	44946
Time above 1 mG =	19884
Time above 2 mG =	12592
Time above 5 mG =	4086
Time above 10 mG =	1941

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Grocery Store #2

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
2.03 mG	1.94 mG	1.86 mG

Minimum and maximum measured area fields

0.18 mG 76.6 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.23	0.25	0.25
5	0.3	0.3	0.29
10	0.35	0.35	0.32
25	0.62	0.6	0.47
50	1.14	1.1	0.96
75	2.17	2.06	1.93
90	4.83	4.26	4.52
95	7.03	6.5	7.14
99	9.46	12.29	9.43

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0	0	0	0
2	0.014	0.021	0	0	0	0
3	0.021	0.03	0	0	0	0
4	0.03	0.042	0	0	0	0
5	0.042	0.061	0	0	0	0
6	0.061	0.087	0	0	0	0
7	0.087	0.125	0	0	0	0
8	0.125	0.179	0	0	0	0
9	0.179	0.257	0.015	0.011	0.011	297
10	0.257	0.368	0.099	0.106	0.149	4194
11	0.368	0.528	0.094	0.1	0.143	4024
12	0.528	0.758	0.103	0.104	0.116	3248
13	0.758	1.087	0.172	0.175	0.135	3792
14	1.087	1.559	0.167	0.165	0.143	4009
15	1.559	2.236	0.113	0.12	0.098	2755
16	2.236	3.207	0.07	0.079	0.06	1685
17	3.207	4.6	0.063	0.052	0.049	1377
18	4.6	6.598	0.05	0.039	0.038	1072
19	6.598	9.463	0.038	0.03	0.047	1315
20	9.463	13.572	0.009	0.012	0.006	173
21	13.572	19.466	0.005	0.003	0.003	87
22	19.466	27.92	0.001	0.001	0.001	17
23	27.92	40.045	0.001	0.001	0.001	17
24	40.045	57.435	0.001	0.001	0.001	21
25	57.435	82.377	0.001	0.001	0.001	26
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	28110

Time Above Field Values

Total time = 28110
 Time above 1 mG = 13431
 Time above 2 mG = 6643
 Time above 5 mG = 2480
 Time above 10 mG = 315

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Grocery Store #3

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
2.81 mG	3.07 mG	2.67 mG

Minimum and maximum measured area fields

0.26 mG 32.5 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.34	0.32	0.29
5	0.43	0.42	0.39
10	0.52	0.49	0.44
25	0.81	0.77	0.66
50	1.53	1.46	1.35
75	3.57	3.56	3.12
90	7.32	8.35	7.55
95	10.31	11.87	10.36
99	27.92	18.37	13.45

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0	0	0	0
2	0.014	0.021	0	0	0	0
3	0.021	0.03	0	0	0	0
4	0.03	0.042	0	0	0	0
5	0.042	0.061	0	0	0	0
6	0.061	0.087	0	0	0	0
7	0.087	0.125	0	0	0	0
8	0.125	0.179	0	0	0	0
9	0.179	0.257	0	0	0	0
10	0.257	0.368	0.014	0.019	0.034	1490
11	0.368	0.528	0.093	0.103	0.145	6362
12	0.528	0.758	0.121	0.124	0.122	5343
13	0.758	1.087	0.124	0.128	0.125	5472
14	1.087	1.559	0.158	0.161	0.133	5846
15	1.559	2.236	0.108	0.111	0.112	4919
16	2.236	3.207	0.106	0.089	0.088	3880
17	3.207	4.6	0.094	0.061	0.057	2489
18	4.6	6.598	0.066	0.062	0.064	2824
19	6.598	9.463	0.059	0.07	0.064	2791
20	9.463	13.572	0.028	0.039	0.035	1523
21	13.572	19.466	0.016	0.029	0.016	705
22	19.466	27.92	0.001	0.003	0.001	52
23	27.92	40.045	0.001	0.002	0.001	42
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	43944

Time Above Field Values

Total time = 43944
 Time above 1 mG = 26337
 Time above 2 mG = 15828
 Time above 5 mG = 7284
 Time above 10 mG = 2089

DISTRIBUTION OF AREA FIELDS

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

Grocery Store #4

Average area fields

w/o weights	weighted by ft ²	weighted by person - hour
1.15 mG	1.21 mG	1.05 mG

Minimum and maximum measured area fields

0.26 mG 8.8 mG

Field cumulative distribution:

Percentile level	field w/o weights	field weighted by ft ²	field weighted by person - hours
1	0.27	0.28	0.26
5	0.33	0.36	0.28
10	0.4	0.41	0.3
25	0.58	0.54	0.38
50	0.9	0.82	0.67
75	1.4	1.4	1.36
90	2.34	2.53	2.52
95	3.19	3.59	3.3
99	4.6	6.8	2.59

Exposure fraction in 30 field bins from 0.01 to 500 mG

Bin (#)	From (mG)	To (mG)	W/o weights (fraction)	Weighted by ft ² (fraction)	Weighted by person - hour (fraction)	Time in bin (person - min)
1	0.01	0.014	0	0	0	0
2	0.014	0.021	0	0	0	0
3	0.021	0.03	0	0	0	0
4	0.03	0.042	0	0	0	0
5	0.042	0.061	0	0	0	0
6	0.061	0.087	0	0	0	0
7	0.087	0.125	0	0	0	0
8	0.125	0.179	0	0	0	0
9	0.179	0.257	0	0	0	0
10	0.257	0.368	0.072	0.056	0.239	1866
11	0.368	0.528	0.133	0.182	0.165	1291
12	0.528	0.758	0.2	0.227	0.156	1215
13	0.758	1.087	0.222	0.193	0.135	1055
14	1.087	1.559	0.183	0.139	0.093	724
15	1.559	2.236	0.084	0.086	0.092	721
16	2.236	3.207	0.057	0.058	0.066	515
17	3.207	4.6	0.027	0.035	0.048	374
18	4.6	6.598	0.016	0.014	0.004	32
19	6.598	9.463	0.006	0.011	0.001	10
20	9.463	13.572	0	0	0	0
21	13.572	19.466	0	0	0	0
22	19.466	27.92	0	0	0	0
23	27.92	40.045	0	0	0	0
24	40.045	57.435	0	0	0	0
25	57.435	82.377	0	0	0	0
26	82.377	118.152	0	0	0	0
27	118.152	169.462	0	0	0	0
28	169.462	243.055	0	0	0	0
29	243.055	348.608	0	0	0	0
30	348.608	500	0	0	0	0
TOTAL			1	1	1	7802

Time Above Field Values

Total time = 7802
 Time above 1 mG = 2620
 Time above 2 mG = 1153
 Time above 5 mG = 34
 Time above 10 mG = 0

Distribution of Area Fields in 30 Field Bins in Geometric Progression from 0.01 to 500 mG.

Cumulative Distribution of Area Fields: Percentage of Measurements Above Given Field Values.

APPENDIX B

STATISTICAL DISTRIBUTION OF AREA FIELDS, FIELDS AT EXPOSURE POINTS, AND COMBINED FIELDS

This Appendix contains figures that show the distribution of area fields, fields at exposure points, and combined (area and exposure point) fields.

Figures are provided for all sites of all environments: office buildings, schools, hospitals, machine shops, and grocery stores.

The top figure in each page reports the total time (person-minute) in each of 30 field bin geometrically distributed between 0.1 and 500 mG. The bottom figure of each page reports the time weighted field in each bin (mG-person-minute).

DISTRIBUTION OF EXPOSURE TO AREA AND TO LOCAL SOURCES

DISTRIBUTION OF EXPOSURE TO AREA AND TO LOCAL SOURCES

DISTRIBUTION OF EXPOSURE TO AREA AND TO LOCAL SOURCES

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DISTRIBUTION OF EXPOSURE TO AREA AND TO LOCAL SOURCES

DISTRIBUTION OF EXPOSURE TO AREA AND TO LOCAL SOURCES

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DISTRIBUTION OF EXPOSURE TO AREA AND TO LOCAL SOURCES

APPENDIX C

MAGNETIC FIELD EXPOSURE BY TYPE OF PEOPLE AND TYPE OF SOURCE FOR ALL SURVEYED SITES

This Appendix contains a breakdown of area source field by type of person and by type of area source.

Two figures are presented for each surveyed site. The top figure in each page shows the cumulative distribution of time weighted magnetic fields for different categories of people. The bottom figure in each page shows the statistical distribution of time spent (by all persons of the site) in each field bin considering each area source separately and then all the area sources together.

CUMULATIVE DISTRIBUTION OF AREA FIELDS

AREA EXPOSURE TO DIFFERENT SOURCES

CUMULATIVE DISTRIBUTION OF AREA FIELDS

AREA EXPOSURE TO DIFFERENT SOURCES

CUMULATIVE DISTRIBUTION OF AREA FIELDS

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CUMULATIVE DISTRIBUTION OF AREA FIELDS

AREA EXPOSURE TO DIFFERENT SOURCES

CUMULATIVE DISTRIBUTION OF AREA FIELDS

AREA EXPOSURE TO DIFFERENT SOURCES

APPENDIX D

DC FIELDS, AC FIELD HARMONICS AND 60Hz FIELD POLARIZATION FOR ALL SURVEYED SITES

The statistical distribution of the DC magnetic field values measured at each site is shown in the following figures:

For Office Buildings: Figures D.1 to D.4
For Schools: Figures D.5 to D.8
For Hospitals: Figures D.9 to D.12
For Machine Shops: Figures D.13 to D.16
For Grocery Stores: Figures D.17 to D.20

The polarization of the 60 Hz field was calculated for each field recorded magnetic field waveshape. Polarization is defined as the ratio between the minor and the major axis of the field ellipse, and is expressed in percentage. Zero polarization means that the field oscillates in one direction and does not describe an ellipse. One hundred percent polarization means that the field describes a circle. Each polarization value is plotted in the following figures:

For Office Buildings: Figures D.21 to D.24
For Schools: Figures D.25 to D.28
For Hospitals: Figures D.29 to D.32
For Machine Shops: Figures D.33 to D.36
For Grocery Stores: Figures D.37 to D.40

The rms value of the third and fifth harmonics of 60 Hz were calculated for each recorded waveshape and each result was plotted versus the rms value of the 60 Hz component in the following figures:

For Office Buildings: Figures D.41 to D.44
For Schools: Figures D.45 to D.48
For Hospitals: Figures D.49 to D.52
For Machine Shops: Figures D.53 to D.56
For Grocery Stores: Figures D.57 to D.60

Figure D.1 Distribution of DC Magnetic Field Measured in Different Areas of Office Building #1.

Figure D.2 Distribution of DC Magnetic Field Measured in Different Areas of Office Building #2.

Figure D.3 Distribution of DC Magnetic Field Measured in Different Areas of Office Building #3.

Figure D.4 Distribution of DC Magnetic Field Measured in Different Areas of Office Building #4.

Figure D.5 Distribution of DC Magnetic Field Measured in Different Areas of School #1.

Figure D.6 Distribution of DC Magnetic Field Measured in Different Areas of School #2.

Figure D.7 Distribution of DC Magnetic Field Measured in Different Areas of School #3.

Figure D.8 Distribution of DC Magnetic Field Measured in Different Areas of School #4.

Figure D.9 Distribution of DC Magnetic Field Measured in Different Areas of Hospital #1.

Figure D.10 Distribution of DC Magnetic Field Measured in Different Areas of Hospital #2.

Figure D.11 Distribution of DC Magnetic Field Measured in Different Areas of Hospital #3.

Figure D.12 Distribution of DC Magnetic Field Measured in Different Areas of Hospital #4.

Figure D.13 Distribution of DC Magnetic Field Measured in Different Areas of Machine Shop #1.

Figure D.14 Distribution of DC Magnetic Field Measured in Different Areas of Machine Shop #2.

Figure D.15 Distribution of DC Magnetic Field Measured in Different Areas of Machine Shop #3.

Figure D.16 Distribution of DC Magnetic Field Measured in Different Areas of Machine Shop #4.

Figure D.17 Distribution of DC Magnetic Field Measured in Different Areas of Grocery Store #1.

Figure D.18 Distribution of DC Magnetic Field Measured in Different Areas of Grocery Store #2.

Figure D.19 Distribution of DC Magnetic Field Measured in Different Areas of Grocery Store #3.

Figure D.20 Distribution of DC Magnetic Field Measured in Different Areas of Grocery Store #4.

Figure D.21 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Office Building #1.

Figure D.22 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Office Building #2.

Figure D.23 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Office Building #3.

Figure D.24 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Office Building #4.

Figure D.25 Distribution of Polarization of 60 Hz Field Measured in Different Areas of School #1.

Figure D.26 Distribution of Polarization of 60 Hz Field Measured in Different Areas of School #2.

Figure D.27 Distribution of Polarization of 60 Hz Field Measured in Different Areas of School #3.

Figure D:28 Distribution of Polarization of 60 Hz Field Measured in Different Areas of School #4.

Figure D.29 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Hospital #1.

Figure D.30 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Hospital #2.

Figure D.31 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Hospital #3.

Figure D.32 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Hospital #4.

Figure D.33 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Machine Shop #1.

Figure D.34 Distribution of Polarization of 60 Hz Field Measured in Different Areas

Figure D.35 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Machine Shop #3.

Figure D.36 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Machine Shop #4.

Figure D.37 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Grocery Store #1.

Figure D.38 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Grocery Store #2.

Figure D.39 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Grocery Store #3.

Figure D.40 Distribution of Polarization of 60 Hz Field Measured in Different Areas of Grocery Store #4.

AMPLITUDE OF HARMONICS

Figure D.41 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Office Building #1.

AMPLITUDE OF HARMONICS

Figure D.42 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Office Building #2.

AMPLITUDE OF HARMONICS

Figure D.43 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Office Building #3.

AMPLITUDE OF HARMONICS

Figure D.44 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Office Building #4.

Figure D.45 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of School #1.

Figure D.46 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of School #2.

Figure D.47 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of School #3.

Figure D.48 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of School #4.

Figure D.49 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Hospital #1.

Figure D.50 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Hospital #2.

Figure D.51 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Hospital #3.

Figure D.52 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Hospital #4.

Figure D.53 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Machine Shop #1.

Figure D.54 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Machine Shop #2.

Figure D.55 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Machine Shop #3.

Figure D.56 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Machine Shop #4.

Figure D.57 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Grocery Store #1.

Figure D.58 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Grocery Store #2.

Figure D.59 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Grocery Store #3.

Figure D.60 Third and Fifth Harmonic versus of 60 Hz Field Measured in Different Areas of Grocery Store #4.

APPENDIX E

TEMPORAL DISTRIBUTION DATA

The temporal distribution data were obtained by placing EMDEX II recorders at a secure location in selected areas of a site. The EMDEX II recorded magnetic field at a sampling rate of once every three seconds.

The EMDEX files were analyzed using EMCALC 95 software. The statistical distribution of the field for the periods of time during which there were normal activities at the site was calculated.

The file identification number, arithmetic mean and standard deviation, median, geometric mean and geometric standard deviations are shown in Table E-1.

The file identification number, minimum, maximum, and various percentile levels are shown in Table E-2.

Table E-1 Temporal Distribution Data (Part 1)

Filename	Site ID	Area ID	Days	Start Time	Stop Time	Number of Recordings	Mean (mG)	Std. Dev.	Median (mG)	Geom. Mean	Std. Dev.
o1_h2253.mdx	Office Bldg #1	68	1	9:40am	3:45pm	7297	7.96	0.12	7.94	8.0	1.02
o1_h3110.mdx	Office Bldg #1	79	1	8:00am	4:00pm	9606	0.58	0.05	0.56	0.6	1.10
o1_h3236.mdx	Office Bldg #1	138	1	8:00am	3:57pm	9559	10.86	0.51	10.83	10.8	1.05
o1_h4101.mdx	Office Bldg #1	148	1	8:00am	4:04pm	9689	9.01	0.99	9.31	9.0	1.13
o1_h410a.mdx	Office Bldg #1	148	1	8:00am	3:52pm	9452	7.95	1.15	7.68	7.9	1.16
o1_h4113.mdx	Office Bldg #1	157	1	8:00am	4:06pm	9731	0.26	0.04	0.23	0.3	1.17
o1_h4219.mdx	Office Bldg #1	195	1	8:00am	4:02pm	9645	2.17	0.21	2.22	2.2	1.11
o2_24h_1.mdx	Office Bldg #2	2	1	8:00am	2:45pm	8107	3.15	0.33	3.24	3.1	1.12
o2_24h_2.mdx	Office Bldg #2	3	1	8:00am	2:46pm	8126	1.52	0.17	1.58	1.5	1.13
o2_24h_3.mdx	Office Bldg #2	28	1	8:00am	4:38pm	10375	2.47	0.22	2.44	2.5	1.10
o2_24h_4.mdx	Office Bldg #2	82	1	8:00am	4:34pm	10289	1.54	0.14	1.57	1.5	1.10
o324ha13.mdx	Office Bldg #3	13	1	12:00pm	5:00pm	6001	1.23	0.09	1.24	1.2	1.08
o324hr20.mdx	Office Bldg #3	20	1	12:00pm	5:00pm	6001	2.45	0.26	2.58	2.4	1.12
o424ar03.mdx	Office Bldg #4		1	7:58am	1:57pm	7188	0.23	0.01	0.23	0.2	1.07
o424h2.mdx	Office Bldg #4	3	1	8:02am	2:01pm	7182	20.01	1.04	20.29	20.0	1.06
s124hlib.mdx	School #1	9	1	8:00am	4:20pm	10008	9.51	1.82	9.54	9.3	1.22
s124hrm8.mdx	School #1	34	1	8:00am	4:22pm	10060	0.24	0.06	0.26	0.2	1.36
s124hrm9.mdx	School #1	35	1	8:00am	4:25pm	10102	1.32	0.29	1.34	1.3	1.26
s2_24h01.mdx	School #2	9	1	8:00am	4:34pm	10296	2.52	0.5	2.69	2.4	1.29
s2_24h02.mdx	School #2	11	1	8:00am	4:33pm	10264	1.22	0.19	1.23	1.2	1.14
s2_24h03.mdx	School #2	15	1	8:00am	4:31pm	10224	0.52	0.17	0.59	0.5	1.60
s2_24h04.mdx	School #2	1	1	8:00am	4:29pm	10190	2.66	0.95	2.49	2.5	1.42
s2_24h05.mdx	School #2	4	1	8:00am	4:31pm	10234	1.17	0.31	1.27	1.1	1.37
s32423_t.mdx	School #3	23	1	8:00am	2:40pm	8004	0.58	0.02	0.58	0.6	1.04
s32430_t.mdx	School #3	30	1	8:00am	2:36pm	7930	9	1.99	8.49	8.8	1.23
s32445_t.mdx	School #3	45	1	11:43am	2:48pm	3690	3.34	0.66	3.51	3.2	1.39
s42401_t.mdx	School #4	1	1	10:54am	5:00pm	7308	5.16	1.1	5.28	5.0	1.27
s42406_t.mdx	School #4	6	1	11:00am	5:00pm	7184	0.93	0.19	0.96	0.9	1.23
s42413_t.mdx	School #4	13	1	11:04am	5:00pm	7102	0.46	0.09	0.47	0.5	1.23
h124hcrd.mdx	Hospital #1	17	2	4:42pm	6:42pm	30402	7.38	1.36	7.07	7.3	1.20
H124HMAL.MDX	Hospital #1	36	2	4:31pm	4:24pm	28675	7.79	1.34	7.63	7.7	1.18
H124HXRY.MDX	Hospital #1	5	2	4:11pm	4:26pm	29110	32.43	0.87	32.5	32.4	1.02
H224H111.MDX	Hospital #2	17	2	2:06pm	4:58pm	32252	7.44	1.63	8.07	7.2	1.29
H224HC13.MDX	Hospital #2	21	2	12:43pm	4:53pm	33802	10.94	2.24	10.01	10.7	1.21
H224HG20.MDX	Hospital #2	33	2	3:25pm	4:36pm	30231	1.36	0.58	1.63	1.2	1.71
H224HB23.MDX	Hospital #2	49	2	2:54pm	4:40pm	30918	0.36	0.06	0.36	0.4	1.17
H3_24H01.MDX	Hospital #3	71	2	12:52pm	4:32pm	33208	4.53	2.47	4.03	4.0	1.66
H3_24H02.MDX	Hospital #3	51	2	9:53am	4:13pm	28799	0.82	0.57	0.64	0.6	2.26
H3_24H03.MDX	Hospital #3	4	2	1:37pm	3:48pm	31409	22.68	0.22	22.7	22.7	1.01
H3_24H04.MDX	Hospital #3	16	2	4:17pm	4:40pm	29270	18.62	4.11	17.69	18.2	1.24
H4_24H01.MDX	Hospital #4	21	2	1:48pm	4:31pm	32069	13.44	0.76	13.29	13.4	1.06
H4_24H02.MDX	Hospital #4	2	2	9:53am	4:13pm	36390	0.64	0.06	0.64	0.6	1.11
H4_24H03.MDX	Hospital #4	89	2	1:56pm	4:27pm	31821	1.79	0.47	1.69	1.7	1.27
H4_24H04.MDX	Hospital #4	102	2	3:33pm	4:30pm	29941	0.92	0.51	0.87	0.8	1.76
m124hlay.mdx	Mach. Shop #1	8	1	8:00am	3:25pm	8921	0.91	0.37	0.76	0.9	1.36
m124hith.mdx	Mach. Shop #1	3	1	8:00am	3:29pm	8982	3	0.98	3.31	2.4	2.61
m124hmil.mdx	Mach. Shop #1	3	1	8:00am	3:18pm	8777	1.17	0.04	1.17	1.2	1.04
m2_24h_1.mdx	Mach. Shop #2	1	1	8:00am	3:21pm	8838	1.44	0.39	1.24	1.4	1.26
m2_24h_2.mdx	Mach. Shop #2	5	1	8:00am	3:23pm	8870	0.35	0.04	0.36	0.4	1.11
m2_24h_3.mdx	Mach. Shop #2	2	1	8:00am	3:25pm	8913	0.39	0.02	0.38	0.4	1.06
m2_24h_4.mdx	Mach. Shop #2	1	1	8:00am	3:28pm	8966	0.46	0.05	0.42	0.5	1.11
m2_24h_5.mdx	Mach. Shop #2	19	1	8:00am	3:29pm	8997	0.54	0.49	0.42	0.5	1.43
m324hr01.mdx	Mach. Shop #3	2	1	10:55am	4:00pm	6089	0.81	0.31	0.76	0.8	1.45
m324hr02.mdx	Mach. Shop #3	4	1	10:52am	4:00pm	6144	0.43	0.07	0.43	0.4	1.17
m424_blu.mdx	Mach. Shop #4	3	1	8:00am	1:59pm	7163	0.51	0.24	0.44	0.5	1.34
m424_lft.mdx	Mach. Shop #4	8	1	8:00am	2:01pm	7226	5.13	1.06	5.33	5.0	1.28
m424_shp.mdx	Mach. Shop #4	4	1	8:00am	2:02pm	7249	2.17	0.38	2.24	2.1	1.21
m424_tri.mdx	Mach. Shop #4	6	1	8:00am	1:56pm	7134	1.04	0.4	0.92	1.0	1.34
m424_wld.mdx	Mach. Shop #4	8	1	8:00am	2:04pm	7286	4.63	2.24	3.76	4.2	1.54
g1cash24_t.mdx	Groc. Store #1	1	1	8:00am	4:13pm	9863	0.46	0.08	0.49	0.4	1.30
g1disp24_t.mdx	Groc. Store #1	2	1	8:00am	4:11pm	9829	0.49	0.06	0.51	0.5	0.12
g1offi24_t.mdx	Groc. Store #1	3	1	8:00am	4:09pm	9790	6.32	1.5	6.83	6.0	1.49
g324h1.mdx	Groc. Store #3	1	1	8:00am	1:41pm	6823	12.83	0.35	12.89	12.8	1.03

Table E-2 Temporal Distribution Data (Part 2)

Filename	Minimum	1%	5%	10%	25%	50%	75%	90%	95%	99%	Maximum
o1_h2253.mdx	6.07	7.56	7.56	7.86	7.86	7.94	8.04	8.17	8.17	8.17	8.29
o1_h3110.mdx	0.43	0.43	0.47	0.56	0.56	0.56	0.64	0.64	0.64	0.64	0.79
o1_h3236.mdx	9.02	9.72	10.07	10.24	10.52	10.83	11.17	11.52	11.74	12.17	13.59
o1_h4101.mdx	5.56	6.19	6.82	7.48	8.56	9.31	9.71	9.89	10.11	10.49	12.30
o1_h410a.mdx	5.77	6.03	6.34	6.54	6.98	7.68	9.09	9.49	9.61	9.89	11.30
o1_h4113.mdx	0.21	0.21	0.21	0.23	0.23	0.23	0.32	0.32	0.32	0.32	0.52
o1_h4219.mdx	1.56	1.67	1.79	1.89	2.02	2.22	2.31	2.43	2.53	2.64	3.04
o2_24h_1.mdx	2.04	2.21	2.43	2.68	3.02	3.24	3.38	3.52	3.36	3.69	3.83
o2_24h_2.mdx	0.96	1.06	1.17	1.26	1.48	1.58	1.62	1.69	1.71	1.73	1.89
o2_24h_3.mdx	1.62	1.83	2.04	2.24	2.34	2.44	2.64	2.76	2.76	2.76	3.04
o2_24h_4.mdx	0.94	1.11	1.29	1.37	1.46	1.57	1.61	1.73	1.74	1.82	1.89
o324ha13.mdx	0.94	1.03	1.06	1.11	1.18	1.24	1.27	1.32	1.34	1.48	1.76
o324hr20.mdx	1.88	1.97	1.97	1.97	2.58	2.58	2.58	2.58	2.58	2.63	2.67
o424ar03.mdx	0.11	0.21	0.21	0.21	0.23	0.23	0.23	0.23	0.23	0.23	0.23
o424h2.mdx	6.96	17.1	17.69	19.49	19.71	20.29	20.71	20.91	21.11	21.49	25.50
s124hlib.mdx	1.07	5.92	6.59	7.13	8.02	9.54	10.49	11.89	12.11	15.29	15.90
s124hlm8.mdx	0.01	0.11	0.14	0.18	0.18	0.26	0.26	0.31	0.32	0.38	2.03
s124hlm9.mdx	0.36	0.68	0.89	0.94	1.09	1.34	1.51	1.69	1.77	1.83	1.84
s2_24h01.mdx	0.89	1.11	1.21	1.44	2.62	2.69	2.77	2.83	2.88	2.98	5.54
s2_24h02.mdx	0.72	0.88	0.99	1.01	1.12	1.23	1.29	1.39	1.42	1.54	4.48
s2_24h03.mdx	0.11	0.14	0.18	0.18	0.38	0.59	0.59	0.68	0.73	0.73	0.82
s2_24h04.mdx	1.28	1.31	1.48	1.62	1.84	2.49	3.33	4.07	4.44	5.23	7.23
s2_24h05.mdx	0.52	0.52	0.59	0.62	0.89	1.27	1.39	1.51	1.56	1.63	2.04
s32423_t.mdx	0.18	0.52	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	1.68
s32430_t.mdx	0.14	6.41	7.09	7.36	7.84	8.49	9.31	11.88	12.71	16.29	28.30
s32445_t.mdx	0.34	0.79	0.92	3.11	3.23	3.51	3.66	3.82	3.96	4.09	4.17
s42401_t.mdx	1.86	2.48	3.04	3.52	4.57	5.28	5.91	6.46	6.78	7.43	9.49
s42406_t.mdx	0.43	0.56	0.64	0.68	0.77	0.96	1.07	1.18	1.22	1.36	1.66
s42413_t.mdx	0.18	0.26	0.34	0.37	0.42	0.47	0.52	0.59	0.62	0.71	0.82
H124HCRD.MDX	4.43	5.08	5.54	5.82	6.29	7.07	8.47	9.21	9.62	10.76	15.90
H124HMAL.MDX	4.68	5.54	5.93	6.16	6.76	7.63	8.64	9.86	10.31	10.89	13.10
H124HXRY.MDX	29.5	31.1	31.50	31.70	31.90	32.50	32.70	33.10	33.50	33.90	83.70
H224H111.MDX	4.28	4.46	4.51	4.52	7.69	8.07	8.62	8.71	8.74	8.83	15.92
H224HC13.MDX	7.14	8.52	8.73	8.87	9.08	10.01	12.98	14.49	14.89	15.89	20.50
H224HG20.MDX	0.31	0.38	0.44	0.48	0.74	1.63	1.82	1.93	1.98	2.49	2.56
H224HB23.MDX	0.26	0.26	0.31	0.31	0.31	0.36	0.38	0.42	0.44	0.49	1.36
H3_24H01.MDX	0.68	1.77	1.94	2.09	2.49	4.03	5.59	7.96	9.33	12.24	20.70
H3_24H02.MDX	0.11	0.14	0.18	0.18	0.29	0.64	1.54	1.63	1.63	1.69	1.73
H3_24H03.MDX	8.64	22.3	22.30	22.30	22.70	22.70	22.70	22.90	22.90	22.90	26.50
H3_24H04.MDX	10.89	12.4	13.29	13.71	15.11	17.69	22.50	24.70	25.50	26.70	30.90
H4_24H01.MDX	10.5	11.8	12.31	12.49	12.89	13.29	14.11	14.49	14.52	14.71	14.94
H4_24H02.MDX	0.26	0.49	0.53	0.54	0.59	0.64	0.69	0.69	0.72	0.76	1.99
H4_24H03.MDX	0.72	1.06	1.24	1.31	1.46	1.69	2.03	2.41	2.68	3.32	5.32
H4_24H04.MDX	0.34	0.38	0.38	0.38	0.47	0.87	1.28	1.64	4.87	2.19	2.66
m124hlay.mdx	0.64	0.71	0.74	0.74	0.74	0.76	0.79	1.79	1.89	1.89	3.77
m124hlth.mdx	0.14	0.14	0.14	0.14	3.22	3.31	3.44	3.44	3.49	3.53	3.71
m124hmil.mdx	0.38	1.06	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	2.53
m2_24h_1.mdx	0.83	1.03	1.11	1.11	1.16	1.24	1.73	1.77	1.83	3.07	4.69
m2_24h_2.mdx	0.26	0.31	0.31	0.31	0.31	0.36	0.38	0.38	0.38	0.42	2.82
m2_24h_3.mdx	0.31	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.44	0.48	0.74
m2_24h_4.mdx	0.38	0.42	0.42	0.42	0.42	0.42	0.49	0.49	0.54	0.62	0.71
m2_24h_5.mdx	0.31	0.34	0.38	0.38	0.38	0.42	0.62	0.68	0.72	4.39	7.14
m324hr01.mdx	0.37	0.46	0.47	0.47	0.54	0.76	1.09	1.18	1.31	1.39	3.68
m324hr02.mdx	0.23	0.32	0.32	0.32	0.42	0.43	0.43	0.53	0.53	0.53	1.21
m424_blu.mdx	0.26	0.34	0.38	0.38	0.42	0.44	0.48	0.64	0.89	1.61	3.48
m424_lft.mdx	0.99	2.13	2.99	3.62	4.64	5.33	5.82	6.27	6.48	7.42	8.26
m424_shp.mdx	0.86	1.18	1.46	1.63	1.97	2.24	2.44	2.57	2.67	3.11	3.39
m424_trl.mdx	0.59	0.66	0.71	0.74	0.79	0.92	1.18	1.34	1.76	2.64	4.77
m424_wld.mdx	0.98	2.23	2.44	2.52	2.89	3.76	6.48	6.89	8.91	11.89	22.90
g1cash24_t.mdx	0.18	0.18	0.18	0.42	0.47	0.49	0.49	0.49	0.49	0.58	1.22
g1disp24_t.mdx	0.29	0.29	0.29	0.43	0.51	0.51	0.52	0.52	0.52	0.52	0.66
g1offi24_t.mdx	0.96	1.31	1.79	4.33	6.63	6.83	6.97	7.16	7.17	7.26	7.74
g324h1.mdx	8.57	11.	12.31	12.31	12.49	12.89	13.11	13.29	13.29	13.49	13.70

APPENDIX F

TRANSIENT SURVEY MEASURING SYSTEM

The Transient Survey Measurement System¹ is a signal waveform data acquisition system developed for EPRI to acquire a database of transient magnetic field and current waveforms. The system comprises an ensemble of magnetic field sensors, anti-aliasing filters, a digital sampling oscilloscope, a personal computer interfaced via GPIB-IEEE 488.2 to the oscilloscope for autonomous control of the system and for short-term data recording, and a digital audio tape drive backup for long term data archiving. A block diagram of the system is shown in Figure F.1.

