FACT SHEET

ON THE GUIDELINES ON LIMITS OF EXPOSURE TO STATIC MAGNETIC FIELDS PUBLISHED IN HEALTH PHYS 96(4):504-514; 2009.

The rapid development of technologies using static magnetic fields in industry and medicine has resulted in an increase in human exposure to these fields. ICNIRP is the internationally recognised body that sets guidelines for protection against adverse health effects of non-ionizing radiation. It has recently published Guidelines on limits of occupational and general public exposure to Static Magnetic Fields; this Fact Sheet describes the content of these Guidelines and the background to them.

Magnetic fields exert physical forces on electric charges, but only when such charges are in motion. The magnetic flux density, measured in teslas (T), is accepted as the most relevant quantity for assessing magnetic field effects. The natural static magnetic field of the earth is ~50 μT, varying geographically from ~30 to 70 μT. Magnetic flux densities of the order of 20 μT are produced under high direct current transmission lines. Fast passenger trains based on magnetic levitation produce relatively high magnetic flux densities close to the motor. Other sources of static magnetic fields in residential and occupational environments include small permanent magnets in magnetic clips and magnetic attachments (such as in bags and magnetic toys), which generate local static fields in excess of 0.5 mT. The highest non-occupational exposure occurs in patients undergoing a diagnostic examination by magnetic resonance imaging (MRI), a technique used to obtain diagnostic information and increasingly to guide surgical interventions. In MRI procedures, magnetic flux densities typically range from 0.15 to 3 T. Staff involved with the manufacture or maintenance of these MRI systems are also exposed to high fields. Interventional medical procedures under direct real-time control by MRI lead to increased exposure for medical staff.

Functional MRI using magnetic fields up to about 10 T is now widely used in academic and medical research on human brain function. Strong fields are also produced in high-energy technologies such as thermonuclear reactors, superconducting generators, research facilities such as bubble chambers and particle accelerators, and industries involving electrolytic processes such as chlorine or aluminium production, with peak exposures up to several 10's of mT, and in the manufacture of permanent magnets and magnetic materials.

The three established physical mechanisms through which static magnetic fields interact with living matter are magnetic induction, magneto-mechanical, and electronic interactions.

Numerous in-vitro studies of potential biological effects of static magnetic fields have been conducted, analysing endpoints including cell orientation, cell growth, metabolic activity and gene expression. Overall, these studies do not give convincing evidence of harmful effects of exposure to magnetic fields with flux densities up to several teslas. Laboratory studies of animals show aversive responses and conditional avoidance of fields of about 4 T or higher, thought to be vestibular in origin.

Fields greater than about 0.1 T induce flow potentials particularly in and around the heart and other major blood vessels, but their significance for health is unclear and no clinically significant neurological effect or effects on cardiovascular function, foetal development, carcinogenesis, or other endpoints have been found from exposures up to 8 T.

In laboratory studies of humans, no pronounced effects on physiological parameters have been found from exposure to fields up to 8 T, except for a small increase in systolic blood pressure. Based on modelling, a clinically significant blood flow reduction is predicted only at fields level over 15 T. There is no evidence of effects of exposures up to 8 T on other aspects of cardiovascular function, or on body temperature, memory, speech or auditory-motor reaction time, or of any serious health effects in human volunteers. There is some evidence for effects on eye-hand co-ordination and visual contrast sensitivity. Fields of 2-3 T can cause transient sensory effects including nausea, vertigo, metallic taste, and phosphenes when moving the eyes or head; sensitivity varies between individuals, and the effects can be minimised or abolished by moving more slowly through the field.

There are few epidemiological data on long-term health in persons exposed to static fields, and none on potentially high exposure groups such as MRI operators. The available studies, on workers exposed up to several tens of mT in work in aluminium smelters, chloralkali plants, or as welders have had methodological limitations, but do not indicate strong effects from exposure of the above levels on cancer incidence, reproductive outcomes, or the other outcomes studied.

Based on review of the scientific evidence summarised above, ICNIRP recommends the following limits for exposure:

Occupational exposures

Exposure limits: It is recommended that occupational exposure of the head and trunk should not exceed a spatial peak magnetic flux density of 2 T. However, for specific work applications, exposure up to 8 T can be permitted, if the environment is controlled and appropriate work practices are implemented to control movement-induced effects. Sensory effects due to movement in the field can be avoided by complying with basic restrictions set in the ELF guidelines. When restricted to the limbs, maximum exposures of up to 8 T are acceptable.

General public exposures

Exposure limits: Acute exposure of the general public should not exceed 400 mT (any part of the body), reflecting a reduction factor of 5 with respect to the occupational limits. However, because of potential indirect adverse effects, ICNIRP recognizes that practical policies need to be implemented to prevent inadvertent harmful exposure of people with implanted electronic medical devices and implants containing ferromagnetic materials, and injuries due to flying ferromagnetic objects, and these considerations can lead to much lower restriction levels, such as 0.5 mT (IEC, 2002). The exposure limits to be set with regard to these non-biological effects are not, however, the remit of ICNIRP.

The rationale for these guidelines limits can be found in full in "Guidelines on limits of exposure to static magnetic fields Health Physics 96(4):504-514; 2009."

The Table summarises the limits:

Exposure characteristics	Magnetic flux density
Occupational[b]	
Exposure of head and of trunk	2 T
Exposure of limbs	8 T
General Public[c]	
Exposure of any part of the body	400 mT

[a] ICNIRP recommends that these limits should be viewed operationally as spatial peak exposure limits.
[b] For specific work applications, exposure up to 8 T can be justified, if the environment is controlled and appropriate work practices are implemented to control movement-induced effects.
[c] Because of potential indirect adverse effects, ICNIRP recognizes that practical policies need to be implemented to prevent inadvertent harmful exposure of person with implanted electronic medical devices and implants containing ferromagnetic material, and dangers from flying objects, which can lead to much lower restriction levels such as 0.5 mT.

Protective Measures

ICNIRP recommends that the use of these guidelines should be accompanied by appropriate protective measures. These measures need to be considered separately for public places, where exposures to static magnetic field are likely to be very low and infrequent, and workplaces, where in some work situations strong static fields may be encountered. For members of the public, there is a need to protect people with implanted medical devices against possible interference and against forces on implants containing ferromagnetic material. In addition, in some specific situations, there is a risk from flying ferromagnetic objects such as tools. In work situations involving exposure to very high fields, there is a need for a set of site-specific work procedures intended to minimise the impact of transient symptoms such as vertigo and nausea. Further details can be found in Health Physics 96(4):504-514; 2009.