

**Health impact from the use of security and similar
devices employing pulsed and continuous
electromagnetic fields**

Concerted Action
within the project: Environment and Health
Health impact of electromagnetic fields
of the Fifth Framework Programme of the European
Commission

**Executive summary
of the
Final Report**

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Contents

Executive Summary	6
1 Introduction	Error! Bookmark not defined.
1.1 Background information	Error! Bookmark not defined.
1.2 The role of ICNIRP.....	Error! Bookmark not defined.
2 Characteristics of systems and devices.....	Error! Bookmark not defined.
2.1 Introduction.....	Error! Bookmark not defined.
2.2 Electronic article surveillance systems	Error! Bookmark not defined.
2.2.1 Introduction.....	Error! Bookmark not defined.
2.2.2 EAS systems operation	Error! Bookmark not defined.
2.2.3 The technology	Error! Bookmark not defined.
2.2.4 Tags and detection or deactivation methods.....	Error! Bookmark not defined.
2.2.5 Current applications of EAS systems	Error! Bookmark not defined.
2.2.6 Future development of EAS systems.....	Error! Bookmark not defined.
2.3 Radiofrequency identification systems	Error! Bookmark not defined.
2.3.1 Introduction.....	Error! Bookmark not defined.
2.3.2 RFID systems operation.....	Error! Bookmark not defined.
2.3.3 The technology	Error! Bookmark not defined.
2.3.4 Range and power levels	Error! Bookmark not defined.
2.3.5 Transponders and tags	Error! Bookmark not defined.
2.3.6 Current applications of RFID systems.....	Error! Bookmark not defined.
2.3.7 Future development of RFID systems	Error! Bookmark not defined.
2.4 Metal Detection systems	Error! Bookmark not defined.
2.4.1 Introduction.....	Error! Bookmark not defined.
2.4.2 The technology	Error! Bookmark not defined.

2.4.3	Current applications of Metal Detector systems	Error! Bookmark not defined.
2.4.4	Future development of Metal Detector systems	Error! Bookmark not defined.
2.5	Conclusions and recommendations	Error! Bookmark not defined.
2.5.1	Conclusions	Error! Bookmark not defined.
2.5.2	Recommendations	Error! Bookmark not defined.
3	Exposure Assessment	Error! Bookmark not defined.
3.1	Introduction	Error! Bookmark not defined.
3.2	Waveforms	Error! Bookmark not defined.
3.3	Measurements and calculations	Error! Bookmark not defined.
3.3.1	Exposures from EAS systems	Error! Bookmark not defined.
3.3.2	Exposures from RFID Equipment	Error! Bookmark not defined.
3.3.3	Exposures from metal detection equipment	Error! Bookmark not defined.
3.4	Conclusions and recommendations	Error! Bookmark not defined.
3.4.1	Conclusions	Error! Bookmark not defined.
3.4.2	Recommendations	Error! Bookmark not defined.
4	Mechanisms	Error! Bookmark not defined.
4.1	Introduction	Error! Bookmark not defined.
4.2	Physical coupling mechanisms	Error! Bookmark not defined.
4.2.1	Coupling with ELF electric fields	Error! Bookmark not defined.
4.2.2	Coupling with ELF magnetic fields	Error! Bookmark not defined.
4.2.3	Absorption of energy from electromagnetic fields	Error! Bookmark not defined.
4.3	Bio-physical mechanisms	Error! Bookmark not defined.
4.3.1	Static and frequencies below 300 Hz (ELF)	Error! Bookmark not defined.
4.3.2	300 Hz < f < 20 MHz	Error! Bookmark not defined.
4.3.3	f > 20 MHz	Error! Bookmark not defined.
4.4	Conclusions	Error! Bookmark not defined.