Transient Survey Measurement System Block Diagram

Figure F.1 Block diagram of the Transient Survey Measurement System used in the DOE Rapid Project.

Transient Magnetic Field Sensors

The magnetic field due to transient events was detected using two groups of magnetic field sensors with complementary frequency responses. Each group consisted of 3 orthogonally mounted single-axis B-field sensors (x, y, and z axes). Thus, the sensors constitute a total of 6 signal channels with each group of 3 sensors monitoring transient events over different frequency ranges. The two complementary frequency ranges extend from 40 Hz - 5 kHz and from 5 kHz - 12.5 MHz and are hereafter referred to as the "upper" and "lower" frequency ranges or bands, respectively.

The two groups of orthogonally mounted magnetic field sensors were housed together as a single unit inside a 20" x 20" x 20" black acrylic plastic housing. They were mounted such that

corresponding pairs of sensors from each group were aligned coaxially. The housing in turn was attached to a support stand which held the antennas at a height of approximately 1 meter relative to the floor. Also mounted to the support stand were a signal conditioning electronics module and two battery packs for power. A photograph of this assembly is shown in Figure F.2. The large black box in the photo is the antenna housing and contains the magnetic field sensors. The three smaller boxes beneath it are the signal conditioning electronics module and the two battery packages, as indicated in the figure.

A photograph of the assembly with the cover of the antenna housing removed is shown in Figure F.3. This figure shows three large diameter loops, which are the upper frequency range magnetic field sensors, and a box mounted atop a clear acrylic plastic cylinder, located near the axial intersection of the large loops. The box contains the three lower frequency range magnetic field sensors, and three RG58 coaxial output signal cables feed through the plastic cylinder to the electronics module below. Three RG58 coaxial output signal cables from the high frequency antennas feed through a hole in the base of the housing, in addition to three power cables which supply power to the antennas.

The upper frequency band magnetic field sensors were EMCO Model-6507 Active Loop Antennas. The sensing loop diameter is 12" and the loop output is fed to battery powered signal conditioning electronics to provide a response which is proportional to magnetic flux density over a specified range.

The antennas were calibrated by the manufacturer over the frequency range extending from 100 Hz to 100 MHz. The calibrated responses of the three antennas are shown in Figures F.4a, F.4b, and F.4c. The maximum response of approximately 40 V/mT occurs for frequencies above 100 kHz, and the response rolls off to approximately 10 V/mT at 10 kHz.

The signal outputs of the magnetic field sensors were filtered to protect against signal aliasing. The upper band sensors were filtered using TTE Model LT10 10-pole Bessel filters with a -3dB response at 25 MHz.

The lower frequency band magnetic field sensors were custom made by ENERTECH Consultants for this application. These sensors were ferrite-core inductor coils. The coil output signals were fed to the signal conditioning electronics module, which conditions the signal in two stages. The first stage integrates and amplifies the input signal to provide a flat response of approximately 0.43 V/mT over the frequency range extending from approximately 20 Hz to 7 kHz. The second stage is a 10-pole Bessel antialiasing filter section with -3dB response at 10 kHz.

Figure F.2 Photograph of the Transient Magnetic Field Antenna Assembly used in the DOE Rapid Project.

Figure F.3 Photograph of the Transient Magnetic Field Antenna Assembly with the antenna housing cover removed.

Figure F.4 Calibrated Responses of the EMCO Model 6507 Active Loop Antennas: (a) x-axis, (b) y-axis, and (c) z-axis.

Transient Data Acquisition System

The Transient Data Acquisition System is a digital sampling oscilloscope operating under the control of a personal computer. The system operates autonomously to acquire data from the transient magnetic field sensors.

The LeCroy Model 7200 Digital Oscilloscope Mainframe with two Model 7234 4-Channel Digitizing Plug-ins was used to acquire the 6 sensor output waveforms. The digitizing plug-ins were independently configured to acquire data from each group of 3 magnetic field sensors. The upper frequency band sensor outputs were sampled at a rate of 200 MSa/s for a total duration of 200 ms with 10% pretrigger sampling. The lower frequency band sensor outputs were sampled at a rate of 100 kSa/s for a total duration of 500 ms, also with 10% pretrigger sampling.

The system was autonomously controlled by a computer program running on a personal computer interfaced via GPIB-IEEE 488.2 to the LeCroy 7200 oscilloscope. The GPIB-IEEE 488.2 interface was a National Instruments AT-GPIB card. The computer program automatically controlled the oscilloscope arming and the data recording functions. The data was stored internally on a 540 Mbytes hard disc drive in the personal computer. A Hewlett-Packard Model 35470A SCSI DAT Drive digital audio tape disc-drive backup system was used to download data from the hard disc drive to digital audio tape cassettes.

The LeCroy 7200 oscilloscope, the personal computer, the keyboard, the video display monitor, and the digital audio tape were configured on a portable cart. These components comprise the Transient Data Acquisition System.

A photograph of the Transient Data Acquisition System is shown in Figure F.5. The components of the system described above are indicated in the figure. Also seen in the Figure are the signal cables and cable reels, and the antialiasing filters.

Triggering/Data Acquisition

The system was set to trigger on positive-polarity signals of the higher bandwidth horizontal x-axis magnetic field sensor, an EMCO Model 6507 Active Loop Antenna. The frequency response of the x-axis sensor, the EMCO 6507 S/N 1284, was shown previously in Figure F.4a.

The choice of this method for triggering the data acquisition system was dictated by the need to have simple and reliable triggering that would give acceptable results for the study.

Triggering was also dependent on the frequency response of the higher bandwidth magnetic field sensor. A transient at lower frequency, for instance at 5 kHz, would need to have much greater amplitude than signals at frequencies greater than 100 kHz in order to trigger the data acquisition system. Specifically, the sensor response at 5 kHz is approximately 8 times smaller than the response above 100 kHz, so a signal at 5 kHz must be 8 times greater in amplitude than the signal trigger threshold at 100 kHz in order to trigger the data acquisition system. For most sites the 100 kHz trigger threshold was set at 0.01 mG, so for these sites the 5 kHz threshold, calculated from the sensor response, was 0.08 mG and the 500 Hz threshold was 1.4 mG.

Figure F.5 Photograph of the Transient Data Acquisition System used in the DOE Rapid Project.

After each trigger, an automatic determination is made whether or not to permanently record the data set, based upon comparison to previously acquired waveforms. This was accomplished by

creating a data file, called the "trigger data file", in which were stored some key parameters of the trigger waveform, including the trigger time, maximum amplitude, peak-to-peak amplitude, and RMS amplitude. The trigger sequence number was also written to this file.

To determine whether or not to store all 6 waveforms of the current acquisition, the peak-to-peak and RMS values of the current trigger waveform are compared to corresponding values of the trigger waveforms for the three previously acquired data records stored in the trigger data file. A comparison is made to determine if the peak-to-peak amplitude is within $\pm 5\%$ and the RMS amplitude is within $\pm 10\%$ of the corresponding values for any one of the three comparisons. The result of this comparison is a number, either "0", "1", "2", or "3", which represents the number of comparisons which meet the criteria, and this number is appended to the trigger data file. If no matches occur, i.e., the number is "0", then the waveform data is stored and the trigger data file is appended with the extension of the 6 stored waveform files. If any matches occur, then the waveform data were not stored. This procedure helps eliminate storing "repetitive" transients such as those generated by light dimmer switches.

System Test

The Transient Survey Measurement System was tested in the laboratory at ENERTECH Consultants and field tested during EPRI studies¹. The system dynamic range was appropriate for the transients observed, and the data storage capacity was sufficient for the numbers of transients obtained during these tests. The algorithm for rejecting repetitive transients worked satisfactorily.

Raw Data Output

An example of the raw output display of the LeCroy Model 7200 Digitizing Oscilloscope is shown in Figure F.6. In the Figure, Signal/channel designations were appended to the left of each of the 6 signal traces of the output display. These designations are B_{xf} , B_{yf} , B_{zf} , B_{xs} , B_{ys} , and B_{zs} , where "B" represents "magnetic flux density", the subscripts "x", "y", and "z" represent the magnetic field axes, the subscript "f" represents the "fast-sampled" or upper frequency band channels, the subscript "s" represents the "slow-sampled" or lower frequency band channels. To the right and slightly above each of the signal traces is a block of text that describes each trace. For trace #2 this text is enclosed in a box. Referring to this text, the top line designates both the data identification number and the record number. The second line designates the units of time per division and volts per division of the signal trace.

Each data acquisition record yields a total of 300 Kbytes of data from the 6 signal channels. With system overhead included, the 540 Mbytes internal hard disc drive has the capacity to store 1,399 data sets. Digital audio tape cassettes with 1.3 Gbyte capacity provided media for long term data archiving. Due to the large quantity of data anticipated, this was a cost effective approach for data archiving.

Figure F.6 Output display of the LeCroy 7200 Digitizing Oscilloscope showing the 6 traces of output channel waveforms. The channel designations are indicated to the left of each trace, with time and volts per division on the right.

System Deadtime

The data acquisition system is in an **unarmed** state while data is being transferred from the digital oscilloscope to the 540 Mbytes hard drive in the computer, which means the system will not respond to any triggers during this time. The system is rearmed after the data is stored. The storage time ranges from approximately 40 seconds to 60 seconds depending on the amount of data already stored in the hard drive. Periods of time when the system is in the unarmed state are called "deadtime."

Transient Survey Measurement System Installation

The Transient Magnetic Field Antenna Assembly was typically placed in a storeroom in the measurement site. The Transient Data Acquisition System was typically placed at least 10 feet away from the antennas in order to avoid pickup of signals generated by the LeCroy 7200 oscilloscope.

Once the system was configured it was necessary to set the trigger threshold of the oscilloscope. This was accomplished by first acquiring and observing the background signal traces. The background signals are due to various electronic noise sources and also to communications signals, such as radio stations. The trigger level was then set to approximately 20 mV above the background voltage level. Using this criteria, the trigger threshold was set at 40 mV for 12 out of the 18 sites. Accounting for the frequency response of the EMCO sensor, this threshold is

equivalent to 0.001 mT (0.01 mG) for frequencies greater than 100 kHz. The threshold then increases from 0.001 mT to 0.005 mT as the frequency decreases from 100 kHz to 10 kHz. For the remaining sites, the trigger threshold had to be increased to avoid triggering on continuous background sources.

Reference

1. "Survey Measurements and Experimental Studies of residential Transient Magnetic Fields", Electric Power Research Institute, Report TR-104532, October 1994.

Environmental Field Surveys

Volume 3: Appendix G

EMF RAPID PROGRAM ENGINEERING PROJECT #3

Prepared by
ENERTECH CONSULTANTS
17 Main Street
P.O.Box 770
Lee, Massachusetts 01238

Principal Investigator
Luciano E. Zaffanella

Prepared for
Lockheed Martin Energy Systems, Inc.
P.O.Box 2002
241 W. Tyrone Road, D104
Oak Ridge, Tennessee 37831-6501

April 1996

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WAVESHAPE MAGNETIC FIELD TRANSIENT DATA

The top ten largest peak to peak transients for each measurement location are included on the following pages. This appendix also includes tables for each transient event which describe the frequency components for each high frequency channel axis.

The figures are actual output displays from the LeCroy Model 7200 Digitizing Oscilloscope. In each figure, signal/channel designations are appended to the left of each of the 6 signal traces of the output display. These designations are B_{xf} , B_{yf} , B_{zf} , B_{xs} , B_{ys} , and B_{zs} , where "B" represents "magnetic flux density", the subscripts "x", "y", and "z" represent the magnetic field axes, the subscript "f" represents the "fast-sampled" or upper frequency band channels, the subscript "s" represents the "slow-sampled" or lower frequency band channels. To the right and slightly above each of the signal traces is a block of text that describes each trace. The top line designates both the data identification number and the record number. The second line designates the units of time per division and volts per division of the signal trace.

Figure G-1 Oscilloscope traces for Hospital H1, largest transient event
(data ID 0926, transient number 0004)

Table G-1 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0004					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.35	0.03	0.00	0.01	0.01
Y	0.11	0.03	0.00	0.01	0.00
Z	1.37	0.10	0.00	0.03	0.02

Figure G-2 Oscilloscope traces for Hospital H1, second largest transient event (data ID 0926, transient number 0656)

Table G-2 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0656					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.12	0.11	0.00	0.04	0.01
Y	0.23	0.09	0.00	0.01	0.00
Z	0.19	0.05	0.00	0.01	0.00

Figure G-3 Oscilloscope traces for Hospital H1, third largest transient event (data ID 0926, transient number 0921)

Table G-3 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0921					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.03	0.10	0.00	0.02	0.01
Y	0.22	0.08	0.00	0.00	0.00
Z	0.17	0.07	0.00	0.00	0.00

Table G-4 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0373

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.94	0.19	0.00	0.03	0.03
Y	0.19	0.06	0.00	0.01	0.01
Z	0.16	0.05	0.00	0.00	0.00

Figure G-5 Oscilloscope traces for Hospital H1, fifth largest transient event (data ID 0926, transient number 0259)

Table G-5 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0259					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.93	0.25	0.00	0.02	0.01
Y	0.20	0.06	0.00	0.01	0.00
Z	0.14	0.04	0.00	0.00	0.00

Figure G-6 Oscilloscope traces for Hospital H1, sixth largest transient event (data ID 0926, transient number 0368)

Table G-6 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0368					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.88	0.24	0.00	0.04	0.04
Y	0.17	0.06	0.00	0.01	0.01
Z	0.16	0.05	0.00	0.01	0.01

Figure G-7 Oscilloscope traces for Hospital H1, seventh largest transient event (data ID 0926, transient number 0155)

Table G-7 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0155					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.87	0.14	0.00	0.02	0.02
Y	0.19	0.06	0.00	0.00	0.00
Z	0.16	0.05	0.00	0.00	0.00

Figure G-8 Oscilloscope traces for Hospital H1, eighth largest transient event (data ID 0926, transient number 0213)

Table G-8 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0213					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.83	0.08	0.00	0.01	0.02
Y	0.17	0.06	0.00	0.00	0.00
Z	0.12	0.05	0.00	0.00	0.00

Figure G-9 Oscilloscope traces for Hospital H1, ninth largest transient event (data ID 0926, transient number 0572)

Table G-9 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0572					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.79	0.22	0.00	0.01	0.02
Y	0.14	0.06	0.00	0.00	0.00
Z	0.12	0.05	0.00	0.00	0.00

Figure G-10 Oscilloscope traces for Hospital H1, tenth largest transient event (data ID 0926, transient number 0861)

Table G-10 Maximum FFT Amplitude in Frequency Bins for Data ID 0926, Transient Number 0861					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.36	0.12	0.00	0.02	0.01
Y	0.31	0.10	0.00	0.02	0.01
Z	0.77	0.12	0.00	0.04	0.01

Figure G-11 Oscilloscope traces for Hospital H2, largest transient event (data ID 1002, transient number 0063)

Table G-11 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0063					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.82	0.26	0.00	0.00	0.00
Y	2.67	1.01	0.01	0.00	0.01
Z	0.67	0.05	0.01	0.00	0.00

Figure G-12 Oscilloscope traces for Hospital H2, second largest transient event (data ID 1002, transient number 0042)

Table G-12 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0042

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.75	0.04	0.01	0.00	0.00
Y	1.80	0.10	0.01	0.00	0.00
Z	1.00	0.09	0.01	0.00	0.00

Figure G-13 Oscilloscope traces for Hospital H2, third largest transient event (data ID 1002, transient number 0067)

Table G-13 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0067					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.68	0.02	0.00	0.00	0.00
Y	1.52	0.50	0.00	0.00	0.00
Z	0.39	0.05	0.00	0.00	0.00

Figure G-14 Oscilloscope traces for Hospital H2, fourth largest transient event
(data ID 1002, transient number 0023)

Table G-14 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0023					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.55	0.02	0.01	0.00	0.00
Y	1.37	0.05	0.01	0.01	0.00
Z	0.69	0.34	0.01	0.01	0.00

Figure G-15 Oscilloscope traces for Hospital H2, fifth largest transient event (data ID 1002, transient number 0060)

Table G-15 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0060					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.51	0.02	0.00	0.00	0.00
Y	1.20	0.39	0.00	0.00	0.00
Z	0.28	0.05	0.00	0.00	0.00

Figure G-16 Oscilloscope traces for Hospital H2, sixth largest transient event (data ID 1002, transient number 0018)

Table G-16 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0018

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.39	0.02	0.00	0.00	0.00
Y	0.95	0.04	0.00	0.00	0.00
Z	0.20	0.08	0.00	0.00	0.00

Figure G-17 Oscilloscope traces for Hospital H2, seventh largest transient event (data ID 1002, transient number 0015)

Table G-17 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0015					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.63	0.12	0.00	0.00	0.01
Y	0.92	0.24	0.01	0.01	0.01
Z	0.55	0.08	0.01	0.01	0.01

Figure G-18 Oscilloscope traces for Hospital H2, eighth largest transient event (data ID 1002, transient number 0016)

Table G-18 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0016					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.35	0.01	0.00	0.00	0.00
Y	0.91	0.04	0.00	0.01	0.00
Z	0.19	0.07	0.00	0.00	0.00

Figure G-19 Oscilloscope traces for Hospital H2, ninth largest transient event (data ID 1002, transient number 0021)

Table G-19 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0021					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.40	0.10	0.00	0.00	0.00
Y	0.83	0.05	0.00	0.00	0.00
Z	0.23	0.08	0.00	0.00	0.00

Figure G-20 Oscilloscope traces for Hospital H2, tenth largest transient event (data ID 1002, transient number 0028)

Table G-20 Maximum FFT Amplitude in Frequency Bins for Data ID 1002, Transient Number 0028

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.19	0.04	0.00	0.00	0.00
Y	0.16	0.11	0.00	0.00	0.00
Z	0.77	0.12	0.01	0.01	0.00

Figure G-21 Oscilloscope traces for Hospital H3, largest transient event
(data ID 1145, transient number 1114-0001)

Table G-21 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1114 0001					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.78	0.23	0.01	0.00	0.00
Y	1.58	0.03	0.02	0.00	0.00
Z	2.70	0.08	0.07	0.02	0.00

Figure G-22 Oscilloscope traces for Hospital H3, second largest transient event (data ID 1145, transient number 1115-0017)

Table G-22 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1115 0017					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.14	0.10	0.00	0.00	0.01
Y	0.37	0.05	0.00	0.00	0.00
Z	2.62	0.34	0.00	0.00	0.09

Figure G-23 Oscilloscope traces for Hospital H3, third largest transient event (data ID 1145, transient number 1115-0016)

Table G-23 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1115 0016					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.75	0.21	0.00	0.00	0.00
Y	0.27	0.06	0.00	0.00	0.00
Z	2.17	0.68	0.00	0.00	0.02

Figure G-24 Oscilloscope traces for Hospital H3, fourth largest transient event (data ID 1145, transient number 1115-0014)

Table G-24 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1115 0014					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.37	0.10	0.02	0.01	0.00
Y	0.50	0.22	0.00	0.00	0.00
Z	1.92	0.90	0.02	0.01	0.00

Figure G-25 Oscilloscope traces for Hospital H3, fifth largest transient event (data ID 1145, transient number 1114-0020)

Table G-25 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1114 0020					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.53	0.04	0.00	0.00	0.00
Y	0.78	0.04	0.00	0.00	0.00
Z	0.78	0.03	0.00	0.00	0.00

Figure G-26 Oscilloscope traces for Hospital H3, sixth largest transient event (data ID 1145, transient number 1115-0007)

Table G-26 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1115 0007					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.30	0.63	0.01	0.00	0.00
Y	0.17	0.08	0.00	0.00	0.00
Z	1.30	0.63	0.01	0.00	0.00

Figure G-27 Oscilloscope traces for Hospital H3, seventh largest transient event (data ID 1145, transient number 1115-0006)

Table G-27 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1115 0006					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.25	0.52	0.00	0.00	0.00
Y	0.14	0.03	0.00	0.00	0.00
Z	1.25	0.53	0.01	0.00	0.00

Figure G-28 Oscilloscope traces for Hospital H3, eighth largest transient event (data ID 1145, transient number 1114-0012)

Table G-28 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1114 0012					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.58	0.09	0.04	0.01	0.00
Y	1.02	0.15	0.05	0.02	0.00
Z	1.12	0.10	0.05	0.02	0.00

Figure G-29 Oscilloscope traces for Hospital H3, ninth largest transient event
(data ID 1145, transient number 1115-0002)

Table G-29 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1115 0002

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.53	0.19	0.00	0.00	0.00
Y	0.14	0.05	0.00	0.00	0.00
Z	1.08	0.06	0.00	0.00	0.00

Figure G-30 Oscilloscope traces for Hospital H3, tenth largest transient event
(data ID 1145, transient number 1115-0010)

Table G-30 Maximum FFT Amplitude in Frequency Bins for Data ID 1145, Transient Number 1115 0010					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.84	0.40	0.00	0.00	0.00
Y	0.09	0.04	0.00	0.00	0.00
Z	0.81	0.38	0.00	0.00	0.00

Figure G-31 Oscilloscope traces for Hospital H4, largest transient event (data ID 1204, transient number 0395)

Table G-31 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 0395					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.28	0.12	0.03	0.02	0.01
Y	0.41	0.07	0.02	0.01	0.00
Z	0.70	0.09	0.07	0.01	0.00

Figure G-32 Oscilloscope traces for Hospital H4, second largest transient event (data ID 1204, transient number 0558)

Table G-32 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 0558					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.27	0.12	0.03	0.02	0.01
Y	0.42	0.06	0.02	0.01	0.00
Z	0.70	0.09	0.08	0.01	0.00

Figure G-33 Oscilloscope traces for Hospital H4, third largest transient event (data ID 1204, transient number 0517)

Table G-33 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 0517					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.59	0.08	0.03	0.01	0.01
Y	0.22	0.06	0.03	0.01	0.00
Z	0.41	0.09	0.07	0.01	0.00

Figure G-34 Oscilloscope traces for Hospital H1, fourth largest transient event
 (data ID 1204, transient number 0114)

Table G-34 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 0114					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.45	0.08	0.05	0.01	0.00
Y	0.53	0.18	0.04	0.01	0.00
Z	0.33	0.08	0.08	0.01	0.00

Figure G-35 Oscilloscope traces for Hospital H4, fifth largest transient event (data ID 1204, transient number 0551)

Table G-35 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 0551

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.53	0.14	0.04	0.01	0.01
Y	0.25	0.10	0.03	0.01	0.00
Z	0.41	0.09	0.08	0.01	0.00

Figure G-36 Oscilloscope traces for Hospital H4, sixth largest transient event (data ID 1204, transient number 0115)

Table G-36 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 0115					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.44	0.07	0.05	0.01	0.00
Y	0.52	0.05	0.04	0.01	0.00
Z	0.39	0.10	0.08	0.01	0.00

Figure G-37 Oscilloscope traces for Hospital H4, seventh largest transient event (data ID 1204, transient number 0116)

Table G-37 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 0116					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.39	0.10	0.03	0.01	0.00
Y	0.50	0.05	0.03	0.01	0.00
Z	0.30	0.08	0.08	0.01	0.00

Figure G-38 Oscilloscope traces for Hospital H4, eighth largest transient event (data ID 1204, transient number 1115)

Table G-38 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 1115					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.47	0.08	0.07	0.01	0.00
Y	0.39	0.05	0.05	0.01	0.00
Z	0.37	0.10	0.08	0.01	0.00

Figure G-39 Oscilloscope traces for Hospital H4, ninth largest transient event (data ID 1204, transient number 1381)

Table G-39 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 1381					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.47	0.12	0.06	0.01	0.00
Y	0.34	0.05	0.05	0.01	0.00
Z	0.36	0.10	0.08	0.01	0.00

Figure G-40 Oscilloscope traces for Hospital H4, tenth largest transient event (data ID 1204, transient number 0113)

Table G-40 Maximum FFT Amplitude in Frequency Bins for Data ID 1204, Transient Number 0113

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.36	0.10	0.03	0.01	0.00
Y	0.45	0.11	0.03	0.00	0.00
Z	0.30	0.08	0.07	0.01	0.00

Figure G-41 Oscilloscope traces for Machine Shop M1, largest transient event (data ID 0929, transient number 0255)

Table G-41 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0255					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	3.22	1.52	0.01	0.01	0.01
Y	3.08	0.69	0.01	0.01	0.01
Z	3.23	0.98	0.01	0.01	0.01

Figure G-42 Oscilloscope traces for Machine Shop M1, second largest transient event (data ID 0929, transient number 0272)

Table G-42 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0272					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	2.58	0.62	0.01	0.01	0.01
Y	2.89	0.18	0.01	0.01	0.01
Z	3.05	0.72	0.01	0.01	0.01

Figure G-43 Oscilloscope traces for Machine Shop M1, third largest transient event (data ID 0929, transient number 0247)

Table G-43 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0247					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.59	0.10	0.00	0.01	0.01
Y	1.83	0.16	0.01	0.01	0.01
Z	0.78	0.10	0.00	0.01	0.01

Figure G-44 Oscilloscope traces for Machine Shop M1, fourth largest transient event (data ID 0929, transient number 0244)

Table G-44 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0244					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.62	0.21	0.00	0.01	0.01
Y	1.50	0.46	0.01	0.01	0.01
Z	0.34	0.10	0.00	0.01	0.00

Figure G-45 Oscilloscope traces for Machine Shop M1, fifth largest transient event (data ID 0929, transient number 0116)

Table G-45 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0116					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.47	0.09	0.00	0.01	0.01
Y	1.47	0.08	0.00	0.00	0.00
Z	0.33	0.12	0.00	0.01	0.00

Figure G-46 Oscilloscope traces for Machine Shop M1, sixth largest transient event (data ID 0929, transient number 0261)

Table G-46 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0261					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.28	0.25	0.00	0.01	0.01
Y	1.34	0.15	0.00	0.01	0.01
Z	1.45	0.28	0.00	0.01	0.01

Figure G-47 Oscilloscope traces for Machine Shop M1, seventh largest transient event (data ID 0929, transient number 0118)

Table G-47 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0118					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.66	0.16	0.01	0.01	0.01
Y	1.42	0.09	0.01	0.01	0.01
Z	0.37	0.11	0.01	0.01	0.01

Figure G-48 Oscilloscope traces for Machine Shop M1, eighth largest transient event (data ID 0929, transient number 0271)

Table G-48 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0271					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.19	0.29	0.00	0.01	0.01
Y	1.36	0.27	0.00	0.01	0.01
Z	1.37	0.32	0.00	0.01	0.01

Figure G-49 Oscilloscope traces for Machine Shop M1, ninth largest transient event (data ID 0929, transient number 0115)

Table G-49 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0115					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.53	0.08	0.01	0.01	0.00
Y	1.36	0.09	0.01	0.01	0.01
Z	0.37	0.08	0.01	0.01	0.00

Figure G-50 Oscilloscope traces for Machine Shop M1, tenth largest transient event (data ID 0929, transient number 0250)

Table G-50 Maximum FFT Amplitude in Frequency Bins for Data ID 0929, Transient Number 0250					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.20	0.43	0.00	0.01	0.01
Y	0.75	0.26	0.00	0.01	0.01
Z	1.30	0.46	0.00	0.01	0.01

Figure G-51 Oscilloscope traces for Machine Shop M2, largest transient event (data ID 1120, transient number 0878)

Table G-51 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 0878					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.61	0.32	0.16	0.00	0.00
Y	0.73	0.22	0.07	0.00	0.00
Z	0.25	0.29	0.02	0.00	0.00

Figure G-52 Oscilloscope traces for Machine Shop M2, second largest transient event (data ID 1120, transient number 0360)

Table G-52 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 0360					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.45	0.30	0.19	0.00	0.00
Y	0.62	0.17	0.08	0.01	0.00
Z	0.19	0.21	0.02	0.00	0.00

Figure G-53 Oscilloscope traces for Machine Shop M2, third largest transient event (data ID 1120, transient number 0555)

Table G-53 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 0555					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.45	0.28	0.19	0.00	0.00
Y	0.69	0.16	0.08	0.01	0.00
Z	0.20	0.22	0.02	0.00	0.00

Figure G-54 Oscilloscope traces for Machine Shop M2, fourth largest transient event (data ID 1120, transient number 0945)

Table G-54 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 0945					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.44	0.32	0.20	0.00	0.00
Y	0.69	0.22	0.08	0.01	0.00
Z	0.23	0.28	0.03	0.00	0.00

Figure G-55 Oscilloscope traces for Machine Shop M2, fifth largest transient event (data ID 1120, transient number 0768)

Table G-55 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 0768					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.42	0.31	0.19	0.00	0.00
Y	0.69	0.21	0.09	0.01	0.00
Z	0.22	0.28	0.02	0.00	0.00

Figure G-56 Oscilloscope traces for Machine Shop M2, sixth largest transient event (data ID 1120, transient number 0316)

Table G-56 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 0316					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.39	0.28	0.23	0.00	0.00
Y	0.72	0.16	0.09	0.00	0.00
Z	0.19	0.21	0.03	0.00	0.00

Figure G-57 Oscilloscope traces for Machine Shop M2, seventh largest transient event (data ID 1120, transient number 0842)

Table G-57 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 0842					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.34	0.32	0.21	0.00	0.00
Y	0.72	0.22	0.09	0.01	0.00
Z	0.22	0.28	0.03	0.00	0.00

Figure G-58 Oscilloscope traces for Machine Shop M2, eighth largest transient event (data ID 1120, transient number 0514)

Table G-58 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 0514					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.73	0.17	0.00	0.00	0.00
Y	1.28	0.14	0.00	0.01	0.00
Z	0.69	0.22	0.00	0.00	0.00

Figure G-59 Oscilloscope traces for Machine Shop M2, ninth largest transient event (data ID 1120, transient number 0893)

Table G-59 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 0893					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.67	0.24	0.00	0.00	0.00
Y	1.14	0.21	0.01	0.01	0.00
Z	0.66	0.29	0.01	0.00	0.00

Figure G-60 Oscilloscope traces for Machine Shop M2, tenth largest transient event (data ID 1120, transient number 1006)

Table G-60 Maximum FFT Amplitude in Frequency Bins for Data ID 1120, Transient Number 1006					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.14	0.23	0.18	0.01	0.00
Y	0.64	0.14	0.08	0.01	0.00
Z	0.19	0.18	0.02	0.00	0.00

Figure G-61 Oscilloscope traces for Machine Shop M3, largest transient event (data ID 0320, transient number 0048)

Table G-61 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0048					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.72	0.61	0.01	0.05	0.05
Y	1.83	0.71	0.00	0.04	0.07
Z	2.20	0.33	0.01	0.03	0.08

Figure G-62 Oscilloscope traces for Machine Shop M3, second largest transient event (data ID 0320, transient number 0088)

Table G-62 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0088					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.17	0.38	0.01	0.00	0.00
Y	1.33	0.19	0.01	0.01	0.00
Z	2.20	0.28	0.01	0.00	0.01

Figure G-63 Oscilloscope traces for Machine Shop M3, third largest transient event (data ID 0320, transient number 0020)

Table G-63 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0020					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.48	0.28	0.01	0.04	0.05
Y	1.69	0.35	0.01	0.05	0.06
Z	2.16	0.41	0.01	0.08	0.07

Figure G-64 Oscilloscope traces for Machine Shop M3, fourth largest transient event (data ID 0320, transient number 0044)

Table G-64 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0044

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.78	0.25	0.01	0.04	0.05
Y	1.83	0.26	0.01	0.03	0.06
Z	2.09	0.34	0.01	0.04	0.08

Figure G-65 Oscilloscope traces for Machine Shop M3, fifth largest transient event (data ID 0320, transient number 0107)

Table G-65 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0107					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.66	0.20	0.01	0.04	0.05
Y	1.77	0.63	0.01	0.02	0.06
Z	2.02	0.70	0.01	0.03	0.08

Figure G-66 Oscilloscope traces for Machine Shop M3, sixth largest transient event (data ID 0320, transient number 0097)

Table G-66 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0097

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.45	0.29	0.01	0.04	0.06
Y	1.50	0.28	0.00	0.03	0.08
Z	1.98	0.37	0.01	0.04	0.11

Figure G-67 Oscilloscope traces for Machine Shop M3, seventh largest transient event (data ID 0320, transient number 0003)

Table G-67 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0003					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.25	0.33	0.01	0.01	0.02
Y	1.39	0.38	0.00	0.01	0.02
Z	1.89	0.50	0.02	0.01	0.03

