

Electromagnetic fields (EMF)

What are electromagnetic fields?

Current standards

Standards are set to protect our health and are well known for many food additives, for concentrations of chemicals in water or air pollutants. Similarly, field standards exist to limit overexposure to electromagnetic field levels present in our environment.

Who decides on guidelines?

Countries set their own national standards for exposure to electromagnetic fields. However, the majority of these national standards draw on the guidelines set by the International Commission on Non-ionizing Radiation Protection (ICNIRP). This non-governmental organization, formally recognized by WHO, evaluates scientific results from all over the world. Based on an in-depth review of the literature, ICNIRP produces guidelines recommending limits on exposure. These guidelines are reviewed periodically and updated if necessary.

Electromagnetic field levels vary with frequency in a complex way. Listing every value in every standard and at every frequency would be difficult to understand. The table below is a summary of the exposure guidelines for the three areas that have become the focus of public concern: electricity in the home, mobile phone base stations and microwave ovens. These guidelines were last updated in April 1998.

Summary of the ICNIRP exposure guidelines

	European power frequency		Mobile phone base station frequency		Microwave oven frequency
Frequency	50 Hz	50 Hz	900 MHz	1.8 GHz	2.45 GHz
	Electric field (V/m)	Magnetic field (μ T)	Power density (W/m^2)	Power density (W/m^2)	Power density (W/m^2)
Public exposure limits	5 000	100	4.5	9	10
Occupational exposure limits	10 000	500	22.5	45	

ICNIRP, EMF guidelines, Health Physics 74, 494-522 (1998)

The exposure guidelines may differ by a factor of more than 100 between some former Soviet countries and Western countries. With the globalization of trade and the rapid introduction of telecommunications worldwide there is a need for universal standards. As many countries from the former Soviet Union are now considering new standards, the WHO has recently launched an initiative to harmonize exposure guidelines worldwide. Future standards will be based on the results of the WHO's [International Electromagnetic Field Project](#).

What are guidelines based on?

An important point to make is that a guideline limit is not a precise delineation between safety and hazard. There is no one level above which exposures become hazardous to health; instead, the potential risk

to human health gradually increases with higher exposure levels. Guidelines indicate that, below a given threshold, electromagnetic field exposure is safe according to scientific knowledge. However, it does not automatically follow that, above the given limit, exposure is harmful.

Nevertheless, to be able to set limits on exposure, scientific studies need to identify the threshold level at which first health effects become apparent. As humans cannot be used for experiments, guidelines critically rely on animal studies. Subtle behavioural changes in animals at low levels often precede more drastic changes in health at higher levels. Abnormal behaviour is a very sensitive indicator of a biological response and has been selected as the lowest observable adverse health effect. Guidelines recommend the prevention of electromagnetic field exposure levels, at which behavioural changes become noticeable.

This threshold level for behaviour is not equal to the guideline limit. ICNIRP applies a safety factor of 10 to derive occupational exposure limits, and a factor of 50 to obtain the guideline value for the general public. Therefore, for example, in the radiofrequency and microwave frequency ranges, the maximum levels you might experience in the environment or in your home are at least 50 times lower than the threshold level at which first behavioural changes in animals become apparent.

Why is the safety factor for occupational exposure guidelines lower than for the general public?

The occupationally exposed population consists of adults who generally experience known electromagnetic field conditions. These workers are trained to be aware of potential risk and to take appropriate precautions. By contrast, the general public consists of individuals of all ages and of varying health status. In many cases, these are unaware of their exposure to EMF. Moreover, individual members of the public cannot be expected to take precautions to minimize or avoid exposure. These are the underlying considerations for more stringent exposure restrictions for the general public than for the occupationally exposed population.

As we have seen earlier, low frequency electromagnetic fields induce currents in the human body (see What happens when you are exposed to electromagnetic fields?). But various biochemical reactions within the body itself generate currents as well. The cells or tissues will not be able to detect any induced currents below this background level. Therefore, at low frequencies, exposure guidelines ensure that the level of currents induced by an electromagnetic fields is below that of natural body currents.

The main effect of radiofrequency energy is the heating of tissue. Consequently, exposure guidelines for radiofrequency fields and microwaves are set to prevent health effects caused by localized or whole-body heating (see What happens when you are exposed to electromagnetic fields?). Compliance with the guidelines will ensure that heating effects are sufficiently small not to be harmful.

