The benefits of electromagnetic surveys in the IT environment

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January 2012

There are two main reasons for conducting an electromagnetic and radio frequency survey or audit of a facility;

- To meet regulations and recommendations concerning the exposure of people to high levels of non-ionising radiation, better known as electromagnetic fields
- To ensure the reliable operation of information technology equipment which can be impaired due to electromagnetic interference

Human exposure requirements

Humans can be exposed to electromagnetic fields from the following;

- High voltage and/or high current cables
- High current transformers
- Microwave ovens
- Radar transmitters
- Medical magnetic imaging
- Mobile/cellular telephones and transmitter masts
- TV and radio transmitters

The use of electricity has become an integral part of everyday life. Whenever electricity flows, both electric and magnetic fields exist close to the lines that carry electricity, and close to appliances. Since the late 1970s, questions have been raised whether exposure to these extremely low frequency (ELF) electric and magnetic fields (EMF) produces adverse health consequences. Since then, much research has been done, successfully resolving important issues and narrowing the focus of future research. *(Electromagnetic fields and public health -Exposure to extremely low frequency fields, Fact sheet N°322, June 2007 World Health Organisation, WHO)*

Electric and magnetic fields exist wherever electric current flows, in power lines and cables, residential wiring and electrical appliances. Electric fields arise from electric charges, are measured in volts per metre (V/m) and are shielded by common materials, such as wood and metal. Magnetic fields arise from the motion of electric charges (i.e. a current), are expressed in tesla (T), or more commonly in millitesla (mT) or microtesla (µT). In some countries another unit called the gauss, (G), is commonly used (10,000 G = 1 T). These fields are not shielded by most common materials, and pass easily through them. Both types of fields are strongest close to the source and diminish with distance.

Most electric power operates at a frequency of 50 or 60 cycles per second, or hertz (Hz). Close to certain appliances, the magnetic field values can be of the order of a few hundred microteslas. Underneath power lines, magnetic fields can be about 20 µT and electric fields can be several thousand volts per metre. However, average residential power-frequency magnetic fields in homes

are much lower - about 0.07 µT in Europe and 0.11 µT in North America. Mean values of the electric field in the home are up to several tens of volts per metre.

Short-term effects

There are established biological effects from acute exposure at high levels (well above 100 µT) that are explained by recognized biophysical mechanisms. External ELF magnetic fields induce electric fields and currents in the body which, at very high field strengths, cause nerve and muscle stimulation and changes in nerve cell excitability in the central nervous system.

Potential long-term effects

Much of the scientific research examining long-term risks from ELF magnetic field exposure has focused on childhood leukaemia. In 2002, IARC published a monograph classifying ELF magnetic fields as "possibly carcinogenic to humans". This classification is used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals (other examples include coffee and welding fumes). This classification was based on pooled analyses of epidemiological studies demonstrating a consistent pattern of a two-fold increase in childhood leukaemia associated with average exposure to residential power-frequency magnetic field above 0.3 to 0.4 µT. The Task Group concluded that additional studies since then do not alter the status of this classification.

A number of other adverse health effects have been studied for possible association with ELF magnetic field exposure. These include other childhood cancers, cancers in adults, depression, suicide, cardiovascular disorders, reproductive dysfunction, developmental disorders, immunological modifications, neurobehavioural effects and neurodegenerative disease. The WHO Task Group concluded that scientific evidence supporting an association between ELF magnetic field exposure and all of these health effects is much weaker than for childhood leukaemia. In some instances (i.e. for cardiovascular disease or breast cancer) the evidence suggests that these fields do not cause them.

International exposure guidelines

Health effects related to short-term, high-level exposure have been established and form the basis of two international exposure limit guidelines (ICNIRP, 1998; IEEE, 2002). At present, these bodies consider the scientific evidence related to possible health effects from long-term, low-level exposure to ELF fields insufficient to justify lowering these quantitative exposure limits.

WHO's guidance

For high-level short-term exposures to EMF, adverse health effects have been scientifically established (ICNIRP, 2003). International exposure guidelines designed to protect workers and the public from these effects should be adopted by policy makers. EMF protection programs should include exposure measurements from sources where exposures might be expected to exceed limit values.

