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Electric and magnetic fields in daily life

Recommendation of the German Commission on Radiological Protection

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Elektrische und magnetische Felder im Alltag

Empfehlung der Strahlenschutzkommission

In the event of any doubts about the meaning, the German original as published shall prevail.

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1 Introduction

A large part of the population anticipates detrimental health effects from electric and magnetic fields. Under discussion are primarily reports describing a connection between field effects and the occurrence of headaches, exhaustion, allergies, genetic damages or cancer. The various electric and magnetic fields in our daily technical environment are often called "electrosmog". This figurative term is, of course, in need of an exact specification since field effects vary in the range of frequency and field strength and also involve different types of effect mechanisms than those connected with smog due to chemical substances. Furthermore, terms such as electro-stress and electro-sensitivity are used by the media, meaning effects from electric and magnetic fields with a frequency of 50 Hz in the vicinity of electric installations, electric household appliances or overhead high-voltage lines.

The current recommendation of the Commission on Radiological Protection provides an overview of electric and magnetic field strengths occurring in everyday life, describing possible biomedical effects and evaluating the introduction of new safety standards.

2 Electric and magnetic fields with mains frequency

The usual domestic operating voltages of 220 or 380 Volt produce electric fields with a field strength of about 10 Volt per meter (V/m). These are also present if appliances are not in operation, i.e. without flow of current. On the surface of some appliances (e.g. electric stoves or blankets) field strengths of 500 V/m may be reached.

Overhead high voltage lines with operating voltages between 110 and 380 Kilovolt (kV) produce electric fields with field strengths of 1 to 10 kV/m near ground level. With underground cables, the electric field is well enough shielded so as to not have any effect on the soil surface. House walls may reduce the field strengths of electric fields by up to 90%.

Magnetic fields are produced by the flow of electric current. Contrary to electric fields, they cannot be shielded for practical purposes. On the immediate surface of electric appliances, magnetic field strengths of up to 800 Ampere per meter (A/m) may be produced in accordance with a magnetic flow density of 1 Millitesla (mT). They may be reduced within a distance of e.g. 30 cm to values below 30 A/m. For example, the natural static magnetic fields on this earth amounts to about 40 A/m.

Below overhead lines and at the highest possible operating current, magnetic field strengths of up to about 25 A/m are produced near the soil surface. Also with underground cables, the magnetic field strength is of the same range. In the immediate vicinity of cable distributor boxes, a top value of about 600 A/m will be reached. At a distance of one to two meters, this value amounts to less than 25 A/m.

The operation of electromotors in subway and streetcar locomotives may produce magnetic field strengths of up to about 40 A/m at the edge of the platform or in the train.

3 Effects of electric and magnetic fields on man

3.1 Acute effects

If man is exposed to an alternating electric field, a redistribution of the body charge with the alternating frequency is taking place, resulting in electric charges alternating with the frequency on the body surface and in electric currents within the body.

At sufficiently high field strengths, surface charges lead to perceptible surface effects, such as vibration of bodyhair or the generation of sparks between skin an clothing. The perception threshold values may differ from person to person. A field strength of 1 kV/m is perceived by about 1 to 3 % of test persons due to the vibration of bodyhair, 10 kV/m by about 20 to 55 % of the test persons. The perception of electric fields by vibrating bodyhair, spark discharges and current discharges as well as the perception of magnetic fields by visual flicker manifestations is occasionally felt as a burden and impediment of the general feeling of well-being.

The currents induced in the body by electric or magnetic fields may produce biological effects, depending on the current density measured in milliampere per square meter (mA/m^2).

Below 1 mA/m^2, scientifically proven biological effects are not known to exist. Such current densities can be produced in the organism by electric fields of more than about 2 kV/m or by alternating magnetic fields of more than 50 A/m.

Laboratory test with cell cultures as well as with rodents showed that cell-biological effects may temporarily occur at current densities above 1 mA/m^2. Corresponding observations refer to mostly marginal changes in cell proliferation, nucleic acid synthesis, membrane functions, ion distributions or hormone levels. There are no indications of long-term effects on the total organism. Tests on volunteers exposed to electric fields of up to 20 kV/m for 3 hours up to 1 week, gave also no evidence of statistically ascertainable effects. Examined were: times of reaction to acoustic and optic irritants, psychological factors, EEG, ECG, blood pressure, pulse frequency, body temperature, hematological parameters, biochemical urine characteristics as well as enzyme functions and metabolic factors.

Acute health detriment from nervous disorders, muscle- and cardiac malfunctions can be observed when body current densities range between 100 mA/m^2 and 1000 mA/m^2. Electric and magnetic fields producing current densities of this magnitude do not occur in daily life.

Various manifestations, which are common in daily life, are called indirect field effects. When approaching conductive objects in an electric field or by touching such objects, discharge currents may flow through the body depending on size and arrangement of these objects. Such effects may also be caused by static charges without direct influence from electric fields. They are commonly called "electrification". Known examples are discharge currents on cars or on door handles after having walked on insulated floor coverings. They may cause a painful emission of sparks.

