EMF Levels & Safety

It can be very hard to say exactly what levels of EMF are safe, because safety in this arena is often a relative concept based on frequency, exposure time, and possible individual sensitivity. Even then, studies are often considered inconclusive plus there is the potential for political and financial agenda to steer perception one way or the other.

In order to be fair and equitable while remaining informative, this document has been assembled in order to examine / compare / contrast various safety standards, average environmental levels and references along a continuum to better explain technical measurements in context. This document is offered free of charge, though if published, posted or reproduced in any fashion, crediting ScanTech as the document creator is requested.

Magnetic Fields Conversion Table

1 mG (milliGauss) = 100 nT (nanoTesla)
1 nT = 10 uG (microGauss) or 0.01 mG
100 microTeslas = 1 Gauss
1 microTesla = 10 mG
1 milliTesla = 10 Gauss   1 Tesla = 10,000 Gauss
1 nT = 1000 pT (picoTeslas) = 0.01 mG (10 microGauss) strongest brainwave is 1,000 times less
1 pT = 1000 fT (femtoTesla)
1 nT = 1,000,000 fT   The best resolution of a SQUID (Super Quantum Interference Device) is 1,000,000 times less

Magnetic Fields - A Relative Comparison

LOW LEVEL MAGNETIC FIELDS

Smallest value in a magnetically shielded room	10^-10 Gauss (0.1 nanoGauss)
SQUID	1.0 fT (femtoTesla) (0.1 nanoGauss)
Human Brain Magnetic Field	0.1 – 1.0 pT (picoTeslas) (0.01 - 0.1 microGauss)
Human Heart Magnetic Field	50^-12 Tesla (5 microGauss)
Galactic magnetic field	10 microGauss
Solar Wind	50 microGauss
Interstellar molecular cloud	1 milligauss
Interstellar Space	10^-6 Gauss (1 microGauss)

Hypothesized & Observed Animal Sensitivies to Magnetic Fields	
Honeybees	0.25 mG
Homing Pigeons	0.1 mG
Sharks & Whales	0.5 mG
Lowest level to cause reaction in Electromagnetically Sensitive Patients	0.1 - 0.2 mG

Swedish Safety standard	**1.0 mG (proposed US EPA standard)**
California Safety Limit for Public Schools	**1.2 mG**
Indoor EMF levels (when good wiring practices followed)	**0.1 – 1.2 mG**
New Swiss Standard	**2.5 mG ELF 0.25 mG VLF**
Maximum residential levels in Brentwood TN & Irvine, CA	**4 mG**

Cancer researchers concerned with recent powerline issues are coming up with many reports on oncological effects of very low-level 1 mG ELF electromagnetic fields

Leukemia studies which link low level EMF fields	2 - 4 mG

A study (Ahlbom & Feychting, 1993) reported that at 2 mG and above, exposed children were 2.7 times as likely to develop cancer as unexposed children, and at 3 mG and above, the odds rose to **3.8 times** as likely!

Computer Monitors - VDTs should produce magnetic fields of no more than 2 mG at a distance of 30 cm (about 1 ft) from the front surface of the monitor and 50 cm (about 1 ft 8 in) from the sides and back of the monitor.

The TCO'92 standard has become a de facto standard in the VDT industry worldwide. A 1999 standard, promulgated by the Swedish TCO (known as the TCO'99 standard), provides for international and environmental labeling of personal computers. Many computer monitors marketed in the U.S. are certified as compliant with TCO'99 for low magnetic fields.

Indoor EMF levels with poor wiring practice	3 – 20 mG
Hotspots near breaker boxes, transformers	20 – 2000 mG
Directly beneath high voltage lines	2 – 250 mG
Amount which affects CRT computer monitors (flat screens immune)	10 mG

STRONGER EMF FIELDS

(please note that the DC Magnetic Fields listed are not generally attributed as having negative health effects - and in fact, a number of alternative health experts actually recommend using magnets for healing and fitness)

Earth DC Magnetic Field (natural)	330 mG(equator) – 670 mG (poles)
Earth DC Magnetic Fields (affected by building structure)	200 mG – 800 mG
Recommended Limit for Pacemakers	1000 mG (1 Gauss)
Refrigerator Magnet (thin label type)	10 Gauss
Magnetic Field which could erase magnetic data	10 Gauss
Average Bar Magnet (DC)	100 Gauss
Independent research finds a change in blood behavior	500 Gauss
Strongest Inexpensive Ferrite Magnets	1000 Gauss

High magnetic field levels exceeding 100 Gauss (100,000 mG) may cause a temporary visual flickering sensation called *magnetophosphenes* which disappears when the field is removed.

