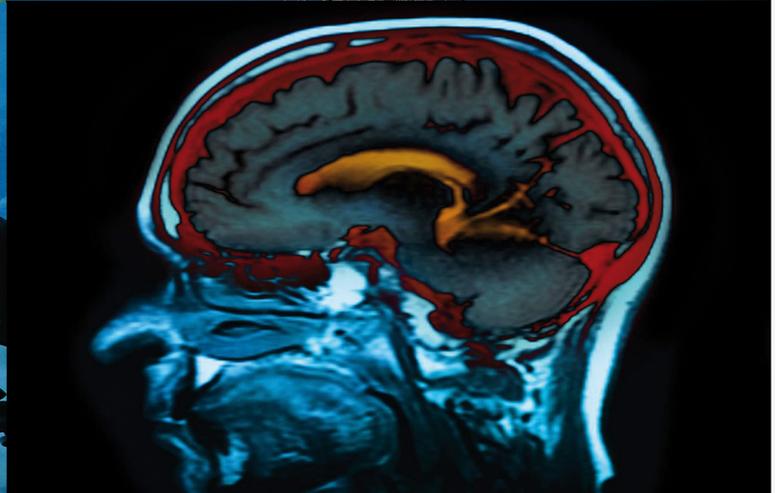
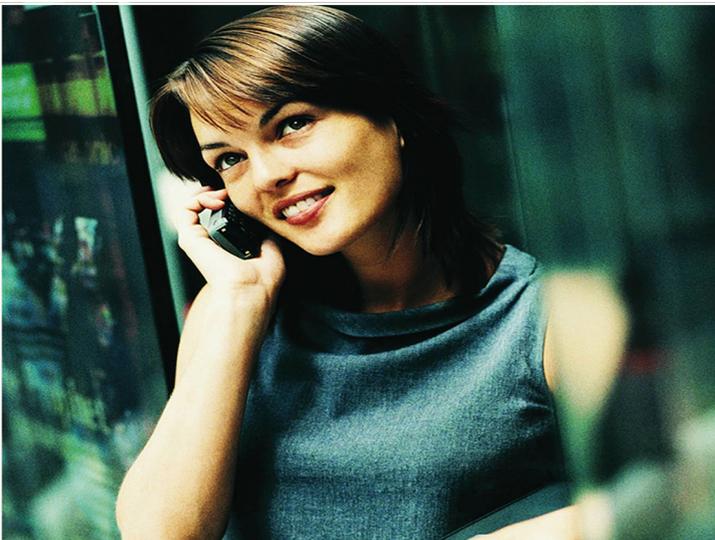




The Knowledge Network

ELECTROMAGNETIC FIELDS AND HEALTH

A Factfile provided by The Institution of
Engineering and Technology
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About This Factfile

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As engineering and technology become increasingly interdisciplinary, global and inclusive, the Institution of Engineering and Technology reflects that progression and welcomes involvement from, and communication between, all sectors of science, engineering and technology.

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Summary

This FactFile is produced by the Institution of Engineering and Technology to provide authoritative information and unbiased advice on the subject of the health risks associated with electromagnetic fields.

What is this factfile about?

Electromagnetic fields (EMFs) are inevitably produced by any electrical apparatus. Examples include power lines and cables, electrical appliances, mobile phones and base stations, and TV and radio transmitters. For more than thirty years there have been concerns about health risks from EMFs. Originally, these concerns were about the fields produced by the electric power system that supplies energy for domestic and industrial use, but more recently, the concerns have included mobile phones as well. The Institution of Engineering and Technology has been examining the issue carefully for many years, and has produced this booklet to provide authoritative information and unbiased advice on the subject.

The Institution of Engineering and Technology Working Group on EMFs.

The Institution first established a Working Group to review the possible health effects of EMFs in 1992. Since then, the Working Group has produced reports roughly every two years. In 1998 its scope was formally expanded from just power frequencies to include radio frequencies. It operates by identifying all relevant published scientific papers, and assessing and rating those papers in a systematic way. Its members have individual expertise in biology, epidemiology, physics and engineering, and come from industry, academia, hospitals, and regulatory agencies, ensuring that a wide range of scientific views is represented.