5	Human studies	Error! Bookmark not defined.
5.1	Epidemiological studies	Error! Bookmark not defined.
5.1.1	Introduction.....	Error! Bookmark not defined.
5.1.2	EMF exposure and the risk of cancer	Error! Bookmark not defined.
5.2	Human laboratory studies	Error! Bookmark not defined.
5.2.1	Introduction.....	Error! Bookmark not defined.
5.2.2	Human laboratory studies (up to 300 Hz)	Error! Bookmark not defined.
5.2.3	Human laboratory studies (300 Hz - 10 MHz)	Error! Bookmark not defined.
5.2.4	Human laboratory studies (10 MHz - 300 GHz)	Error! Bookmark not defined.
5.2.5	Epidemiology and human laboratory studies – Conclusions	Error! Bookmark no
6	Animal and cellular studies	Error! Bookmark not defined.
6.1	Introduction.....	Error! Bookmark not defined.
6.2	Animal studies.....	Error! Bookmark not defined.
6.2.1	Animal studies (up to 300 Hz).....	Error! Bookmark not defined.
6.2.2	Animal studies (300 Hz - 10 MHz)	Error! Bookmark not defined.
6.2.3	Animal studies (10 MHz – 300 GHz).....	Error! Bookmark not defined.
6.3	Cellular studies.....	Error! Bookmark not defined.
6.3.1	ELF cellular studies (up to 300 Hz).....	Error! Bookmark not defined.
6.3.2	Cellular studies (300 Hz – 10 MHz).....	Error! Bookmark not defined.
6.3.3	Cellular studies (10 MHz – 300 GHz)	Error! Bookmark not defined.
6.4	Summary and conclusions	Error! Bookmark not defined.
7	Electromagnetic interference with medical devices	Error! Bookmark not defined.
7.1	Introduction.....	Error! Bookmark not defined.
7.2	Present status of knowledge on interference between security systems and medical devices.....	Error! Bookmark not defined.
7.3	Possible medical consequences of security systems interference with medical devices	Error! Bookmark not defined.

7.4	Medical Device Consensus Standards Related to EMC	Error! Bookmark not defined.
7.5	The EC Recommendation and ICNIRP EMF Exposure Guidelines	Error! Bookmark not defined.
7.6	Collaboration between Security and Medical Device Industries	Error! Bookmark not defined.
7.7	Conclusions and Recommendations	Error! Bookmark not defined.
7.7.1	Conclusions.....	Error! Bookmark not defined.
7.7.2	Recommendations.....	Error! Bookmark not defined.
8	Health Protection Guidelines.....	Error! Bookmark not defined.
8.1	ICNIRP guidelines on limiting exposure to electromagnetic fields	Error! Bookmark not defined.
8.2	EC Recommendation on Public Exposure	Error! Bookmark not defined.
9	Technical standards	Error! Bookmark not defined.
9.1	Introduction.....	Error! Bookmark not defined.
9.2	The Regulatory Framework in the European Union	Error! Bookmark not defined.
9.2.1	European directives.....	Error! Bookmark not defined.
9.2.2	European standards	Error! Bookmark not defined.
9.3	Other standards of relevance to security and similar devices	Error! Bookmark not defined.
9.3.1	Global/International standards	Error! Bookmark not defined.
9.3.2	National regulations and standards	Error! Bookmark not defined.
9.4	Conclusions and Recommendations	Error! Bookmark not defined.
9.5	Collection of Directives, Recommendations, Guidelines and Standards.....	Error! Bookmark not defined.
10	Conclusion and Recommendations	Error! Bookmark not defined.
10.1	Conclusions.....	Error! Bookmark not defined.
10.1.1	Characteristics of systems and devices	Error! Bookmark not defined.
10.1.2	Exposure assessment.....	Error! Bookmark not defined.
10.1.3	Mechanisms	Error! Bookmark not defined.
10.1.4	Human studies.....	Error! Bookmark not defined.
10.1.5	Animal and cellular studies.....	Error! Bookmark not defined.

