



International EMF Project Information Sheet



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ELECTROMAGNETIC FIELDS AND PUBLIC HEALTH Intermediate Frequencies (IF)

Exposure to human-made electromagnetic fields (EMF) has increased over the past century. The widespread use of EMF sources has been accompanied by public debate about possible adverse effects on human health. As part of its charter to protect public health and in response to these concerns, the World Health Organization (WHO) established the International EMF Project to assess the scientific evidence of possible health effects of EMF in the frequency range from 0 to 300 GHz. The EMF Project encourages focused research to fill important gaps in knowledge and to facilitate the development of internationally acceptable standards limiting EMF exposure.

Public concerns have ranged from possible effects of exposure to extremely low frequency (ELF) electric and magnetic fields (e.g. electricity supply including power lines) having frequencies between 0 and 300 Hz to possible effects of exposure to radiofrequency (RF) fields (e.g. microwave ovens and broadcast and other radio-transmission devices including mobile phones) having frequencies in the range 10 MHz - 300 GHz. A large body of scientific research in these two frequency ranges now exists. For the purpose of this document, the intermediate frequency (IF) region of the EMF spectrum is defined as being between the ELF and RF ranges; 300 Hz to 10 MHz. A relatively small number of studies has been conducted on the biological effects or health risks of IF fields. This is due, in part, to the fact that fewer types of devices produce fields in this frequency range. But because these devices now have a high consumer and industrial market penetration, it is important to evaluate their impact on human health. This information sheet addresses the known health effects of IF fields, and offers recommendations for further study.

Sources

Common sources of IF fields can be found in the following settings:

- **Industry:** Dielectric heater sealers, induction and plasma heaters, broadcast and communications transmitters,
- **General public:** Domestic induction cookers, proximity readers, electronic article surveillance systems and other anti-theft devices, computer monitors and television sets,
- **Hospitals:** MRI systems, electromagnetic nerve stimulators, electro-surgical units, and other devices for medical treatment,
- **Military:** Power units, submarine communication transmitters and high frequency (HF) transmitters.

Except for medical diagnostic and treatment devices, levels of human exposure from IF devices normally fall below limits recommended by the International Commission on Non-ionizing Radiation Protection (ICNIRP). However, workers in a few categories (e.g. operators of dielectric heater sealers and induction heaters, some military personnel and

technicians working near high powered broadcast equipment) may be exposed to considerably higher levels of IF fields.

How EMF Affects the Human Body

Several mechanisms, both thermal and non-thermal, by which electromagnetic (primarily, electric) fields can interact with biological systems are well established. The limiting hazard will arise from the adverse effect (thermal or non-thermal) that has the lowest threshold under given exposure conditions. While strong fields in the upper IF range may cause *thermal damage* (a relatively slow process that requires tissue to be maintained at high temperatures for a given period of time), some of the most obvious hazards from acute exposure to electric currents in the body may occur through *membrane excitation*. This non-thermal mechanism results from changes in membrane potential induced by external fields and occurs, for example, in the stimulation of peripheral nerves and muscle cells. Another mechanism is *electroporation*, which is the reversible or irreversible disruption of cell membranes when a field induces excessive electrical potentials across them. This can provoke tissue injury through electric shock, but is also being investigated for therapeutic purposes by using short electric field pulses to make human tissues more permeable to drugs.

External IF fields can induce these effects inside the human body but only at field strengths many times higher than typical environmental levels.

Reported Biological and Health Effects

Health benefits from electric and magnetic fields have been claimed since the 18th century, and pulsed EMFs in the IF range have found a place in modern medical practice for the treatment of bone healing and nerve stimulation and regeneration. However, concern has been expressed about possible health hazards associated with technology, both at home and in the workplace. These concerns include worker complaints of disturbances (e.g. swelling, prickling of fingers, headaches) and public anxiety about possible adverse health effects of IF fields from computer monitors and televisions. Types of research conducted so far have included:

- **Human studies:** Until now, most epidemiological studies concerning IF exposure have focused on *reproductive and ocular effects* from the use of computer monitors. Several major reviews have concluded that these, with their extremely weak IF fields, do not constitute a threat to human health and that they do not interfere with reproductive processes or pregnancy outcomes. Also, no association between such exposure and eye abnormalities has been established. A large study on female radio and telegraph operators showed a slight increased risk of *breast cancer*. However, this group of workers is also exposed to many other factors that could explain this increased risk. The high degree of biological variability and the multitude of EMF parameters make it difficult to reach firm conclusions about the significance of any of these studies for human health. Some of the most important health hazards due to IF sources relate to *indirect* action of EMF. For example, EMF produced by electronic anti-theft systems may interfere with implanted electronic medical devices (e.g. pacemakers, neurological stimulators).
- **Laboratory studies:** Few reported *cellular studies* using IF fields have shown independently-confirmed biological effects. Studies on mice have shown no morbidity, change in behaviour or lymphoma development with exposure to low-strength magnetic field signals in the kHz range. Although a few studies of effects on *reproduction and development* of mice, rats, and chick embryos and a few other studies suggest the possibility of minor skeletal anomalies; overall there is no clear evidence for increased malformations.