What are electromagnetic fields?

Electric and magnetic fields are caused wherever electricity is used. Electric fields are produced by voltages and magnetic fields are produced by currents. In other words, electric fields exist around all wires and electrical devices whenever they are connected to a supply of electricity, but magnetic fields are only produced when current flows and hence power is being used. The higher the voltage (or greater the current) the stronger the field produced. At higher frequencies, the electric and magnetic fields can be coupled together in a particular relationship. They are then referred to as electromagnetic waves or radio waves.

The units used to measure these phenomena are related to each other but, due to historic reasons, their relative sizes vary by many orders of magnitude. Units are described below as are their multipliers and, in theory, any combination of unit and multiplier can be used. As can be seen in the following sections, when describing the levels of phenomena actually encountered, certain combinations are more common than others.

Table of units and multipliers

Units	Multipliers
V - volts -electrical potential	μ - micro - one millionth
A - amperes -electrical current	m - milli - one thousandth
W - watt -power	k - kilo - one thousand
T - tesla - magnetic field	M - mega one million
Hz - hertz - cycles per second - frequency	G - giga - one thousand million

What different frequencies are there?

The electromagnetic spectrum spans a vast range of frequencies. All frequencies less than the ultraviolet are referred to as "non-ionising" because they have insufficient energy to break chemical bonds. Concerns about EMFs and health have focussed on two quite separate non-ionising frequency bands. One is 50 or 60 Hz, the frequency of electric power systems. The other is around 1 and 2 GHz, where mobile phones operate. For simplicity, this FactFile considers these two ranges of frequencies separately from now on.

Power frequencies

- 50 Hz (Europe) or 60 Hz (America)
- Separate electric and magnetic fields
- Electric fields measured in volts per metre (V/m), magnetic fields measured in tesla (T). In practice, kilovolts per metre (kV/m) and microteslas (μ T) are often used

Mobile phone frequencies

- Typically 900 MHz or 1.8 GHz
- Electric and magnetic fields coupled together as electromagnetic or radio waves.
- Usually measured in watts per square metre (W/m²). In practice, milliwatts per square metre (mW/m²) or microwatts per square metre (μ W/m²) are often used.
- A useful quantity to specify the amount of power absorbed by living tissues is the Specific energy Absorption Rate (SAR), measured in watts per kilogram (W/kg).

Where do fields come from?

Power frequencies

Background fields in most homes come from low-voltage electric wiring - average values in UK homes 20 V/m and 0.05 μ T.

Higher fields are produced by overhead power lines - up to 10 kV/m and 100 μ T - and by mains appliances - up to about 200 V/m and 1000 μ T. These fields have limited range - a few hundred metres at most for power lines, a metre or so for appliances.

Mobile phone frequencies

The highest fields come from the mobile phones themselves - these have maximum powers of less than 2 W and typically produce maximum absorbed powers (SAR) within the head of less than 1 W/kg. In normal operation these figures can be hundreds of times lower.

Fields from base stations and other broadcast antennas (such as TV) are much lower (usually less than 1 mW/m² in areas of public access).

What is a safe level?

In the UK, the body responsible for advising on EMF exposure levels is the Health Protection Agency – Radiation Protection Division (HPA-RPD) formerly (pre April 2005) the National Radiological Protection Board (NRPB). Internationally, the International Commission on Non-Ionising Radiation Protection (ICNIRP) performs a similar role, and in 2004 the NRPB recommended that the ICNIRP guidelines be used in the UK.

Power frequencies

HPA-RPD and ICNIRP advise that if exposures to the public do not exceed 5 kV/m and 100 μ T (at 50 Hz), then the basic restriction (a limit of 2 mA/m² on the current induced in the brain and central nervous system) will not be exceeded.

The limits for occupational exposure are higher, with a basic restriction of 10 mA/m² and corresponding fields of 10 kV/m and 500 μ T.