Gauss required to affect / erase magnetic tape	2000 - 3000 Gauss
Magnets used in Biomagnetic Therapy (DC)	300 - 3000 Gauss
High Powered Neodymium N42 - N45 Magnets (DC)	7500 - 9200 Gauss

EXTREME LEVEL MAGNETIC FIELDS

High Level Laboratory Superconducting Electromagnet	100,000 - 130,000 Gauss
Strongest Sustained Magnetic Field in a Lab	450,000 Gauss
Strongest Magnetic Spike artificially produced (4 - 8 microseconds)	10,000,000 Gauss +
Magnetic Field Instantly Lethal to Organic Life	10^9 Gauss
Surface of a Neutron Star	10^12 - 10^13 Gauss
Surface of a Magnetar	10^15 Gauss
Highest Theorietical Magnetic Field	10^49 - 10^53 Gauss

EMF MEASURING INSTRUMENT RANGES

Typical Range for inexpensive EMF meter	1 – 10 mG
Range for Quality EMF meter	0.1 – 200 mG
Sensitive High Quality Reference Meter	0.01 – 2000 mG
Commerical High Field Gaussmeter	1 mG - 20 kilogauss

ICNIRP Guidelines for EMF Exposure

International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an organization of 15,000 scientists from 40 nations who specialize in radiation protection.

Exposure (60 Hz)	Electric field	Magnetic field
Occupational	8.3 kV/m	4.2 G (4,200 mG)
General Public	4.2 kV/m	0.833 G (833 mG)

International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an organization of 15,000 scientists from 40 nations who specialize in radiation protection.
Source: ICNIRP, 1998.

The National Radiological Protection Board (NRPB) says the UK should adopt international exposure standards. The NRPB has recommended for many years that nobody should be exposed to a level higher than 1,600 microTeslas. (16 mG)

But in a consultation document on restricting people's exposure, it now recommends the UK should adopt the guidelines of the International Committee on Non-Ionizing Radiation Protection (Icnirp).

The commission's recommended level is far lower, at 100 microTeslas. (1 mG)

ACGIH Occupational Threshold Limit Values for 60-Hz EMF

American Conference of Governmental Industrial Hygienists (ACGIH) is a professional organization that facilitates the exchange of technical information about worker health protection. It is not a government regulatory agency.

	Electric field	Magnetic field
Occupational exposure should not exceed for longer than 2 hours	25 kV/m	10 G (10,000 mG)
Exposure limit for workers as suggested by the ACGIH	20 kV/m	- 1 G (1,000 mG)
Prudence dictates the use of protective clothing above	15 kV/m	
Exposure Limit for workers as suggested by the IRPA/INIRC	10 kV/m	5 G (5,000 mG)
German Limit	5 kV/m	1 G (1,000 mG)
Exposure of workers with cardiac pacemakers and other electronic implants should not exceed. Montana has adopted this exposure limit and may be authoritative in the EU soon.	1 kV/m	1 G (1,000 mG)
Recommended 1996 as maximum for "workers" and their working environments by the NCRP, but not yet official. Influences Melatonin synthesis** Already viewed as "critical" by many scientists	100 V/m	10 mG
Aaronia "E2" recommendation Recommended 1996 as maximum for "private individuals" by the NCRP, but not yet official	10 V/m	1.0 mG
Aaronia "E1" recommendation	1 V/m	0.1 mG

American Conference of Governmental Industrial Hygienists (ACGIH) is a professional organization that facilitates the exchange of technical information about worker health protection. It is not a government regulatory agency.

Source: ACGIH, 2001.

RF Levels & Safety

OSHA 1910 Subpart G 1910.97 Occupational health and environmental control Non-ionizing radiation
The exposure limit in this standard (10 mW/sq. cm.) is expressed in voluntary language and has been ruled unenforceable for Federal OSHA enforcement. The standard does specify the design of an RF warning sign.

For PCS antennas, the 1992 ANSI/IEEE exposure standard for the general public is 1.2 mW/cm-sq

For cellular phones, the ANSI/IEEE exposure standard for the general public is 0.57 mW/cm-sq

ICNIRP standard is 0.40 mW/cm-sq for cellular phone frequencies and 0.90 mW/cm-sq for PCS phone frequencies

NCRP guideline is 0.57 mW/cm-sq for cellular phone frequencies and 1.00 mW/cm-sq for PCS phone frequencies

C95.1 - 1999 IEEE / ANSI Standard 1 mW/cm^2 controlled environment 0.2 mW/cm^2 public averaged over 6 minutes

IEEE guidelines **legally enforceable** vary by frequency (10000 / frequency^2)

Pacemaker Manufacturers

Guidant 5.2 mW / cm^2

Medtronics 2.6 mW / cm^2

Massachusetts adopted IRPA recommendations 200 microwatts/ cm^2 SAR 0.04 W / kg

Kirkland AFT Portland, Oregon 100 microwatts / cm^2

Soviet Union 1 microwatt / cm^2

Humans absorb most radiation between 30 - 100 MHz and especially between 77 - 87 MHz.