The perception threshold for spark emissions depends on the affected parts of the body. The strength of perception depends on the strength of conductivity in the object and on the prevailing field strength. In electric fields, such as under a high voltage line, "electrifications" may already be perceived at a field strength of about 0.5 kV/m under unfavourable conditions.

Indirect effects occurring in daily life are not considered to be detrimental to health but can be perceived as burden or pain.

3.2 Late effects

Although neither dose-effect-relationships nor an induction of carcinogenic mechanisms are so far known in connection with electric or magnetic fields, several authors have discussed the promotion of a carcinogenic effect. In particular epidemiological studies in North America and Sweden gave rise to the assumption that long-term exposure to magnetic fields in daily life may promote the induction of cancer and leukaemia. However, these assumptions are contradicted by negative results. Due to the great statistic variance, none of the investigations could prove a clear connection. The majority of studies showed insufficiencies in defining accompanying factors as well as in the choice of control collectives. Furthermore, the World Health Organisation (WHO) as well as the International Radiological Protection Association (IRPA) are considering such a connection as unfounded. For a final clarification of late effects from electric and magnetic fields, also in view of combined effects, apparently further research is needed.

3.3 Interference with cardiac pacemakers

In Germany the heart function of about 170,000 patients is controlled by electronic cardiac pacemaker implants which, if a heartbeat fails to appear, release a contraction by electronic impulse. If signals from electromagnetic fields are coupled into the circuit formed by the electrode between the inner heart and the implant in the upper thorax region, the pacemaker function may be influenced. Effects range from an insignificant single interval extension up to a "stumbling rhythm" when the rhythm of the cardiac pacemaker is added to the intrinsic rhythm. A life-threatening interference is extremely rare and so far has been observed only from the combined effect of a variety of unfavourable constellations.

An interference may be produced by magnetostatic fields of more than 240 A/m or by 50 Hz-alternating fields of more than 16 A/m or 2.5 kV/m. Even if these values are exceeded, especially in the vicinity of magnetic fields in households or industries, there is no danger for pacemaker patients that would result from common daily activities. As a rule, a distance of 30 cm between the field-producing device (including microwave cookers) and the cardiac pacemaker excludes an interference.

The problem of a possible interference with cardiac pacemakers has meanwhile been recognized. This resulted in warning legends on or protective fences around appliances and installations possibly causing interference with cardiac pacemakers. There is no reason for pacemaker patients to be unduly concerned.

4 Limits

Limits for the protection of individuals from the effects of electromagnetic fields are defined in the Federal Republic by DIN-VDE-Standards. Since the effects from electric or magnetic fields at the place of work or in daily life cannot be unequivocally connected with late effects (cancer) on the basis of the presently available data, the recommended limits apply to acute effects (compare 3.1: acute effects).

The DIN-VDE-Standard 0848 part 4, October 1989, defines safety limits for occupationally exposed workers and the overall population. According to this standard at a frequency of 50 Hz, 20 kV/m for electric fields and 4,000 A/m for magnetic fields may not be exceeded. These limit values exclude induced current densities for the head or the heart of more than 10 mA/m^2.

Lower limits are currently under discussion, which shall take into account the special protective needs of sensitive individual groups, the possibility of permanent field effects as well as the involuntary or unaware effect on individuals. The Commission on Radiological Protection from the aspect of prevention recommends an orientation on the limits recommended by IRPA. These recommended limits for the overall population exclude considerable disturbances from direct acute and indirect effects which have so far been considered acceptable like those for individuals occupationally exposed to electric and magnetic fields. The IRPA-recommendations for limits are based on limiting the body current densities produced in the organism by electric or magnetic alternating fields. The permanent exposure of members of the population should not exceed electric body current densities of 1 to 2 mA/m^2 . Derived from these are the limits of 5 kV/m for electric and of 80 A/m for magnetic field strengths. The Commission on Radiological Protection is calling attention to the fact that measurement devices are available at electric power plants whereby electric and magnetic fields can be measured to maintain the limits.

The Commission on Radiological Protection is aware of the fact that the limits are designed for the effects from only one environmental influence. The possible combination with other physical influences, chemical toxic agents or biological factors has not been taken into account. In addition, it is known that sensitive individuals may perceive electric fields as disturbing even below the limits and consider them as an impediment of their general well-being. Long-term health damages, however, are not known to exist.

5 Summarized evaluation of effects from electric and magnetic fields in daily life

According to the current status of research there is no indication of a connection between the effects from electric or magnetic fields in daily life and the occurrence of headaches, excitability, exhaustion, allergies or late effects such as genetic damages and cancer. The indications derived from epidemiological investigations of a possible cancer or leukaemia induction from electric power systems are not sufficiently convincing due to a lack in methodology. On the other hand, on account of insufficient knowledge about corresponding effect mechanisms, the possibility of an induction or promotion of late effects cannot be generally excluded. The significance of experimentally observed short-term effects (e.g. change of ion distribution, membrane function, cell proliferation) as well as the possibility of effects in "response windows" (at certain field strengths, frequencies or waveforms) should be further clarified by additional research studies, also in view of a possible induction of late effects. Concerning the electric and magnetic fields in daily life, all presently known data and experiences speak against effects that are damaging to health.