What guidelines cannot account for...

At present, speculations about potential long-term health effects cannot form the basis for the issuing of guidelines or standards. Adding up the results of all scientific studies, the overall weight of evidence does not indicate that electromagnetic fields cause long-term health effects such as cancer. National and international bodies set and update standards on the basis of the latest scientific knowledge to protect against known health effects.

Guidelines are set for the average population and cannot directly address the requirements of a minority of potentially more sensitive people. Air pollution guidelines, for example, are not based on the special needs of asthmatics. Similarly, electromagnetic field guidelines are not designed to protect people from interference with implanted medical electronic devices such as heart pacemakers. Instead, advice about exposure situations to be avoided should be sought from the manufacturers and from the clinician implanting the device.

What are typical maximum exposure levels at home and in the

environment?

Some practical information will help you to relate to the international guideline values given above. In the following table you will find the most common sources of electromagnetic fields. All values are maximum levels of public exposure – your own exposure is likely to be much lower. For a closer look at field levels around individual electrical appliances, please see the section Typical exposure levels at home and in the environment.

Source	Typical maximum public exposure	
	Electric field (V/m)	Magnetic flux density (μT)
Natural fields	200	70 (Earth's magnetic field)
Mains power (in homes not close to power lines)	100	0.2
Mains power (beneath large power lines)	10 000	20
Electric trains and trams	300	50
TV and computer screens (at operator position)	10	0.7
	Typical maximum public exposure (W/m^2)	
TV and radio transmitters	0.1	

Mobile phone base stations	0.1
Radars	0.2
Microwave ovens	0.5

Source: WHO Regional Office for Europe

How are guidelines put into practice and who checks on them?

The responsibility to investigate fields around power lines, mobile phone base stations or any other sources accessible to the general public lies with government agencies and local authorities. They must ensure that compliance with guidelines is maintained.

With electronic devices, the manufacturer is responsible for complying with the standard limits. However, as we have seen above, the nature of most devices ensures that the emitted fields are well below the cut-off values. Furthermore, many consumer associations carry out tests on a regular basis. In case of any particular concern or worry, contact the manufacturer directly or enquire with your local public health authority.

Are exposures above the guidelines harmful?

It is perfectly safe to eat a pot of strawberry jam up to the expiration date – but if you consume the jam any later the manufacturer cannot guarantee good food quality. Nevertheless, even a few weeks or months after the expiration date, it will usually be safe to eat the jam. Similarly, electromagnetic field guidelines ensure that, within the given exposure limit, no known adverse health effects will occur. A large safety factor is applied to the level known to cause a health consequence. Therefore, even if you experienced field strengths several times higher than the given limit value, your exposure would still be within this safety margin.

In everyday situations, most people do not experience electromagnetic

fields that exceed the guideline limits. Typical exposures are far below these values. However, there are occasions where a person's exposure may, for a short period, approach or even exceed the guidelines. According to ICNIRP, radiofrequency and microwave exposures should be averaged over time to address cumulative effects. The guidelines specify a time-averaging period of six minutes and short-term exposures above the limits are acceptable.

In contrast, exposure to low frequency electric and magnetic fields is not time-averaged in the guidelines. To make things even more complicated, another factor called coupling comes into play. Coupling refers to the interaction between the electric and magnetic fields and the exposed body. This depends on the size and shape of the body, the type of tissue and the orientation of the body relative to the field. Guidelines must be conservative: ICNIRP always assumes maximum coupling of the field to the exposed individual. Thus the guideline limits provide maximum protection. For example, even though the magnetic field values for hairdryers and electric shavers appear to exceed the recommended values, extremely weak coupling between the field and the head prevents the induction of electrical currents that could exceed guideline limits.

Key points

1. ICNIRP issues guidelines on the basis of the current scientific knowledge. Most countries draw on these international guidelines for their own national standards.
2. Standards for low frequency electromagnetic fields ensure that induced electric currents are below the normal level of background currents within the body. Standards for radiofrequency and microwaves prevent health effects caused by localized or whole body heating.
3. Guidelines do not protect against potential interference with electromedical devices.
4. Maximum exposure levels in everyday life are typically far below guideline limits.
5. Due to a large safety factor, exposure above the guideline limits is

not necessarily harmful to health. Furthermore time-averaging for high frequency fields and the assumption of maximum coupling for low frequency fields introduce an additional safety margin.

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