



FACTFILE

**Electromagnetic Fields and Health
(March 2001)**



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ELECTROMAGNETIC FIELDS AND HEALTH

This FactSheet is produced by the Institution of Electrical Engineers (IEE) to provide authoritative information and unbiased advice on the subject of the health risks associated with electromagnetic fields.

WHAT IS THIS FACTSHEET 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 IEE 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 ELECTRICAL ENGINEERS

The IEE is Europe's largest professional engineering body with over 130,000 members in the UK and overseas. As well as representing the interests of its members – all of whom work with electricity in one way or another and therefore have a keen interest in the safety of the fields to which they are exposed – the IEE provides influential briefings to Government and industry on matters within its remit.

THE IEE WORKING GROUP ON EMFs

IEE 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 - watts - 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 GHz, where mobile phones operate. For simplicity, this FactSheet considers these two ranges of frequencies separately from now on.

POWER (FREQUENCIES)	MOBILE PHONE FREQUENCIES
<ul style="list-style-type: none"> ★ 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 (μT) are often used 	<ul style="list-style-type: none"> ★ 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/m^2). In practice, milliwatts per square metre (mW/m^2) or microwatts per square metre ($\mu W/m^2$) 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	MOBILE PHONE FREQUENCIES
<p>Background fields in most homes come from low-voltage electric wiring – average values in UK homes 20 V/m and 0.05 μT.</p> <p>Higher fields are produced by overhead power lines – up to 10 kV/m and 100 μT – and by mains appliances – up to about 200 V/m and 1000 μT. These fields have limited range – a few hundred metres at most for power lines, a metre or so for appliances.</p>	<p>The highest fields come from the mobile phones themselves – these have maximum powers of less than 2W 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.</p> <p>Fields from base stations and other broadcast antennas (such as TV) are much lower (usually less than 1 mW/m^2 in areas of public access).</p>

WHAT IS A SAFE LEVEL?

In the UK, the body responsible for advising on EMF exposure levels is the National Radiological Protection Board (NRPB). Internationally, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) performs a similar role. Both bodies come to very similar conclusions about acceptable exposure levels – in fact their basic restrictions for workers are virtually identical. The main difference is that ICNIRP recommends lower levels for the general public than for occupational exposures, generally by a factor of 5.

POWER FREQUENCIES	MOBILE PHONE FREQUENCIES
<p>NRPB advises that if exposures do not exceed 12 kV/m and 1600 μT (at 50 Hz), then its basic restriction (a limit of 10 mA/m² on the current induced in the brain and central nervous system) will not be exceeded.</p> <p>ICNIRP's corresponding basic restriction for the public is 2 mA/m². It recommends that levels of 5 kV/m and 100 μT should not be exceeded.</p>	<p>NRPB has recently accepted ICNIRP's recommendations for exposure to the public at mobile phone frequencies. 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, it recommends that the level of electromagnetic field should not exceed about 4.5 W/m² (900 MHz) or 9 W/m² (1.8 GHz).</p>

In normal circumstances exposures to the general public at power and mobile phone frequencies comply with the basic restrictions recommended by both NRPB 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	MOBILE PHONE FREQUENCIES
<p>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 NRPB and ICNIRP are designed to stop this happening.</p> <p>Very high electric fields can also cause “microshocks” when a metal object is touched – much as walking across a nylon carpet does. These can be annoying but are not in themselves dangerous.</p>	<p>If large enough, these fields also induce currents – but because the frequency is higher, rather than interfering with nerves, they can cause heating. NRPB 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.</p>

Can they cause cancer?

POWER FREQUENCIES	MOBILE PHONE FREQUENCIES
<p>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 in a Report of the NRPB’s Advisory Group on Non-ionising Radiation published by the NRPB (2001). 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.</p> <p>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.</p>	<p>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. There is, at present, no real 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 particular reason to suppose that mobile phones or their base stations cause cancer, 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.</p>

And can they affect my brain?

POWER FREQUENCIES	MOBILE PHONE FREQUENCIES
<p>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.</p>	<p>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.</p>

Should I be worried?

POWER FREQUENCIES	MOBILE PHONE FREQUENCIES
<p>It will, unfortunately, never be possible to say with certainty that fields are safe. Science can never prove 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 IEE): the balance of this evidence is against the fields encountered by the public being a cause of cancer or any other disease.</p>	<p>Until more research has been done, no-one knows for certain. There is no 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”.</p> <p>IEE feels that taking such precautionary measures is not unreasonable at this juncture – but this should only be as a stop-gap until research delivers firmer answers one way or the other.</p>

How could I reduce my exposure if I wanted to?