SAR for cell phones - SAR stands for Specific Absorption Rate, which is the unit of measurement for the amount of RF energy absorbed by the body when using a mobile phone. **Energy absorption** from RF fields in tissues is measured as a **SAR** within a given tissue mass

The unit of **SAR** is **watts per kilogram** (**W/kg**)

RESOURCE LINKS FOR LOOKING UP THE SAR RATINGS OF VARIOUS CELL PHONES
http://www.mmfai.org/public/sar.cfm
www.fcc.gov/oet/fccid

FCC CELL PHONE RADIATION STANDARDS

North American Standard 1.6 Watts per Kg averaged over 1 gram of body tissue
European Standard 2.0 Watts per Kg average over 10 grams of body tissue
Safety factor of 10 later added to create a 0.4 W / kg standard
NCRP recommends 0.08 W / kg

A typical 802.11b wireless network card will transmit at around 30 milliwatts (a few 100mW and 200mW cards out there) and operates in the 2.4 GHz frequency band. Current FCC regulations limit power output to 1 Watt EIRP (Effective Isotropic Radiated Power) for 802.11b (2.4GHz) devices

A study conducted in the Unites States found that, **in large cities** , **the average background** RF levels were **about 50 μ W/m 2** . About 1% of people living in large cities are exposed to RF fields **exceeding 10 mW/m 2** . Higher RF field levels can occur in areas located close to transmitter sites or radar systems.

The average GSM mobile handset has a power output of around 600 milliwatts

Compare this with microwave ovens, which can emit 500 to 700 Watts

RF fields between 10 MHz and 10 GHz penetrate exposed tissues and produce **heating** due to **energy absorption** in these tissues. The depth of penetration of the RF field into the tissue depends on the frequency of the field and is greater for lower frequencies.

SAR is the basic dosimetric quantity for RF fields **between about 1 MHz and 10 GHz.** A **SAR** of at least **4 W/kg** is needed to produce adverse health effects in people exposed to RF fields in this frequency range. Such energies are found tens of meters away from powerful FM antennas at the top of high towers, which makes these areas inaccessible.

RF fields above 10 GHz are absorbed at the skin surface, with very little of the energy penetrating into the underlying tissues.

For adverse health effects, such as eye cataracts and skin burns, to occur from exposure to RF fields above 10 GHz, power densities **above 1000 W/m 2** are needed. Such densities are not found in everyday life. They do exist in very close proximity to powerful radars. Current exposure standards preclude human presence in this areas.

RADIATION LEVELS & SAFETY

Rem (R oentgen E quivalent M an) is the unit of Dose (actually absorbed taking biological effects into account)

Rad (Roentgen Absorbed Dose) is simply the actual amount of radiation absorbed

Rem = Rads x Quality Factor (QF)

where the Quality Factor depends on the type of radiation. Heavy particles as alphas have a QF of 20, neutrons have a QF of 3-10 depending on the energy of the neutrons. Betas and gammas have a QF of 1.

The amount of ionising radiation, or 'dose', received by a person is measured in terms of the energy absorbed in the body tissue, and is expressed in **gray** . One gray (Gy) is one joule deposited per kilogram of mass.

Equal exposure to different types of radiation expressed as gray do not however necessarily produce equal biological effects. One gray of alpha radiation, for example, will have a greater effect than one gray of beta radiation. When we talk about radiation effects, we therefore express the radiation as effective dose, in a unit called the **sievert** (Sv).

1 Rem = .01 Sieverts

A former unit of (radio)activity is the Curie - 1 Bq is 27 x 10 -12 curies.
Title 10 Code of Federal Regulations Part 20 (10CFR20) is the NRC regulation governing radiation protection at a nuclear power plant. This regulation imposes requirements on such important items as annual allowed radiation exposure, radiation protection methods, radioactive releases, and records.

Adult workers may receive a whole body dose 5 Rem per year; minors are restricted to 0.5 Rem per year; pregnant women are restricted to 0.5 Rem during the term of the pregnancy (for protection of the embryo). For comparison, actual physical effects (minor blood changes) from radiation exposure are not expected until a person receives 25 Rem in a short period of time. Higher eye and extremity doses are allowed because these have less effect than on that part of the body containing blood-forming organs.

However there is no scientific evidence of risk at doses below about 50 millisieverts in a short time or about 100 millisieverts per year. At lower doses and dose rates, up to at least 10 millisieverts per year, the evidence suggests that beneficial effects are as likely as adverse ones.