Regulations and recommendations

The organisations that have most to say on exposure levels to electromagnetic fields are the World Health Organisation, WHO, European Union and the American Occupational Safety and Health Administration, OSHA. In turn they often look to the International Commission on non-ionizing Radiation Protection, ICNIRP, and the Institute of Electrical and Electronic Engineers, IEEE, for detailed guidance.

European Union

Non-ionising radiation - The Electro Magnetic Fields (EMF) Directive

The deadline for introducing legislation on workers' exposure to electromagnetic fields has now been adopted by the European Union as 30 April 2012

The Directive [PDF 11kb] deals only with health and safety at work, and applies to work activities where workers are exposed to risks from electromagnetic fields.

What duties does it place on employers?

The Directive places a number of duties on employers. The main ones being that it:

- Places a duty on the employer to conduct a risk assessment and calculate EMF strengths.
- Places a duty on the employer to eliminate or reduce as low as possible the risk of exposure; and where risk can't be eliminated that measures are devised by the employer to reduce the risk of exposure below ELV (Exposure Limit Value).
- Requires the employer to provide: the risk assessment to the nominated person responsible for health surveillance;
- Requires an investigation and medical examination where an employee is 'detected' as having been exposed;
- Records of Health surveillance activities are kept.

United States

The American Occupational Safety and Health Administration, OSHA, has published Standard Number: 1910.97, Occupational Safety and Health Standards, Subpart: G, Subpart Title: Occupational Health and Environmental Control, Title: Nonionizing radiation.

Typical occupational health guidelines quoted from *ICNIRP GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC AND ELECTROMAGNETIC FIELDS (UP TO 300 GHZ) PUBLISHED IN: HEALTH PHYSICS 74 (4):494-522; 1998.*

Table 7. Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	3.2×10^4	4×10^4	—
1–8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8–25 Hz	10,000	$4{,}000/f$	$5{,}000/f$	—
0.025–0.8 kHz	$250/f$	$4/f$	$5/f$	—
0.8–3 kHz	$250/f$	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	$0.73/f$	$0.92/f$	—
1–10 MHz	$87/f^{1/2}$	$0.73/f$	$0.92/f$	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2–300 GHz	61	0.16	0.20	10

Requirements for the reliable operation of information technology equipment

Information Technology equipment (IT) covers everything from computers, servers, local area networks, storage and telecommunications equipment. It is designed to tolerate a certain amount of attack from electrostatic and electromagnetic fields. Once these levels have been exceeded however they will malfunction; this will be manifested as lost and corrupted data, a slowing down of LAN traffic (as the error correcting codes keep asking for data to be re-transmitted) and logging on and off of terminal equipment.

Most IT equipment is labelled with the American UL FCC and European Union CE mark to demonstrate that it can tolerate certain levels of electromagnetic fields and that it in turn will not radiate more than a certain amount of electromagnetic radiation.

If the amount of electromagnetic interference is likely to cause a problem e.g. if the electric field is greater than 3 V/m, then the following remedies can be applied;

- Measure the local electromagnetic environment
- Use screened/shielded copper data cables
- Use optical fibre connections
- Place all IT equipment in steel racks/cabinets that are correctly earthed
- Ensure the building has an IT grade earthing system e.g. EN 50310 or TIA 607
- Screen the room e.g. with copper foil
- Use a steel framed-steel clad building

European Union

Electromagnetic compatibility is mandated under two Directives within the EU.

DIRECTIVE 1999/5/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity

EMC (ElectroMagnetic Compatibility) Directive 2004/108/EC

The CE symbol in the EU indicates compliance of the equipment to the EMC Directive and the Low Voltage Directive of the European Union. Such marking is indicative that the equipment meets the following technical standards:

EN 55022 — *Information Technology Equipment — Radio Disturbance Characteristics — Limits and Methods of Measurement*

EN 55024 *Information Technology Equipment - Immunity Characteristics - Limits and Methods of Measurement*

EN 61000 *Electromagnetic Compatibility (EMC)*

EN 60950 *Safety of Information Technology Equipment*

NOTE: EN 55022 emissions requirements provide for two classifications: Class A is for typical commercial areas and Class B is for typical domestic areas.