10.1.6	Electromagnetic interference with medical devices	Error! Bookmark not defined.
10.2	Recommendations	Error! Bookmark not defined.
10.2.1	Characteristics of systems and devices	Error! Bookmark not defined.
10.2.2	Exposure assessment	Error! Bookmark not defined.
10.2.3	Electromagnetic interference with medical devices	Error! Bookmark not defined.
10.2.4	Technical standards	Error! Bookmark not defined.
11	References	Error! Bookmark not defined.

Executive Summary

Scope

The objective of this advisory document is to address the possible adverse effects on public health and exposure to pulsed and continuous wave (cw) electromagnetic fields (EMFs) associated with the use of electronic security and similar devices. The document will provide advice to the EC and Members States as an input to policy development. Secondary objectives include: a review of the scientific evidence of harm to human health from EMF exposure relevant to the operating frequencies of such devices; a review of the applicability and limitations of currently available exposure assessment techniques and recommendations for future health risk assessment and research needs.

Characteristics of systems and devices

Electronic Article Surveillance (EAS), Radiofrequency Identification (RFID) and metal detector systems operate over a wide range of frequencies, using continuous wave and different pulse modalities. Emission frequencies for devices currently in use range from tens of hertz to several gigahertz. While individual systems generally use single frequencies or narrow bands of frequencies, future applications may also exploit combinations of different frequency bands used simultaneously (although not necessarily exactly time coincident). There is a large global market for such devices. With regard to exposure of the general public it is important to note that EAS systems are likely to become ubiquitous in retail stores and together with low cost tagging of goods will become standard pieces of equipment at stores points of sale and checkouts. The applications of radiofrequency identification devices are also likely to increase, to perhaps include libraries, airline baggage checking and parcels and products transport and generally high value checking. The primary application for metal detecting devices is weapon location and metal object theft prevention.

Exposure assessment

There is a wide and complex range of exposure situations related to the use of security and identification devices. The complexity is manifested by the number of different spatial and temporal characteristics of emissions (range of frequencies and pulse modalities) and by differences in the physical design of equipment.

There are a number of measurement and computational dosimetric tools currently available with which to carry out health hazard assessments. However, there is a need to further develop such tools and particularly computational methods. While anatomically realistic computational phantoms for adult males have been used to

provide exposure data over a wide range of frequencies and exposure situations, few such data are available for adult female phantoms or for children. Given the widespread use of security and identification devices where the general public have access, exposure of women and children is most likely and it is therefore important that computational tools specifically addressing differences in body size, anatomy and age are further developed.

Mechanisms

There is a wide range of thermal and nonthermal interaction mechanisms by which electromagnetic fields can interact with biological systems. From a practical point of view, three sets of phenomena (heating, membrane stimulation, and electroporation) are responsible for most of the obvious hazards from acute exposure to electromagnetic fields. Because of the weak coupling between external fields and the body, these generally require currents to be passed directly into the body.

Comparing the thresholds of these effects is complicated by the fact that they vary in different ways with frequency or pulse width. Electroporation requires very high membrane field strengths, but is a very fast process. Membrane excitation requires somewhat lower membrane potentials but is also a fast process (milliseconds).

Thermal damage is a much slower process, both because of the thermal inertia of the process and because of the kinetics of thermal damage itself. In general, the hazards from low-frequency fields are associated with membrane effects and those from high frequency fields are associated with heating.

Between 100 kHz and about 20 MHz transition from induced currents to RFR absorption occurs. Many other mechanisms of EMF interaction with biological systems have been proposed, most directed at ELF or RF effects that cannot be readily explained in terms of the classical mechanisms. The EAS/RFID fields will produce no heating and no thermoregulation stress. There are also no contact currents. ICNIRP's basic restrictions accommodate all known biophysical mechanisms in the EAS/RFID range. Although, it is known that pulsed EMF's produce more excitations and less heat, there is little evidence that pulsed fields are more efficient than continuous electromagnetic fields in eliciting effects in the EAS frequency range. Specific effects of high peak powers are not relevant to EAS.