Mobile phone frequencies

The UK has used ICNIRP's recommendations for exposure to the public at mobile phone frequencies since 2000. Hence the average power absorbed by the whole body should not exceed 0.08 W/kg (additional restrictions apply to particular parts of the body eg. 2 W/kg for the head). It is estimated that this will limit temperature rises in the body to fractions of a °C. To achieve this, HPA-RPD and ICNIRP recommend that the level of electromagnetic field should not exceed about 4.5 W/m² (900 MHz) or 9 W/m² (1.8 GHz).

In normal circumstances exposures to the general public at power and mobile phone frequencies comply with the basic restrictions recommended by HPA-RPD and ICNIRP.

What effect do fields have?

Some effects of fields - those at relatively high levels, often called "acute" effects - are well established and well understood. These are described on this page. Other effects have been suggested at much lower fields. There is much less scientific agreement on these effects. They are dealt with on the next page.

Power frequencies

The main effect of these fields is to cause small electric currents to flow in the body. If large enough, the currents could interfere with the action of nerves, particularly in the brain and spinal cord, or even cause stimulation of nerves and muscles. The limits recommended by HPA-RPD and ICNIRP are designed to stop this happening.

Very high electric fields can also cause "micro-shocks" when a metal object is touched - much as walking across a nylon carpet does. These can be annoying but are not in themselves dangerous.

Mobile phone frequencies

If large enough, these fields also induce currents - but because the frequency is higher, rather than interfering with nerves, they can cause heating. HPA-RPD and ICNIRP guidelines are designed to limit heating in any part of the body to acceptable levels - no more than 38°C for most of the body or 40°C for the limbs. Taken overall this heating is less than that caused by moderate exercise such as brisk walking.

What effect might lower levels of EMFs have?

Can they cause cancer?

Power Frequencies

For twenty years, the biggest concern has been that magnetic fields from power lines might cause cancer in general and childhood leukaemia in particular. This concern has been largely driven by epidemiological studies - statistical studies of the patterns of disease and exposure in a population. Some studies have suggested increases in risk for some cancers.

Others, including the world's largest study which was conducted in the UK in the last few years, found no such increases. Overall, the evidence that magnetic fields cause cancer is weak, a view endorsed by the NRPB in March 2004. One major consideration is that the limited epidemiological evidence has no real support from the vast number of laboratory studies that have been performed, and scientists have been unable to suggest a plausible biophysical mechanism for these effects to occur.

Most studies have been performed on magnetic fields. There have also been suggestions that either electric fields or small charged particles - corona ions - given off by power lines might cause health effects. As yet, there is little evidence to substantiate these suggestions. published literature as they become more established.

Mobile phone frequencies

The two biggest concerns are that base stations may cause cancer in exposed children and nearby residents and that using a mobile phone may cause brain cancer or other tumours. There is, at present, only very limited evidence to support either of these suggestions. However, this may reflect the fact that these concerns are recent. Only a few large-scale studies of the sort needed to settle these issues (which are underway in a number of countries) have yet been completed. So, whilst there is no strong reason to suppose that mobile phones or their base stations cause tumours, neither is there a solid body of evidence to refute that suggestion. Studies investigating other, longer established, sources of radio frequency fields such as radar, radio and TV, have not found consistent evidence of health effects.

As with power frequencies, scientists have been unable to propose plausible biophysical mechanisms for the fields to cause cancer. There is some robust laboratory evidence to suggest that radio waves at mobile phone (and other) frequencies do not cause cancer in animals. National, and international, investigations into possible health effects are considering all mobile phone technologies - analogue, GSM, CDMA, 3G and TETRA. The latter three technologies increasingly feature in the published literature as they become more established.

And can they affect my brain?

Power frequencies

Some studies have looked at whether fields, lower than those required for induced current effects, might affect the brain. There are some reports that they can, but so far they are not strong enough for a scientific consensus to emerge. There is no suggestion that these subtle effects are in any way harmful.

Mobile phone frequencies

There have been claims that heavy users of mobile phones experience more headaches, migraines, loss of memory and insomnia. At present it has not been shown that these symptoms are caused by EMFs. Laboratory studies have suggested that very subtle changes in sleep pattern and reaction times may occur. Whether these have any relevance to health is not clear at present. One thing, however, can be said with certainty: using a mobile phone whilst driving is clearly dangerous and should be avoided.

