FACT SHEET

ON THE GUIDELINES FOR LIMITING EXPOSURE TO ELECTRIC FIELDS INDUCED BY MOVEMENT OF THE HUMAN BODY IN A STATIC MAGNETIC FIELD AND BY TIME-VARYING MAGNETIC FIELDS BELOW 1 HZ
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The rapid development of technologies using static magnetic fields particularly in medicine has resulted in an increase in human exposure to very high static magnetic fields. ICNIRP is the internationally recognised body that sets guidelines for protection against adverse health effects of non-ionizing radiation including static magnetic fields. It has recently published guidelines on limiting exposure to electric fields induced by movement of the human body in a static magnetic field and by time varying magnetic fields below 1 Hz. Previously ICNIRP published Guidelines for limiting exposure to time-varying electric and magnetic fields from 1 Hz to 100 kHz.

This Fact Sheet describes the content and background of the guidelines on limiting motion induced electric fields and magnetic fields below 1 Hz. The main objective of the guidelines is to provide protection of workers against established adverse direct health effects arising from these exposures and to avoid sensory effects which may be annoying and impair working ability.

Magnetic fields exert physical force on charges moving with the body. This force is equivalent to an electromotive electric field which causes polarization of charges and circulating internal electric fields in the body. In the steady state the internal electric field is determined by the magnetic flux changing due to the movement (Faraday's law).

Extremely high static magnetic fields above 2 T may cause various temporary biological effects such as vertigo, nausea, visual sensations (magnetic phosphenes), metallic taste in the mouth and even stimulation of peripheral nerve cells. Studies with human volunteers indicate that effects on higher cognitive levels such as temporary disturbances in concentration, attention, memory and coordination of eye movements are possible; sensitivity varies between individuals, and the effects can be minimised or abolished by slowing down movements. Most of the effects are clearly due to the electric field induced by the movements of the body in a magnetic field but in the case of vertigo recent studies suggest that a direct effect of the magnetic field on the ionic currents in the vestibular organ may contribute to the vertigo perception.

Except peripheral nerve stimulation the effects do not indicate any serious hazard but they can be disturbing and may impair working ability. For normal movements, the threshold for peripheral nerve stimulation is unlikely to be reached with exposures below 8 T, although it is possible that the basic restrictions for peripheral nerve stimulation (see below) may slightly be exceeded by very fast movements.

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

Basic restrictions

In order to prevent vertigo arising from relatively slow motions in a static magnetic field, the change of the magnetic flux density ΔB should not exceed 2 T during any 3 s period.

For specific work applications, exposure to a static magnetic field up to 8 T can be justified, if appropriate work practices are implemented to control movement-induced sensory effects (controlled conditions)

In the case of a stationary body in a time-varying magnetic field, the peak-to-peak value of the magnetic flux density is equivalent to ΔB and consequently should be limited to 2 T.

Vertigo and resulting nausea may be annoying and disturbing, but they do not indicate a serious long-term health effect. Therefore, no additional reduction factor has been applied to their threshold.

In order to prevent peripheral nerve stimulation (PNS) arising from fast transient motions, the peak internal electric field should not exceed 1.1 V/m.
Because the stimulation of peripheral nerves is regarded as an adverse health effect the reduction factor 5 has been applied to the threshold to account for biological uncertainties.

Reference levels

A practical way for determining compliance with the basic restrictions for fast transient motions is to ensure that the magnetic flux density does not exceed the reference levels derived conservatively from the basic restrictions.

In order to avoid electrical stimulation of peripheral nerves, the reference level for peak dB/dt, i.e. the time derivative of the magnetic flux density, has been set to 2.7 Ts-1. Note that to account for uncertainties arising from the conversion of the basic restriction to the reference level a reduction factor of approximately 3 is included in this reference level.

The below table summarizes the basic restrictions and reference levels:

Basic restrictions					Reference levels	
Frequency (Hz)	ΔB (T) [1]	$B_{peak\ to\ peak}$ (T)	Internal electric field strength (Vm^{-1} ($_{peak}$))		dB/dt (Ts^{-1} ($_{peak}$))	
Critical effect	Vertigo due to movement in static B field	Vertigo due to time-varying B field	PNS effects due to movement in static B field and due to time-varying B field	Phosphenes due to movement in static B field and due to time-varying B field	PNS effects due to movement in static B field and due to time-varying B field	Phosphenes due to movement in static B field and due to time-varying B field
Exposure condition [2]	uncontrolled	uncontrolled	Controlled	Uncontrolled	Controlled	Uncontrolled
0	2					
0-1		2				
0-0.66			1.1	1.1	2.7	2.7
0.66-1 [3]			1.1	0.7/f	2.7	1.8/f

Notes:
1) The maximum change of magnetic flux density ΔB is determined over any 3 s period.
2) For controlled work environments, a ΔB of 2 T may be exceeded.
3) f in Hz

To prevent magnetophosphenes it is recommended to limit the internal electric field below 0. 7/f and peak dB/dt below 1.8 /f (f is frequency in Hz). Because the spectrum of the magnetophosphenes extends well above 1 Hz it is necessary to extend the limits above 1 Hz by using the ICNIRP 2010 guidelines for time varying electric and magnetic fields. At 1 Hz the basic restrictions and reference levels in the table above join with the corresponding limits presented by the 2010 guidelines. Because the limits for the magneto phosphenes change as a function of frequency it is necessary to apply the weighted peak procedure explained in the 2010 guidelines.

Further details can be found in Health Physics 106(3):418-425; 2014.