Figure G-68 Oscilloscope traces for Machine Shop M3, eighth largest transient event (data ID 0320, transient number 0112)

Table G-68 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0112					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.55	0.21	0.01	0.04	0.04
Y	1.55	0.22	0.01	0.03	0.04
Z	1.81	0.29	0.01	0.05	0.05

Figure G-69 Oscilloscope traces for Machine Shop M3, ninth largest transient event (data ID 0320, transient number 0008)

Table G-69 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0008					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.41	0.22	0.01	0.02	0.10
Y	1.45	0.29	0.01	0.03	0.13
Z	1.78	0.34	0.01	0.04	0.15

Figure G-70 Oscilloscope traces for Machine Shop M3, tenth largest transient event (data ID 0320, transient number 0013)

Table G-70 Maximum FFT Amplitude in Frequency Bins for Data ID 0320, Transient Number 0013					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.23	0.11	0.01	0.01	0.01
Y	1.36	0.29	0.01	0.01	0.01
Z	1.78	0.39	0.01	0.01	0.02

Figure G-71 Oscilloscope traces for Machine Shop M4, largest transient event (data ID 0404, transient number 0025)

Table G-71 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0025					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.42	0.09	0.01	0.01	0.00
Y	0.81	0.10	0.03	0.02	0.02
Z	3.86	0.37	0.14	0.10	0.00

Figure G-72 Oscilloscope traces for Machine Shop M4, second largest transient event (data ID 0404, transient number 0120)

Table G-72 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0120					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	2.27	0.11	0.00	0.01	0.00
Y	3.20	0.15	0.01	0.03	0.01
Z	1.62	0.09	0.00	0.01	0.01

Figure G-73 Oscilloscope traces for Machine Shop M4, third largest transient event (data ID 0404, transient number 0100)

Table G-73 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0100					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.31	0.58	0.01	0.01	0.01
Y	2.77	1.08	0.02	0.02	0.01
Z	1.08	0.10	0.00	0.00	0.00

Figure G-74 Oscilloscope traces for Machine Shop M4, fourth largest transient event (data ID 0404, transient number 0158)

Table G-74 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0158					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.56	0.06	0.00	0.00	0.00
Y	2.45	0.06	0.00	0.01	0.02
Z	1.52	0.06	0.00	0.00	0.00

Figure G-75 Oscilloscope traces for Machine Shop M4, fifth largest transient event (data ID 0404, transient number 0196)

Table G-75 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0196					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.12	0.09	0.01	0.02	0.00
Y	2.20	0.14	0.01	0.05	0.01
Z	0.53	0.08	0.00	0.01	0.00

Figure G-76 Oscilloscope traces for Machine Shop M4, sixth largest transient event (data ID 0404, transient number 0005)

Table G-76 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0005

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.64	0.03	0.01	0.00	0.00
Y	0.69	0.05	0.02	0.01	0.01
Z	2.16	0.19	0.08	0.05	0.00

Figure G-77 Oscilloscope traces for Machine Shop M4, seventh largest transient event (data ID 0404, transient number 0115)

Table G-77 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0115					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.09	0.10	0.00	0.01	0.00
Y	2.03	0.11	0.00	0.01	0.01
Z	0.81	0.08	0.00	0.01	0.00

Figure G-78 Oscilloscope traces for Machine Shop M4, eighth largest transient event (data ID 0404, transient number 0165)

Table G-78 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0165

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.92	0.22	0.00	0.01	0.00
Y	2.03	0.10	0.01	0.01	0.01
Z	0.94	0.08	0.00	0.01	0.00

Figure G-79 Oscilloscope traces for Machine Shop M4, ninth largest transient event (data ID 0404, transient number 0225)

Table G-79 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0225					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.08	0.08	0.00	0.03	0.00
Y	2.03	0.15	0.00	0.06	0.01
Z	0.47	0.07	0.00	0.01	0.00

Figure G-80 Oscilloscope traces for Machine Shop M4, tenth largest transient event (data ID 0404, transient number 0139)

Table G-80 Maximum FFT Amplitude in Frequency Bins for Data ID 0404, Transient Number 0139					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.41	0.09	0.00	0.00	0.01
Y	1.92	0.17	0.00	0.02	0.04
Z	0.37	0.08	0.00	0.00	0.01

Figure G-81 Oscilloscope traces for School S1, largest transient event
(data ID 1101, transient number 0091)

Table G-81 Maximum FFT Amplitude in Frequency Bins for Data ID 1101, Transient Number 0091					
Channel	Peak to Peak (v)	RMS (v)	10 kHz-100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.03	0.15	0.08	0.01	0.01
Y	1.59	0.20	0.12	0.04	0.00
Z	1.41	0.19	0.10	0.04	0.00

Figure G-82 Oscilloscope traces for School S1, second largest transient event (data ID 1101, transient number 0067)

Table G-82 Maximum FFT Amplitude in Frequency Bins for Data ID 1101, Transient Number 0067					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.39	0.27	0.01	0.01	0.02
Y	1.27	0.13	0.01	0.01	0.02
Z	1.00	0.14	0.04	0.01	0.02

Figure G-83 Oscilloscope traces for School S1, third largest transient event (data ID 1101, transient number 0282)

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.37	0.42	0.00	0.01	0.01
Y	1.09	0.31	0.00	0.04	0.01
Z	1.03	0.38	0.01	0.01	0.00

Figure G-84 Oscilloscope traces for School S1, fourth largest transient event
 (data ID 1101, transient number 0469)

Table G-84 Maximum FFT Amplitude in Frequency Bins for Data ID 1101, Transient Number 0469

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.27	0.38	0.00	0.01	0.01
Y	1.14	0.36	0.00	0.03	0.01
Z	0.78	0.19	0.00	0.01	0.00

Figure G-85 Oscilloscope traces for School S1, fifth largest transient event (data ID 1101, transient number 0432)

Table G-85 Maximum FFT Amplitude in Frequency Bins for Data ID 1101, Transient Number 0432					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.23	0.26	0.00	0.01	0.02
Y	1.11	0.22	0.00	0.02	0.01
Z	0.77	0.08	0.01	0.01	0.00

Figure G-86 Oscilloscope traces for School S1, sixth largest transient event (data ID 1101, transient number 0441)

Table G-86 Maximum FFT Amplitude in Frequency Bins for Data ID 1101, Transient Number 0441					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.23	0.23	0.00	0.01	0.02
Y	1.05	0.23	0.00	0.03	0.01
Z	0.91	0.08	0.00	0.01	0.01

Figure G-87 Oscilloscope traces for School S1, seventh largest transient event (data ID 1101, transient number 0229)

Table G-87 Maximum FFT Amplitude in Frequency Bins for Data ID 1101, Transient Number 0229					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.20	0.13	0.00	0.01	0.01
Y	1.08	0.32	0.00	0.03	0.01
Z	0.75	0.26	0.00	0.01	0.01

Figure G-88 Oscilloscope traces for School S1, eighth largest transient event (data ID 1101, transient number 0352)

Table G-88 Maximum FFT Amplitude in Frequency Bins for Data ID 1101, Transient Number 0352					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.64	0.03	0.00	0.01	0.03
Y	0.75	0.03	0.00	0.03	0.00
Z	1.16	0.04	0.00	0.02	0.01

Figure G-89 Oscilloscope traces for School S1, ninth largest transient event (data ID 1101, transient number 0165)

Table G-89 Maximum FFT Amplitude in Frequency Bins for Data ID 1101, Transient Number 0165					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.14	0.09	0.00	0.01	0.01
Y	1.00	0.33	0.00	0.02	0.00
Z	0.70	0.09	0.00	0.01	0.00

Figure G-90 Oscilloscope traces for School S1, tenth largest transient event (data ID 1101, transient number 0373)

Table G-90 Maximum FFT Amplitude in Frequency Bins for Data ID 1101, Transient Number 0373					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.52	0.05	0.02	0.01	0.01
Y	0.84	0.13	0.08	0.03	0.00
Z	1.00	0.09	0.04	0.03	0.00

Figure G-91 Oscilloscope traces for School S2, largest transient event
(data ID 1106, transient number 0398)

Table G-91 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0398					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	3.98	1.82	1.85	0.22	0.01
Y	3.34	1.11	1.00	0.02	0.01
Z	3.98	1.59	1.50	0.05	0.00

Figure G-92 Oscilloscope traces for School S2, second largest transient event
(data ID 1106, transient number 0577)

Table G-92 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0577

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.77	0.53	0.00	0.03	0.01
Y	1.39	0.03	0.00	0.02	0.01
Z	1.22	0.03	0.00	0.01	0.00

Figure G-93 Oscilloscope traces for School S2, third largest transient event (data ID 1106, transient number 0641)

Table G-93 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0641					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.33	0.24	0.14	0.02	0.01
Y	0.31	0.05	0.02	0.02	0.01
Z	0.67	0.10	0.07	0.01	0.00

Figure G-94 Oscilloscope traces for School S2, fourth largest transient event (data ID 1106, transient number 0316)

Table G-94 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0316					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.30	0.41	0.45	0.02	0.00
Y	0.37	0.08	0.09	0.02	0.01
Z	0.39	0.13	0.12	0.00	0.00

Figure G-95 Oscilloscope traces for School S2, fifth largest transient event (data ID 1106, transient number 0085)

Table G-95 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0085					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.62	0.16	0.00	0.02	0.01
Y	1.17	0.05	0.01	0.02	0.01
Z	1.28	0.06	0.01	0.00	0.00

Figure G-96 Oscilloscope traces for School S2, sixth largest transient event (data ID 1106, transient number 0362)

Table G-96 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0362

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.06	0.12	0.08	0.03	0.01
Y	0.20	0.06	0.01	0.02	0.01
Z	0.27	0.07	0.03	0.00	0.00

Figure G-97 Oscilloscope traces for School S2, seventh largest transient event (data ID 1106, transient number 0006)

Table G-97 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0006					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.03	0.64	0.02	0.01	0.01
Y	0.80	0.32	0.02	0.01	0.01
Z	0.89	0.08	0.02	0.01	0.00

Figure G-98 Oscilloscope traces for School S2, eighth largest transient event (data ID 1106, transient number 0384)

Table G-98 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0384

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.03	0.13	0.06	0.03	0.01
Y	0.27	0.05	0.01	0.03	0.01
Z	0.20	0.07	0.02	0.00	0.00

Figure G-99 Oscilloscope traces for School S2, ninth largest transient event (data ID 1106, transient number 0565)

Table G-99 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0565					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.98	0.15	0.08	0.02	0.00
Y	0.25	0.06	0.01	0.02	0.01
Z	0.28	0.07	0.03	0.01	0.00

Figure G-100 Oscilloscope traces for School S2, tenth largest transient event (data ID 1106, transient number 0271)

Table G-100 Maximum FFT Amplitude in Frequency Bins for Data ID 1106, Transient Number 0271					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.98	0.15	0.08	0.02	0.00
Y	0.22	0.06	0.01	0.01	0.01
Z	0.28	0.07	0.03	0.01	0.00

Figure G-101 Oscilloscope traces for School S3, largest transient event (data ID 0206, transient number 0010)

Table G-101 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0010					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	3.23	0.83	0.01	0.01	0.00
Y	3.11	1.54	0.03	0.01	0.00
Z	3.31	1.19	0.03	0.01	0.00

Figure G-102 Oscilloscope traces for School S3, second largest transient event
(data ID 0206, transient number 0017)

Table G-102 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0017					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	3.02	1.46	0.07	0.03	0.01
Y	2.47	1.38	0.07	0.03	0.00
Z	2.59	1.56	0.08	0.03	0.00

Figure G-103 Oscilloscope traces for School S3, third largest transient event (data ID 0206, transient number 0009)

Table G-103 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0009					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.69	0.12	0.00	0.00	0.01
Y	0.95	0.21	0.00	0.00	0.00
Z	0.89	0.25	0.02	0.00	0.00

Figure G-104 Oscilloscope traces for School S3, fourth largest transient event (data ID 0206, transient number 0003)

Table G-104 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0003					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.89	0.31	0.01	0.00	0.00
Y	1.55	0.05	0.01	0.00	0.00
Z	0.64	0.33	0.03	0.01	0.00

Figure G-105 Oscilloscope traces for School S3, fifth largest transient event (data ID 0206, transient number 0008)

Table G-105 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0008					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.27	0.43	0.00	0.00	0.01
Y	0.84	0.20	0.00	0.00	0.00
Z	0.62	0.19	0.02	0.00	0.00

Figure G-106 Oscilloscope traces for School S3, sixth largest transient event (data ID 0206, transient number 0012)

TableG-106 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0012

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.09	0.33	0.00	0.00	0.01
Y	0.66	0.15	0.00	0.00	0.00
Z	0.48	0.17	0.02	0.00	0.00

Figure G-107 Oscilloscope traces for School S3, seventh largest transient event (data ID 0206, transient number 0006)

Table G-107 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0006					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.08	0.32	0.00	0.00	0.01
Y	0.59	0.13	0.00	0.00	0.00
Z	0.56	0.14	0.01	0.01	0.00

Figure G-108 Oscilloscope traces for School S3, eighth largest transient event (data ID 0206, transient number 0016)

Table G-108 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0016					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.06	0.33	0.00	0.00	0.01
Y	0.64	0.15	0.00	0.00	0.00
Z	0.41	0.15	0.02	0.00	0.00

Figure G-109 Oscilloscope traces for School S3, ninth largest transient event (data ID 0206, transient number 0005)

Table G-109 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0005					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.84	0.07	0.00	0.00	0.00
Y	1.02	0.35	0.01	0.00	0.00
Z	0.67	0.08	0.02	0.00	0.00

Figure G-110 Oscilloscope traces for School S3, tenth largest transient event (data ID 0206, transient number 0007)

Table G-110 Maximum FFT Amplitude in Frequency Bins for Data ID 0206, Transient Number 0007					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.62	0.07	0.00	0.00	0.00
Y	1.02	0.06	0.01	0.00	0.00
Z	0.64	0.08	0.02	0.01	0.00

Figure G-111 Oscilloscope traces for School S4, largest transient event
(data ID 0118, transient number 0124)

Table G-111 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0124					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.19	0.26	0.12	0.01	0.00
Y	1.27	0.27	0.13	0.01	0.00
Z	0.89	0.24	0.09	0.00	0.00

Figure G-112 Oscilloscope traces for School S4, second largest transient event (data ID 0118, transient number 0125)

Table G-112 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0125

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.97	0.23	0.07	0.01	0.00
Y	0.95	0.22	0.07	0.01	0.00
Z	0.78	0.21	0.06	0.00	0.00

Figure G-113 Oscilloscope traces for School S4, third largest transient event (data ID 0118, transient number 0088)

Table G-113 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0088					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.83	0.22	0.07	0.01	0.00
Y	0.92	0.22	0.08	0.01	0.00
Z	0.61	0.20	0.05	0.00	0.00

Figure G-114 Oscilloscope traces for School S4, fourth largest transient event (data ID 0118, transient number 0126)

Table G-114 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0126					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.78	0.21	0.07	0.00	0.00
Y	0.89	0.21	0.08	0.00	0.00
Z	0.50	0.19	0.04	0.00	0.00

Figure G-115 Oscilloscope traces for School S4, fifth largest transient event (data ID 0118, transient number 0128)

Table G-115 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0128					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.87	0.23	0.08	0.01	0.00
Y	0.86	0.23	0.08	0.01	0.00
Z	0.80	0.22	0.08	0.00	0.00

Figure G-116 Oscilloscope traces for School S4, sixth largest transient event (data ID 0118, transient number 0043)

Table G-116 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0043					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.84	0.26	0.00	0.00	0.02
Y	0.50	0.20	0.00	0.00	0.01
Z	0.52	0.21	0.00	0.00	0.01

Figure G-117 Oscilloscope traces for School S4, seventh largest transient event (data ID 0118, transient number 0122)

Table G-117 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0122					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.81	0.22	0.07	0.01	0.00
Y	0.78	0.21	0.08	0.01	0.00
Z	0.67	0.21	0.06	0.01	0.00

Figure G-118 Oscilloscope traces for School S4, eighth largest transient event (data ID 0118, transient number 0016)

Table G-118 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0016					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.75	0.25	0.00	0.00	0.01
Y	0.45	0.18	0.00	0.00	0.01
Z	0.50	0.13	0.00	0.00	0.01

Figure G-119 Oscilloscope traces for School S4, ninth largest transient event (data ID 0118, transient number 0121)

Table G-119 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0121					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.64	0.21	0.05	0.01	0.00
Y	0.69	0.21	0.06	0.01	0.00
Z	0.48	0.20	0.04	0.00	0.00

Figure G-120 Oscilloscope traces for School S4, tenth largest transient event (data ID 0118, transient number 0077)

Table G-120 Maximum FFT Amplitude in Frequency Bins for Data ID 0118, Transient Number 0077

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.55	0.21	0.05	0.00	0.00
Y	0.64	0.21	0.06	0.00	0.00
Z	0.37	0.20	0.04	0.00	0.00

Figure G-121 Oscilloscope traces for Office Building O1, largest transient event (data ID 1129, transient number 0040)

Table G-121 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 0040					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.62	0.11	0.01	0.03	0.01
Y	1.34	0.25	0.03	0.09	0.01
Z	0.30	0.05	0.01	0.02	0.00

Figure G-122 Oscilloscope traces for Office Building O1, second largest transient event (data ID 1129, transient number 0009)

Table G-122 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 0009					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.97	0.05	0.02	0.02	0.00
Y	1.27	0.11	0.04	0.07	0.00
Z	0.73	0.43	0.02	0.01	0.00

Figure G-123 Oscilloscope traces for Office Building O1, third largest transient event (data ID 1129, transient number 1297)

Table G-123 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 1297					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.97	0.31	0.02	0.02	0.00
Y	1.25	0.10	0.04	0.07	0.00
Z	0.77	0.06	0.02	0.01	0.00

Figure G-124 Oscilloscope traces for Office Building O1, fourth largest transient event (data ID 1129, transient number 1387)

Table G-124 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 1387					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.92	0.06	0.02	0.02	0.00
Y	1.05	0.12	0.04	0.07	0.00
Z	0.81	0.06	0.02	0.02	0.00

Figure G-125 Oscilloscope traces for Office Building O1, fifth largest transient event (data ID 1129, transient number 1321)

Table G-125 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 1321					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.44	0.07	0.01	0.02	0.00
Y	1.03	0.11	0.03	0.07	0.01
Z	0.25	0.03	0.01	0.02	0.00

Figure G-126 Oscilloscope traces for Office Building O1, sixth largest transient event (data ID 1129, transient number 0456)

Table G-126 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 0456					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.98	0.39	0.01	0.02	0.00
Y	0.78	0.29	0.03	0.07	0.00
Z	0.48	0.16	0.02	0.01	0.00

Figure G-127 Oscilloscope traces for Office Building O1, seventh largest transient event (data ID 1129, transient number 1362)

Table G-127 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 1362					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.39	0.04	0.01	0.02	0.00
Y	0.87	0.33	0.03	0.07	0.00
Z	0.19	0.03	0.01	0.01	0.00

Figure G-128 Oscilloscope traces for Office Building O1, eighth largest transient event (data ID 1129, transient number 0048)

Table G-128 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 0048					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.81	0.35	0.02	0.03	0.00
Y	0.84	0.11	0.03	0.07	0.00
Z	0.64	0.06	0.02	0.02	0.00

Figure G-129 Oscilloscope traces for Office Building O1, ninth largest transient event (data ID 1129, transient number 1287)

Table G-129 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 1287					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.28	0.03	0.01	0.02	0.00
Y	0.83	0.11	0.03	0.08	0.00
Z	0.16	0.02	0.01	0.02	0.00

Figure G-130 Oscilloscope traces for Office Building O1, tenth largest transient event (data ID 1129, transient number 0064)

Table G-130 Maximum FFT Amplitude in Frequency Bins for Data ID 1129, Transient Number 0064					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.34	0.07	0.01	0.02	0.00
Y	0.81	0.11	0.03	0.08	0.00
Z	0.16	0.05	0.01	0.02	0.00

Figure G-131 Oscilloscope traces for Office Building O2, largest transient event (data ID 1220, transient number 0032)

Table G-131 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0032					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	2.61	0.79	0.00	0.04	0.01
Y	0.92	0.04	0.00	0.01	0.00
Z	2.91	0.06	0.00	0.00	0.00

Figure G-132 Oscilloscope traces for Office Building O2, second largest transient event (data ID 1220, transient number 0021)

Table G-132 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0021					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.34	0.15	0.05	0.03	0.02
Y	1.00	0.09	0.04	0.00	0.00
Z	2.08	0.16	0.03	0.01	0.01

Figure G-133 Oscilloscope traces for Office Building O2, third largest transient event (data ID 1220, transient number 0005)

Table G-133 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0005					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	2.05	0.76	0.03	0.03	0.01
Y	1.39	0.62	0.03	0.01	0.00
Z	1.28	0.60	0.02	0.01	0.00

Figure G-134 Oscilloscope traces for Office Building O2, fourth largest transient event (data ID 1220, transient number 0048)

Table G-134 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0048					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.34	0.16	0.06	0.03	0.02
Y	0.98	0.12	0.04	0.01	0.00
Z	2.00	0.24	0.03	0.00	0.02

Figure G-135 Oscilloscope traces for Office Building O2, fifth largest transient event (data ID 1220, transient number 0085)

Table G-135 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0085					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.20	0.14	0.07	0.03	0.02
Y	0.91	0.10	0.06	0.01	0.00
Z	2.00	0.15	0.04	0.01	0.02

Figure G-136 Oscilloscope traces for Office Building O2, sixth largest transient event (data ID 1220, transient number 0053)

Table G-136 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0053					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.08	0.13	0.06	0.03	0.01
Y	0.78	0.10	0.04	0.01	0.00
Z	1.97	0.22	0.04	0.01	0.02

Figure G-137 Oscilloscope traces for Office Building O2, seventh largest transient event (data ID 1220, transient number 0027)

Table G-137 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0027					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.16	0.13	0.03	0.03	0.01
Y	0.83	0.09	0.02	0.00	0.00
Z	1.95	0.33	0.02	0.00	0.02

Figure G-138 Oscilloscope traces for Office Building O2, eighth largest transient event (data ID 1220, transient number 0051)

Table G-138 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0051					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.17	0.11	0.06	0.04	0.02
Y	0.80	0.07	0.04	0.01	0.00
Z	1.94	0.09	0.03	0.01	0.01

Figure G-139 Oscilloscope traces for Office Building O2, ninth largest transient event (data ID 1220, transient number 0080)

Table G-139 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0080					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.27	0.15	0.03	0.02	0.02
Y	0.75	0.09	0.02	0.00	0.01
Z	1.92	0.30	0.02	0.01	0.02

Figure G-140 Oscilloscope traces for Office Building O2, tenth largest transient event (data ID 1220, transient number 0028)

Table G-140 Maximum FFT Amplitude in Frequency Bins for Data ID 1220, Transient Number 0028					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.08	0.14	0.04	0.02	0.01
Y	0.80	0.10	0.03	0.00	0.00
Z	1.91	0.31	0.02	0.00	0.02

Figure G-141 Oscilloscope traces for Office Building O3, largest transient event (data ID 0122, transient number 0016)

Table G-141 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0016					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	2.37	0.07	0.02	0.00	0.00
Y	0.97	0.06	0.01	0.01	0.00
Z	0.53	0.17	0.01	0.00	0.00

Figure G-142 Oscilloscope traces for Office Building O3, second largest transient event (data ID 0122, transient number 0073)

Table G-142 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0073					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.11	0.34	0.02	0.00	0.08
Y	0.92	0.20	0.01	0.00	0.07
Z	0.27	0.11	0.02	0.00	0.01

Figure G-143 Oscilloscope traces for Office Building O3, third largest transient event (data ID 0122, transient number 0005)

Table G-143 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0005					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.05	0.34	0.02	0.01	0.04
Y	0.66	0.06	0.01	0.00	0.02
Z	0.27	0.09	0.01	0.00	0.00

Figure G-144 Oscilloscope traces for Office Building O3, fourth largest transient event (data ID 0122, transient number 0018)

Table G-144 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0018					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.03	0.29	0.03	0.00	0.05
Y	0.84	0.24	0.01	0.00	0.04
Z	0.30	0.08	0.02	0.00	0.00

Figure G-145 Oscilloscope traces for Office Building O3, fifth largest transient event (data ID 0122, transient number 0009)

Table G-145 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0009					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.02	0.22	0.02	0.01	0.05
Y	0.86	0.25	0.01	0.00	0.05
Z	0.23	0.08	0.02	0.00	0.00

Figure G-146 Oscilloscope traces for Office Building O3, sixth largest transient event (data ID 0122, transient number 0046)

Table G-146 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0046

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.91	0.16	0.02	0.00	0.05
Y	0.86	0.17	0.01	0.00	0.03
Z	0.48	0.10	0.01	0.00	0.01

Figure G-147 Oscilloscope traces for Office Building O3, seventh largest transient event (data ID 0122, transient number 0032)

Table G-147 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0032					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.36	0.16	0.02	0.00	0.00
Y	0.41	0.14	0.01	0.00	0.00
Z	0.86	0.29	0.01	0.00	0.00

Figure G-148 Oscilloscope traces for Office Building O3, eighth largest transient event (data ID 0122, transient number 0051)

Table G-148 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0051					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.86	0.26	0.02	0.01	0.02
Y	0.83	0.20	0.01	0.00	0.01
Z	0.56	0.06	0.01	0.00	0.01

Figure G-149 Oscilloscope traces for Office Building O3, ninth largest transient event (data ID 0122, transient number 0044)

Table G-149 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0044					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.84	0.24	0.03	0.00	0.05
Y	0.84	0.19	0.01	0.00	0.03
Z	0.50	0.10	0.02	0.00	0.01

Figure G-150 Oscilloscope traces for Office Building O3, tenth largest transient event (data ID 0122, transient number 0072)

Table G-150 Maximum FFT Amplitude in Frequency Bins for Data ID 0122, Transient Number 0072

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.84	0.22	0.02	0.01	0.01
Y	0.70	0.10	0.01	0.00	0.01
Z	0.19	0.10	0.01	0.00	0.00

Figure G-151 Oscilloscope traces for Office Building O4, largest transient event (data ID 0123, transient number 0061)

Table G-151 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0061					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.53	0.33	0.02	0.01	0.01
Y	0.86	0.24	0.00	0.00	0.00
Z	0.50	0.10	0.01	0.00	0.00

Figure G-152 Oscilloscope traces for Office Building O4, second largest transient event (data ID 0123, transient number 0171)

Table G-152 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0171					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.37	0.45	0.01	0.00	0.01
Y	0.61	0.21	0.01	0.00	0.00
Z	0.45	0.14	0.01	0.00	0.00

Figure G-153 Oscilloscope traces for Office Building O4, third largest transient event (data ID 0123, transient number 0150)

Table G-153 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0150					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.34	0.59	0.02	0.01	0.00
Y	0.37	0.15	0.00	0.00	0.00
Z	1.06	0.43	0.02	0.00	0.00

Figure G-154 Oscilloscope traces for Office Building O4, fourth largest transient event (data ID 0123, transient number 0073)

Table G-154 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0073

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.23	0.08	0.01	0.00	0.00
Y	0.97	0.06	0.00	0.00	0.00
Z	0.58	0.09	0.01	0.00	0.00

Figure G-155 Oscilloscope traces for Office Building O4, fifth largest transient event (data ID 0123, transient number 0007)

Table G-155 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0007					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.17	0.31	0.01	0.01	0.00
Y	0.72	0.08	0.00	0.00	0.00
Z	0.48	0.10	0.01	0.00	0.00

Figure G-156 Oscilloscope traces for Office Building O4, sixth largest transient event (data ID 0123, transient number 0188)

Table G-156 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0188					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.16	0.38	0.01	0.00	0.01
Y	0.67	0.12	0.01	0.00	0.00
Z	0.55	0.23	0.01	0.00	0.00

Figure G-157 Oscilloscope traces for Office Building O4, seventh largest transient event (data ID 0123, transient number 0003)

Table G-157 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0003					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.12	0.32	0.02	0.01	0.01
Y	0.52	0.14	0.01	0.00	0.00
Z	0.33	0.11	0.01	0.00	0.00

Figure G-158 Oscilloscope traces for Office Building O4, eighth largest transient event (data ID 0123, transient number 0018)

Table G-158 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0018					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.12	0.16	0.01	0.00	0.00
Y	0.72	0.09	0.00	0.00	0.00
Z	0.52	0.12	0.01	0.00	0.00

Figure G-159 Oscilloscope traces for Office Building O4, ninth largest transient event (data ID 0123, transient number 0123)

Table G-159 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0123					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.12	0.34	0.01	0.00	0.03
Y	1.02	0.26	0.02	0.00	0.02
Z	0.67	0.19	0.01	0.00	0.01

Figure G-160 Oscilloscope traces for Office Building O4, tenth largest transient event (data ID 0123, transient number 0165)

Table G-160 Maximum FFT Amplitude in Frequency Bins for Data ID 0123, Transient Number 0165					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.11	0.23	0.01	0.00	0.00
Y	0.61	0.13	0.00	0.00	0.00
Z	0.37	0.13	0.01	0.00	0.00

Figure G-161 Oscilloscope traces for Grocery Store G2, largest transient event (data ID 0130, transient number 0640)

Table G-161 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0640					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	2.16	0.87	0.02	0.01	0.00
Y	2.86	0.07	0.02	0.01	0.00
Z	1.42	0.07	0.02	0.01	0.00

Figure G-162 Oscilloscope traces for Grocery Store G2, second largest transient event (data ID 0130, transient number 0684)

Table G-162 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0684					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	2.80	0.88	0.01	0.00	0.03
Y	2.09	0.61	0.00	0.00	0.02
Z	0.50	0.35	0.03	0.01	0.00

Figure G-163 Oscilloscope traces for Grocery Store G2, third largest transient event (data ID 0130, transient number 0673)

Table G-163 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0673					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.53	0.33	0.00	0.00	0.04
Y	1.00	0.21	0.00	0.00	0.02
Z	0.31	0.08	0.02	0.00	0.00

Figure G-164 Oscilloscope traces for Grocery Store G2, fourth largest transient event (data ID 0130, transient number 0491)

Table G-164 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0491					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.37	0.24	0.00	0.00	0.03
Y	0.87	0.15	0.01	0.00	0.02
Z	0.25	0.08	0.02	0.00	0.00

Figure G-165 Oscilloscope traces for Grocery Store G2, fifth largest transient event (data ID 0130, transient number 0705)

Table G-165 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0705					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.34	0.26	0.01	0.01	0.02
Y	0.80	0.25	0.01	0.01	0.01
Z	0.64	0.17	0.02	0.01	0.01

Figure G-166 Oscilloscope traces for Grocery Store G2, sixth largest transient event (data ID 0130, transient number 0497)

Table G-166 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0497					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.17	0.14	0.00	0.01	0.01
Y	0.77	0.10	0.01	0.01	0.01
Z	0.55	0.08	0.03	0.00	0.01

Figure G-167 Oscilloscope traces for Grocery Store G2, seventh largest transient event (data ID 0130, transient number 0670)

Table G-167 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0670

Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.16	0.22	0.00	0.01	0.02
Y	0.73	0.22	0.01	0.01	0.01
Z	0.25	0.14	0.03	0.01	0.00

Figure G-168 Oscilloscope traces for Grocery Store G2, eighth largest transient event (data ID 0130, transient number 0171)

Table G-168 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0171					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.05	0.07	0.00	0.01	0.02
Y	0.64	0.19	0.01	0.00	0.01
Z	0.23	0.07	0.03	0.00	0.00

Figure G-169 Oscilloscope traces for Grocery Store G2, ninth largest transient event (data ID 0130, transient number 0053)

Table G-169 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0053					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.03	0.09	0.01	0.01	0.02
Y	0.84	0.07	0.02	0.01	0.01
Z	0.33	0.07	0.02	0.00	0.00

Figure G-170 Oscilloscope traces for Grocery Store G2, tenth largest transient event (data ID 0130, transient number 0777)

Table G-170 Maximum FFT Amplitude in Frequency Bins for Data ID 0130, Transient Number 0777					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.86	0.16	0.00	0.00	0.00
Y	1.00	0.17	0.01	0.00	0.00
Z	0.47	0.14	0.03	0.00	0.00

Figure G-171 Oscilloscope traces for Grocery Store G3, largest transient event (data ID 0226, transient number 0528)

Table G-171 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0528					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.62	0.43	0.00	0.08	0.00
Y	1.87	0.51	0.01	0.04	0.00
Z	0.77	0.18	0.03	0.04	0.00