High radiation areas are those where a person could receive more than 100 millirem in an hour.

At a nuclear plant, areas containing radioactive materials may be classified according to radiation level, contamination level, and airborne radioactivity level. Unrestricted areas are those where a person could expect to receive less than 500 millirem in a year.

Background radiation levels are typically around 300 millirem per year. In some areas of the world, background levels can reach as high as 15,000 millirem

Naturally occurring background radiation is the main source of exposure for most people. Levels typically range from about 1.5 to 3.5 millisievert per year but can be more than 50 mSv/yr. The highest known level of background radiation affecting a substantial population is in Kerala and Madras States in India where some 140,000 people receive doses which average over 15 millisievert per year from gamma radiation in addition to a similar dose from radon. Comparable levels occur in Brazil and Sudan, with average exposures up to about 40 mSv/yr to many people.

Several places are known in Iran, India and Europe where natural background radiation gives an annual dose of more than 50 mSv and up to 260 mSv (at Ramsar in Iran). Lifetime doses from natural radiation range up to several thousand millisievert. However, there is no evidence of increased cancers or other health problems arising from these high natural levels.

1 adult human (100 Bq/kg)	7000 Bq
1 kg of coffee	1000 Bq
1 kg superphosphate fertiliser	5000 Bq
The air in a 100 sq metre Australian home (radon)	3000 Bq
The air in many 100 sq metre European homes (radon)	30 000 Bq
1 household smoke detector (with americium)	30 000 Bq
Radioisotope for medical diagnosis	70 million Bq
Radioisotope source for medical therapy	100 000 000 million Bq
1 kg 50-year old vitrified high-level nuclear waste	10 000 000 million Bq
1 luminous Exit sign (1970s)	1 000 000 million Bq
1 kg uranium	25 million Bq
1 kg uranium ore (Canadian, 15%)	25 million Bq
1 kg uranium ore (Australian, 0.3%)	500 000 Bq
1 kg low level radioactive waste	1 million Bq
1 kg of coal ash	2000 Bq
1 kg of granite	1000 Bq

RADIATION LEVELS & THEIR EFFECTS

The following table gives an indication of the likely effects of a range of whole body radiation doses and dose rates to individuals:

10,000 mSv (10 sieverts) as a short-term and whole-body dose would cause immediate illness, such as nausea and decreased white blood cell count, and subsequent death within a few weeks.
Between 2 and 10 sieverts in a short-term dose would cause severe radiation sickness with increasing likelihood that this would be fatal.

1,000 mSv (1 sievert) in a short term dose is about the threshold for causing immediate radiation sickness in a person of average physical attributes, but would be unlikely to cause death. Above 1000 mSv, severity of illness increases with dose.

If doses greater than 1000 mSv occur over a long period they are less likely to have early health effects but they create a definite risk that cancer will develop many years later.

Above about **100 mSv** , the probability of cancer (rather than the severity of illness) increases with dose. The estimated risk of fatal cancer is 5 of every 100 persons exposed to a dose of 1000 mSv (ie. if the normal incidence of fatal cancer were 25%, this dose would increase it to 30%).

50 mSv is, conservatively, the lowest dose at which there is any evidence of cancer being caused in adults. It is also the highest dose which is allowed by regulation in any one year of occupational exposure. Dose rates greater than 50 mSv/yr arise from natural background levels in several parts of the world but do not cause any discernible harm to local populations.

20 mSv/yr averaged over 5 years is the limit for radiological personnel such as employees in the nuclear industry, uranium or mineral sands miners and hospital workers (who are all closely monitored).

10 mSv/yr is the maximum actual dose rate received by any Australian uranium miner.

3-5 mSv/yr is the typical dose rate (above background) received by uranium miners in Australia and Canada.

3 mSv/yr (approx) is the typical background radiation from natural sources in North America, including an average of almost 2 mSv/yr from radon in air.

2 mSv/yr (approx) is the typical background radiation from natural sources, including an average of 0.7 mSv/yr from radon in air. This is close to the minimum dose received by all humans anywhere on Earth
.

0.3-0.6 mSv/yr is a typical range of dose rates from artificial sources of radiation, mostly medical.

0.05 mSv/yr , a very small fraction of natural background radiation, is the design target for maximum radiation at the perimeter fence of a nuclear electricity generating station. In practice the actual dose is less.

NOISE LEVELS OSHA Safety Limits

90 dB	8 hours
92 dB	6 hours
95 dB	4 hours
97 dB	3 hours
100 dB	2 hours
102 dB	1.5 hours
105 dB	1 hour
110 dB	0.5 hours
115 dB	0.25 hours or less