Epidemiological studies

Childhood leukaemia in relation to postnatal exposures above 0.4 μT is the one for which there is most evidence of an association. The evidence is, however, not conclusive. Nevertheless, IARC has concluded that ELF magnetic fields are possibly carcinogenic to humans, based on consistent statistical associations of high level residential magnetic fields with a double risk of childhood leukaemia.

The few studies examining brain cancer and residential exposure in adults have found little or no evidence of an association.

Most studies exploring the link between EMF and adult cancers have been based on occupational groups with possibly high exposures. Of these, a number of studies have reported an increased risk of leukemia among electrical workers. Some occupational studies indicate also a higher risk of brain cancer for workers in electrical occupations.

The available epidemiological studies all have limitations that prevent drawing clear-cut conclusions on the effects of EMFs on human reproduction. No conclusions can be drawn for radiofrequencies and microwaves because of lack of data, but there is no convincing evidence today that EMFs of the sort pregnant women or potential fathers meet in occupational or daily life exposures do any harm to human reproductive process.

Human laboratory studies

In the ELF region (up to 300 Hz), surface electric charges due to ELF electric fields can be perceived by people. Electrically excitable cells in the retina can be affected by current densities of 10 mA m^{-2} or more, induced by exposure to ELF magnetic fields. Evidence consistent with these phenomena has been seen in animal studies. International guidance on limiting human exposure (ICNIRP, 1998) seeks to avoid the annoying effects of surface charge and the effects of induced current on the neural circuitry of the retina and other parts of the CNS.

Generally, below these levels of exposure, few consistent effects have been found in either animal or volunteer studies. In particular, there is no convincing evidence of any effect on reproduction and development, on haematology or the immune system or on carcinogenesis.

In the intermediate frequency region (300 Hz – 10 MHz), the threshold for effects of induced current on electrically excitable cells in the CNS will predominate over possible heating effects at low frequencies (up to about 100 kHz). At some point, as frequencies increase from about 100 kHz to about 10 MHz, heating effects predominate. International guidance (ICNIRP, 1998) is based on the extrapolation of neural tissue thresholds identified in the ELF region according to the known frequency dependence of nervous tissue responses, and the heating effects identified at frequencies greater than 10 MHz.

In the RF region (10 MHz – 300 GHz), heating effects are well established in volunteer and animal experiments. International guidelines on limiting exposure to electromagnetic fields (ICNIRP, 1998) seek to prevent adverse effects of excessive whole-body and localised heating. In addition, guidance is given concerning the avoidance of the annoying auditory perception of pulsed RF. There are no well-established health effects below these levels of exposure, although the possibility has been raised in connection with mobile phone radiation that there may be subtle transitory effects on nervous system function and behaviour.

Animal and cellular studies

A large number of animal studies have been carried out at ELF and RF frequencies. Many have focussed on effects on the nervous system and behaviour or on possible effects on carcinogenic processes. However, most indices of general physiological status appear relatively unaffected by exposure and there is at present no convincing evidence of adverse health effects for humans or animals. In contrast, at intermediate frequencies, few studies have been carried out and the scientific literature is scant.

With regard to cellular studies, the possibility that there are subtle biological effects due to ELF exposure cannot be ruled out. However, the results that are claimed to demonstrate a positive effect of exposure tend to show only small changes whose biological consequences are not clear.

In the intermediate frequency region, few cellular studies have been carried out; the evidence to date concerning signal transduction, protein expression and cell proliferation, is largely contradictory.

RF radiation can affect cellular processes when sufficiently intense to induce heating. Generally, however, exposures from security and similar devices are at levels many times below those that would induce heating.