Should I be worried?

Power frequencies

It may, unfortunately, never be possible to say with certainty that fields are safe. That is not the nature of science, which cannot guarantee that anything is totally safe. Quite properly, on a sensitive public-health issue, research continues. However, there is a broad consensus among the many national and international bodies that have reviewed the evidence (including the Institution): although there is some evidence suggesting a risk, the balance of this evidence is against the fields encountered by the public being a cause of cancer or any other disease.

Mobile phone frequencies

Until more research has been done, no one knows for certain. There is no strong reason to suppose the fields do cause harm, but not enough research has been done to give firm assurance that they are safe either. Under these circumstances, some feel this is a case for taking precautionary measures - you may wish to reduce your personal exposure "just in case". The Institution feels that taking such precautionary measures is not unreasonable at this juncture - but this should only be as a stopgap until research delivers firmer answers one way or the other.

How could I reduce my exposure if I wanted to?

Power frequencies

The Institution does not feel the scientific evidence requires taking any action. But if you do want to reduce your exposure, some of the things which contribute to above average exposures are:

- mains appliances such as clock-radios close to the bed;
- electric blankets left on overnight;
- homes close to high-voltage power lines.

Mobile phone frequencies

The largest source of exposure is a mobile-phone itself; so, if you want to reduce your exposure consider limiting the number or length of calls or using a hands-free kit. The SAR of a phone, available at the point of sale, or from www.sarvalues.com, is a guide to "low-absorption" phones, but where you hold the phone and how strongly it needs to transmit to reach the base station are also important. By contrast, base stations are much weaker sources, and produce exposures comparable to or lower than those from broadcasting antennas such as television or radio.

How can I find out more?

Advice

General advice on mobile phones is available from a number of Government Departments, for example:

- Department of Health: http://www.dh.gov.uk/en/Policyandguidance/Healthandsocialcaretopics/DH_4069598
- Department for Children, Schools and Families - Teacher Net: <http://www.teachernet.gov.uk/management/atoz/m/mobilephonesandbasestations/>

Any of the following will be able to give further advice and information on a one-to-one basis:

- HPA-RPD, telephone no 01235 831600
- Your local electricity company, via the National help-line number 084 5702 3270 (they are often willing to perform measurements in your home)
- Most mobile phone companies have their own help-line.

Action Groups

There are a number of protest, action or lobbying groups concerned with EMF. The Institution does not endorse or recommend any of these groups but you may wish to contact:

- PowerWatch <http://www.powerwatch.org.uk/>
- Mast Sanity <http://www.mastsanity.org/>
- Revolt <http://www.revolt.co.uk/>
- Mast Action UK <http://www.mastaction.co.uk>

How can I find out more?

Information

The World Health Organization EMF Project Website <http://www.who.int/peh-emf/>

The latest Recommendations of the HPA-RPD on public exposure are contained in Documents of the NRPB, volume 15 number 2, 2004. <http://www.hpa.org.uk/radiation/>

Various Reports of the HPA-RPD and its Advisory Group on Non-ionising Radiation are also available from them, <http://www.hpa.org.uk/radiation/publications/index.htm>.

Report NRPB-W65 summarises mobile phone and health reports issued during 2000 - 2004: http://www.hpa.org.uk/radiation/publications/w_series_reports/2005/nrpb_w65.pdf.