Compared to extremely low frequency fields (ELF, which includes AC power frequencies) and radio frequency fields (RF, which includes mobile phone communications), little research has been done of the effects of IF fields. The scientific evidence is not convincing that adverse health effects occur from exposure to IF fields normally found in the living and working environment. This conclusion is partly based on the studies conducted with IF fields but also on the fact that IF fields act on the body in a way similar to ELF and RF fields, depending on the frequency of the IF field.

International Standards

ICNIRP is an independent scientific commission formally recognized by WHO that has published guidelines on exposure limits for all EMF in the 0 to 300 GHz frequency range. Exposure guidelines in the IF range have been established from rigorous review of the scientific literature on possible adverse health effects and by extrapolating limits from the ELF and RF ranges, based on coupling of external fields with the body and assumptions about the frequency dependence of biological effects.

What Should Be Done?

The scientific evidence does not suggest any health risk from IF fields at exposures below the ICNIRP guideline levels. However, there is a need for more high quality research to address uncertainties in current knowledge. The following key areas have been identified for further research:

- **Epidemiological studies:** It is recommended that epidemiological studies be considered only if pilot studies demonstrate the feasibility of gathering high quality exposure data in appropriate highly exposed populations, thereby achieving adequate statistical power and identifying relevant health outcomes.
- **Exposure evaluation:** The degree and type of EMF exposure currently encountered in occupational and domestic settings need to be better characterized. Periodic checks must be made and documented in industrial and other occupational settings where IF fields are used, to ensure that the equipment is operating properly and that exposure guidelines are not exceeded.
- **Animal studies:** Future animal studies should attempt to use exposure conditions that are similar to human exposures from industrial and other sources, and also should explore higher exposure levels. If specific suspect pathways are identified, these studies could be supplemented by cell or tissue studies to clarify how IF fields affect organisms.
- **Biological interaction:** More comprehensive understanding of the biological interaction and hazard thresholds is required to refine exposure guidelines, particularly for pulsed fields or fields with complex waveforms.
- **Dosimetry:** Computer modelling techniques exist that enable the calculation of fields induced inside the bodies of people exposed to IF fields. The most advanced of these techniques employ anatomically realistic computational phantoms. Such methods are particularly appropriate in risk assessment and testing compliance of measured IF fields with exposure limits in a consistent manner. It is important that, where appropriate, female and child phantoms are also considered for use in such assessments.

What is the World Health Organization doing about the issue?

The WHO's International EMF Project has established a programme to review research results and conduct risk assessments of EMF exposure. It is developing public information materials, and bringing together standards groups world-wide in an attempt to harmonize approaches to the development of EMF exposure standards. Health risks from EMF exposure, including cancer, are being evaluated by WHO in collaboration with the International Agency for Research on Cancer (IARC) – the specialized cancer research agency of WHO – and by ICNIRP.

Further Reading

Bernhardt JH, McKinlay AF and Matthes R, editors: Possible health risk to the general public from the use of security and similar devices. Report to the European Commission Concerted Action QLK4-1999-01214, ICNIRP, 2002 (ICNIRP 12/2002).

Matthes R., van Rongen E., Repacholi M., editors: *Proceedings of the International Seminar on Health Effects of Exposure to Electromagnetic Fields in the Frequency Range 300 Hz to 10 MHz*, Maastricht, The Netherlands, ICNIRP, 1999 (ICNIRP 8/99).

Litvak E, Foster K R and Repacholi M H (2002): Health and safety implications of exposure to electromagnetic fields in the frequency range 300 Hz to 10 MHz. *Bioelectromagnetics* 23(1): 68-82.

Matthes R., Bernhardt J., McKinlay A., editors: *Guidelines on Limiting Exposure to Non-ionizing Radiation*, ICNIRP, 1999 (ICNIRP 7/99) <http://www.icnirp.org>.