Electromagnetic interference with medical devices

Electromagnetic Interference with medical devices by security systems that produces clinically significant effects appears relatively rare and thus does not appear to be a major public health problem. However, there have been several dozen incident reports

suggesting that certain types of electrically powered active medical devices or passive devices, worn by people who are ambulatory and may pass through security systems, can have their medical function disrupted by the emissions from the security systems. In addition, there are several hundred records of interference of medical devices from security systems, including both clinical data and in-vitro laboratory studies designed to deliberately provoke such interactions. The reported cases of EMI with certain critical medical devices remains a concern.

RECOMMENDATIONS

Characteristics of systems and devices

- The identification of possible risks to health from the use of such devices depends on the availability of information on their operating characteristics, specifically their operating frequencies, details of their physical design and the pulse modalities used. There is a need to continue to measure levels of exposure to people passing security systems and at work places near security systems. There is also a need to collect exposure data about RFID systems. When such technical information becomes available during the development of a new product or application, a health hazard assessment should be undertaken to identify likely problems in complying with exposure guidelines. Awareness of the magnitude of the likely exposure of people as a result of the envisaged use of a system should be an integral part of the development process.
- Information relevant to a health hazard assessment on a particular system should be made available by the manufacturer to the purchaser.

Exposure assessment

- Support should be provided for the further development and dosimetric application of anatomically realistic computational phantoms based on medical imaging data – such phantoms should include adult male and female phantoms and child phantoms at different stages of growth.
- Support should be provided for experimental studies measuring the dielectric properties of relevant body tissues. Such studies should address all frequencies of relevance to the practical exposure of people and the variations of dielectric properties as a function of age.
- Where measurements and/or calculations are made to assess the exposure of the general public, they should include assessments of the exposure of children.

Electromagnetic interference with medical devices

It is recommended that the following actions are taken to address the issue of medical device electromagnetic interference (EMI) by security systems.

- There is a need to minimize the risks of EMI caused by emissions due to security systems. It is recommended for the development of security systems to require the minimization of exposures as a quality criterion.
- There is a need for more knowledge about how these devices interact with the emissions and how to design and test both medical devices and emitting equipment to reduce their risks of EMI. A European forum should be established to continue and enhance the collaboration between the medical

device and security system industries, with physician input. Further, this forum will enable manufacturers of medical devices and security systems to provide sufficient information about current and new products so that both industries can work to minimise the risks of EMI caused by emissions from security systems.

- Medical device manufacturers should provide physicians and device users with information to make them aware of the possibility of EMI problems. This information should enable physicians to advise their patients about relevant EMI sources and means to minimise their risk. The security industry must address these risks in their product information and device labelling (such as recommended in the document “FDA Guidance for Labelling for Electronic Anti-theft Systems” August 15, 2000).
- One of the most appropriate routes for information to patients with medical devices is through their physicians or the responsible health care authorities. Comprehensive information for the medical device patient should enable them to be aware of the risks. Societies such as the European Society of Cardiology, etc. could be consulted for appropriate forms of advice.
- More data are needed on the emissions of EAS, RFID or metal detector systems and on the interference with all kinds of active implantable medical devices. The data must be publicly available so that the device manufacturers, physicians, and patients can make informed choices.
- Further studies should be carried out on functional and technology imposed limitations of various medical devices, the characterisation and influences of emitted waveform types and the refinement of medical device electromagnetic field interaction models for security systems exposures. Compatibility between neurostimulators and other new developed devices and security systems should be tested.
- The ultimate goal should be for complete compatibility between the security systems and medical devices that may pass through the systems. The risk for the public, including medical device users, resulting from EMI from the security systems should be minimized. This task addresses standardisation bodies, manufacturers of emitting devices and manufacturers of active implantable medical devices. It will be necessary for product standards for emitting systems and for active implantable medical devices to both rely on the same limiting values concerning EMI problems. As long as older devices are still in use, means are needed to manage the remaining incompatibilities between existing emitting systems and existing active implantable medical devices. This task addresses authorities, system users, physicians and patients.