Figure G-172 Oscilloscope traces for Grocery Store G3, second largest transient event (data ID 0226, transient number 0143)

Table G-172 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0143					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.77	0.09	0.01	0.00	0.00
Y	0.69	0.07	0.01	0.01	0.00
Z	1.81	0.13	0.02	0.01	0.01

Figure G-173 Oscilloscope traces for Grocery Store G3, third largest transient event (data ID 0226, transient number 0512)

Table G-173 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0512					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.75	0.49	0.01	0.16	0.00
Y	1.78	0.56	0.00	0.08	0.00
Z	0.87	0.23	0.03	0.07	0.00

Figure G-174 Oscilloscope traces for Grocery Store G3, fourth largest transient event (data ID 0226, transient number 0144)

Table G-174 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0144					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.75	0.08	0.01	0.01	0.00
Y	0.69	0.07	0.01	0.01	0.01
Z	1.73	0.11	0.02	0.01	0.01

Figure G-175 Oscilloscope traces for Grocery Store G3, fifth largest transient event (data ID 0226, transient number 0526)

Table G-175 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0526					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.58	0.45	0.01	0.12	0.00
Y	1.70	0.53	0.00	0.06	0.00
Z	0.77	0.20	0.02	0.05	0.00

Figure G-176 Oscilloscope traces for Grocery Store G3, sixth largest transient event (data ID 0226, transient number 0132)

Table G-176 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0132					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.77	0.11	0.01	0.01	0.01
Y	0.69	0.09	0.01	0.00	0.01
Z	1.69	0.17	0.03	0.01	0.02

Figure G-177 Oscilloscope traces for Grocery Store G3, seventh largest transient event (data ID 0226, transient number 0529)

Table G-177 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0529					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	1.56	0.45	0.00	0.12	0.00
Y	1.69	0.53	0.00	0.06	0.00
Z	0.77	0.20	0.03	0.05	0.00

Figure G-178 Oscilloscope traces for Grocery Store G3, eighth largest transient event (data ID 0226, transient number 0145)

Table G-178 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0145					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.81	0.10	0.01	0.01	0.00
Y	0.75	0.11	0.01	0.01	0.01
Z	1.67	0.14	0.02	0.02	0.01

Figure G-179 Oscilloscope traces for Grocery Store G3, ninth largest transient event (data ID 0226, transient number 0137)

Table G-179 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0137					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.70	0.11	0.01	0.01	0.01
Y	0.70	0.10	0.01	0.01	0.01
Z	1.66	0.17	0.02	0.01	0.02

Figure G-180 Oscilloscope traces for Grocery Store G3, tenth largest transient event (data ID 0226, transient number 0150)

Table G-180 Maximum FFT Amplitude in Frequency Bins for Data ID 0226, Transient Number 0150					
Channel	Peak to Peak (v)	RMS (v)	10 kHz -100 kHz (v)	100 kHz-1 MHz (v)	1 MHz-10 MHz (v)
X	0.87	0.08	0.01	0.01	0.00
Y	0.77	0.07	0.01	0.02	0.00
Z	1.66	0.10	0.03	0.01	0.01

Environmental Field Surveys

Volume 4: Appendices H and I

**EMF RAPID PROGRAM
ENGINEERING PROJECT #3**

Prepared by
ENERTECH CONSULTANTS
17 Main Street
P.O.Box 770
Lee, Massachusetts 01238

Principal Investigator
Luciano E. Zaffanella

Prepared for
Lockheed Martin Energy Systems, Inc.
P.O.Box 2002
241 W. Tyrone Road, D104
Oak Ridge, Tennessee 37831-6501

April 1996

APPENDIX H

METADATA FILE FOR THE EMF MEASUREMENT DATABASE

```
<!DOCTYPE METADATA PUBLIC "-//DOE RAPID5//DTD EMF Metadata Ver 0//EN">
<metadata>
  <dataset-reference>
    <title>DOE EMF Rapid Engineering Project #3 "Environmental Surveys"</title>
    <version>19960430</version>
    <status>Complete</status>
    <revision-history>
    <date>19960430</date>
    <contact>
      <organization>Enertech Consultants</organization>
      <name>Luciano Zaffanella</name>
      <address>
        Main Street
        Lee, MA 01238
      </address>
      <phone-voice>413-243-2800</phone-voice>
      <phone-fax>413-243-4620</phone-fax>
      <email-address>etceast@bcn.net</email-address>
    </contact>
    <description></description>
  </revision-history>
</dataset-reference>
<dataset-description>
  <abstract>The goal of this engineering project is to provide data
  for the assessment of exposure in different environments by type
  of people and by type of source.</abstract>
  <keyword>Magnetic Field Survey of Hospitals, Schools, Grocery
  Stores, Office Buildings, and Machine Shops. Magnetic Field
  Spatial Distribution. Exposure to are sources and point sources.
  Source Characterization. Time weighted magnetic field for
  different occupations. DC Magnetic Fields in combination with AC
  magnetic fields. Magnetic Field waveshape and harmonic output.
  Magnetic Field Transients.</keyword>
  <producer>
  <contact>
    <organization>Enertech Consultants</organization>
    <name>Luciano Zaffanella</name>
    <address>
      Main Street
      Lee, MA 01238
```

</address>
 <phone-voice>413-243-2800</phone-voice>
 <phone-fax>413-243-4620</phone-fax>
 <email-address>etceast@bcn.net</email-address>
 </contact>
 </producer>
 <time-period>Measurements were made between September 26, 1995 and April 4, 1996</time-period>
 <geographic-location>Measurements were all made in the United States. Approximately half of the measurements were made on the east coast, the other half being made on the west coast. The west coast measurements consist of 4 hospitals, 3 machine shops, 2 office buildings, 2 schools, and 1 grocery store. The east coast measurements include 3 grocery stores, 2 office buildings, 2 schools, and 1 machine shop.</geographic-location>
 <general-location>The measurements were made in 5 specific environment types, hospitals, schools, office buildings, machine shops, and grocery stores. Four sites of each environment type were measured yielding a total of 20 measured sites.</general-location>
 <exposure-metric>RMS magnetic field in the frequency range from 40 Hz to 800Hz measured along three orthogonal axes and combined to give a resultant value. Amplitude and phase angle of the individual frequency components at 60 Hz and its harmonics. Amplitude of DC magnetic field. Peak to Peak value of magnetic field transients.</exposure-metric>
 <sampling-interval>For area measurements, an EMDEX II is used taking samples every 1.5 seconds. For source measurements, a Wavecorder is used to capture 2 60Hz cycles with a sampling rate of 15.4 kHz. 24 hour recorders take samples every 3 seconds.</sampling-interval>
 <duration-of-measurements>Area measurements with the EMDEX II last 30 seconds to 3 minutes gathering data at a rate of 1 sample every 1.5 seconds. Exposure points measurements were either 3 spot measurements, or a single EMDEX Snap measurement. 24 Hour recorders gathered data at a rate of 1 measurement every 3 seconds and usually lasted 24 hours. Transient Measurements typically lasted 24 hours for each site.</duration-of-measurements>
 <type-of-measurement>Area exposure, and source characterization measurements</type-of-measurement>
 <methodology>Measurements were performed according to the protocol described in the Final Report of DOE Rapid Engineering Project #3 "Environmental Field Surveys". The basic components of the protocol of a site are: mapping of the magnetic field in the areas of the site, area activity questionnaire, exposure point activity

questionnaire, point source characterization, simultaneous AC waveshape and DC field measurements, 24-hour field recordings, magnetic field transient recordings.</methodology>

<selection>Qualified sites of each environment type were selected based upon their willingness to participate.</selection>

<sample-size>Four sites for each of five different environments: Hospitals, Schools, Grocery Stores, Office Building, and Machine Shops.</sample-size>

<instrumentation>

<instrument>EMDEX II</instrument>

<manufacturer>

<contact>

<organization>Enertech Consultants</organization>

<address>

300 Orchard City Drive, Suite #132

Campbell, California 95008

</address>

</contact>

</manufacturer>

<version>Version 2.1</version>

<associated-software>Emcalc95 was used download and process the data. In cases where the EMDEX II was used in conjunction with the LINDA wheel, Emcalc95 was used to initialize the instrument.</associated-software>

<discussion>The EMDEX II was used to capture the area fields in all surveyed areas as well as being used as a temporal recorder.</discussion>

<frequency-response>40Hz - 800 Hz</frequency-response>

<dynamic-range>Magnetic Field, .1mG - 3 Gauss in each of three orthogonal directions.</dynamic-range>

</instrumentation>

<instrumentation>

<instrument>EMDEX Snap</instrument>

<manufacturer>

<contact>

<organization>Enertech Consultants</organization>

<address>

300 Orchard City Drive, Suite #132

Campbell, California 95008

</address>

</contact>

</manufacturer>

<version>None</version>

<associated-software>None</associated-software>

<discussion>Hand held instrument with digital display refreshed

every .5 seconds</discussion>
 <frequency-response>40Hz - 1 kHz</frequency-response>
 <dynamic-range>Magnetic Field, .1mG - 700mG in each of three
 orthogonal directions.</dynamic-range>
 </instrumentation>
 <instrumentation>
 <instrument>Wavecorder</instrument>
 <manufacturer>
 <contact>
 <organization>Enertech Consultants</organization>
 <address>
 300 Orchard City Drive, Suite #132
 Campbell, California 95008
 </address>
 </contact>
 </manufacturer>
 <version>1.2</version>
 <associated-software>Windows Wavecorder software is used to
 download and manipulate the data from the
 Wavecorder.</associated-software>
 <discussion>For each significant source, the waveshape of the
 magnetic field was captured using the EMDEX
 Wavecorder. DC Field Measurements were made by attaching a DC
 probe to the Wavecorder. (This measurement system gives the
 magnitude of the DC field and the magnitude of the AC field
 components parallel and perpendicular to the DC Field)</discussion>
 <frequency-response>30Hz - 3000Hz</frequency-response>
 <dynamic-range>.3mG - 25.6G</dynamic-range>
 </instrumentation>
 <instrumentation>
 <instrument>DC Meter</instrument>
 <manufacturer>
 <contact>
 <organization>Bartington</organization>
 <address>
 </address>
 </contact>
 </manufacturer>
 <version>N/A</version>
 <associated-software></associated-software>
 <discussion>Single Axis DC Meter with digital readout.</discussion>
 <frequency-response>N/A</frequency-response>
 <dynamic-range>1 to 10000 mG</dynamic-range>
 </instrumentation>
 <associated-project>

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<project-name>DOE EMF Rapid Engineering Project #3:
"Environmental Field Surveys"</project-name>
<sponsorship>
  <contact>
    <name>US Department of Energy through contract with Lockheed
    Martin</name>
  </contact>
</sponsorship>
</associated-project>
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  <entity>
    <name>Environment</name>
    <description>The classification of an environment in which
    measurements were made.</description>
    <attribute>
      <name>Environment Type</name>
      <description>A place where activities of specific groups of
      people occur and which may be a source of characteristic
      exposure to EMF, by virtue of the type of electrical
      facilities and equipment typical of that place.</description>
      <codeset-domain>
        <codeset-code>
          <codeset-value>S</codeset-value>
          <description>School</description>
        </codeset-code>
        <codeset-code>
          <codeset-value>O</codeset-value>
          <description>Office Building</description>
        </codeset-code>
        <codeset-code>
          <codeset-value>G</codeset-value>
          <description>Grocery Store</description>
        </codeset-code>
        <codeset-code>
          <codeset-value>M</codeset-value>
          <description>Machine Shop</description>
        </codeset-code>
        <codeset-code>
          <codeset-value>H</codeset-value>
          <description>Hospital</description>
        </codeset-code>
      </codeset-domain>
    </attribute>
  </entity>

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<entity>
  <name>Site</name>
  <description>A complete architectural structure and associated
area that serve the purpose of the environment.</description>
  <attribute>
    <name>Site ID</name>
    <description>Uniquely identifies a site at which measurements
have been made.</description>
    <simple-domain>The site ID is made up of two characters.
The first character is the code of the environment type,
while the second character is a number from 1 to the
number of sites measured of a particular environment
type. i.g..."S3" represents "School Number 3"</simple-domain>
  </attribute>
  <attribute>
    <name>Number of Floors</name>
    <description>Describes the number of floors of the building
at a measured site.</description>
    <simple-domain>Positive Integer for floor above ground.
Negative integers for floors below ground. Zero for outdoor
areas.</simple-domain>
  </attribute>
  <attribute>
    <name>Number of Areas Surveyed</name>
    <description>Represents the total number of areas in a
particular site that have been measured.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Number of areas where ACDC Measurements were made</name>
    <description>Represents the total number of areas in a
particular site in which simultaneous measurements of AC and
DC field were made.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Unperturbed DC Geomagnetic Field</name>
    <description>Represents the unperturbed geomagnetic field for
a particular site.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Building Material</name>
    <description>Describes the material of the building, such
as: brick, metal, or concrete

```



```

    was constructed from.</description>
    <simple-domain>Free text</simple-domain>
  </attribute>
</entity>
<entity>
  <name>Area Type</name>
  <description>An entity that characterizes the function of an
area. The area type table presents a list of these
area type classifications for a particular environment
type.</description>
  <attribute>
    <name>Area Type Number</name>
    <description>A number that uniquely identifies an area
type.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Area Type Name</name>
    <description>A description of the area type number.
An example would be "Classroom" in the environment type
schools.</description>
    <simple-domain>Free Text</simple-domain>
  </attribute>
</entity>
<entity>
  <name>Person Type</name>
  <description>An entity that characterizes the function of a
person at a site. The person type table presents a list of
different person types for each particular environment
type.</description>
  <attribute>
    <name>Person Type Number</name>
    <description>A number that uniquely identifies a person
type.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Person Type Description</name>
    <description>A description of the person type number.
An example would be "Welder" in the environment type
"machine shops".</description>
    <simple-domain>Free Text</simple-domain>
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<name>Surveyed Area</name>
<description>Each environment site is divided into different
"areas". An area is defined on the basis that the people that
occupy that area are a well defined group, or the activities
that take place in that are well defined.</description>
<attribute>
  <name>Area ID</name>
  <description>Uniquely identifies an area within a
site.</description>
  <simple-domain>Positive Integer</simple-domain>
</attribute>
<attribute>
  <name>Area Name</name>
  <description>Describes the type of area by assigning
a name to each surveyed area.</description>
  <simple-domain>Free Text</simple-domain>
</attribute>
<attribute>
  <name>Surface Area</name>
  <description>The floor surface of a surveyed
area.</description>
  <simple-domain>Postive Integer in Square Feet</simple-domain>
</attribute>
<attribute>
  <name>Percent Surveyed</name>
  <description>The percentage of the area surveyed.</description>
  <simple-domain>Percentile</simple-domain>
</attribute>
<attribute>
  <name>Floor Number</name>
  <description>The floor on which a surveyed area is located.
</description>
  <simple-domain>Positive integer for floors above ground.
Negative integers for floors below ground. Zero for outdoor
areas.</simple-domain>
</attribute>
<attribute>
  <name>Area Type Number</name>
  <description>The type of area that has been surveyed. The
area type is derived from the "Area Type"
table.</description>
  <simple-domain>Positive integer from 1 to the number of
area types for a particular environment.</simple-domain>
</attribute>
</entity>