CISPR standards are also used (*Comité International Spécial des Perturbations Radioélectriques* – part of the IEC)

CISPR 22 *Information technology equipment - Radio disturbance characteristics – Limits and methods of measurement*

CISPR 24 *Information technology equipment - Immunity characteristics - Limits and methods of measurement*

United States

Most IT equipment is classified by the Federal Communications Commission (FCC) as Class A or B digital devices according to Part 15 of the FCC (Federal Communications Commission) Rules. Devices may not cause harmful interference and must accept any interference received, including interference that may cause undesired operation.

Class A

“This equipment has been tested and found to comply with the limits for a Class A digital device pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the manufacturer's instruction manual, may cause harmful interference with radio

communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case you will be required to correct the interference at your own expense."

Class B

"This equipment has been tested and found to comply with the limits for a Class B digital device pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the manufacturer's instruction manual, may cause interference with radio communications. However, there is no guarantee that interference will not occur in a particular installation."

American telecommunications equipment may also be covered by *Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment*, Telcordia Document Number GR-1089 Issue Number 06 Issue Date May 2011

MICE classifications

MICE is the system of classifying the environment in which the equipment, including cabling, has to function - "M" stands for "mechanical" characteristics, "I" covers "ingress", "C" addresses the "climatic/chemical" aspects while "E" represents the "electromagnetic" domain.

Each group (M, I, C and E) has three assessment levels i.e. M1, M2 and M3 within which the environment becomes more "aggressive". So an $M_1I_1C_1E_1$ classification represents a relatively benign overall environment, such as an office, whereas the $M_3I_3C_3E_3$ classification represents a mores severe industrial environment.

The MICE concept was founded in Europe during the development of EN 50173-3 but is now completely harmonised at international level in IEC 24702:2006 and in North America within ANSI/TIA/EIA-1005, ANSI/TIA-568-C and ANSI/TIA-942. MICE is also used in other standards and, in due course, cables and connecting hardware will be advertised with their MICE classifications.

The TIA-942 standard on data centre design now specifies the electromagnetic performance requirements of a computer room according to the MICE standard;

TIA 942 Site selection (*Telecommunications Infrastructure Standard for Data Centers Addendum 2-Additional Guidelines for Data Centers*, 2010)

> "The computer room should be located away from sources of EMI and RFI such as x-ray equipment, radio transmitters, and transformers. The recommended location of the data center should be a MICE $M_1I_1C_1E_1$ environment (ANSI/TIA-568-C.0). Note: alternatively, the computer room should be designed to create a MICE $M_1I_1C_1E_1$ environment."

From this standard the electromagnetic performance of a computer room is defined below.

Electromagnetic	E_1
Electrostatic discharge – Contact (0,667 µC)	4 kV
Electrostatic discharge – Air (0,132 µC)	8 kV
Radiated radio frequency, amplitude modulated (RF – AM)	3 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz
Conducted radio frequency (RF)	3 V at 150 kHz to 80 MHz
Electrical fast transient/Burst (EFT/B)	AC 500 V
Surge (transient ground potential difference) - signal, line to earth	500 V
Magnetic Field (50/60 Hz)	1 A/m
Magnetic Field (60 Hz to 20 000 Hz)	ffs

Talk to Capitoline about our electromagnetic and Radio Frequency audits and surveys of your site along with a wide range of environmental, safety, power and energy efficiency audits for data centres.

References

Human exposure and health standards

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION, ICNIRP PUBLICATION – 1998, ICNIRP GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC AND ELECTROMAGNETIC FIELDS (UP TO 300 GHZ)

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION, ICNIRP PUBLICATION – 2009, ICNIRP GUIDELINES ON LIMITS OF EXPOSURE TO STATIC MAGNETIC FIELDS PUBLISHED IN: HEALTH PHYSICS 96(4):504-514; 2009

ICNIRP STATEMENT ON THE "GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS (UP TO 300 GHZ)" PUBLISHED IN: HEALTH PHYSICS 97(3):257-258; 2009

ICNIRP GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC AND MAGNETIC FIELDS (1 HZ – 100 kHz) PUBLISHED IN: HEALTH PHYSICS 99(6):818-836; 2010

World Health Organization, International Labour Organization, International Commission on Non-Ionizing Radiation Protection. Environmental Health Criteria 232, Static fields. Geneva: World Health Organization; 2006.