POWER FREQUENCIES	MOBILE PHONE FREQUENCIES
<p>IEE does not feel the scientific evidence warrants taking any action. But if you do want to reduce your exposure, some of the things which contribute to above average exposures are:</p> <ul style="list-style-type: none">★ mains appliances such as clock-radios close to the bed;★ electric blankets left on overnight;★ homes close to high-voltage power lines.	<p>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. It should soon be possible to choose a “low-absorption” phone, indicated by the SAR which will be printed on the packaging. 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.</p>

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.doh.gov.uk/mobilephones/basestations.html>
- ★ Department for Education & Employment <http://www.dfee.gov.uk/a-z/mobilephones.html>

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

- ★ NRPB, telephone number 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. IEE does not endorse or recommend any of these groups but you may wish to contact:

PowerWatch <http://www.powerwatch.org.uk/>

NIFATT <http://www.nifatt.8m.com/>

Revolt <http://www.revolt.co.uk/>

Mast Action UK <http://freespace.virginnet.co.uk/mast.action/>

INFORMATION

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

The Recommendations of the NRPB on public exposure are contained in Documents of the NRPB, volume 4 number 5, 1993. www.nrpb.org.uk

The Report of the NRPB's Advisory Group on Non-ionising Radiation is also available from them, with the conclusions available at <http://www.nrpb.org.uk/Absd12-1.htm>.

ICNIRP's Recommendations were published in: Health Physics 1998 volume 74 number 4, pages 494-522. www.icnirp.de

The Electricity Association, the Trade Association for the electricity industry, maintain a web site at www.electricity.org.uk

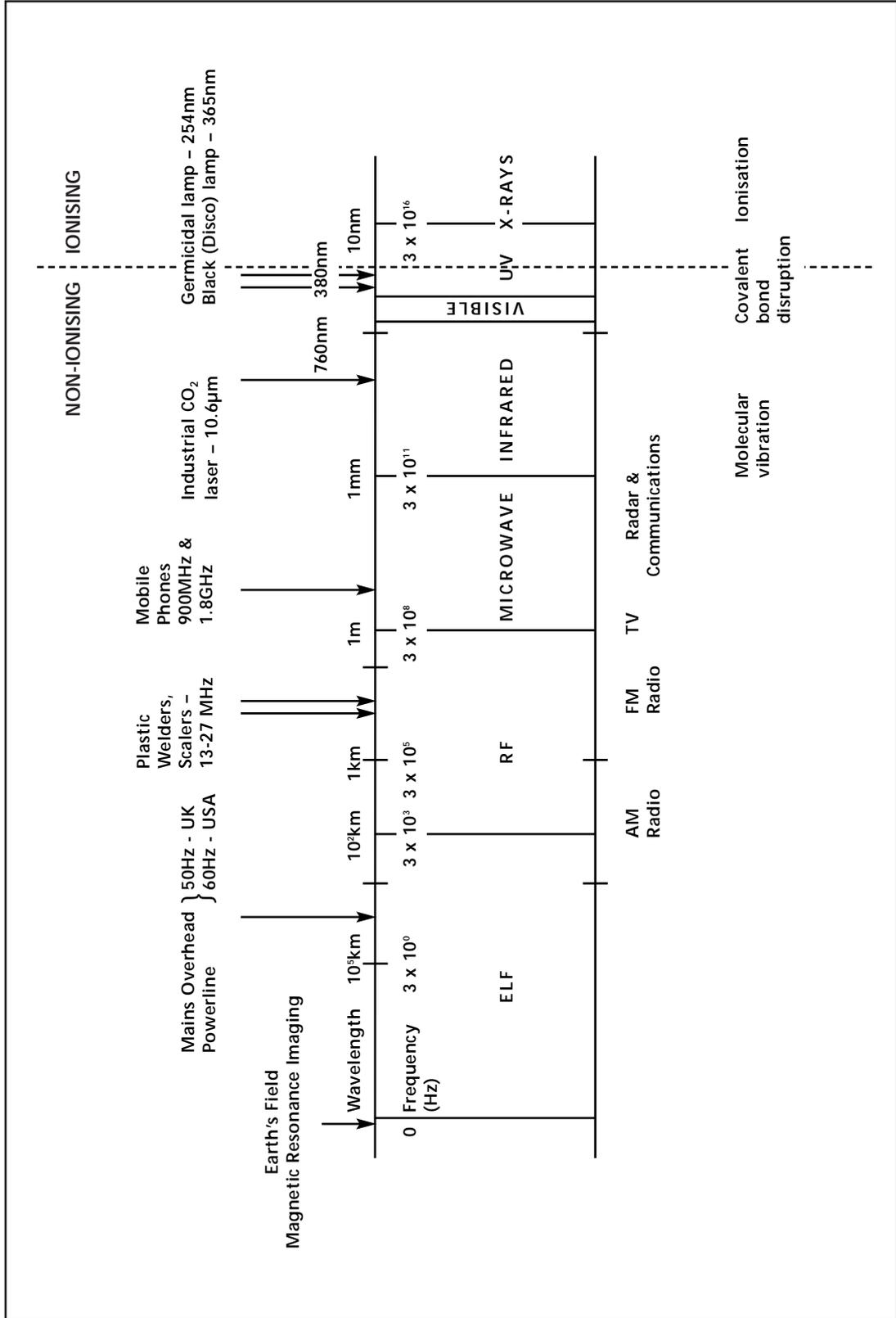
For mobile phones, the issue is handled by the Federation for the Electronics Industry <http://fei.interliant.com/fei/feiwweb.nsf>

A Report from the Independent Expert Group on Mobile Phones (the "Stewart Report" 2000) is available from the NRPB, or www.iegmp.org.uk.

IEE

The Reports of the IEE's Working Group are available on the IEE's web site http://www.iee.org.uk/PAB/Bio_effects/

NON-IONISING ELECTROMAGNETIC SPECTRUM





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