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<entity>
  <name>Point Source Type</name>
  <description>An entity that contains descriptions of point
  source type numbers.</description>
  <attribute>
    <name>Point Source ID Number</name>
    <description>A number that uniquely identifies a point
    source.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Point Source Description</name>
    <description>A description of a point source ID Number.</description>
    <simple-domain>Free Text</simple-domain>
  </attribute>
</entity>
<entity>
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  <description>An entity containing descriptions of area source
  type numbers.</description>
  <attribute>
    <name>Area Source Type Number</name>
    <description>A number that uniquely identifies an area source
    type.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Area Source Description</name>
    <description>A description of an Area Source Type
    Number.</description>
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</entity>
<entity>
  <name>Main Area Source</name>
  <description>An entity that characterizes the magnetic field
  source that is judged most responsible for the magnetic field
  in an area, when the local sources are neglected.</description>
  <attribute>
    <name>Area Source Type Number</name>
    <description>A number that uniquely identifies the type of
    main area source.</description>
    <simple-domain>Positive integer from 1 to the total
    number of main area sources identified in all
    environments.</simple-domain>
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```

```

</attribute>
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  <name>Area Source Description</name>
  <description>The description of the main area source. An
  example would be : "Electrical Panels".</description>
  <simple-domain>Free Text</simple-domain>
</attribute>
</entity>
<entity>
  <name>Set of ACDC Measurements</name>
  <description>Set of simultaneous AC and DC field measurements
  taken in a particular area.</description>
  <attribute>
    <name>Wavecoder Filename</name>
    <description>The name of the Wavecoder file in which
    the measurement data for the ACDC measurements is
    stored.</description>
    <simple-domain>Wavecoder filenames can be any eight
    characters with a filename extension of "WCD".</simple-domain>
  </attribute>
  <attribute>
    <name>Number of ACDC Measurements</name>
    <description>Number of simultaneous AC and DC field
    measurements that make up the set of ACDC Measurements
    for an area where ACDC measurements were made.</description>
    <simple-domain>Positive integer from 1 to 5.</simple-domain>
  </attribute>
</entity>
<entity>
  <name>ACDC Measurement</name>
  <description>Measurement information derived from
  Wavecoder files and DC fields.</description>
  <attribute>
    <name>Record Number</name>
    <description>Uniquely identifies an "ACDC Measurement"
    Entity.</description>
    <simple-domain>Positive integer from 1 to number of ACDC
    measurements.</simple-domain>
  </attribute>
  <attribute>
    <name>Wavecoder Wave Number</name>
    <description>Identifies the wave contained within the
    "Wavecoder Filename" of the "Set of ACDC Measurements" entity.
    </description>
    <simple-domain>Positive integer from 1 to number of waves

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contained within a particular Wavecorder file.</simple-domain>
</attribute>
<attribute>
<name>DC Field</name>
<description>Value of the measured DC Field</description>
<simple-domain>Positive Integer expressing the DC field value
in milligauss.</simple-domain>
</attribute>
<attribute>
<name>X 60 Magnitude</name>
<description>RMS value of the AC 60Hz field component along
the X axis, which is parallel to the DC field.</description>
<simple-domain>Floating Point Value in (mG)</simple-domain>
</attribute>
<attribute>
<name>X 60 Phase Angle</name>
<description>Phase Angle of the AC 60Hz field component along
the X axis. The reference for this angle is the instant
when the instrument is triggered.</description>
<simple-domain>Floating Point Value, degree</simple-domain>
</attribute>
<attribute>
<name>Y 60 Magnitude</name>
<description>RMS value of the AC 60Hz field component along
the Y axis, which is perpendicular to the DC field.</description>
<simple-domain>Floating Point Value in (mG)</simple-domain>
</attribute>
<attribute>
<name>Y 60 Phase Angle</name>
<description>Phase Angle of the AC 60Hz field component along
the Y axis. The reference for this angle is the instant
when the instrument is triggered.</description>
<simple-domain>Floating Point Value, degree</simple-domain>
</attribute>
<attribute>
<name>Z 60 Magnitude</name>
<description>RMS value of the AC 60Hz field component along
the Z axis, which is perpendicular to the DC field.</description>
<simple-domain>Floating Point Value in (mG)</simple-domain>
</attribute>
<attribute>
<name>Z 60 Phase Angle</name>
<description>Phase Angle of the AC 60Hz field component along
the Z axis. The reference for this angle is the instant
when the instrument is triggered.</description>

<simple-domain>Floating Point Value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>B Max Magnitude (60)</name>
 <description>RMS value of the AC 60Hz field component along
 the direction of the major axis of the field ellipse.
 Magnitude of the maximum field component.</description>
 <simple-domain>Floating Point Value in (mG)</simple-domain>
 </attribute>
 <attribute>
 <name>Angle between B Max (60) and BDC</name>
 <description>Angle in the space between the major axis of the
 60Hz field ellipse and the direction of the DC field.</description>
 <simple-domain>Floating Point Value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>B Perp. Max (60)</name>
 <description>Maximum AC 60Hz field component perpendicular
 to the DC Field.</description>
 <simple-domain>Floating point value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>Polarization (60)</name>
 <description>Ratio between the semi-minor and the semi-major
 axes of the ac 60Hz field ellipse.</description>
 <simple-domain>Floating point value,
 between 0 and 1</simple-domain>
 </attribute>
 <attribute>
 <name>X 180 Magnitude</name>
 <description>RMS value of the AC 180Hz field component along
 the X axis, which is parallel to the DC field.</description>
 <simple-domain>Floating Point Value in (mG)</simple-domain>
 </attribute>
 <attribute>
 <name>X 180 Phase Angle</name>
 <description>Phase Angle of the AC 180Hz field component along
 the X axis. The reference for this angle is the instant
 when the instrument is triggered.</description>
 <simple-domain>Floating Point Value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>Y 180 Magnitude</name>
 <description>RMS value of the AC 180Hz field component along
 the Y axis, which is perpendicular to the DC field.</description>

<simple-domain>Floating Point Value in (mG)</simple-domain>
 </attribute>
 <attribute>
 <name>Y 180 Phase Angle</name>
 <description>Phase Angle of the AC 180Hz field component along
 the Y axis. The reference for this angle is the instant
 when the instrument is triggered.</description>
 <simple-domain>Floating Point Value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>Z 180 Magnitude</name>
 <description>RMS value of the AC 180Hz field component along
 the Z axis, which is perpendicular to the DC field.</description>
 <simple-domain>Floating Point Value in (mG)</simple-domain>
 </attribute>
 <attribute>
 <name>Z 180 Phase Angle</name>
 <description>Phase Angle of the AC 180Hz field component along
 the Z axis. The reference for this angle is the instant
 when the instrument is triggered.</description>
 <simple-domain>Floating Point Value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>B Max Magnitude (180)</name>
 <description>RMS value of the AC 180Hz field component along
 the direction of the major axis of the field ellipse.
 Magnitude of the maximum field component.</description>
 <simple-domain>Floating Point Value in (mG)</simple-domain>
 </attribute>
 <attribute>
 <name>Angle between B Max (180) and BDC</name>
 <description>Angle in the space between the major axis of the
 180Hz field ellipse and the direction of the DC field.</description>
 <simple-domain>Floating Point Value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>B Perp. Max (180)</name>
 <description>Maximum AC 180Hz field component perpendicular
 to the DC Field.</description>
 <simple-domain>Floating point value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>Polarization (180)</name>
 <description>Ratio between the semi-minor and the semi-major
 axes of the ac 180Hz field ellipse.</description>

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    <simple-domain>Floating point value,
    between 0 and 1</simple-domain>
  </attribute>
  <attribute>
    <name>X 300 Magnitude</name>
    <description>RMS value of the AC 300Hz field component along
    the X axis, which is parallel to the DC field.</description>
    <simple-domain>Floating Point Value in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>X 300 Phase Angle</name>
    <description>Phase Angle of the AC 300Hz field component along
    the X axis. The reference for this angle is the instant
    when the instrument is triggered.</description>
    <simple-domain>Floating Point Value, degree</simple-domain>
  </attribute>
  <attribute>
    <name>Y 300 Magnitude</name>
    <description>RMS value of the AC 300Hz field component along
    the Y axis, which is perpendicular to the DC field.</description>
    <simple-domain>Floating Point Value in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Y 300 Phase Angle</name>
    <description>Phase Angle of the AC 300Hz field component along
    the Y axis. The reference for this angle is the instant
    when the instrument is triggered.</description>
    <simple-domain>Floating Point Value, degree</simple-domain>
  </attribute>
  <attribute>
    <name>Z 300 Magnitude</name>
    <description>RMS value of the AC 300Hz field component along
    the Z axis, which is perpendicular to the DC field.</description>
    <simple-domain>Floating Point Value in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Z 300 Phase Angle</name>
    <description>Phase Angle of the AC 300Hz field component along
    the Z axis. The reference for this angle is the instant
    when the instrument is triggered.</description>
    <simple-domain>Floating Point Value, degree</simple-domain>
  </attribute>
  <attribute>
    <name>B Max Magnitude (300)</name>
    <description>RMS value of the AC 300Hz field component along

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the direction of the major axis of the field ellipse.
 Magnitude of the maximum field component.</description>
 <simple-domain>Floating Point Value in (mG)</simple-domain>
 </attribute>
 <attribute>
 <name>Angle between B Max (300) and BDC</name>
 <description>Angle in the space between the major axis of the
 300Hz field ellipse and the direction of the DC field.</description>
 <simple-domain>Floating Point Value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>B Perp. Max (300)</name>
 <description>Maximum AC 300Hz field component perpendicular
 to the DC Field.</description>
 <simple-domain>Floating point value, degree</simple-domain>
 </attribute>
 <attribute>
 <name>Polarization (300)</name>
 <description>Ratio between the semi-minor and the semi-major
 axes of the ac 300Hz field ellipse.</description>
 <simple-domain>Floating point value,
 between 0 and 1</simple-domain>
 </attribute>
 <attribute>
 <name>THD</name>
 <description>Total Harmonic Distortion</description>
 <simple-domain>Floating Point Value</simple-domain>
 </attribute>
 <attribute>
 <name>Frequency of largest other harmonic.</name>
 <description>Frequency of the largest harmonics, other
 than 180Hz and 300Hz, if greater than .05mG.</description>
 <simple-domain>Positive Integer, Hz</simple-domain>
 </attribute>
 <attribute>
 <name>Magnitude of Largest other harmonic.</name>
 <description>RMS value of the largest harmonics other than
 180Hz and 300Hz, if greater than .05 (mG)</description>
 <simple-domain>Floating Point Value, mG</simple-domain>
 </attribute>
 <attribute>
 <name>30 / 60 Ratio</name>
 <description>Ratio between the 30Hz and the 60Hz
 components.</description>
 <simple-domain>Positive, floating point value.</simple-domain>

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    </attribute>
  </entity>
  <entity>
    <name>Spatial Distribution Data Set</name>
    <description>Data Set containing information about a set
    of measurements taken at different points uniformly distributed
    over a surveyed area using the EMDEX II.</description>
    <attribute>
      <name>EMDEX Filename</name>
      <description>The name of the file in which a set or sets
      of data are stored.</description>
      <simple-domain>Valid filenames are any 8 characters
      followed by the "MDX" filename extension.</simple-domain>
    </attribute>
    <attribute>
      <name>Number of Observations</name>
      <description>Number of field measurements included in the data
      set.</description>
      <simple-domain>Positive Integer</simple-domain>
    </attribute>
    <attribute>
      <name>Average</name>
      <description>Average value of the resultant magnetic
      field.</description>
      <simple-domain>Positive Real</simple-domain>
    </attribute>
    <attribute>
      <name>Std. Deviation</name>
      <description>Standard Deviation of the resultant magnetic
      field in the data set.</description>
      <simple-domain>Positive Real</simple-domain>
    </attribute>
    <attribute>
      <name>Geometric Mean</name>
      <description>Geometric Mean of the resultant magnetic field
      values in the data set.</description>
      <simple-domain>Positive Real</simple-domain>
    </attribute>
    <attribute>
      <name>Geometric Std. Deviation</name>
      <description>Geometric Standard Deviation of the resultant
      magnetic field values in the data set.</description>
      <simple-domain>Positive Real</simple-domain>
    </attribute>
  </entity>

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    <name>Minimum</name>
    <description>Minimum resultant magnetic field value in the
    data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>One Percent</name>
    <description>Shows the values below which lay 1% of all the
    resultant magnetic field values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Five Percent</name>
    <description>Shows the values below which lay 5% of all the
    resultant magnetic field values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Ten Percent</name>
    <description>Shows the values below which lay 10% of all the
    resultant magnetic field values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Twenty Five Percent</name>
    <description>Shows the values below which lay 25% of all the
    resultant magnetic field values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Fifty Percent</name>
    <description>Shows the values below which lay 50% of all the
    resultant magnetic field values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Seventy Five Percent</name>
    <description>Shows the values below which lay 75% of all the
    resultant magnetic field values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Ninety Percent</name>
    <description>Shows the values below which lay 90% of all the
    resultant magnetic field values in the data set.</description>

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    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Ninety Five Percent</name>
    <description>Shows the values below which lay 95% of all the
    resultant magnetic field values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Ninety Nine Percent</name>
    <description>Shows the values below which lay 99% of all the
    resultant magnetic field values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Maximum</name>
    <description>Maximum resultant magnetic field value in the
    data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Median</name>
    <description>Median of the resultant magnetic field value
    in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
</entity>
<entity>
  <name>Temporal Distribution Data Set</name>
  <description>Data Set containing information about a set
  of measurements taken in a surveyed area using the
  EMDEX II as a long term stationary recorder.</description>
  <attribute>
    <name>Days</name>
    <description>The number of days with at least one temporal
    record.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Start Time</name>
    <description>Time during the long term recording at which
    the measured values become meaningful for use in
    calculations. i.g. School data is not of much interest during
    the night, henceforth calculations on the data might only be done
    after 8:00am when school is in session.</description>

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    <simple-domain>HH:MM</simple-domain>
  </attribute>
  <attribute>
    <name>End Time</name>
    <description>Time during the long term recording at which
    the measured values become meaningless for use in
    calculations. i.g. School data is not of much interest during
    the night, henceforth calculations on the data might stop
    after 5:00pm when school is out of session.</description>
    <simple-domain>HH:MM</simple-domain>
  </attribute>
  <attribute>
    <name>EMDEX Temporal Filename</name>
    <description>The name of the file in which a set or sets
    of data are stored.</description>
    <simple-domain>Valid filenames are any 8 characters
    followed by the "MDX" filename extension.</simple-domain>
  </attribute>
  <attribute>
    <name>Number of Temporal Observations</name>
    <description>Number of field measurements included in the data
    set.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Temporal Average</name>
    <description>Average value of the resultant magnetic
    field.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Temporal Std. Deviation</name>
    <description>Standard Deviation of the resultant magnetic
    field in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Temporal Geometric Mean</name>
    <description>Geometric Mean of the resultant magnetic field
    values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
  <attribute>
    <name>Temporal Geometric Std. Deviation</name>
    <description>Geometric Standard Deviation of the resultant

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    magnetic field values in the data set.</description>
    <simple-domain>Positive Real</simple-domain>
  </attribute>
</attribute>
  <name>Temporal Minimum</name>
  <description>Minimum resultant magnetic field value in the
  data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
</attribute>
  <name>Temporal One Percent</name>
  <description>Shows the values below which lay 1% of all the
  resultant magnetic field values in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
</attribute>
  <name>Temporal Five Percent</name>
  <description>Shows the values below which lay 5% of all the
  resultant magnetic field values in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
</attribute>
  <name>Temporal Ten Percent</name>
  <description>Shows the values below which lay 10% of all the
  resultant magnetic field values in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
</attribute>
  <name>Temporal Twenty Five Percent</name>
  <description>Shows the values below which lay 25% of all the
  resultant magnetic field values in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
</attribute>
  <name>Temporal Fifty Percent</name>
  <description>Shows the values below which lay 50% of all the
  resultant magnetic field values in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
</attribute>
  <name>Temporal Seventy Five Percent</name>
  <description>Shows the values below which lay 75% of all the
  resultant magnetic field values in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>

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<attribute>
  <name>Temporal Ninety Percent</name>
  <description>Shows the values below which lay 90% of all the
  resultant magnetic field values in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
<attribute>
  <name>Temporal Ninety Five Percent</name>
  <description>Shows the values below which lay 95% of all the
  resultant magnetic field values in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
<attribute>
  <name>Temporal Ninety Nine Percent</name>
  <description>Shows the values below which lay 99% of all the
  resultant magnetic field values in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
<attribute>
  <name>Temporal Maximum</name>
  <description>Maximum resultant magnetic field value in the
  data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
<attribute>
  <name>Temporal Median</name>
  <description>Median of the resultant magnetic field value
  in the data set.</description>
  <simple-domain>Positive Real</simple-domain>
</attribute>
</entity>
<entity>
  <name>Exposure Point Source</name>
  <description>The location where persons engage in fixed, site
  specific activities, e.g. sitting in front of a desktop computer
  or standing at a lathe in a machine shop, or where a local source
  creates a significant increase in the area field.</description>
  <attribute>
    <name>Source ID Number</name>
    <description>Uniquely identifies an exposure point
    source.</description>
    <simple-domain>Positive integer from 1 to the number
    of exposure point sources for a particular site.</simple-domain>
  </attribute>
  <attribute>

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<name>Source Type Number</name>
 <description>Identifies which type of source by a unique number for groups of sources. i.g... Source type number "9" represents fluorescent lights.</description>
 <simple-domain>Positive integer from 1 to the number of source types found in the source type table.</simple-domain>
 </attribute>
 <attribute>
 <name>Activity Zone Minimum</name>
 <description>The minimum distance between the exposure point source and persons during their activities at the exposure point.</description>
 <simple-domain>Real number expressed in feet as a positive distance.</simple-domain>
 </attribute>
 <attribute>
 <name>Activity Zone Maximum</name>
 <description>The maximum distance between the exposure point source and persons during their activities at the exposure point.</description>
 <simple-domain>Real number expressed in feet as a positive distance.</simple-domain>
 </attribute>
 <attribute>
 <name>Source Data Set Number</name>
 <description>Given a characterization number and a source data set number, all the information needed to locate information about that source is had. A Source Data Set number is contained within the Source method #1, method #2, and method #3 output files and the dataset is a field within these files. This field uniquely identifies a source within one of those files.</description>
 <simple-domain>Positive Integer</simple-domain>
 </attribute>
 <attribute>
 <name>Characterization Method</name>
 <description>"Characterization Method" describes the method by which a source was characterized. There are 4 methods - Method 1 consists of measurements at three points with a Wavecorder with a reference signal, Method 2 consists of measurements at one to three points with a Wavecorder without a reference signal, Method 3 consists of a single measurement with a EMDEX Snap, and Method 4 consists of no measurements because the source was found to be similar to another measured source with Method 1.</description>


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<codeset-domain>
  <codeset-code>
    <codeset-value>1</codeset-value>
    <description>If an "Exposure Point Source" has a characterization
method that is "1" or "4" then information about that source
will be contained in the "Three Point Characterization
Method with Reference" Entity. When the characterization
method is a "1", a three point characterization method using
the Wavecorder at 3 distances with a reference has been made.
However, if the characterization method is "4", the source
has been found to be similar to a source with a
characterization method "1". When processing a source
with a characterization method "4", the data about that
source is obtained using the data of a similar source
measured with a characterization method "1".</description>
  </codeset-code>
  <codeset-code>
    <codeset-value>2</codeset-value>
    <description>If an "Exposure Point Source" has a characterization
method of "2" then information about that source will be contained
in the "Characterization Method w/o Reference" Entity. When
the characterization method is "2", the source has been measured
at three points using the Wavecorder without a reference
signal. Using the FFT summary from the Wavecorder software, the
field at three points is calculated. If the source has only
been measured at one or two points instead of three, then
the data for the non-measured points must be set to
zero.</description>
  </codeset-code>
  <codeset-code>
    <codeset-value>3</codeset-value>
    <description>If an "Exposure Point Source" has a characterization
method of "3" then information about that source will be
contained in the "Snap Measurement" Entity. When the
characterization method is "3" no measurements of the source
have been made with the Wavecorder.</description>
  </codeset-code>
  <codeset-code>
    <codeset-value>4</codeset-value>
    <description>If an "Exposure Point Source" has a characterization
method that is "4" then information about that source
will be contained in the "Three Point Characterization
Method with Reference" Entity. When the characterization
method is a "1", a three point characterization method using
the Wavecorder at 3 distances with a reference has been made.

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However, if the characterization method is "4", the source has been found to be similar to a source with a characterization method "1". When processing a source with a characterization method "4", the data about that source is obtained using the data of a similar source measured with a characterization method "1".</description>
</codeset-code>
</codeset-domain>
</attribute>
</entity>
<entity>
<name>Group of Persons within an Area</name>
<description>Group of people grouped by person type within a particular area.</description>
<attribute>
<name>Person Type Number</name>
<description>A number that represents a group of people of a certain type. This number can be looked up the Person Type table to find out what group of people in particular this is. i.e.. Person Type "1" in machine shops is a machinist.</description>
<simple-domain>Positive Integer</simple-domain>
</attribute>
<attribute>
<name>Person Number Minimum</name>
<description>Minimum number of people of "person type number" that are exposed to area sources in a day.</description>
<simple-domain>Positive Integer</simple-domain>
</attribute>
<attribute>
<name>Person Number Maximum</name>
<description>Maximum number of people of "person type number" that are exposed to an exposure point source during a day.</description>
<simple-domain>Positive Integer</simple-domain>
</attribute>
<attribute>
<name>Person Time Minimum</name>
<description>Minimum time that people of "person type number" are in a surveyed area in a day.</description>
<simple-domain>Positive Real Number expressed in minutes</simple-domain>
</attribute>
<attribute>
<name>Person Time Maximum</name>

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    <description>Maximum time that people of "person type
    number" are in a surveyed area in a day.</description>
    <simple-domain>Positive Real Number expressed in
    minutes</simple-domain>
  </attribute>
  <attribute>
    <name>Person Mobility Minimum</name>
    <description>Minimum mobility of "person type number"
    in an area during a day. Mobility is the time persons
    moves around in an area expressed as a percentage of the
    total time the persons are in the area.</description>
    <simple-domain>Positive integer expressed in
    percentage</simple-domain>
  </attribute>
  <attribute>
    <name>Person Mobility Maximum</name>
    <description>Maximum mobility of "person type number"
    in an area during a day. Mobility is the time persons
    moves around in an area expressed as a percentage of the
    total time the persons are in the area.</description>
    <simple-domain>Positive integer expressed in
    percentage</simple-domain>
  </attribute>
</entity>
<entity>
  <name>Group of Persons near a Source</name>
  <description>Group of people that are exposed at an exposure
  point source.</description>
  <attribute>
    <name>Person Type Number</name>
    <description>A number that represents a group of people
    of a certain type. This number can be looked up the
    Person Type table to find out what group of people in
    particular this is. i.g... Person Type "1" in machine
    shops is a machinist.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Person Number Minimum</name>
    <description>Minimum number of people of "person type
    number" that are exposed at an exposure point source
    during a day.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>

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    <name>Person Number Maximum</name>
    <description>Maximum number of people of "person type
    number" that are exposed to an exposure point source
    during a day.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Person Time Minimum</name>
    <description>Minimum time that person "person type
    number" spends at an exposure point source during a
    day.</description>
    <simple-domain>Positive integer expressed in
    minutes</simple-domain>
  </attribute>
  <attribute>
    <name>Person Time Maximum</name>
    <description>Maximum time that person "person type
    number" spends at an exposure point source during a
    day. </description>
    <simple-domain>Positive integer expressed in
    minutes</simple-domain>
  </attribute>
</entity>
<entity>
  <name>Three Point Characterization Method with Reference</name>
  <description>If an "Exposure Point Source" has a characterization
  method that is "1" or "4" then information about that source
  will be contained in the "Three Point Characterization
  Method with Reference" Entity. When the characterization
  method is a "1", a three point characterization method using
  the Wavecorder at 3 distances with a reference has been made.
  However, if the characterization method is "4", the source
  has been found to be very similar to a source with a
  characterization method "1". When processing a source
  with a characterization method "4", the data about that
  source is obtained using the data of a similar source that
  measured with a characterization method "1".</description>
  <attribute>
    <name>Source Wavecorder Filename</name>
    <description>The Wavecorder filename that contains information
    about the source that have been measured.</description>
    <simple-domain>8 Characters concatenated with "WCD"</simple-domain>
  </attribute>
  <attribute>
    <name>Record Number 1</name>

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    <description>Describes the record number which corresponds to a
    Wavecorder wave number in the Source Wavecorder Filename
    describing information about a particular wave.</description>
    <simple-domain>Positive Integer</simple-domain>
</attribute>
<attribute>
    <name>Record Number 2</name>
    <description>Describes the record number which corresponds to a
    Wavecorder wave number in the Source Wavecorder Filename
    describing information about a particular wave.</description>
    <simple-domain>Positive Integer</simple-domain>
</attribute>
<attribute>
    <name>Record Number 3</name>
    <description>Describes the record number which corresponds to a
    Wavecorder wave number in the Source Wavecorder Filename
    describing information about a particular wave.</description>
    <simple-domain>Positive Integer</simple-domain>
</attribute>
<attribute>
    <name>Distance Number 1</name>
    <description>Describes the distance at which Record Number 1
    of Source Wavecorder filename was taken from the
    source.</description>
    <simple-domain>Positive Integer (Inches)</simple-domain>
</attribute>
<attribute>
    <name>Distance Number 2</name>
    <description>Describes the distance at which Record Number 2
    of Source Wavecorder filename was taken from the
    source.</description>
    <simple-domain>Positive Integer (Inches)</simple-domain>
</attribute>
<attribute>
    <name>Distance Number 3</name>
    <description>Describes the distance at which Record Number 3
    of Source Wavecorder filename was taken from the
    source.</description>
    <simple-domain>Positive Integer (Inches)</simple-domain>
</attribute>
<attribute>
    <name>Field at Zero Meters</name>
    <description>The field at 0.0 Meters calculated from
    the measured data in the Wavecorder FFT Summary files
    at the three measured points.</description>

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    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -0.15 Meters</name>
    <description>The field at -0.15 Meters calculated from
the measured data in the Wavecorder FFT Summary files
at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -0.31 Meters</name>
    <description>The field at -0.31 Meters calculated from
the measured data in the Wavecorder FFT Summary files
at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -0.46 Meters</name>
    <description>The field at -0.46 Meters calculated from
the measured data in the Wavecorder FFT Summary files
at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -0.61 Meters</name>
    <description>The field at -0.61 Meters calculated from
the measured data in the Wavecorder FFT Summary files
at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -0.76 Meters</name>
    <description>The field at -0.76 Meters calculated from
the measured data in the Wavecorder FFT Summary files
at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -0.92 Meters</name>
    <description>The field at -0.92 Meters calculated from
the measured data in the Wavecorder FFT Summary files
at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
</attribute>

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    <name>Field at -1.07 Meters</name>
    <description>The field at -1.07 Meters calculated from
    the measured data in the Wavecorder FFT Summary files
    at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -1.22 Meters</name>
    <description>The field at -1.22 Meters calculated from
    the measured data in the Wavecorder FFT Summary files
    at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field as -1.37 Meters</name>
    <description>The field at -1.37 Meters calculated from
    the measured data in the Wavecorder FFT Summary files
    at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -1.58 Meters</name>
    <description>The field at -1.58 Meters calculated from
    the measured data in the Wavecorder FFT Summary files
    at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -1.68 Meters</name>
    <description>The field at -1.68 Meters calculated from
    the measured data in the Wavecorder FFT Summary files
    at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Field at -1.87 Meters</name>
    <description>The field at -1.87 Meters calculated from
    the measured data in the Wavecorder FFT Summary files
    at the three measured points.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
</entity>
<entity>
  <name>Characterization Method w/o Reference</name>
  <description>If an "Exposure Point Source" has a characterization

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method of "2" then information about that source will be contained in the "Characterization Method w/o Reference" Entity. When the characterization method is "2", the source has been measured at three points using the Wavecorder without a reference signal. Using the FFT summary from the Wavecorder software, the field at three points is calculated. If the source has only been measured at one or two points instead of three, then the data for the non-measured points are set to zero.</description>

<attribute>

<name>Source Wavecorder Filename</name>

<description>The Wavecorder filename that contains information about the source that have been measured.</description>

<simple-domain>8 Characters concatenated with "WCD"</simple-domain>

</attribute>

<attribute>

<name>Record Number 1</name>

<description>Describes the record number which corresponds to a Wavecorder wave number in the Source Wavecorder Filename describing information about a particular wave.</description>

<simple-domain>Positive Integer</simple-domain>

</attribute>

<attribute>

<name>Record Number 2</name>

<description>Describes the record number which corresponds to a Wavecorder wave number in the Source Wavecorder Filename describing information about a particular wave.</description>

<simple-domain>Positive Integer</simple-domain>

</attribute>

<attribute>

<name>Record Number 3</name>

<description>Describes the record number which corresponds to a Wavecorder wave number in the Source Wavecorder Filename describing information about a particular wave.</description>

<simple-domain>Positive Integer</simple-domain>

</attribute>

<attribute>

<name>Distance Number 1</name>

<description>Describes the distance at which Record Number 1 of Source Wavecorder filename was taken from the source.</description>

<simple-domain>Positive Integer (Inches)</simple-domain>

</attribute>

<attribute>

<name>Distance Number 2</name>

<description>Describes the distance at which Record Number 2

of Source Wavecorder filename was taken from the
source.</description>
<simple-domain>Positive Integer (Inches)</simple-domain>.
</attribute>
<attribute>
<name>Distance Number 3</name>
<description>Describes the distance at which Record Number 3
of Source Wavecorder filename was taken from the
source.</description>
<simple-domain>Positive Integer (Inches)</simple-domain>
</attribute>
<attribute>
<name>Distance #1</name>
<description>Distance at which a Wavecorder measurement
has been made.</description>
<simple-domain>Negative real number in (Meters)</simple-domain>
</attribute>
<attribute>
<name>Field at Distance #1</name>
<description>Magnetic Field calculated from the Wavecorder
FFT Summary at distance #1.</description>
<simple-domain>Magnetic Field in (mG)</simple-domain>
</attribute>
<attribute>
<name>Distance #2</name>
<description>Distance at which a Wavecorder measurement
has been made.</description>
<simple-domain>Negative real number in (Meters)</simple-domain>
</attribute>
<attribute>
<name>Field at Distance #2</name>
<description>Magnetic Field calculated from the Wavecorder
FFT Summary at distance #2.</description>
<simple-domain>Magnetic Field in (mG)</simple-domain>
</attribute>
<attribute>
<name>Distance #3</name>
<description>Distance at which a Wavecorder measurement
has been made.</description>
<simple-domain>Negative real number in (Meters)</simple-domain>
</attribute>
<attribute>
<name>Field at Distance #3</name>
<description>Magnetic Field calculated from the Wavecorder
FFT Summary at distance #3.</description>

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    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
</entity>
<entity>
  <name>Snap Measurement</name>
  <description>If an "Exposure Point Source" has a characterization
  method of "3" then information about that source will be
  contained in the "Snap Measurement" Entity. When the
  characterization method is "3" no measurements of the source
  have been made with the Wavecorder. One measurement only
  has been made using the EMDEX Snap.</description>
  <attribute>
    <name>Source Data Set</name>
    <description>Uniqely identifies a source the file containing
    information about sources that have been characterized using
    an EMDEX Snap field at a point.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Field</name>
    <description>Measurement of the magnetic field at a source
    from an EMDEX Snap.</description>
    <simple-domain>Magnetic Field in (mG)</simple-domain>
  </attribute>
  <attribute>
    <name>Distance</name>
    <description>The distance from the source at which the
    magnetic field was measured using the EMDEX Snap.</description>
    <simple-domain>Positive Distance in (Feet)</simple-domain>
  </attribute>
</entity>
<entity>
  <name>Transient Data Set</name>
  <description>Contains information about a set of transient
  measurements that have been taken at a particular
  site.</description>
  <attribute>
    <name>Data Set ID</name>
    <description>Uniquely identifies a set a Transient
    Data.</description>
    <simple-domain>Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Number of Detected Transients</name>
    <description>Describes the number of transient measurements

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    that have been detected.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Number of Recorded Transients</name>
    <description>Describes the number of transient measurements
    that have actually been recorded.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Threshold</name>
    <description>The threshold value at which the transient
    equipment is triggered.</description>
    <simple-domain>Positive Integer in Millivolts</simple-domain>
  </attribute>
  <attribute>
    <name>Conversion Factor V to (mG)</name>
    <description>The conversion factor needed to convert Volts
    to (mG).</description>
    <simple-domain>Real Number</simple-domain>
  </attribute>
</entity>
<entity>
  <name>Transient Record</name>
  <description>Contains information about a specific transient
  that has been recorded.</description>
  <attribute>
    <name>Transient Number</name>
    <description>Uniquely describes a set of transient
    record.</description>
    <simple-domain>Positive Integer</simple-domain>
  </attribute>
  <attribute>
    <name>Time of Occurrence</name>
    <description>Time at which the Transient Record was
    recorded.</description>
    <simple-domain>HH:MM:SS</simple-domain>
  </attribute>
  <attribute>
    <name>Peak to Peak X</name>
    <description>Maximum Peak to Peak voltage of the signal on the
    X Axis.</description>
    <simple-domain>Volts</simple-domain>
  </attribute>
</attribute>

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<name>Peak to Peak Y</name>
<description>Maximum Peak to Peak voltage of the signal on the
Y Axis</description>
<simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Peak to Peak Z</name>
  <description>Maximum Peak to Peak voltage of the signal on the
Z Axis.</description>
  <simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Max FFT (V) Bin1 (10kHz - 100 kHz) X</name>
  <description>Max FFT (V) Bin1 (10kHz - 100 kHz) X</description>
  <simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Max FFT (V) Bin1 (10kHz - 100 kHz) Y</name>
  <description>Max FFT (V) Bin1 (10kHz - 100 kHz) Y</description>
  <simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Max FFT (V) Bin1 (10kHz - 100 kHz) Z</name>
  <description>Max FFT (V) Bin1 (10kHz - 100 kHz) Z</description>
  <simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Principal Frequency (Bin1) X</name>
  <description>Principal Frequency (Bin1) X</description>
  <simple-domain>Hz</simple-domain>
</attribute>
<attribute>
  <name>Principal Frequency (Bin1) Y</name>
  <description>Principal Frequency (Bin1) Y</description>
  <simple-domain>Hz</simple-domain>
</attribute>
<attribute>
  <name>Principal Frequency (Bin1) Z</name>
  <description>Principal Frequency (Bin1) Z</description>
  <simple-domain>Hz</simple-domain>
</attribute>
<attribute>
  <name>Max FFT (V) Bin2 (100kHz - 1 MHz) X</name>
  <description>Max FFT (V) Bin2 (100kHz - 1 MHz) X</description>
  <simple-domain>Volts</simple-domain>

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</attribute>
<attribute>
  <name>Max FFT (V) Bin2 (100kHz - 1 MHz) Y</name>
  <description>Max FFT (V) Bin2 (100kHz - 1 MHz) Y</description>
  <simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Max FFT (V) Bin2 (100kHz - 1 MHz) Z</name>
  <description>Max FFT (V) Bin2 (100kHz - 1 MHz) Z</description>
  <simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Principal Frequency (Bin2) X</name>
  <description>Principal Frequency (Bin2) X</description>
  <simple-domain>Hz</simple-domain>
</attribute>
<attribute>
  <name>Principal Frequency (Bin2) Y</name>
  <description>Principal Frequency (Bin2) Y</description>
  <simple-domain>Hz</simple-domain>
</attribute>
<attribute>
  <name>Principal Frequency (Bin2) Z</name>
  <description>Principal Frequency (Bin2) Z</description>
  <simple-domain>Hz</simple-domain>
</attribute>
<attribute>
  <name>Max FFT (V) Bin3 (1MHz - 10MHz) X</name>
  <description>Max FFT (V) Bin3 (1Mhz - 10MHz) X</description>
  <simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Max FFT (V) Bin3 (1Mhz - 10MHz) Y</name>
  <description>Max FFT (V) Bin3 (1Mhz - 10MHz) Y</description>
  <simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Max FFT (V) Bin3 (1MHz - 10MHz) Z</name>
  <description>Max FFT (V) Bin3 (1MHz - 10MHz) Z</description>
  <simple-domain>Volts</simple-domain>
</attribute>
<attribute>
  <name>Principal Frequency (Bin3) X</name>
  <description>Principal Frequency (Bin3) X</description>
  <simple-domain>Hz</simple-domain>

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</attribute>
<attribute>
  <name>Principal Frequency (Bin3) Y</name>
  <description>Principal Frequency (Bin3) Y</description>
  <simple-domain>Hz</simple-domain>
</attribute>
<attribute>
  <name>Principal Frequency (Bin3) Z</name>
  <description>Principal Frequency (Bin3) Z</description>
  <simple-domain>Hz</simple-domain>
</attribute>
</entity>
<relationship>
  <name>Environments to Site</name>
  <description>Relates environments to sites. Each environment
has many sites.</description>
  <relationship-from>Environment</relationship-from>
  <relationship-to>Sites</relationship-to>
  <Cardinality>1 to Many</cardinality>
</relationship>
<relationship>
  <name>Environment to Area Type</name>
  <description>Relates Environment to Area Type. Each environment
has many area types. For instance, the "school" environment
has "classrooms", "main office", "auditorium", "cafeteria",
etc..</description>
  <relationship-from>Environment</relationship-from>
  <relationship-to>Area Type</relationship-to>
  <Cardinality>1 to Many</cardinality>
</relationship>
<relationship>
  <name>Environment to Person Type</name>
  <description>Relates Environment to Person Type. Each environment
has many person types. For instance, the "school" environment
has "teachers", "students", "custodians", "administrative staff",
and "Volunteer Parents".</description>
  <relationship-from>Environment</relationship-from>
  <relationship-to>Person Type</relationship-to>
  <Cardinality>1 to Many</cardinality>
</relationship>
<relationship>
  <name>Site to Set of ACDC Measurements</name>
  <description>Relates one site to many Sets of ACDC
Measurements.</description>
  <relationship-from>Site</relationship-from>

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    <relationship-to>Set of ACDC Measurements</relationship-to>
    <Cardinality>1 to Many</cardinality>
</relationship>
<relationship>
    <name>Set of ACDC Measurements to ACDC Measurement</name>
    <description>Relates a set of ACDC Measurements to (1 to 5)
    ACDC Measurement(s).</description>
    <relationship-from>Set of ACDC Measurements</relationship-from>
    <relationship-to>ACDC Measurement</relationship-to>
    <Cardinality>1 to (1 to 5)</Cardinality>
</relationship>
<relationship>
    <name>Set of ACDC Measurements to Surveyed Area</name>
    <description>Relates a Set of ACDC Measurements to a
    surveyed area.</description>
    <relationship-from>Set of ACDC Measurements</relationship-from>
    <relationship-to>Surveyed Area</relationship-to>
    <Cardinality>1 to 1</cardinality>
</relationship>
<relationship>
    <name>Surveyed Area to Main Area Source</name>
    <description>Relates on Surveyed Area to one Main Area
    Source</description>
    <relationship-from>Surveyed Area</relationship-from>
    <relationship-to>Main Area Source</relationship-to>
    <Cardinality>1 to 1</cardinality>
</relationship>
<relationship>
    <name>Surveyed Area to Exposure Point Source</name>
    <description>Relates a surveyed area to (0 to many) Exposure
    Point Source(s) in that area.</description>
    <relationship-from>Surveyed Area</relationship-from>
    <relationship-to>Exposure Point Source</relationship-to>
    <Cardinality>1 to (0 to many)</Cardinality>
</relationship>
<relationship>
    <name>Surveyed Area to Group of Person within an Area</name>
    <description>Relates one Surveyed Area to (1 to many) Group
    of Persons within an Area. For instance, in a school
    area there could be a group of teachers, and a group
    of students. Areas with no persons were not surveyed.</description>
    <relationship-from>Surveyed Area</relationship-from>
    <relationship-to>Group of Persons within an Area</relationship-to>
    <Cardinality>1 to (1 to many)</Cardinality>
</relationship>

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<relationship>
  <name>Surveyed area to Spatial Distribution Data Set</name>
  <description>Relates one Surveyed Area to one Spatial
  Distribution Data Set.</description>
  <relationship-from>Surveyed Area</relationship-from>
  <relationship-to>Spatial Distribution Data Set</relationship-to>
  <Cardinality>1 to 1</cardinality>
</relationship>
<relationship>
  <name>Exposure Point Source to Group of Persons near a Source</name>
  <description>Relates one Exposure Point Source to (1 to 2)
  Group of Person(s) near a Source. For instance, near a checkout
  counter there could be several clerks (at different times of the
  day_ and several customers. No more than two groups of persons
  were considered.</description>
  <relationship-from>Exposure Point Source</relationship-from>
  <relationship-to>Group of Persons near a Source</relationship-to>
  <Cardinality>1 to (1 or 2)</Cardinality>
</relationship>
<relationship>
  <name>Surveyed Area to Temporal Distribution Data Set</name>
  <description>Relates one Surveyed Area to (0 or 1) Temporal
  Distribution Sets.</description>
  <relationship-from>Surveyed Area</relationship-from>
  <relationship-to>Temporal Distribution Set</relationship-to>
  <Cardinality>1 to (0 or 1)</Cardinality>
</relationship>
<relationship>
  <name>Exposure Point Source to Three Point Characterization Method
  with Reference.</name>
  <description>Relates one Exposure Point Source to (0 or 1)
  Three Point Characterization Methods with reference.</description>
  <relationship-from>Exposure Point Source</relationship-from>
  <relationship-to>Three Point Characterization Method with
  Reference</relationship-to>
  <Cardinality>1 to (0 or 1)</Cardinality>
</relationship>
<relationship>
  <name>Exposure Point Source to Three Point Characterization Method
  without a Reference.</name>
  <description>Relates one Exposure Point Source to (0 or 1)
  Characterization Methods without Reference.</description>
  <relationship-from>Exposure Point Source</relationship-from>
  <relationship-to>Characterization Method without
  Reference</relationship-to>

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    <Cardinality>1 to (0 or 1)</Cardinality>
</relationship>
<relationship>
  <name>Exposure Point Source to Snap Measurement</name>
  <description>Relates one Exposure Point source to (0 or 1) Snap
  Measurements.</description>
  <relationship-from>Exposure Point Source</relationship-from>
  <relationship-to>Snap Measurement</relationship-to>
  <Cardinality>1 to (0 or 1)</Cardinality>
</relationship>
<relationship>
  <name>Site to Transient Data Set</name>
  <description>Relates one Site to (0 or 1) Transient Data Sets
  Measurements.</description>
  <relationship-from>Site</relationship-from>
  <relationship-to>Transient Data Set</relationship-to>
  <Cardinality>1 to (0 or 1)</Cardinality>
</relationship>
<relationship>
  <name>Transient Data Set to Transient Record</name>
  <description>Relates one Transient Data Set to many
  Transient Records.</description>
  <relationship-from>Transient Data Set</relationship-from>
  <relationship-to>Transient Record</relationship-to>
  <Cardinality>1 to many</Cardinality>
</relationship>
<relationship>
  <name>Site to Surveyed Area</name>
  <description>Relates one Site to many Surveyed Areas</description>
  <relationship-from>Site</relationship-from>
  <relationship-to>Surveyed Area</relationship-to>
  <Cardinality>1 to many</Cardinality>
</relationship>
<relationship>
  <name>Environment to Point Source Type</name>
  <description>Relates all Environments to many Point Source
  Types</description>
  <relationship-from>Environment</relationship-from>
  <relationship-to>Point Source Type</relationship-to>
  <Cardinality>1 to many</Cardinality>
</relationship>
<relationship>
  <name>Environment to Area Source Type</name>
  <description>Relates all Environments to many Area Source
  Types</description>

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    <relationship-from>Environment</relationship-from>
    <relationship-to>Area Source Type</relationship-to>
    <Cardinality>1 to many(</Cardinality>
</relationship>
</data-model>
<data-products>
  <distributor>
    <contact>
      <name>T. Dan Bracken</name>
    </contact>
  </distributor>
  <delimited-ASCII-data-product>
    <name>ACDC FILE</name>
    <description>The file has two lines, each subsequent line
in the file consists of an ACDC Measurement
that has been processed. The data is presented by each Site
that was measured. For each site, the data is presented by area
and then by ACDC Measurements in that area. The naming convention
of the files is ACDC concatenated with (SITE ID).OUT.</description>
    <level-of-interpretation>Calibrated and Derived Data.
    </level-of-interpretation>
    <availability>CD-ROM</availability>
    <record-delimiter>Carriage Return</record-delimiter>
    <field-delimiter>Comma</field-delimiter>
    <missing-value>N/A</missing-value>
    <filesize>Filesize is dependent upon the number of Sets
of ACDC Measurements and also upon the number of ACDC
Measurements within each set. Filesize of an ACDC
files ranged from 3029 - 126493 bytes</filesize>
    <number-of-records>Number of records is dependent the number of
area that have been measured and also upon the number of
ACDC Measurements within each area.</number-of-records>
    <number-of-fields>40</number-of-fields>
    <maximum-record-length>N/A</maximum-record-length>
    <delimited-ASCII-field>
      <name>Record Number</name>
      <field-number>1</field-number>
      <entity-membership>ACDC Measurement</entity-membership>
    </delimited-ASCII-field>
    <delimited-ASCII-field>
      <name>Area Number</name>
      <field-number>2</field-number>
      <entity-membership>Surveyed Area</entity-membership>
    </delimited-ASCII-field>
    <delimited-ASCII-field>

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<name>Floor Number</name>
 <field-number>3</field-number>
 <entity-membership>Surveyed Area</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Wavecorder Filename</name>
 <field-number>4</field-number>
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  <name>Angle between B Max(60) and BDC</name>
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  <name>B Max Magnitude(180)</name>
  <field-number>23</field-number>
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</delimited-ASCII-field>
  <name>Angle between Bmax(180) and BDC</name>
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  <name>B Perp. Max(180)</name>
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  <field-number>26</field-number>
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  <field-number>27</field-number>
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  <name>Polarization(300)</name>
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  <name>Frequency of Largest other Harmonic</name>
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<name>Magnitude of Largest other Harmonic</name>
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 <name>30/60 Ratio</name>
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 <filesize>Filesize is dependent upon the number of areas that have been measured for each particular site. Filesize of MAP files ranged from 941-30348 bytes.</filesize>
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 <name>Median</name>
 <field-number>23</field-number>
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 <description>The Activity File contains 7 lines of header information,
 each subsequent line in the ACT file contains information
 about the people in a surveyed area. An Activity file exists for each
 SITE and a line in the Activity file exists for each surveyed area in
 that site. The naming convention for the Activity file is "ACT"
 concatenated with (SITE ID).CSV. Each line contains 34 fields,
 it is important to note that fields 5-10 apply to person type 1,
 fields 11-16 apply to person type 2, fields 17 -22 apply to
 person type 3, fields 23 - 28 apply to person type 4, and fields
 29-34 apply to person type 5.</description>
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 Data</level-of-interpretation>
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 have been surveyed. Filesize of the activity files ranged
 from 1041 - 24138 bytes.</filesize>
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 exactly the number of surveyed areas in one particular
 site.</number-of-records>
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  <entity-membership>Surveyed Area</entity-membership>
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  <field-number>6</field-number>
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  <field-number>7</field-number>
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  <name>Person Mobility Minimum</name>
  <field-number>9</field-number>
  <entity-membership>Group of Person within an Area</entity-membership>
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  <name>Person Mobility Maximum</name>
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  <field-number>13</field-number>
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  <name>Person Time Maximum</name>
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  <entity-membership>Group of Person within an Area</entity-membership>
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  <name>Person Mobility Minimum</name>
  <field-number>15</field-number>
  <entity-membership>Group of Person within an Area</entity-membership>
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  <name>Person Mobility Maximum</name>
  <field-number>16</field-number>
  <entity-membership>Group of Person within an Area</entity-membership>
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  <name>Person Number Minimum</name>
  <field-number>17</field-number>
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  <name>Person Number Maximum</name>
  <field-number>18</field-number>
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 <field-number>22</field-number>
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 <name>Person Mobility Maximum</name>
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 <delimited-ASCII-data-product>
 <name>EXPOSURE POINT ACTIVITY FILE</name>
 <description>The Exposure Point Activity File contains 7 lines of header information, subsequent lines each line in the exposure point activity file consists of information about exposure to different person types and the time that they were exposed. Naming convention for this file is "EPA" concatenated with (SITE ID).CSV. Each line contains 17 fields. It is important to note that fields 6-9 apply to the person type number specified in field number 5, and the fields 11-14 apply to the person type number specified in field 10.</description>
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 <record-delimiter>Carriage Return</record-delimiter>
 <field-delimiter>Comma</field-delimiter>

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 point sources for a particular site. Filesize of the exposure
 point activity files ranged from 1041 - 24138 bytes.</filesize>
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 of exposure points contained within a particular
 site.</number-of-records>
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 <entity-membership>Exposure Point Source</entity-membership>
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 <name>Activity Zone Maximum</name>
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 <entity-membership>Exposure Point Source</entity-membership>
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 <entity-membership>Group of Persons Near a Source</entity-membership>
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<name>Time of Exposure Minimum</name>
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 <entity-membership>Group of Persons Near a Source</entity-membership>
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 <name>Time of Exposure Maximum</name>
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 <name>Person Type Number</name>
 <field-number>10</field-number>
 <entity-membership>Group of Persons Near a Source</entity-membership>
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 <name>Number Minimum</name>
 <field-number>11</field-number>
 <entity-membership>Group of Persons Near a Source</entity-membership>
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 <name>Number Maximum</name>
 <field-number>12</field-number>
 <entity-membership>Group of Persons Near a Source</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Time of Exposure Minimum</name>
 <field-number>13</field-number>
 <entity-membership>Group of Persons Near a Source</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Time of Exposure Maximum</name>
 <field-number>14</field-number>
 <entity-membership>Group of Persons Near a Source</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Source ID Number</name>
 <field-number>15</field-number>
 <entity-membership>Exposure Point Source</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Characterization Method</name>
 <field-number>16</field-number>
 <entity-membership>Exposure Point Source</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>


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    <name>Source Data Set</name>
    <field-number>17</field-number>
    <entity-membership>Source Data Set</entity-membership>
  </delimited-ASCII-field>
</delimited-ASCII-data-product>
<delimited-ASCII-data-product>
  <name>MAIN AREA SOURCE FILE</name>
  <description>The Main Area Source File contains 6 lines
of header information, each subsequent line in the Main Area
Source File contains data about each surveyed area's main area
source. The data is presented by each surveyed area with each
site. The naming convention for this file is "MAS" concatenated with
"SITE ID".CSV.</description>
  <level-of-interpretation>Derived Data.</level-of-interpretation>
  <availability>CD-ROM</availability>
  <record-delimiter>Carriage Return</record-delimiter>
  <field-delimiter>Comma</field-delimiter>
  <missing-value>N/A</missing-value>
  <filesize>Filesize is dependent upon the number of areas for a
particular site. Filesize of the Main Area Source files
ranged from 126 - 2394 bytes.</filesize>
  <number-of-records>The number of records is equal to the number
of surveyed areas for a particular site.</number-of-records>
  <number-of-fields>2</number-of-fields>
  <maximum-record-length>N/A</maximum-record-length>
  <delimited-ASCII-field>
    <name>Area ID</name>
    <field-number>1</field-number>
    <entity-membership>Surveyed Area</entity-membership>
  </delimited-ASCII-field>
  <delimited-ASCII-field>
    <name>Area Source Type Number</name>
    <field-number>2</field-number>
    <entity-membership>Main Area Source</entity-membership>
  </delimited-ASCII-field>
</delimited-ASCII-data-product>
<delimited-ASCII-data-product>
  <name>TEMPORAL DISTRIBUTION FILE</name>
  <description>The Temporal Distribution File contains 4 lines
of header information, each subsequent line in this file contains
information about data collected at a location in an area with
an EMDEX II for a time period, usually 24 hours. For each site,
the data is presented including one line for each surveyed area
in which a recorder has been placed. The name of this file is
"TEMPORAL.CSV"</description>

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<level-of-interpretation>Calibrated and Derived
 Data.</level-of-interpretation>
 <availability>CD-ROM</availability>
 <record-delimiter>Carriage Return</record-delimiter>
 <field-delimiter>Comma</field-delimiter>
 <missing-value>N/A</missing-value>
 <filesize>File size is dependent upon the number of surveyed
 areas in which a 24 hour recorder has been placed. The filesize
 of the temporal distribution file is approximately 10000
 bytes.</filesize>
 <number-of-records>The temporal distribution data file contains
 63 records.</number-of-records>
 <number-of-fields>23</number-of-fields>
 <maximum-record-length>N/A</maximum-record-length>
 <delimited-ASCII-field>
 <name>EMDEX Temporal Filename</name>
 <field-number>1</field-number>
 <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
 <name>Site ID</name>
 <field-number>2</field-number>
 <entity-membership>Site</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
 <name>Area ID</name>
 <field-number>3</field-number>
 <entity-membership>Surveyed Area</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
 <name>Days</name>
 <field-number>4</field-number>
 <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
 <name>Start Time</name>
 <field-number>5</field-number>
 <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
 <name>Stop Time</name>
 <field-number>6</field-number>
 <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>

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<name>Number of Temporal Observations</name>
<field-number>7</field-number>
<entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Temporal Average</name>
<field-number>8</field-number>
<entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Temporal Std. Deviation</name>
<field-number>9</field-number>
<entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Temporal Geometric Mean</name>
<field-number>10</field-number>
<entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Temporal Geometric Std. Deviation</name>
<field-number>11</field-number>
<entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Temporal Minimum</name>
<field-number>12</field-number>
<entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Temporal One Percent</name>
<field-number>13</field-number>
<entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Temporal Five Percent</name>
<field-number>14</field-number>
<entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Temporal Ten Percent</name>
<field-number>15</field-number>
<entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>

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    <name>Temporal Twenty Five Percent</name>
    <field-number>16</field-number>
    <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
    <name>Temporal Fifty Percent</name>
    <field-number>17</field-number>
    <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
    <name>Temporal Seventy Five Percent</name>
    <field-number>18</field-number>
    <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
    <name>Temporal Ninety Percent</name>
    <field-number>19</field-number>
    <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
    <name>Temporal Ninety Five Percent</name>
    <field-number>20</field-number>
    <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
    <name>Temporal Ninety Nine Percent</name>
    <field-number>21</field-number>
    <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
    <name>Temporal Maximum</name>
    <field-number>22</field-number>
    <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
    <name>Temporal Median</name>
    <field-number>23</field-number>
    <entity-membership>Temporal Distribution Data Set</entity-membership>
</delimited-ASCII-field>
</delimited-ASCII-data-product>
<delimited-ASCII-data-product>
    <name>Source Characterization Method 1 or 4 File</name>
    <description>Each Source Characterization Method 1 or 4
file has 2 lines of header information, each subsequent line
contains information about exposure points that have been

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measured using characterization method 1 or 4 (Three point Wavecorder capture with a reference signal). Each line represents data about one source. Each file contains all information about sources characterized using method 1 for a particular site. The naming convention for these files is (SITE ID)SCM1.CSV.</description>
<level-of-interpretation>Calibrated and Derived Data</level-of-interpretation>
<availability>CD-ROM</availability>
<record-delimiter>Carriage Return</record-delimiter>
<field-delimiter>Comma</field-delimiter>
<missing-value>N/A</missing-value>
<filesize>Filesize is dependent upon the number of exposure points that were characterized as method 1. Filesize of the Source Characterization Method 1 or 4 files ranged from 1707 - 28488 bytes.</filesize>
<number-of-records>The number of records is equal to the number of exposure point sources that have characterized as method 1.</number-of-records>
<number-of-fields>28</number-of-fields>
<maximum-record-length>N/A</maximum-record-length>
<delimited-ASCII-field>
<name>Source Data Set Number</name>
<field-number>1</field-number>
<entity-membership>Exposure Point Source</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Source Description</name>
<field-number>2</field-number>
<entity-membership>Three Point Characterization Method with Reference.</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Field at Zero Meters</name>
<field-number>4</field-number>
<entity-membership>Three Point Characterization Method with Reference</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
<name>Field at -.15 Meters</name>
<field-number>6</field-number>
<entity-membership>Three Point Characterization Method with Reference</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>

<name>Field at -.31 Meters</name>
 <field-number>8</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -.46 Meters</name>
 <field-number>10</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -.61 Meters</name>
 <field-number>12</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -.76 Meters</name>
 <field-number>14</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -.92 Meters</name>
 <field-number>16</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -1.07 Meters</name>
 <field-number>18</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -1.22 Meters</name>
 <field-number>20</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -1.37 Meters</name>
 <field-number>22</field-number>
 <entity-membership>Three Point Characterization Method

with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -1.58 Meters</name>
 <field-number>24</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -1.68 Meters</name>
 <field-number>26</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Field at -1.87 Meters</name>
 <field-number>28</field-number>
 <entity-membership>Three Point Characterization Method
 with Reference</entity-membership>
 </delimited-ASCII-field>
 </delimited-ASCII-data-product>
 <delimited-ASCII-data-product>
 <name>Source Characterization Method 2 File</name>
 <description>Source Characterization Method 2 Files have
 three line of header information, each subsequent line in the
 file contains information about exposure point
 sources that were measured using characterization method 2
 (One to Three Wavecorder points without a reference
 signal). Each line represents data about one source. Each file
 contains all information about all exposure point sources that
 have been measured using characterization method 2 for a particular
 site. The naming convention for this file is
 (SITE ID)SCM2.SCV </description>
 <level-of-interpretation>Calibrated and Derived
 Data.</level-of-interpretation>
 <availability>CD-ROM</availability>
 <record-delimiter>Carriage Return</record-delimiter>
 <field-delimiter>Comma</field-delimiter>
 <missing-value>N/A</missing-value>
 <filesize>Filesize is dependent upon the number of sources that
 have characterized using method number 2. Filesize of the
 Source Characterization Method 2 files ranged from 96 - 227
 bytes.</filesize>
 <number-of-records>The number of records in this file is equal
 to the number of sources of a particular site that have been

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measured using characterization method 2.</number-of-records>
<number-of-fields>7</number-of-fields>
<maximum-record-length>N/A</maximum-record-length>
<delimited-ASCII-field>
  <name>Source Data Set Number</name>
  <field-number>1</field-number>
  <entity-membership>Exposure Point Source</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Distance #1</name>
  <field-number>2</field-number>
  <entity-membership>Characterization Method without
  Reference</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Field at Distance #1</name>
  <field-number>3</field-number>
  <entity-membership>Characterization Method without
  Reference</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Distance #2</name>
  <field-number>4</field-number>
  <entity-membership>Characterization Method without
  Reference</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Field at Distance #2</name>
  <field-number>5</field-number>
  <entity-membership>Characterization Method without
  Reference</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Distance #3</name>
  <field-number>6</field-number>
  <entity-membership>Characterization Method without
  Reference</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Field at Distance #3</name>
  <field-number>7</field-number>
  <entity-membership>Characterization Method without
  Reference</entity-membership>
</delimited-ASCII-field>
</delimited-ASCII-data-product>

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<delimited-ASCII-data-product>
  <name>Source Characterization Method 3 File</name>
  <description>Source Characterization Method 3 Files have 3
lines of header information, each subsequent line in the file
contains information about sources of a particular site that have
been characterized using method #3(Snap Measurement).Each line
represents data about one source. The naming convention for
these files is (SITE ID)SCM3.CSV</description>
  <level-of-interpretation>Calibrated Data.</level-of-interpretation>
  <availability>CD-ROM</availability>
  <record-delimiter>Carriage Return</record-delimiter>
  <field-delimiter>Comma</field-delimiter>
  <missing-value>N/A</missing-value>
  <filesize>The filesize is dependent upon the number of exposure
point sources that have been characterized using method number
3. Filesize of the Source Characterization Method 3 files
ranged from 78 - 859 bytes.</filesize>
  <number-of-records>The number of records is equal to the number
of exposure point sources that have characterized using method
number 3 for a particular site.</number-of-records>
  <number-of-fields>3</number-of-fields>
  <maximum-record-length>N/A</maximum-record-length>
  <delimited-ASCII-field>
    <name>Source Data Set Number</name>
    <field-number>1</field-number>
    <entity-membership>Exposure Point Source</entity-membership>
  </delimited-ASCII-field>
  <delimited-ASCII-field>
    <name>Field at Distance</name>
    <field-number>2</field-number>
    <entity-membership>Snap Measurement</entity-membership>
  </delimited-ASCII-field>
  <delimited-ASCII-field>
    <name>Distance</name>
    <field-number>3</field-number>
    <entity-membership>Snap Measurement</entity-membership>
  </delimited-ASCII-field>
</delimited-ASCII-data-product>
<delimited-ASCII-data-product>
  <name>Transient Data Set Information File</name>
  <description>The file contains information about transient data
that have been taken at a particular site. For each site at
which transients have been recorded, a Transient Data Set
Information File Exists. The file naming convention for the
Transient Data Set Information File is "SORT" concatenated with

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a 4 digit date."CSV".</description>
 <level-of-interpretation>Calibrated and Derived
 Data.</level-of-interpretation>
 <availability>CD-ROM</availability>
 <record-delimiter>Carriage Return</record-delimiter>
 <field-delimiter>Space</field-delimiter>
 <missing-value>N/A</missing-value>
 <filesize>The filesize is dependent upon the number of Transient
 Records that have been recorded at a site. The filesize
 of the Transient Data Set Information Files range from
 30K to 1.5 Mb.</filesize>
 <number-of-records>The number of records is equal to the number
 Transient Records that have been recorded at a particular
 site.</number-of-records>
 <number-of-fields>105</number-of-fields>
 <maximum-record-length>N/A</maximum-record-length>
 <delimited-ASCII-field>
 <name>Time of Occurrence</name>
 <field-number>2</field-number>
 <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Peak to Peak X</name>
 <field-number>4</field-number>
 <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Peak to Peak Y</name>
 <field-number>39</field-number>
 <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Peak to Peak Z</name>
 <field-number>74</field-number>
 <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Principal Frequency (Bin1) X</name>
 <field-number>10</field-number>
 <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
 <delimited-ASCII-field>
 <name>Max FFT (V) Bin1 (10kHz-100kHz) X</name>
 <field-number>12</field-number>
 <entity-membership>Transient Record</entity-membership>

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</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Principal Frequency (Bin1) Y</name>
  <field-number>20</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Max FFT (V) Bin1 (10kHz-100kHz) Y</name>
  <field-number>22</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Principal Frequency (Bin1) Z</name>
  <field-number>26</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Max FFT (V) Bin1 (10kHz-100kHz) Z</name>
  <field-number>28</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Principal Frequency (Bin2) X</name>
  <field-number>45</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Max FFT (V) Bin2 (100kHz-1MHz) X</name>
  <field-number>47</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Principal Frequency (Bin2) Y</name>
  <field-number>55</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Max FFT (V) Bin2 (100kHz-1MHz) Y</name>
  <field-number>57</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Principal Frequency (Bin2) Z</name>
  <field-number>61</field-number>
  <entity-membership>Transient Record</entity-membership>

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</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Max FFT (V) Bin2 (100kHz-1MHz) Z</name>
  <field-number>63</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Principal Frequency (bin3) X</name>
  <field-number>80</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Max FFT (V) bin3 (1MHz-10MHz) X</name>
  <field-number>82</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Principal Frequency (bin3) Y</name>
  <field-number>90</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Max FFT (V) bin3 (1MHz-10MHz) Y</name>
  <field-number>92</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Principal Frequency (bin3) Z</name>
  <field-number>96</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
<delimited-ASCII-field>
  <name>Max FFT (V) bin3 (1MHz-10MHz) Z</name>
  <field-number>98</field-number>
  <entity-membership>Transient Record</entity-membership>
</delimited-ASCII-field>
</delimited-ASCII-data-product>
<delimited-ascii-data-product>
  <name>Person Type File</name>
  <description>The Person Type File contains information so that a
correlation can be made between a Person Type Number and
Person Type Descriptions. To find out a person type description,
an environment type and person type number are needed. The person
type file contains 4 lines of header information. The name of
the Person Type File is "PTF.CSV".</description>

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<level-of-interpretation>Derived</level-of-interpretation>
<availability>CD-ROM</availability>
<record-delimiter>Carriage Return</record-delimiter>
<field-delimiter>Comma</field-delimiter>
<missing-value>N/A</missing-value>
<filesize>784 bytes</filesize>
<number-of-records>22</number-of-records>
<number-of-fields>3</number-of-fields>
<maximum-record-length>N/A</maximum-record-length>
<delimited-ascii-field>
  <name>Environment Type</name>
  <field-number>1</field-number>
  <entity-membership>Environment</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Person Type Number</name>
  <field-number>2</field-number>
  <entity-membership>Person Type</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Person Type Description</name>
  <field-number>3</field-number>
  <entity-membership>Person Type</entity-membership>
</delimited-ascii-field>
</delimited-ascii-data-product>
<delimited-ascii-data-product>
  <name>Point Source Type File</name>
  <description>The Point Source Type File contains information
so that a correlation can be made between Point Source ID numbers
and Point Source Descriptions. The Point Source Type File
contains 4 lines of header information. The name of the Point
Source Type File is "PSF.CSV"</description>
  <level-of-interpretation>Derived</level-of-interpretation>
  <availability>CD-ROM</availability>
  <record-delimiter>Carriage Return</record-delimiter>
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  <maximum-record-length>N/A</maximum-record-length>
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    <field-number>1</field-number>
    <entity-membership>Exposure Point Source</entity-membership>

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</delimited-ascii-field>
<delimited-ascii-field>
  <name>Point Source Description</name>
  <field-number>2</field-number>
  <entity-membership>Point Source Type</entity-membership>
</delimited-ascii-field>
</delimited-ascii-data-product>
<delimited-ascii-data-product>
  <name>Area Source Type File</name>
  <description>The Area Source Type File contains information so
that a correlation can be made between Area Source Type numbers
and Area Source Type Descriptions. This file contains 4 line
of header information. The name of the Area Source Type File
is "ASF.CSV".</description>
  <level-of-interpretation>Derived</level-of-interpretation>
  <availability>CD-ROM</availability>
  <record-delimiter>Carriage Return</record-delimiter>
  <field-delimiter>Comma</field-delimiter>
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  <number-of-records>27</number-of-records>
  <number-of-fields>2</number-of-fields>
  <maximum-record-length>N/A</maximum-record-length>
  <delimited-ascii-field>
    <name>Area Source Type #</name>
    <field-number>1</field-number>
    <entity-membership>Main Area Source</entity-membership>
  </delimited-ascii-field>
  <delimited-ascii-field>
    <name>Area Source Description</name>
    <field-number>2</field-number>
    <entity-membership>Area Source Type</entity-membership>
  </delimited-ascii-field>
</delimited-ascii-data-product>
<delimited-ascii-data-product>
  <name>Area Type File</name>
  <description>The Area Type File contains information so that a
correlation can be made between Area Type Numbers and Area Type
Descriptions. An environment type as well as an area type number
are needed to get a description of that area type. This file
contains 4 lines of header information. The name of the Area
Type File is "ATF.CSV"</description>
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  <availability>CD-ROM</availability>
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  <entity-membership>Environment</entity-membership>
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<delimited-ascii-field>
  <name>Area Type #</name>
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  <entity-membership>Area Type</entity-membership>
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  <name>Area Type Description</name>
  <field-number>3</field-number>
  <entity-membership>Area Type</entity-membership>
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</delimited-ascii-data-product>
<delimited-ascii-data-product>
  <name>Wave File</name>
  <description>The Wave file contains 4 lines of header information
each subsequent line contains information about sources
that have been characterized using characterization methods
1 or 2. It describes the method by which a source has been measured
well as the data set of the source so that it can be located
in the source characterization files The naming convention for the
Wave File is "WAV" concatenated with "(SITE ID).CSV".
in the </description>
  <level-of-interpretation>Calibrated</level-of-interpretation>
  <availability>CD-ROM</availability>
  <record-delimiter>Carriage Return</record-delimiter>
  <field-delimiter>Comma</field-delimiter>
  <missing-value>N/A</missing-value>
  <filesize>Files are approximately 2000 Bytes.</filesize>
  <number-of-records>The number of records in the Wave File is equal
to the number of the sources that have been measured using
Source Characterization Method 1 or Source Characterization
Method 2.</number-of-records>
  <number-of-fields>11</number-of-fields>
  <maximum-record-length>N/A</maximum-record-length>
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<name>Characterization Method</name>
<field-number>1</field-number>
<entity-membership>Exposure Point Source</entity-membership>
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<delimited-ascii-field>
  <name>Source Data Set Number</name>
  <field-number>2</field-number>
  <entity-membership>Exposure Point Source</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Area ID</name>
  <field-number>4</field-number>
  <entity-membership>Surveyed Area</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Source Wavecorder Filename</name>
  <field-number>5</field-number>
  <entity-membership>Three Point Characterization Method with
  Reference or Three Point Characterization Method without
  a Reference.</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Record Number 1</name>
  <field-number>6</field-number>
  <entity-membership>Three Point Characterization Method with
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</delimited-ascii-field>
<delimited-ascii-field>
  <name>Record Number 2</name>
  <field-number>7</field-number>
  <entity-membership>Three Point Characterization Method with
  Reference or Three Point Characterization Method without
  a Reference.</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Record Number 3</name>
  <field-number>8</field-number>
  <entity-membership>Three Point Characterization Method with
  Reference or Three Point Characterization Method without
  a Reference.</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Distance Number 1</name>
  <field-number>9</field-number>

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<entity-membership>Three Point Characterization Method with
Reference or Three Point Characterization Method without
a Reference.</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Distance Number 2</name>
  <field-number>10</field-number>
  <entity-membership>Three Point Characterization Method with
Reference or Three Point Characterization Method without
a Reference.</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Distance Number 3</name>
  <field-number>11</field-number>
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Reference or Three Point Characterization Method without
a Reference.</entity-membership>
</delimited-ascii-field>
</delimited-ascii-data-product>
<delimited-ascii-data-product>
  <name>Site File</name>
  <description>Contains site specific information including the
number of areas that have been surveyed, unperturbed geomagnetic
field, number of floors, and the material that the site has been
constructed of. The Site file has 4 lines of header information.
The name of the Site File is: "SITE.CSV".</description>
  <level-of-interpretation>Derived</level-of-interpretation>
  <availability>CD-ROM</availability>
  <record-delimiter>Carriage Return</record-delimiter>
  <field-delimiter>Comma</field-delimiter>
  <missing-value>N/A</missing-value>
  <filesize>964 Bytes</filesize>
  <number-of-records>20</number-of-records>
  <number-of-fields>6</number-of-fields>
  <maximum-record-length>N/A</maximum-record-length>
</delimited-ascii-field>
  <name>Site ID</name>
  <field-number>1</field-number>
  <entity-membership>Site</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Number of Areas Surveyed</name>
  <field-number>2</field-number>
  <entity-membership>Site</entity-membership>
</delimited-ascii-field>

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<delimited-ascii-field>
  <name>Number of area where ACDC Measurements were made</name>
  <field-number>3</field-number>
  <entity-membership>Site</entity-membership>
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<delimited-ascii-field>
  <name>Unperturbed Geomagnetic Field</name>
  <field-number>4</field-number>
  <entity-membership>Site</entity-membership>
</delimited-ascii-field>
<delimited-ascii-field>
  <name>Number of Floors</name>
  <field-number>5</field-number>
  <entity-membership>Site</entity-membership>
</delimited-ascii-field>
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  <name>Building Material</name>
  <field-number>6</field-number>
  <entity-membership>Site</entity-membership>
</delimited-ascii-field>
</delimited-ascii-data-product>
</data-products>
</metadata>