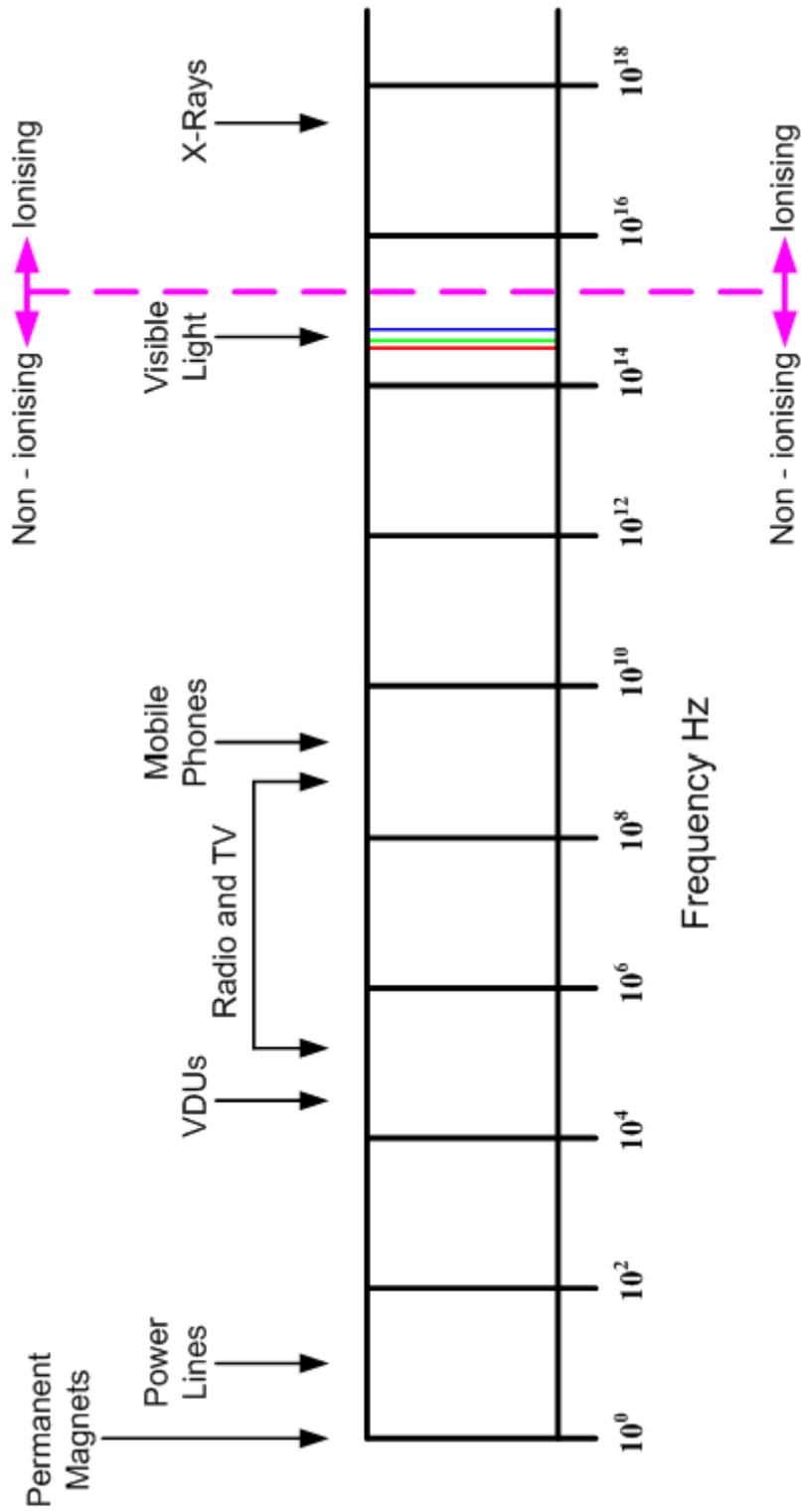
ICNIRP's Recommendations were published in: Health Physics 1998 volume 74 number 4, pages 494-522: <http://www.icnirp.de/documents/emfgdl.pdf>.

National Grid Transco, on behalf of the electricity industry, maintains a web site at <http://www.emfs.info>.

For mobile phones, the issue is handled by the Mobile Operators Association <http://www.mobilemastinfo.com>.

A Report from the Independent Expert Group on Mobile Phones (the "Stewart Report") is available from the HPA-RPD, or <http://www.iegmp.org.uk>.

The Institution of Engineering and Technology: The Reports of the Institution's Working Group are available on the Institution's web site: <http://www.theiet.org/publicaffairs/panels/bepag/index.cfm>.



The Electromagnetic Spectrum (part of)