World Health Organization, International Labour Organization, International Commission on Non-Ionizing Radiation Protection. Environmental Health Criteria 238, Extremely low frequency

Health Protection Agency. *Static magnetic fields*. Report of an independent Advisory Group on non-Ionising Radiation. Chilton: HPA; Doc HPA, RCE-6; 2008.

IEEE C95.1–2005 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

IEEE C95.3–1999 IEEE recommended practice for the measurement of potentially hazardous electromagnetic fields, RF and microwave.

ANSI C95.3 1979 American national standard techniques and instrumentation for the measurement of potentially hazardous electromagnetic fields, RF and microwave

OSHA Occupational Safety and Health Standards, Subpart: G : Occupational Health and Environmental Control Standard Number: 1910.97 Non-ionizing radiation.

DIRECTIVE 2004/40/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)

Information Technology standards

DIRECTIVE 1999/5/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity

EMC (ElectroMagnetic Compatibility) Directive 2004/108/EC

FEDERAL COMMUNICATIONS COMMISSION, SUBCHAPTER A—GENERAL, PART 15--RADIO FREQUENCY DEVICES

CISPR standards

CISPR 22, Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement

CISPR 24, Information technology equipment - Immunity characteristics - Limits and methods of measurement.

IEC standards

IEC/TR EN 61000-1-1, Electromagnetic compatibility (EMC) - Part 1: General - Section 1: Application and interpretation of fundamental definitions and terms

IEC/TR EN 61000-2-1, Electromagnetic compatibility (EMC) - Part 2: Environment - Section 1: Description of the environment - Electromagnetic environment for low-frequency conducted disturbances and signaling in public power supply systems

IEC/TR EN 61000-2-3, Electromagnetic compatibility (EMC) - Part 2: Environment - Section 3: Description of the environment - Radiated and non-network-frequency-related conducted phenomena

IEC EN 61000-3-2, Electromagnetic compatibility (EMC) - Part 3-2 - Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)

IEC EN 61000-3-4, Electromagnetic compatibility (EMC) - Part 3-4: Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A

IEC/TS EN 61000-3-5, Electromagnetic compatibility (EMC) - Part 3: Limits - Section 5: Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 16 A

IEC EN 61000-4-2, Electromagnetic compatibility (EMC)- Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test

IEC EN 61000-4-3, Electromagnetic compatibility (EMC)- Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test

IEC EN 61000-4-4, Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test

IEC EN 61000-4-5, Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test

IEC EN 61000-4-6, Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields

IEC EN 61000-4-7, Electromagnetic compatibility (EMC) - Part 4-7: Testing and measurement techniques - General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto

IEC EN 61000-4-8, Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test

IEC EN 61000-4-9, Electromagnetic compatibility (EMC) - Part 4-9: Testing and measurement techniques - Pulse magnetic field immunity test

IEC EN 61000-4-11, Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests

EN 55 011 European limits and methods of measurement of radio disturbance characteristics for scientific and medical equipment

EN 55 013 European limits and methods of measurement of radio disturbance characteristics of broadcast receivers

EN 55 022 European limits and methods of measurement of radio disturbance characteristics of information technology equipment

VDE 0875 German EMC directive for broadband interference generated by household appliances

VDE 0871 German EMC directive for broadband and narrowband interference generated by information technology equipment

EN 50310:2010 Application of equipotential bonding and earthing in buildings with information technology equipment

EN 50 093 European, immunity to short dips in the power supply (brownouts)

EN 55 020 European, immunity from radio interference of broadcast receivers

EN 55 024 European immunity requirements for information technology equipment

EN 55 101 older draft of immunity requirements for information technology equipment, replaced by EN 55 024

GR-1089-CORE. Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment.

TIA-607 Revision / Edition: B Date: 08/26/11 GENERIC TELECOMMUNICATIONS BONDING AND GROUNDING (EARTHING) FOR CUSTOMER PREMISES