```

APPENDIX I

REVIEW OF PAST EMF SURVEYS

I-1 LIST OF PAPERS AND DOCUMENTS REVIEWED

Residential

1. Perry, S., et al "Power Frequency Magnetic Field and Illness in Multi-Story Blocks" Public Health 102, pp. 11-18 (Jan. 1988)
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9. Wilson, B.W., et al., "Magnetic-Field Flux Density and Spectral Characteristics of Motor-Driven Personal Appliances" Bioelectromagnetics 15:439-446 (1994)
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21. Warenberg, D., et al, "Identification and characterization of populations living near high-voltage transmission lines: a pilot study". Environmental Health Perspectives 1993 December: 101:626-32.
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Shopping Mall

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2. Matanoski, G.M., et al, "Cancer Incidence in New York Telephone Workers", reference??????

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1. Barroetavena, M., et al, "Electric and magnetic fields at three pulp and paper mills". American Industrial Hygiene Association Journal 1994: 55(4):358-63.

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2. Bowman, J., et al., "Exposure to ELF electromagnetic fields in occupations with elevated leukemia rates," Appl. Ind. Hyg., Vol. 3, pp. 189-194, 1988.
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I-2 REVIEWS

The following are the main points extracted from the reviews of 56 of the papers and documents listed in Section I-1. These reviews were prepared for the purpose of helping the development of the protocol for the environmental surveys performed under RAPID Engineering Project #3. They do not constitute an exhaustive review, which was beyond the scope of the project.

Title:

Measurements of Electric and Magnetic Fields in and around Homes Near a 500 kV Transmission Line

Period:

2 day period - 1982

Environment Types:

Residential

Areas Surveyed:

Inside and outside the home

Purpose of the Survey:

Determine shielding of power line magnetic field caused by house walls(Model Verification)

Instrumentation:

Single axis measurement with Power Frequency Field Meter Model 110 and sensing coil made by Electric Field Measurement Company

Number of sites:

3 houses, 2 near and one remote from a 500 kV line

Selection of Sites:

Volunteer

Protocol:

Measurements of electric field in many points inside and outside the house.

Measurements of magnetic field inside (at unspecified points) and outside (in the parking lot) with the house power "on". Transmission line carried about 1200 A.

Data:

Fields inside and outside were the same. It was concluded that the house walls did not provide any shielding.

Sources:

500 kV transmission line about 300 feet away

Reference:

R.J. Caola, D.W. Deno, V.S.W. Dymek, "Measurement of Electric and Magnetic fields in and around homes near a 500 kV transmission line", IEEE PAS-102 pp. 3338-3347, Oct. 1983

Title:

Analysis of Electric and Magnetic Fields Measured near TVA's 500-kV Transmission Lines

Period:

1981-1982

Environment Type:

Outdoor areas near transmission lines

Areas Surveyed:

Road crossing, agricultural areas (various crops), wooded areas, flat and rolling terrain

Purpose of the Survey:

Build a data base of TVA 500-kV line fields to analyze statistically the fields as a function of line parameters and topographical factors. Compare measurements with calculations

Instrumentation:

Field meter with single axis probe of Electric Field Measurement Company

Number of Sites:

About 2000 locations on TVA's 500-kV grid

Selection of Sites:

All different types of sites in terms of line geometry and terrain

Protocol:

Magnetic field profile from center line to 100 feet from center line at 1m height above ground.

Manual measurements to find maximum field component (Bmax). Line current data were obtained.

Line and terrain perimeters were measured.

Data:

Database consisting of 2000 profiles, transmission line name, site identification, line geometry data, voltage and current, weather data, terrain description. A statistical survey is provided, e.g. the mean field at 100 ft was 37 mG/kA and the max was 365 mG/kA.

Sources:

500 kV Transmission lines

Reference:

M. Sendaula et al., "Analysis of Electric and Magnetic Fields Research near TVA's 500-kV Transmission Lines", IEEE PAS-103, No. 2, pp. 328-336, Feb. 1984

Title:

Analysis of 60-Hz Magnetic Fields Near Ground Level in 187-kV Switchyard of a 187/66-kV AC Substation

Period:

1990

Environment Type:

Transmission substation

Areas Surveyed:

Substation areas inside the fence classified according to the voltage of the nearest buses

Purpose of the Survey:

Validation of analytical model (computer program)

Instrumentation:

(see previous paper by same author)

Number of sites:

One

Selection of Sites:

Most convenient site (availability and flexibility)

Protocol:

Field profile at 1 m above ground in different areas of the substation. Comparison with calculations. Bus currents were measured. Bmax and Bmin were calculated, rather than Bresultant.

Data:

Measurements compared well with calculations. The model was validated. Model assumptions are: bus currents are balanced; earth is non-magnetic; steel structure distortion is negligible; image currents can be reflected; induced currents in counterpoises and ground lines can be ignored. Calculations produce percentages of total area with fields greater than given value. Max. values from 27mG to 313mG.

Sources:

Substation buses and transmission lines entering substation. Important parameters: bus currents, live currents, bus phasing, height and spacing of lines and buses.

Reference:

N. Hayashi, K. Isaka, Y. Yokoi, "Analysis of 60-Hz Magnetic Fields Near Ground Level in 187-kV Switchyard of a 187/66-kV AC Substation", IEEE, PWRD-7 pp. 237-244, Jan. 1992

Title:

Measurements and Computations of Electromagnetic Fields in Electric Power Substations

Period:

One day - 1992

Environment Type:

Transmission Substation (Transmission-Distribution)

Areas Surveyed:

All the areas inside the substation fence

Purpose of the Survey:

Validation of analytical model (computer program)

Instrumentation:

3-axis digital recorder and mapping wheel (Dexsil Model FS1000)

Number of Sites:

One

Selection of Sites:

Most convenient

Protocol:

Measurements made in a short period of time so that currents do not change much. Magnetic field profiles about 10 feet apart covering the entire substation. Contour lines and 3-D plots.

Measurements at 1m above ground. Current measurements in transmission lines (with power donuts) and buses. Unbalanced currents in neutrals and ground wires measured with an ammeter.

Data:

Sets of measured and calculated profiles. Resultant from 10 to 150 mG. Comparison with calculations show that currents in the neutral and ground conductors are important (distribution substation). Circulating currents in some structures cause local distortions.

Sources:

Transmission and Distribution lines. Neutral and ground currents. Bus currents. Currents induced in structures.

Reference:

W.K. Daily, F. Dawalibi, "Measurements and Computations of Electromagnetic Fields in Electric Power Substations" PWRD-9 pp. 324-333 Jan 1994

Title:

A Protocol for Spot Measurement of Residential Power Frequency Magnetic Fields

Period:

Reports data from other surveys

Environment Types:

Residential

Areas Surveyed:

Different rooms

Purpose of the Survey:

Develop protocol for residential measurement

Instrumentation:

Single axis meters, 24-hour recorders (reports data from other surveys)

Number of Sites:

Reports data from other surveys

Selection of Sites:

Volunteers

Protocol:

Protocol for spot measurements. A sample data sheet is recommended. All lights and appliances as found. Height of 1m above floor. Bmax or Bresultant. At least 3 rooms, near the center of the room. Average over a 5 second interval. Peripheral measurements every 10 feet at 3-6 feet from walls. Repeat indoor measurements. Spot measurement at locations of interest to residents.

Data:

Reports data from other surveys. Correlation between center of room and corners is 0.79 for living room, 0.64 for kitchens.

Sources:

No Discussion

Reference:

IEEE Task Force. "A Protocol for Spot Measurement of Residential Power Frequency Magnetic Fields", PWRD-8, pp. 1386-1393, July 1993

Title:

Characterization of Power Frequency Magnetic Fields in Different Environments

Period:

1991

Environment Type:

Residential - Offices - Light industrial settings - Agricultural environments - Generating stations - Substations - Pad mounted transformers

Areas Surveyed:

Living room, kitchen, bedroom, front and back entrances - one point in each office - 3 points in industrial and agricultural settings - substations: high voltage areas, transformer bay, low voltage area

Purpose of the survey:

Determine statistical correlation between fields and residence parameters. Determine range of field values

Instrumentation:

Holladay HI-3600-02, Emdex C 3-axis recorder with mapping wheel, instrumentation to monitor and record service drop currents

Number of Sites:

18 residences, 3 offices, 4 light-industrial settings, 4 agricultural environments, 2 generating stations, 3 substations

Selection of Sites:

Volunteers

Protocol:

For residences: spot measurements in 3 rooms and front and back entrances, 24-hour measurements in 3 rooms, spot measurements with power off, 24-hour measurements of the 3 currents in the service drop and in the ground connection. For offices: 24 hour measurements. For industrial and agricultural: 24 hour measurements at 3 points. Profiles in generating stations and substations.

Data:

Database for 18 residences. Average of 3 rooms is taken. Exceedance levels are calculated for each residence and for all 18. L95=0.2 mG, L50=1.25 mG, L5=6.25 mG Median of medians=1.07 mG, median of L5=1.91 mG (Corresponding values in EPRI Survey are 0.5 mG [L50] and 1.1 mG [highest room]). Data show that spot measurements are well correlated to 24-hour averages. Office field averages: 0.35-1.97. Light Industrial: 0.7-2.5. Agricultural: 0.25-2.14. Generating stations: 2-1000 mG. Substations: exceedance levels in the high voltage, transformer bay, and low voltage areas. Range of values 1.1-180 mG

Sources:

Net and ground currents in residences, wiring in offices, generators in generating stations, lines and buses and shunt reactors in substations.

Reference:

P. S. Maruvada, "Characterization of Power Frequency Magnetic Fields in Different Environments" IEEE PWRD-8 pp. 598-606, April 1993

Title:

Magnetic Fields from Electric Power Lines - Theory and Comparison to measurements

Period:

Not specified

Environment Types:

Areas near overhead transmission and distribution lines

Areas Surveyed:

Outdoor areas within about 300 feet of center line

Purpose of the Survey:

Development of analytical model

Instrumentation:

Not specified - B resultant

Number of Sites:

One transmission, one distribution line

Selection of Sites:

Convenience

Protocol:

Lateral profile

Data:

Statistical variation of currents and imbalances are presented. It is recommended that fields be described statistically. It shows the importance of net currents and ground currents.

Source:

Phase currents, ground currents

Reference:

IEEE Task Force, "Magnetic Fields from Electric Power Lines - Theory and Comparison to measurements", IEEE PWRD-3 pp. 2127-2135, Oct. 1988

Title:

Magnetic Fields Near Overhead Distribution Lines - Measurements and Estimating Techniques

Period:

July 1987 and March 1989

Environment Type:

Outdoor areas near power distribution lines

Areas Surveyed:

Outdoor areas up to 150 feet from center line

Purpose of the Survey:

Assessment of distribution line field environment. Development of a database.

Instrumentation:

Single axis meter (Monitor Industries)

Number of Sites:

51 line locations

Selection of Sites:

For the purpose of obtaining a large range of line currents

Protocol:

Profiles with manual measurement every 5 feet at 1 m above ground. Measured maximum field component Bmax. Simultaneous measurements of line and neutral current amplitude (not phase angle)

Data:

Database of measured values versus distance for different types of lines: primary (1 or 2 phases), 3-phase primary, secondary, primary and secondary. Max fields: L5=16 mG, L50=3.6 mG, L95=0.6 mG. Scatterplots give range of fields at different distances. Maximum fields are reasonably well predicted assuming balanced currents.

Sources:

Balance currents

Reference:

T. Vinh, T.L. Jones, C.H. Shih, "Magnetic Fields Near Overhead Distribution Lines - Measurements and Estimating Technique", IEEE PWRD-6, pp. 912-919, April 1991

Title:

Magnetic Fields Remote from Substations

Period:

June 1984 and July 1988

Environment Type:

Outdoor areas outside a transmission-to-distribution substation

Area Surveyed:

Outside the fence, up to 700 feet from the substation and same profile 2 miles down the line.

Purpose of the Survey:

Assess magnetic field produced by a substation

Instrumentation:

Two single axis meters (Monitor Industries)

Number of Sites:

One

Selection of Sites:

Convenience

Protocol:

Profiles up to 700 feet

Data:

Fields decays from 1 mG to 0.2 mG going from 300 to 700 feet. Some results were obtained at the substation and 2 miles away from it. It was concluded that the line field is not affected when a distribution substation is cut into the line.

Sources:

Transmission line

Reference:

W.E. Feero, J. Youtz, J.H. Dunlap, "Magnetic Fields Remote from Substations", IEEE PWRD-4, pp. 1862-1868, July 1989.

Title:

Analysis of Magnetic Field Profiles in Electric Blanket Users

Period:

1988

Environment Type:

Bed (with electric blanket)

Area Surveyed:

Space near electric blanket

Purpose of Survey:

Verification of analytical model. Exposure assessment

Instrumentation:

Small probe (4 mm long, 5 mm diameter)

Number of Sites:

One blanket

Selection of Sites:

Convenience

Protocol:

Manual measurements on each of 3 orthogonal axes at 10 cm from the blanket.

Data:

0-40 mG at 10 cm from the blanket. Good comparison between calculations and measurements.

Sources:

Electric Blanket

Reference:

N. Hayashi, K. Isaka, Y. Yokoi, "Analysis of Magnetic Field Profiles in Electric Blanket Users", IEEE PWRD-4, pp. 1897-1903, July 1989

Title:

Power Frequency Magnetic Fields in the Home

Period:

1986

Environment Type:

Residential, church, office, school, trailer

Area Surveyed:

Living rooms, dining rooms, bedrooms, kitchens, bathrooms

Purpose of Survey:

Exposure assessment

Instrumentation:

Single axis meter, Electric Field Measurements Co. Model 113.

Number of Sites:

77 houses, 6 apartments, 1 motel, 1 church, 2 offices, 1 school, 3 trailers

Selection of Sites:

Volunteer

Protocol:

Extensive series of spot measurements (2-4 hours per site). One measurement for each axis at each location. At three body reference locations (head, chest, belt). Measurements under normal use conditions. Center of room and other locations usually occupied by residents. Near appliances. House characteristics (distance to power line, age, locale, ground type, geographic location)

Data:

Well organized database that can be used to find correlation among variables. Overall mean 0.6 mG with a standard deviation of 1.1 mG. Log-normal distributions were found.

Sources:

Sources were not directly investigated. Fields near a large variety of appliances were measured. Grounding to water pipes was found an important parameter.

Reference:

M. Silva, N. Hummon, D. Rutter, C. Hooper, "Power Frequency Magnetic Fields in the Home", IEEE PWRD-4, pp. 465-478, Jan. 1988.

Title:

New Jersey Schools - EMF Survey

Period:

1993

Environment Types:

Schools grade K-12 near (<100 ft) four transmission lines (69kV or higher)

Areas Surveyed:

Outdoor areas near transmission line.

Purpose of the Survey:

Verify transmission lines calculation model.

Instrumentation:

EMDEX II, Dexsil 310

Number of Sites:

About 35 schools (4 utilities)

Selection:

A sample from all schools distant less than 100 feet from transmission lines 69kV or above.

Protocol:

Spot measurements of Bresultant in outdoor areas, simultaneous measurements of line current.

Determination of line geometry and calculation of fields using ENVIRO.

Data:

At least 16 schools had measured transmission line field at the school building greater than 2 mG, 13 schools greater than 5 mG, 7 schools greater than 10 mG. Measured field in outdoor areas was >2 mG for 34 schools, >5 mG for 37 schools, >10 mG for 22 schools. Calculations and measurements do not always agree for fields inside the schools indicating the presence of other sources.

Sources:

Transmission Lines

Reference:

State of New Jersey, Board of Public Utilities, Two Gateway Center, Newark, NJ 07102 "New Jersey Schools - EMF Survey", BESE:86-94.

Title:

ELF Magnetic Field in Electro-Steel and Welding Industries

Period:

1983

Environmental Type:

Metal fabrication and welding shops

Area Surveyed:

At the position of the operator near welding machines

Purpose of the Survey:

Establish range of field levels

Instrumentation:

F.W. Bell mod 6102 gaussmeter

Number of Sites:

16 different welding machines and 22 different industrial steel processes

Selection of Sites:

As many different machines as convenient

Protocol:

3 axis measured separately and then the resultant is calculated, at the operator position.

Data:

Fields from 1 to 100 gauss. Mostly caused by the proximity of the working area to the welding cables. Induction heaters have the highest values 10~600 gauss, at frequency 50Hz-10,000 Hz.

Sources:

Welding cables, induction heaters

Reference:

P. Lovsund et al., "ELF Magnetic Field in Electrical, Steel and Welding Industries", Dept. of Biomedical Eng. and Ophthalmology, Linkoping Univ., Sweden, 1983 .

Title:

Cancer Incidence Among Welders: Possible Effects of Exposure to ELF and Welding Fumes

Period:

This is not a survey

Environmental Type:

This is not a survey

Area Surveyed:

This is not a survey

Purpose of the Survey:

This is not a survey

Instrumentation:

This is not a survey

Number of Sites:

This is not a survey

Selection of Sites:

This not a survey

Protocol:

This is not a survey

Data:

The paper mentions that welding transformers and current carrying cables produce 1 to 100 gauss at distances from 0.2 to 1 m, which are 2 to 200 times the levels for other electrical occupation.

Sources:

Welding transformers, welding cables

References:

R.M. Stern, "Cancer Incidence Among Welders: Possible Effects of Exposure to Extremely Low Frequency Electromagnetic Radiation and to Welding Fumes", Environmental Health Perspectives, Vol. 76, pp. 221-228, 1987.

Title:

A Survey of Electric and Magnetic Fields Among VDT Operators in Offices

Period:

1989

Environment Types:

Offices

Area Surveyed:

Several office areas and proximity to VDTs.

Purpose of the Survey:

Determine general level of EMF in offices and establish a technical basis for a case/control study of skin symptoms among VDT workers.

Instrumentation:

Background field in room with single axis 50 Hz magnetic field meter. Electric field with probe grounded. DC E field with a field mill. Holladay HI-3600 instrument with both an ELF HI-3602 and a VLF HI-3601 probe to measure AC fields (E and B).

Number of Sites:

150 VDT workplaces

Selection of Sites:

Following questionnaire among about 500 office workers, 75 cases of skin symptoms (erythema, itching, burning sensation) and 75 matched controls were chosen.

Protocol:

Background: 5 measurements in each room, one in the center and the other 4 on the diagonals halfway to the corners of the room. DC Electric field at 10 cm from the screen 20 min after turning on the VDT. The Holladay probe was positioned 50 cm in front of the screen and oriented along each axis at a time. B was calculated as the square root of the sum of the squares of the 3 rms components. Same for E. Two hours per VDT workplace.

Data:

Table with geometric means, first quartile, median, third quartile, and maximum. Median B for 150 offices was 0.7 mG, upper quartile 1.5 mG, max 10 mG. 5% level was 5 mG. VDT fields (at 50 cm from the screen): median 2.1 mG, upper quartile 3.0 mG, max 12 mG. In the VLF range median value was 0.26 mG.

Sources:

Video Display Terminals

Reference:

Monica Sandstrom, Kjell Hansson Mild, Berndt Stenberg and Stig Wall, "A Survey of Electric and Magnetic Fields Among VDT Operators in Offices", IEEE Transactions on Electromagnetic Compatibility, Vol. 35, No. 3, August 1993.

Title:

Magnetic Fields of Video Display Terminals and Spontaneous Abortion

Period:

1991

Environment Types:

Offices

Area Surveyed:

Proximity to VDTs

Purpose of Survey:

Exposure assessment for epidemiological study on spontaneous abortion

Instrumentation:

Single axis magnetic field meter

Number of Sites:

Not specified

Selection of Sites:

Measurements of some units of different VDT models in the laboratory

Protocol:

Measurements of B in the ELF range 50 cm from the screen and 25 cm down (site appropriate for the fetus). Repeated measurements 12 times for each unit.

Data:

VDT's were divided in three groups of about the same size: one group with $B < 4$ mG, one group with $4 \text{ mG} < B < 9$ mG, and one group with $B > 9$ mG.

Sources:

Video Display Terminals

Reference:

M.L. Lindbohn et al. "Magnetic Fields of Video Display Terminals and Spontaneous Abortion" American Journal of Epidemiology, Vol. 136, No. 9, Nov. 1992

Title:

EMF Exposure Assessment for Office Employees: A Pilot Study

Period:

1993

Environment Type:

Office

Area Surveyed:

Personal dosimetry of office workers

Purpose of Study:

Pilot study for residential exposure assessment study

Instrumentation:

Positron for 50/60 Hz electric field and 3 axis magnetic field

Number of Sites:

Eleven people

Selection of sites:

Volunteer

Protocol:

24 hour personal exposure measurements, data collected once a minute. Period divided between working, sleeping and leisure.

Data:

24 hour arithmetic means ranged from 0.65 to 5.8 mG with an average of 1.8 mG. No significant difference between people working with a computer and those who did not. Magnetic fields during sleeping and leisure periods were significantly lower. Higher fields were explained by the presence of electrical wires under the floor.

Sources:

Electrical wires under the floor

Reference:

D. Gauvin, P. Levellois, S. Gingras, "EMF Exposure Assessment for Office Employees: A Pilot Study", Poster P-28 presented at the DOE and others Contractor Review Meeting, Savannah, GA, Nov. 1993

Title:

Sources of 60 Hz Magnetic Fields in Office

Period:

1993

Environment Type:

Office

Areas Surveyed:

Office areas

Purpose:

Identification of sources

Instrumentation:

Not described

Number of Sites:

A few office buildings (not specified)

Selection of Sites:

Volunteer

Protocol:

Spot measurements for source identification

Data:

Not reported

Sources:

The most significant sources of magnetic fields in offices are: 1) Neutral grounding to building grounding system at breaker panels throughout the building, 2) Distribution lines adjacent to the building, 3) Raceways from transformers to the electrical distribution rooms with wires arranged so that neutrals and hot phases are not close to each other, 4) Switches and relays in the electrical distribution room, 5) Portable heaters, 6) Fluorescent lights, 7) Fans, 8) Back of computers.

Transformers are not a significant source.

Reference:

D.N. March, "Sources of 60 Hz Magnetic Fields in Office", Poster P-40, DOE and others Contractor Review Meeting, Savannah, GA, Nov. 1993

Title:

Pilot Study of Nonresidential Power Frequency Magnetic Fields

Period:

February 1989 to April 1990

Environmental Types:

Offices, Generating Plants, Substations, Schools, Large Open Areas (cafeteria/kitchens, machine shops, test/repair/service centers, stockrooms/storerooms, garages)

Area Surveyed:

All space of each environment.

Purpose:

Pilot study to determine range of magnetic field levels and identify significant field sources

Instrumentation:

Three-axis magnetic field recorder for 60 Hz and third harmonic.

Number of Sites:

4 office buildings, 4 generating plants, 6 substations, 4 schools, 16 large open areas.

Selection of Sites:

Volunteered by 5 US Electric Utilities.

Protocol:

Large areas were divided into smaller areas. Each area was surveyed with a magnetic field recorder on a surveyor wheel to relate field values with recorder position. Identification of sources by

correlation of peak in the field profiles with location of the peak along the traveled path. 24 hour recordings near significant sources. Three-D maps of magnetic field to facilitate source location.

Data:

	Average	St. Dev.	Min	Median	L10	L5	Max
For office buildings:	3.8	16.5	0	1.1	5.9	12.2	580
Generating plants:	36.4	70	0	7.6	100	159	670
Substations:	41.9	72	0	16.8	100	170	750
Schools:	1.1	2.1	0	0.5	2.4	4.0	71
Large open spaces:	2.0	8.0	0	0.6	3.0	5.7	286

Third harmonic could be a significant fraction of the fundamental.

Sources:

Office buildings:	Net currents in electrical wiring, currents in cable channels, office appliances and equipment, fluorescent lights.
Generating plants:	Exciters of generators, bus from generators, motors, electrical panels, currents in the structural steel.
Substations:	Buses, lines, ground leads from structural steel, air core reactors.
Schools:	Computers, clocks, aquariums, heaters, vending machines, electrical panels, net currents on conduits.
Large Open Spaces:	Electrical panels, net currents on conduits, appliances, equipment

Reference:

EPRI, "Pilot Study of Nonresidential Power Frequency Magnetic Fields", EL-7452, August 1991

Title:

Magnetic Field Survey, Magnetic Field Source Assessment and Magnetic Field Reduction Recommendations for Hewlett-Woodmere School District"

Period:

April-May 1994

Environment Type:

School

Area Surveyed:

All rooms occupied by students and staff

Purpose:

Determine levels, identify sources, recommend field reduction options.

Instrumentation:

Three-axis magnetic field recorder (40 Hz - 800 Hz) with surveyor wheel for generating field profiles, contour lines and 3-D maps.

Number of Sites:

381 rooms in 6 different school buildings

Selection of Sites:

All rooms of all school buildings of the school district.

Protocol:

Measurements at 1 m height uniformly over each room to generate representative statistics, contour lines and 3-D maps. Peripheral profiles, lateral profiles of power lines. 24-hour recordings at selected locations. Source location immediately following the survey of each area. Source identification using spot measurements.

Data:

Average field in all schools 1.3 mG. The average field was found greater than 1 mG in 38% of the rooms, greater than 2 mG in 15% of the rooms, greater than 5 mG in 4 % of the rooms.

Source:

Most significant sources of magnetic fields were the following: A transmission line adjacent to one of the school buildings, two distribution lines each adjacent to a school building; net current in electrical conduits; transformer, switch gear and main distribution panel; electrical panels; fluorescent lights; personal computers; copiers; air conditioners; aquariums; analog clocks; record players; electric pencil sharpeners; an electric kiln. The predominant source was by far the net current in electrical conduits caused by: connection of ground wires to the neutral bar at an electrical sub-panel, connection of the neutral bar to the sub-panel, loss of insulation of neutral wire inside a conduit or junction box, use of neutral from a conduit and phone wire from another conduit to feed the same load, connection between different neutrals, incorrect wiring of three-way switches, ground currents in water pipe due to grounding of the building service to the water system

Reference:

L.E. Zaffanella, "Magnetic Field Survey, Magnetic Field Source Assessment and Magnetic Field Reduction" Library of Hewlett-Woodmere School District, Hewlett, N.Y., May 1994

Title:

Magnetic Fields in Schools, Sources and Mitigation

Period:

Collection of data from 1985 to 1995

Environment Type:

Schools

Areas Surveyed:

Rooms occupied by students or staff

Purpose:

Review of available information on EMF in schools. Discussion of options to reduce exposure.

Instrumentation:

Generally 3-axis magnetic field recorders

Number of Sites:

30 different schools

Selection of Sites:

Schools that have asked for EMF surveys

Protocol:

More or less systematic data covering the areas of all the rooms or of a sample of rooms in each school. Measurement of 1 m height. Also spot measurements for source identification, 24-hour measurements, peripheral profiles, lateral profiles of adjacent power lines.

Data:

Average field for the 30 schools 1.28 mG, the lowest school average was 0.44 mG, the highest 3.03 mG. Schools near transmission lines (6 out of 30) had average fields from 0.56 mG to 1.68 mG with an average of 1.36 mG, which is not significantly different from the average for the schools without transmission lines.

Sources:

Most significant sources: net currents in electrical conduits; fluorescent lights; computer monitors; transformer, switchgear and main distribution panel; power transmission lines; air conditioners;

other electrical equipment (typewriters, tape recorders, aquarium pumps, overhead projectors, shop machinery, copiers); power distribution lines. The major source is the net current in electrical conduits. Identified field reduction options included: no-cost or low-cost techniques (selective utilization of space, purchase of low-field monitors, optimum arrangement of computer classrooms, placing fluorescent lights at same distance from the ceiling, using fluorescent lights with electronic ballasts, include EMF information request when reporting equipment quotations); correction of wiring problems; modifications to transmission lines; and others. Example of cost figures were given.

Reference:

L.E. Zaffanella, "Magnetic Fields in Schools, Sources and Mitigation", Paper given at Seminar on EMF of the New York State Insurance Reciprocal, March 2, 1995. Paper available at Eneritech, P.O. Box 770, Lee, MA 01238.

Title:

Magnetic Fields in Schools: Sources and Management

Period:

Collection of data from 1985 to 1993

Environment Type:

Schools

Areas Surveyed:

Classrooms, outdoor area

Purpose:

Establish field levels, identify field source, assess contribution of transmission line fields.

Instrumentation:

Generally 3-axis magnetic field recorders

Number of Sites:

19 schools

Selection of Sites:

Schools requesting EMF survey

Protocol:

Spot measurements at different points covering different areas: lateral profiles of transmission lines; 24-hour recordings.

Data:

Average field for 11 schools: 1.07 mG. Lowest school average 0.44 mG, highest school average 2.09 mG. A summary of magnetic field for selected school equipment is given (0.5 - 3 feet the source). Examples: Filmstrip projector - 109 mG at 1', 14 mG at 2', 4.8 mG at 4'; Water fountain - 23 mG at 0.5'; graphic arts light table - 18-30 mG at 0.5'; pencil sharpener - 40 mG at 1'; vending machine - 23 mG at 0.5'.

Sources:

Transmission lines, net currents, three-way switches, transformers, school equipment.

Reference:

J. Michael Silva, T.D. Marshall, "Magnetic Fields in Schools: Sources and Management", TLD Conference of IEEE/PES, Chicago, April 1994

Title:

Power Frequency Magnetic Fields: Measurements and Exposure Assessment

Period:

1989

Environment Type:

Residential, Electric Facilities

Area Surveyed:

House, work

Purpose:

Exposure Assessment

Instrumentation:

Digital magnetic field meters (Positron) for personal exposure and long term measurements at different locations

Number of Sites:

Pilot study with few sites (60 volunteers at six sites)

Selection:

Volunteers

Protocol:

Combination of personal exposure, spot measurements, long term measurements at a point

Data:

Residences - Field range 0.1-1.2mG (urban), 0.05-0.8 mG (suburban), 0.1-1.1 mG (rural). At work the field ranges from 0.6 mG to 90 mG.

Sources:

Sources of residential fields are underground distribution cables and overhead distribution lines.

Reference:

D.C. Renew, T. C. Male, B.L. Maddock, "Power Frequency Magnetic Fields: Measurements and Exposure Assessment", Paper 36-105 CIGRE 1990.

Title:

Extremely-Low-Frequency and Very Low-Frequency-Magnetic Fields Emitted by Video Display Units

Period:

1989

Equipment Type:

Office

Area Surveyed:

Proximity of VDTs

Purpose:

Characterization of field source

Instrumentation:

EMCO model 7604 coil antenna with Hewlett-Packard model 3561A spectrum analyzer

Number of Sites:

4 different VDTs

Selection:

Most commonly used models

Protocol:

Measurements of frequency spectrum on lines perpendicular to VDT's sides at 10, 20, 30, 40, and 50 cm. Points were chosen to give maximum readings using the coil in an area equal to the side, antenna was oriented for maximum reading.

Data:

At 30 cm from screen the field ranges from 0.6 to 6 mG in the ELF range and from 0.2 to 0.6 mG in the VLF range. Total harmonic distortion is about 50%, with harmonics decreasing by a factor of about 2 going from each harmonic to the next.

Sources:

Video Display Terminals

Reference:

S. Tofani, G. D'Amore, "Extremely-Low-Frequency and Very Low-Frequency-Magnetic Fields Emitted by Video Display Units", Bioelectromagnetics, Vol. 12, pp. 35-45, 1991

Title:

Exposure to Extremely Low Frequency (ELF) Electromagnetic Fields in Occupations with Elevated Leukemia Rates

Period:

1988

Environment Types:

Work sites of electrical workers, residential, offices

Area surveyed:

Area occupied by workers

Purpose:

Assess exposure of electrical workers

Instrumentation:

Single axis magnetic field meter

Number of Sites:

114 electrical workers at their work place, in 22 work environments

Selection:

Volunteers

Protocol:

Spot measurements with sensor placed near the workers. Three orthogonal components were measured and the resultant calculated. "Measurements as close to the worker as possible and in the direction of the most likely field source".

Data:

Geometric measure of electrical workers: 5.0 mG; in residences: 0.6 mG.

Sources:

Electrical facilities, soldering gun, sputtering chamber, welding gun, rectifiers, xenon arc lamps, fork lifts, scissor lifts, oscilloscopes, He-Ne lasers, TV's, VDT, dispatcher radios.

Reference:

J. Bowman et al., "Exposure to Extremely Low Frequency (ELF) Electromagnetic Fields in Occupations with Elevated Leukemia Rates", Appl. Ind. Hyg., Vol. 3, pp. 189-194, 1988.

Title:

Power Frequency Magnetic Field and Illness in Multi-Story Blocks

Environment Types:

Residential, multi-story blocks (9 or more stories)

Areas Surveyed:

Indoor areas of multi-story buildings

Purpose:

Exposure assessment for epidemiological study

Instrumentation:

Not described

Number of Sites:

49 multi-story blocks

Selection:

Not described

Protocol:

Spot measurements of magnetic field in blocks with rising cable to establish existence of field decay from the cable.

Data:

The rising cable was found to be a significant source of magnetic field. Flats near the cables had average fields of 3.8 mG; flats far from the cables had average fields of 1.0 mG.

Sources:

Rising cables of multi-story buildings

Reference:

S. Perry, L. Pearl "Power Frequency Magnetic Field and Illness in Multi-story Blocks", Public Health, Vol. 102, pp. 11-18, 1988.

Title:

Assessment of Children's Long-Term Exposure to Magnetic Fields (The Enertech Study)

Period:

1991

Environmental Type:

Residential, School

Area Surveyed:

Personal exposure, locations most frequently occupied by children in the house, periphery of schools.

Purpose:

Exposure assessment study

Instrumentation:

Personal dosimeters, 3-axis magnetic field recorders with mapping wheel

Number of Sites:

35 homes, about 20 schools

Selection:

Among a pool of 75 volunteers for which preliminary measurements were made. The 35 homes were selected to give a large spread of data.

Protocol:

Elaborate protocol with spot measurements, 24-hour measurements, field profiles, net current measurements in order to separate contributions of different sources.

Data:

School fields (average of peripheral profile) from 0.1 to 5 mG. Overall average: 1.4 mG (range: 0.1-5 mG). Residences: kitchen (1.1 mG), Living Room (1.4 mG), Family Room (0.7 mG), Bedroom (0.9 mG), Bathroom (1.2 mG), Yard (0.7 mG) at time of occupancy.

Sources:

Distribution lines, grounding systems

Reference:

W. T. Kaune, L. E. Zaffanella, "Assessment of Children's Long-Term Exposure to Magnetic Fields (The Enertech Study)", EPRI Report TR-101407, Nov. 1992.

Title:

Characterization of ELF Magnetic Fields in Carleton Board of Education Schools

Period:

June 1993

Environmental type:

School

Area Surveyed:

Classrooms

Purpose:

Obtain representative child exposure data in the school environment

Instrumentation:

3-axis 60 Hz magnetic field meter and mapping wheel

Number of Sites:

79 schools

Selection:

All schools of the Carleton Board of Education

Protocol:

Measurements with mapping wheel at 1m height along an S shaped path at 4 foot interval. Average number of measuring points for school: 545. Measurements in a sample of rooms, lights were turned on in the room, simulation of common use conditions (schools were not in session).

Data:

Database with field values and school characteristics: age, number of stories, school type, room type, student density, energy consumption. Overall average 0.82 mG, geometric mean 0.33 mG. A weak trend was found with school age, enrollment, student density, secondary schools greater than others. A moderate trend with energy consumption (>750,000 Kwhr/month), and for more than one story buildings.

Sources:

Most significant sources were: wireways in or under floors, electric typewriters. Proximity to high voltage lines was not significant. Alteration of exterior AC field by building structures was found. Field was found largest in typing rooms (2.7 mG), hallways (1.1 mG), kindergartens (0.8 mG),

computer rooms (0.6 mG), home economics (0.8 mG). A total of 350 "hot spots" with fields greater than 2 mG were found, including electrical panels, boiler rooms, power feed cables, wire conduits in/under floors of hallways, overhead projectors, shop machines, typewriters, VDT's.

Reference:

W. Sun, P. Heroux, T. Clifford, F. Hamade, V. Sadilek "Characterization of ELF Magnetic Fields in Carleton Board of Education Schools", presented at DOE and others Contractor Review Meeting, Albuquerque, NM, November 1994.

Title:

Measurements of 50 Hz Magnetic Fields from Infant Incubators and Heating Beds

Period:

1994

Environment Type:

Hospital

Area Surveyed:

Infant incubators and heating beds

Purpose:

Exposure assessment and field management

Instrumentation:

3-axis magnetic field meter (MFM10, Conbinova AB)

Number of Sites:

Four incubators and two heating beds

Selection of Sites:

Different types depending on availability

Protocol:

Spot measurements at different heights of the bed and different heating conditions

Data:

For 3 incubators strongest fields were 10-20 mG in a small region. For the 4th incubator the field was >10 mG for the whole bed. Heating conditions influenced the field of 2 of the incubators. Harmonic content relatively high. Heating beds created a 10 mG DC field. Fields could be reduced by changing the construction details.

Sources:

Incubators

Reference:

G. Auger, "Measurements of 50 Hz Magnetic Fields from Infant Incubators and Heating Beds", Abstract presented at the DOE's and others' Contractor review meeting. Albuquerque, NM, November 1994

Title:

Electromagnetic Survey of Children's Video Arcade

Period:

1994

Environment Type:

Shopping Malls

Area Surveyed:

Video Arcade

Purpose:

Exposure assessment

Instrumentation:

Single axis magnetic field meter (Walker Scientific ELF Monitor ELF-60D)

Number of Sites:

One site, several video games and pinball machines

Selection of Sites:

Convenience

Protocol:

Spot measurements at head, hand, chest, lower extremities of a child

Data:

Field was greater during game cycle than during idle cycle. Head (2.6 to 9.9 mG), chest (2.0 to 6.9 mG), hands (2.0 to 16.1 mG). At VDT screen: 16-51 mG.

Sources:

Pinball machines, video games

Reference:

J.D. Paz et al. "Electromagnetic Survey of Children's Video Arcade", Poster P.58 presented at the DOE's and others' contractor review meeting, Albuquerque, NM, Nov. 1994.

Title:

An Exposure Assessment of a Telephone Central Office Facility

Period:

1992

Environment Type:

Office

Area Surveyed:

All areas of the building

Purpose:

Field measurements in response to perceived health problems (exposure assessment)

Instrumentation:

3-axis digital magnetic field recorders (EMDEX II), 3-axis magnetic field meters for ELF and VLF (Holladay), personal exposure meters (AMEX). Special transient capturing equipment.

Number of Sites:

One office building

Selection:

Site specifically requested for measurements

Protocol:

Measurements at chest height while walking in the building. Exposure meters placed at fixed locations. Transient equipment near equipment racks.

Data:

ELF magnetic field from 0.1 to 2100 mG and for VLF from 0.1 to 30 mG. Most of the measurements between 2 and 5 mG. Transients were captured close to switching equipment.

Sources:

Not specified

Reference:

R. Malkin, C.E. Moss "An Exposure Assessment of a Telephone Central Office Facility", Poster P-76 presented at the DOE's and others' contractor review meeting, Albuquerque, NM, Nov. 1994.

Title:

Study of Population Exposure to Magnetic Fields due to Secondary Utilization of Transmission Line Corridors

Period:

1994

Environment Type:

Electric Utility Facilities: Transmission Line Corridors used for different activities (bicycle paths, sports arenas, community gardens, mini-golf courses and parking lots)

Areas Surveyed:

Sites within transmission line corridors used for secondary activities

Purpose of the Survey:

Validation of an exposure assessment model

Instrumentation:

Personal dosimeters (Positron)

Number of Sites:

2 backyards, 6 community gardens, 3 mini-golf courses, 2 recreation parks, 2 bicycle paths

Selection of Sites:

Based on availability and convenience

Protocol:

Personal dosimetry on volunteers for 2-4 days with a diary noting time, place and nature of activities. The period of activity in the right of way was separated from the rest ("ambient")

Data:

Time weighted average field in: mini-golfs (14 mG), bicycle paths (7.1 mG), community gardens (6.0 mG), recreation parks (4.6 mG) and backyards (4.6 mG). Calculated values were higher than measured because of a tendency to over-estimate the time of activity.

Sources:

Transmission lines (735 kV and 315 kV)

Reference:

P. Sarma Maruvada et al., "Study of Population Exposure to Magnetic Fields due to Secondary Utilization of Transmission Line Corridors", IEEE 94 SM 485-3 PWRD, San Francisco, CA., July 1994

Title:

Magnetic and Electric Field Testing of the Amtrak Northeast Corridor, and New Jersey Transit/North Jersey Coastline Rail System

Period:

April 1992

Environment type:

Transportation

Areas Surveyed:

Coach and engineer's compartments of trains, along wayside of tracks, passenger stations, power substations, rail traffic control facilities.

Purpose of the Survey:

Assessment of EMF environment of existing transportation technology. Comparison with emerging technologies (advanced high speed guided ground transportation). Identification of magnetic field sources.

Instrumentation:

Portable waveform capture system recorder. Ruis personal exposure monitors. Wheel for magnetic field profiles. Digital audio tape recorder.

The portable waveform capture system recorder includes:

- Fluxgate magnetometers (0-5 G; 5 Hz to 3 kHz) as input sensors.
- Simultaneous monitoring of 10 3-axis sensors, with 4 sensors incorporated into a measuring staff.
- Battery-powered system box which houses amplifiers, analog-to-digital conversion circuitry, bus interface to computer.
- 386-based notebook computer

The advantages of the portable capture system recorder are: portability, AD and DC measurements at the same location, measurement staff for simultaneous measurements at four different locations (e.g. four heights above floor).

Number of sites:

Four

Selection of sites:

Availability

Protocol:

Measurements were made with the portable waveform capture system and a vertical staff containing 4 sensors (3-axis) of different heights (10, 60, 110, 160 cm) above the floor plus a sensor at another (reference) location. Several (10-100) waveform data samples (0.2-1 seconds) with a (5-60) second sample interval were taken at different locations and at different times. Ruis magnetic field (40-800 Hz) recorders were used to monitor personal exposure. Long term recordings of magnetic field waveshape and one 3-axis pulse were made using the digital audio tape recorder. Length of these recordings was from 1 to 98 minutes. These recordings were reviewed for transient magnetic field conditions.

Data:

The report and its appendix report a large volume of data measurement in the coach.

Magnetic field rms values recorded in a passenger seat were:

- For a 25 Hz section: 7-630 mG; 134 mG average
- For a 60 Hz section: 4.2-305 mG; 52 mG average
- For another 60 Hz section: 2.9-60 mG; 19 mG average
- For a non-electrified section: 1.0-13 mG; 6.4 mG average

Most of the fields were caused by the current in the catenary and track circuit (25 Hz or 60 Hz). Power harmonic fields (65-300 Hz) were about 10% of the total rms value in the 5 Hz-2560 Hz range. Fields in the 305-2560 Hz range were about 2% of the total rms value in the 5 Hz-2560 Hz range. DC magnetic fields varied from 170 to 1200 mG. No magnetic field transients were observed.

Magnetic field rms values recorded on the platform of passenger stations:

- For 25 Hz section: 6-530 mG; 39 mG average

- For a 60 Hz section: 1-350 mG; 60 mG average
- For another 60 Hz section: 1.5-200 mG; 29 mG average
- For a non-electrified section: 0.3-0.6 mG; 0.4 mG average

Sources:

- Electric locomotive
- Catenary and track circuit
- Substations

The electric locomotives operate on both a 25 Hz and a 60 Hz section; its major electrical components are: roof-mounted pantograph, circuit breaker, braking resisters, main power transformer, thyristor rectifier cabinet, filter and contactor cabinet, 4 truck-mounted motors beneath the locomotive and auxiliary devices. Magnetic field levels produced by traction power equipment varied in proportion to traction power need. The principal source of magnetic fields in the rear coaches is the current (25 Hz or 60 Hz) in the catenary/track circuit. The hotel power cable beneath the coach floor is a source of 60 Hz field. Harmonic currents in the catenary and track circuit cause harmonic field in the 65-300 Hz band. Despite the presence of DC motors, the DC field present in the coach is predominantly caused by the geomagnetic field distorted by the presence of iron and steel components of the coach.

Reference:

F.M. Dietrich et al., "Magnetic and Electric Field Testing of the Amtrak Northeast Corridor, and New Jersey Transit/North Jersey Coastline Rail System", DOT/FRA/ORD-93/01.I, April 1993.

Title:

The EMDEX Project: Technology Transfer and Occupational Measurements

Period:

1988-1990

Environment Type:

Occupational Measurements of Electric Utility Workers

Areas Surveyed:

Electric Utility Facilities and Residences (generation facilities, transmission lines, distribution lines, substations, shops, offices and homes).

Purpose of the Survey:

Collect, analyze and document utility worker's personal exposure to electric and magnetic fields both on the job and at home for a geographically diverse population. Create a database.

Instrumentation:

EMDEX 100 3-axis recorder with an electric field sock and the DATACALC software package.

Number of Sites:

59 Utility Measurement Sites, 1,991 Employees (50,178 hours of magnetic field data and 23,171 hours of electric field data, 71% work environment and 29% residential environment, 4,411 workdays and 1,512 non-work periods of magnetic field data, 2,082 workdays and 657 non-work periods for electric field data.

Selection of Sites:

Volunteers selected to have a large spread of work sites.

Protocol:

Employees wore the EMDEX 100 unit (with sock) in a pouch on the volunteer's hip during the workday and at home. The EMDEX sampled electric and magnetic fields every 10 seconds. Event markers and diaries were used to record the environment type and duration of time spent within that

environment. Data records were placed within a database and analyzed generally by primary work environment and time duration.

Data:

10-Second Magnetic Field Measurements by Environment - Mean Values and Sample Size:

Environment:

Generation	8.35 mG	n = 2,365,435
Transmission	15.70 mG	n = 524,275
Distribution	47.38 mG	n = 1,238,612
Substation	34.43 mG	n = 1,753,215
Office	2.07 mG	n = 2,690,502
Shop	2.87 mG	n = 1,367,358
Travel	3.09 mG	n = 2,056,525
Other	3.46 mG	n = 879,383
Home	1.47 mG	n = 3,320,924
Travel (non-work)	1.56 mG	n = 1,165,844
Other (non-work)	1.36 mG	n = 701,983

Sources:

Source identification was not a consideration in this study; obviously typical electrical facilities and equipment were significant sources.

Reference:

T. Dan Bracken, "The EMDEX Project: Technology Transfer and Occupational Measurements", EPRI EN-7048, Vols. 1,2 &3, Proj 2966-1, Interim Report, Nov. 1990.

Title:

Ambient 60-Hz Magnetic Flux Density in an urban Neighborhood

Period:

July 1987 - (7 days), and March 1988 (3 evenings)

Environment Type:

Residential

Area Surveyed:

Sidewalks at corners of 33 intersections in an urban neighborhood, sidewalks in front of 50 dwellings, doorsteps of 45 dwellings, indoor for 4 homes.

Purpose:

Establish reliability of spot measurements and wire codes as predictors of field at urban residences.

Instrumentation:

Single axis rms magnetic field meter (Model 113 Power Frequency Field Meter - Electric Field Measurement Company)

Number of sites:

33 intersections, 50 dwellings

Selection of sites:

All intersections of the neighborhood were surveyed. The 50 dwellings were chosen randomly.

Protocol:

Measurements at 33 intersections were made during 7 non-consecutive evenings between 6 and 9 p.m. At a well defined point, one spot measurement of rms value of 3 orthogonal components, 1.3m

above ground. Field resultant was calculated. Measurements at sidewalk and doorsteps of residences were made on 3 evenings, 3 months later.

Data:

Mean field at all intersections was 5.3 mG (St. Dev.=3.6 mG). Min = 0.6, Max. = 16.2. Day to day variation much less than variation between sites. Field at doorsteps (mean = 1.0) less than 1/2 the level at sidewalks (mean = 2.7). Thus, substantial exposure may occur outside the home on street corners.

Sources:

23 kV transmission line, 3-phase primary distr. lines (4.1 kV), service drops

References:

L.J. Dlugosz, T. Byers, J. Vena, Zielezky, "Ambient 60-Hz Magnetic Flux Density in an urban Neighborhood", Bioelectromagnetics 10:187-196 (1989)

Title:

Use of Wiring Configuration and Wiring Codes for Estimating Externally Generated Electric and of Magnetic Fields

Period:

1987

Environment Type:

Residential

Areas Surveyed:

Different rooms inside residences

Purpose:

Assess validity of wire code as predictor of magnetic fields

Instrumentation:

Magnetic field meter (single axis) mounted on electrical stand

Number of Sites:

434 residences

Selection of Sites:

Case and control residences of an epidemiological study

Protocol:

Spot measurements in the center of 3-6 rooms. Three orthogonal components were used to calculate the magnitude of the resultant field. The average of all rooms was taken as house average. Vertical component of electric field was also measured. Measurements were made for "low" and "high" power-use conditions.

Data:

There was a slight trend of the field to increase in the order of wire code: buried, very low, low, high, very high current configuration. Mean values and standard deviations (in parenthesis) for the different wire codes for low power-use conditions were: 0.49 mG (0.53), 0.53 mG (0.53), 0.71 mG (0.68), 1.22 mG (0.84), 2.12 mG (1.19). The relationship between fields and wire codes is well beyond chance but the correlation is far from perfect".

Sources:

Appliances, wiring, ground loops, distribution lines

Reference:

F. Barnes, H. Wachtel, D. Savitz, T. Fuller, "Use of Wiring Configuration and Wiring Codes for Estimating Externally Generated Electric and of Magnetic Fields", Bioelectromagnetics 10:13-21 (1989)

Title:

ELF Electromagnetic Environment in Power Substations

Period:

1988

Environment type:

Electric Utility Facility

Area surveyed:

Transmission substation

Purpose:

Verification of field calculation method

Instrumentation:

One axis coil, runs digital voltmeter, FFT wave analyzer

Number of Sites:

One (187-66 kV substation)

Selection of Sites:

Availability and convenience

Protocol:

Measurements along profiles. All 3 orthogonal field components were measured. Line and bus currents were measured. Field measurement at 1 m above ground.

Data:

Max. field 70 mG, field varies greatly with position. Calculated and measured field show good agreement, except close to a step-down transformer. A significant fifth harmonic (1.8-5.6%) was observed.

Sources:

Substation buses, transmission lines

Reference:

N. Hayashi, K. Isaka, Y. Yokoi, "ELF Electromagnetic Environment in Power Substations" Bioelectromagnetics 10:51-64 (1989)

Title:

Hypothesis: The Risk of Childhood Leukemia is Related to Combinations of Power Frequency and Static Magnetic Fields

Environment Type:

Residential

Area Surveyed:

Bedrooms of cases and controls of an epidemiological study

Purpose:

Verify title hypothesis

Instrumentation:

DC field with a single axis fluxgate magnet meter (Bartington MAG-01). AC runs field with a 3-axes digital recorder.

Number of Sites:

223 bedrooms (124 cases and 99 controls)

Selection of Sites:

Cases selected from a tumor registry, controls selected using random digit dialing

Protocol:

24-hour time weighted runs field averages. Static magnetic field in the center of the bedroom along 3 orthogonal axes at 3 feet above the floor. Static field resultant was calculated.

Data:

Static magnetic field $436 \text{ mG} \pm 23 \text{ mG}$ inside bedrooms, whereas the geomagnetic reference field in the same area ranged from 491 to 496 mG. Stucco houses attenuated the field by 9 mG. Building characteristics influenced the static field.

Sources:

Source of static field was the geomagnetic field perturbed by ferromagnetic materials in the buildings.

Reference:

J.D. Bowman, D.C. Thomas, S.J. London, J.M. Peters, "Hypothesis: The Risk of Childhood Leukemia is Related to Combinations of Power Frequency and Static Magnetic Fields", Bioelectromagnetics 16:48-59 (1995)

Title:

Magnetic Field Effects in the Victoria Transmission System. Design and Measurements

Period:

1987-1988

Environment Type:

Electric Utility Facilities, Residential, Substations

Area Surveyed:

220 kV, 330 kV, and 500 kV Transmission lines, underground cables (220 kV), under street lines, front door, bedroom, kitchen and living room of residences, areas near different substation equipment.

Purpose:

Assessment of magnetic field levels existing near electric utility facilities.

Instrumentation:

Non specified. Field value given in the rms resultant.

Number of Sites:

47 homes

Selection of Sites:

Homes of employees of the organizations sponsoring the survey.

Protocol:

Residential measurements: under street lines, at front door, in bedroom, in kitchen with "low" and "high load conditions. Measurements in the center of the room.

Data:

Under street lines 0.4-14.7 mG with an average of 4.0 mG. Bedrooms 0.1-16.1 mG, average low load = 1.0 mG, high load = 2.5 mG. Maximum fields for electric utility workers, ground level

occupations: 2350 mG (transformer enclosures), 1020 mG (GIS enclosed bus), 1005 (Phase isolated bus of generating station), 880 mG (large motors), 584 mG (switchgear cables).

Sources:

Home wiring, appliances, ground current in metallic water pipes.

Reference:

A.T. Wilson, P.J. Wallace, D.C. Smith, "Magnetic Field Effects in the Victoria Transmission System. Design and Measurements", CIGRE Paper 36-103, 1990, 112 boulevard Haussman 75008 Paris.

Title:

"Measurements of Power-Frequency Electric and Magnetic Fields Around Different Industrial and Household Sources"

Environment Type:

Electric utility facility, industrial, office

Areas Surveyed:

Outdoor transmission substations, distribution substations, power plants, transmission tower (line-line working conditions), near welding and other machines

Purpose:

Assessment of field levels in electric utility facilities, industrial, office, and residential environments.

Instrumentation:

Single axis meter for 50 Hz fields and harmonics. Mobile unit with 3-axes recording system for 50 Hz and third harmonic.

Number of Sites:

One to three sites for each electric utility facility.

Selection of Sites:

Availability and convenience

Protocol:

Spot measurements or profiles at 1 m above ground

Data:

Max. level recorded in substations was 100 mG. In hydro power plants max. fields were measured in the machine room near the generator (3150 mG), and in the corridors near the busbars (2140 mG). Near welding machines, fields were 50-41000 mG, near grinding machines, 23-173 mG. Electric typewriter produced the highest fields in offices (32 mG).

Sources:

Substation buses, generators of power plants, buses of power plants, welding machines, grinding machines, electric typewriters.

Reference:

D. Armanini, R. Conti, A. Mantini, P. Nicolini, "Measurements of Power-Frequency Electric and Magnetic Fields Around Different Industrial and Household Sources", CIGRE Paper 36-107, 1990 112 boulevard Haussmann 75008 Paris

Title:

Magnetic-Field Flux Density and Spectral Characteristics of Motor-Driven Personal Appliances

Period:

1992

Environment:

Residential

Area Surveyed:

Personal Appliances

Purpose:

Exposure assessment

Instrumentation:

Detection coil with resonance at about 9 MHz, 20 turns on a square 0.45 x 0.45 inches. Another coil with resonance at 290 MHz, 22 turns on a 1/4 inch diameter rod. Sample rates of acquisition 200 kHz (for 40 ms) and 400 MHz (for 100 μ s)

Number of Sites:

5 blowdryers, 4 massagers, 8 shavers

Selection:

Different models of 3 appliances

Protocol:

Coil adjusted near appliance to provide maximum dB/dt. Waveform was digitized and analyzed.

Data:

Blowdryers - Peak dB/dt 290-600 T/S, B = 210-310 mG

Massagers - Peak dB/dt 2.2-86 T/S, B = 1-4.7G

Shavers - Peak dB/dt 2-4.7G, B = 20-5000 mG

Several units exhibited high frequency components in the low MHz range.

Sources:

Blowdryers, Massagers, Shavers

Reference:

B.W. Wilson, N.H. Hansen, K.C. Davis, "Magnetic-Field Flux Density and Spectral Characteristics of Motor-Driven Personal Appliances", Bioelectromagnetics Vol. 15, pp. 439-446 (1994)

Title:

Association between Exposure to Pulsed Electromagnetic Fields and Cancer in Electric Utility Workers in Quebec, Canada, and France

Period:

1991-1992

Environment:

Electrical Facilities

Area Surveyed:

Personal exposure measurements during tasks performed by different electric utility occupations.

Purpose:

Epidemiological Study

Instrumentation:

Positron personal exposure monitor. This is a 3-axis magnetic field recorder. It records also electric field and high frequency transients.

Number of Sites:

Utility workers at Electricite de France, Ontario Hydro, Hydro-Quebec. Exposure measurements were made on 2066 workers performing different tasks.

Selection:

Volunteers stratified on the basis of tasks for which exposure students were needed.

Protocol:

The Positron recorders function when a threshold field is detected. A rapid counter is triggered. The quantity recorded is the proportion of time (in parts per billion) during which the electric field in the 5-20 MHz band is greater than 200V. Exposed workers were defined when the proportion of time was greater than 100 ppb.

Data:

In Hydro Quebec, 21% of the workers had more than 100 ppb, in EdF, only 2%. Ontario Hydro data were not analyzed. Highest exposures were for transmission linemen, transmission cable splicers, distribution cable splicers, distribution linemen, and substation mobile operators.

Sources:

Not discussed

Reference:

B. Armstrong, G. Theriault, P. Guenel, J. Deadman, M. Goldberg, P. Heroux, "Association between Exposure to Pulsed Electromagnetic Fields and Cancer in Electric Utility Workers in Quebec, Canada, and France", American Journal of Epidemiology, Vol. 140, No. 9, pp. 805-820, 1994.

Title:

Cancer Risks Associated with Occupational Exposure to Magnetic Fields among Electric Utility Workers in Ontario and Quebec, Canada, and France: 1970-1989

Period:

1991-1992

Environment:

Electrical Facilities

Area Surveyed:

Personal exposure measurements during tasks performed by different electric utility occupations.

Purpose:

Epidemiological Study

Instrumentation:

Positron personal exposure monitor. This is a 3-axis magnetic field recorder. It records also electric field and high frequency transients.

Number of Sites:

Utility workers at Electricite de France, Ontario Hydro, Hydro-Quebec. Exposure measurements were made on 2066 workers performing different tasks.

Selection:

Volunteers stratified on the basis of tasks for which exposure students were needed.

Protocol:

The meter was worn on the worker's belt or in a shirt pocket for a 5-day work week. The worker kept an activity diary. The time weighted average during the working hours was calculated.

Data:

Mean exposure (TWA) highest for: hydroelectric operators (54 mG), Hydroelectric workers in general (6-21 mG), Transmission cable splicers (11-18 mG), substation maintenance workers (4-24 mG), distribution cable splicers (2-19 mG).

Sources:

Not discussed

Reference:

G. Theriault, M. Goldberg, A.B. Biller, B. Armstrong, P. Guenel, J. Deadman, E. Imbernon, T. To, A. Chevalier, D. Cyr, C. and Wall, "Cancer Risks Associated with Occupational Exposure to Magnetic Fields among Electric Utility Workers in Ontario and Quebec, Canada, and France: 1970-1989", American Journal of Epidemiology, Vol. 139, No. 6, 1994.

Title:

Adult Leukemia Risk and Personal Appliance Use: A Preliminary Study

Period:

1981-1984

Environment:

Residential

Area Surveyed:

Proximity to personal electrical appliances

Purpose:

Test hypothesis that use of personal electrical appliances is associated with increased risk of leukemia in adults

Instrumentation:

Calibrated single-axis and three-axis field meter (60 Hz). Single axis sensor connected to fast digital scope for waveshape analysis

Number of Sites:

144 cases and 133 controls

Selection:

Cases from population-based cancer registry. Controls by random digit dialing.

Protocols:

No systematic measurements were made. Protocol is described elsewhere. Five or more representative models of each of three types of personal appliances were characterized: electric razor, massage unit, hair dryer.

Data:

Massage units: peak fields = 3500 mG (± 1500)

Electric razors: peak fields = 1900 mG (± 1700)

Hair dryers: peak fields = 300 mG (± 40)

dB/dt in excess of 10,000 G/S. High spectral content up to 100,000 Hz.

Sources:

Electric razors, massage units, hair dryers

Reference:

R.H. Lovely, R.L. Buschbom, A.L. Slavich, L.E. Anderson, N.H. Hansen, and B.W. Wilson, "Adult Leukemia Risk and Personal Appliance Use: A Preliminary Study", American Journal of Epidemiology, Vol. 140, No. 6, 1994.

Title:

Measurements of static magnetic fields in homes in the UK and their implication for epidemiological studies of exposure to alternating magnetic fields

Period:

June and October 1992

Environment:

Residential

Area Surveyed:

Main living room and bedroom

Purpose:

Study variations of DC field inside residences and among residences

Instrumentation:

DC Fields: Single-axis fluxgate magnetometer.

AC field with three-axis field meter built by power company

Number of Sites:

55 homes in southeast England

Selection:

Volunteers working at power company , stratified by job type

Protocol:

1m above ground. Measurements of three orthogonal components of AC and DC fields. At seven designated points: a point outside the house away from the structure, center of main living room, 4 points about 1m from each of the four corners of main living room, next to the bed. A set of six measurements at each point, each measurement was the average reading, by eye, over a few seconds.

Data:

Variations of DC field within a home was greater than variations among homes. Standard deviation was 5.5% of the geomagnetic field for room corners, 2.5% for room center, 3.6% near beds, and 3.2% outside the homes. The DC fields inside residences were higher near beds (1.3% higher than geomagnetic field). Direction was within 10 degrees of direction of geomagnetic field. Median AC fields were less than 0.4 mG.

Sources:

Not discussed

Reference:

J. Swanson, "Measurements of static magnetic fields in homes in the UK and their implication for epidemiological studies of exposure to alternating magnetic fields", J. Radiol. Prot. Vol. 14, No. 1, pp. 67-75, 1994 (Printed in the UK)

Title:

Magnetic Fields and Cancer in Children Residing Near Swedish High-voltage Power Lines

Period:

1991-1992

Environment:

Residential - Electrical Facilities

Area Surveyed:

Rooms at different distances from transmission lines in each room

Purpose:

Epidemiological study

Instrumentation:

Three-dimensional magnetic flux meter specifically designed for the study

Number of Sites:

142 cases and 558 controls

Selection:

All children under 16 who lived within 300 meters of 220 or 440 kV lines in Sweden during 1960-1985. There were 142 cases. A total of 558 controls were selected at random from the study base.

Protocol:

Meter at 1m above ground. Three orthogonal components were measured and the resultant was calculated. Sampling time: 10 seconds. Four periods of 5-minute measurements in each house in and central (2 periods) from the line. Measurements with "low" and "high" power in the house. Average fields were obtained for each house.

Data:

Spot measurements were correlated ($r = 0.70$) with calculation of fields using line leads and geometrics. Field varied from zero to about 30 mG. 808 houses had fields lower than 1 mG, 227 between 1 and 2 mG, and 265 greater than 2 mG.

Sources:

High voltage transmission lines

References:

M. Feychting, A. Ahlbom, "Magnetic Fields and Cancer in Children Residing Near Swedish High-voltage Power Lines", American Journal of Epidemiology, Vol. 138, No. 7, pp. 467-481, 1993.

Title:

Magnetic Fields and Cancer in Children Residing Near Swedish High-voltage Power Lines

Period:

1991-1992

Environment:

Residential - Electrical Facilities

Area Surveyed:

Rooms at different distances from transmission lines in each room

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Sources:

High voltage transmission lines

References:

M. Feychting, A. Ahlbom, "Magnetic Fields and Cancer in Children Residing Near Swedish High-voltage Power Lines", Kerolinska Institute, IEM, Report 6/92, Stockholm, 1992.

This information also reported in American Journal of Epidemiology, 1993.

Title:

Magnetic Field Exposure Assessment for Adult Residents of Maine Who Live Near and Far Away From Overhead Transmission Lines

Period:

1989

Environment:

Residential - Electrical Facilities

Area Surveyed:

Bedroom, other rooms, outside the residence

Purpose:

Determine effect of living near transmission lines or magnetic field exposure

Instrumentation:

EMDEX II for 24-hour increments and personal exposure measurements. EMF Model 113 meter and Monitor Industries Model 42 meter (both single axis meters) for spot measurements.

Number of Sites:

45

Selection:

Recruitment from people living within specified distances from the center of transmission lines (115 kV and 345 kV).

Protocol:

a) 24-hour personal exposure monitoring with indication of the periods "at home" and "away from home", b) 24-hour fixed bedroom measurement, c) indoor spot measurements in living room, kitchen, bedroom, d) at four corners of house and lateral profiles of transmission lines.

Data:

Personal exposure data for the time at home were: TWA = 3.2 mG (houses near 345 kV lines), 2.4 mG (345 and 115 kV), 1.1 mG (115 kV), and 1.59 (away from lines).

Sources:

High voltage transmission lines

Reference:

R. Kavet, J.M. Silva, D. Thornton, "Magnetic Field Exposure Assessment for Adult Residents of Maine Who Live Near and Far Away From Overhead Transmission Lines", Bioelectromagnetics 13:35-55, 1992

Title:

Occupational exposure to electromagnetic fields in relation to leukemia and brain tumors. A case-control study.

Period:

1983-1987 (This is the period when leukemia and brain tumor cases in men occurred). The study was performed from 1988 to 1992.

Environment:

Occupational: workplace of cases and controls

Area Surveyed:

Areas occupied during a typical workday

Purpose:

Epidemiological study

Instrumentation:

EMDEX carried by people around the waist.

Number of Sites:

850 cases, 1700 controls

Selection:

All cases for whom acceptance to participate was obtained, random controls matched on age.

Protocol:

The task held longest during the 10 years prior to diagnosis. Workplace was visited. EMDEX was carried during a representative workday for at least 6 consecutive hours by the person or a surrogate. Sampling rate set to one a second.

Data:

High exposure jobs were defined as those with average TWA greater than 2.8 mG, low exposure for less than 1.9 mG. The distribution of all records from 1015 measurements at workplaces in Sweden (25 million data points) goes from 0 to 10 mG with a mode of 0.5 mG.

Sources:

Not discussed

Reference:

B. Floderus, T. Persson, C. Stenlund, G. Linder, C. Johansson, J. Kiviranta, H. Parsman, M. Lindblom, A. Wennberg, A. Ost, B. Knave, "Occupational exposure to electromagnetic fields in relation to leukemia and brain tumors. A case-control study.", National Institute of Occupational Health, Solna, Sweden, 1992

Title:

Exposure to Residential Electric and Magnetic Fields and Risk of Childhood Leukemia

Period:

1989-1990

Environment:

Residential

Area Surveyed:

Living room, bedrooms, near water pipes

Purpose:

Epidemiological Study

Instrumentation:

Spot measurements doing the three axes using Electric Field Measurement Model 113 meter. DC measurements using flux-gate magnetometer (Bartington). 24-hour measurements with EMDEX.

Number of Sites:

There were 232 cases and 232 controls in total. Measurements were performed for 24 hours in the houses of 164 cases and 144 controls, spot measurements in 140 cases and 109 controls.

Selection of Sites:

All cases of childhood leukemia diagnosed between 1980 and 1987 that could be contacted and were willing to participate. Random selection of controls, with an attempt to match on sex, ethnicity and age.

Protocol:

24-hour measurements at the place where the child's bed had been. Spot measurements in living room, parent's bedroom, child's bedroom, room closet to distribution line, in the low-power and high-power conditions. Outdoor measurements at location of child's play, and over water pipe. Field was expressed as rms resultant.

Data:

24-hour averages were 0.48, 0.47, 0.65, 0.72 and 1.15 mG for underground, VLCC, OLCC, OHCC, and VHCC respectively.

Sources:

Power lines and house wiring

Reference:

S.J. London, D.C. Thomas, J.D. Bowman, E. Sobel, TC Cheng and J.M. Peters, "Exposure to Residential Electric and Magnetic Fields and Risk of Childhood Leukemia", American Journal of Epidemiology, Vol. 131, No. 9, Nov. 1991.

Title:

Occupational and Residential 60-Hz Electromagnetic Fields and High-Frequency Electric Transients: Exposure Assessment Using a New Dosimeter

Period:

1987

Environment:

Electrical Facilities - Residential

Areas Surveyed:

Areas occupied at work and at home by electric utility workers

Purpose:

Pilot exposure assessment study using a new dosimeter

Instrumentation:

(Positron) - Pocket-sized battery-operated device worn by workers. Records electric and magnetic field of power frequency and electric field transients [5 to 20 MHz range]. Recording is once a minute of E perpendicular to body, B_x , B_y , B_z and high frequency transient electric field.

Number of Sites:

Group of 20 electric utility workers from six different high field occupations and a comparison group of office workers.

Selection of Sites:

Volunteer

Protocol:

Measurements over a 7-day period. People kept an activity diary. Time could be divided between work, non-work and sleep. Time at work could be divided among different tasks. Weekly time weighted averages (TWA) were calculated. The geometric means and geometric standard deviations of the TWAs were calculated for each group.

Data:

Highest magnetic fields (geometric means of the TWAs) during work were measured for apparatus electricians involved in the repair and maintenance of high voltage substation equipment (34.4 mG), distribution cable splicer (20.8 mG), distribution linemen (14.5 mG), transmission linemen (13.1 mG), apparatus mechanics involved in the maintenance of generating station equipment (11.8 mG), and generating station assistant operators (11.4 mG). Non-work values were 3.1 mG for workers in high field occupations and 1.9 mG for office workers. Sleep TWA was about 1.5 mG for both groups. Highest transient exposure was measured during work for the generating station assistant operator and transmission linemen. Very little transient exposure for office workers or during non-work and sleep.

Sources:

Electric motors in repair shops. Low-end medium-voltage cables in access manholes. Overhead distribution lines during live line maintenance. Overhead transmission lines during ground inspection and testing of high voltage insulators. Power tools in mechanical workshops.

References:

J.E. Deadman, M. Camus, B.G. Armstrong, P. Heroux, D. Cyr, M. Plante and G. Theriault, "Occupational and Residential 60-Hz Electromagnetic Fields and High-Frequency Electric Transients: Exposure Assessment Using a New Dosimeter", American Industrial Hygiene Association Journal, Vol. 49, No. 8, pp. 409-419, August 1988.

Title:

Repeatability of Residential Power Frequency Magnetic Fields and Wire Codes

Period:

1985 and 1990

Environment:

Residential

Areas Surveyed:

All rooms and the front door of homes

Purpose:

Study repeatability of magnetic field measurements over time (a 5-year period)

Instrumentation

In 1990: EMDEX-100 to measure the 3 orthogonal components of the rms field. In 1985: manual measurements with an Electric Field Measurement - Model 113 meter.

Number of Sites:

81 homes

Selection:

The 81 homes were a random sample of the 579 case and control homes of a previous epidemiological study [Savitz, 1988]. The sample was stratified along two dimensions: wire code HCC and LCC and case/control

Protocol:

A two-member measurement team. One that performed wire coding and the other spot measurements. Spot measurements were made under "low" and "high" power use conditions in all rooms. Measurements were made at 1 m above ground at the center of each room. Twenty-four hour recordings near center of bedroom, dining room, and living room with a record every 30 seconds. The arithmetic mean of all measured rooms was calculated.

Data:

The wire codes differed for 8 out of the 81 homes coded 5 years apart. The averages of the three rooms measured for 24 hours were highly correlated with the spot measurement averages. Averages of spots measured at centers of rooms in 1985 and in 1990 were highly correlated ($r = 0.7$). The average of the average of all room spot measurements for the low power conditions were: 0.39/0.53, 0.41/0.80, 0.59/0.64, 1.40/1.31, 2.05/2.26 for 1985/1990 and underground, VLCC, OLCC, OHCC and VHCC wire codes respectively. Individual home data ranged from 0.02 to 5 mG.

Sources:

Distribution lines and house wiring

Reference:

T. Doan, W.T. Kaune, D.A. Savitz, "Repeatability of Residential Power Frequency Magnetic Fields and Wire Codes", Bioelectromagnetics, Vol. 14, pp. 145-159, 1993.

Title

EPRI Survey of Residential Magnetic Field Sources - The 1000 Home Study

Period

1989 - 1990

Environment Types

Residences

Areas Surveyed

All rooms (Kitchens, Bedrooms, Living rooms, Bathrooms, Dining rooms, Family rooms, Halls),
Outdoor periphery,
Under power lines near residences,
Near electrical appliances.

Purpose of the Survey

Identification of all significant sources of 60 Hz magnetic fields in residences.
Estimation of the magnetic field levels caused by each source inside the residences. Estimate, for each source, of the percentage of residences where magnetic fields exceed specified levels.
Determination of the relationship between magnetic field, source parameters, and source characteristics.
Characterization of field variations in space and time.
The survey was not intended to measure exposure of people to magnetic fields.

Instrumentation

Three-axis digital recorders for measurements of:

- the rms value of the 60 Hz component,
- the rms value of the third harmonic (180 Hz),
- and the total harmonic field (100 Hz - 1 kHz).

Wheel for measurements of field versus distance.

Special device called "tracer load", to be inserted at a 120 V outlet, for measuring the contribution of house loads to the ground current, and to the residential fields caused by ground currents.

Clamp-on ammeters to measure the net current in the service drop.

Number of Sites

996 residences

Selection of Sites

Random selection from all residential customers of EPRI member utilities

Protocol

Especially designed for source identification and characterization by a crew of two operators for the measurements (one indoors and one outdoors) plus a utility representative who answered resident's questions and administered a questionnaire.

Two visits to the residence, the first lasting 1 1/2 hours to make measurements and install 24 hour recorders, and the second to retrieve the recorders.

Activities during the first visit included:

- Introduction of the measuring team.

- Documentation (questionnaire, photos and sketches) of residence and power lines.

- Automatic diagnostics with special instrumentation, including spot measurements at the center of each room.

- Detection of unusual wiring inside the residence.

- Installation of 24-hour recorders at 4 characteristic locations.

- Lateral profiles of neighboring transmission and distribution lines.

- Measurements of fields around the periphery of the residence.

- Magnetic field measurements made at 3 different distances from selected electrical appliances.

Data

Several analyses were made to obtain characteristic magnetic field quantities from the raw recorder data. A comprehensive database was constructed containing up to 1400 variables per residence. The database contains information on the characteristics of the residence, characteristics of the power lines, spot measurements in each room of the residence, fields variations versus time over 24 hours, third harmonics, total harmonic contents, relative values of field components, field from electrical appliances, field around the periphery, etc. The data base can be used for statistical analyses and to determine the correlation between fields, residence characteristics, and power line characteristics.

Sources

The following sources were identified and characterized:

- Overhead power distribution lines (sources of highest average fields)

- Overhead power transmission lines (sources of highest average fields)

- Underground power distribution lines

- Residence grounding system (sources of the highest top 5% fields)

- Electrical appliances (sources of the highest maximum fields)

- Some multiple way switches and associated wiring.

- Grounding of sub-panels

- Wires for floor or ceiling heating

Reference

"Survey of Residential Magnetic Field Sources", EPRI Report TR-102759-
Volume 1 and Volume 2. September 1993