10 Electrostatic and electromagnetic fields

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10.1 Electrostatic fields

Static electricity can occur when two different materials are rubbed against each other and then separated (this is known as “frictional electricity”). The friction generates heat, resulting in a momentary change in the structure of both materials’ surfaces. This leads electrons to migrate from one surface to the other, producing an excess charge on both surfaces, equal in size but with opposite polarities. If these charges cannot move away when the surfaces are separated, in other words if they are not able to equalize each other out, the result is an electrical field known as “static electricity”.

The size and polarity of the field depend on

- the nature of the materials involved, particularly their relative position in the electrochemical series,
- the intensity of the contact/separation process,
- the surface conductivity and
- the ambient conditions (e.g. the relative humidity).

Charges occur whenever there is contact and movement between different, non-conductive materials. This mostly happens between synthetic materials, e.g. when

- someone walks across a synthetic carpet,
- fabric is separated,
- tape is unwound from a roll,
- materials are shredded, sprayed or atomised and
- substances, e.g. liquids or dust, flow along walls.

People can become charged through movement or charge transfer (electrostatic induction). Garments that do not provide sufficient conductivity promote charge build-up. Touching charged objects can also cause charge transfer. Table 18 shows the voltage levels generated by electrostatic charges during typical office activities.

Table 18:
Voltage levels that can be generated by electrostatic charge

Activity	Voltage in V
Walking across a carpet	1,500 to 35,000
Walking across an untreated vinyl floor covering	250 to 12,000
Working at a desk	700 to 6,000
Inserting a sheet of paper into a vinyl document wallet	600 to 7,000
Picking up a plastic bag from a desk	1,200 to 20,000

For electrostatic charge to be produced, the surface resistance of the materials involved must be higher than 109 W and the relative humidity lower than 45%.

If charged objects or persons come into contact with earthed, electrically conductive substances or other persons or get so close to them that sparks are caused due to the strength of the electrical field, electrostatic discharge can occur. Some of the factors that influence the discharge process are the:

- electrostatic voltage level,
- speed at which the electrostatically charged object approaches the conductive or earthed object,
- ambient conditions, e.g. temperature, air pressure, humidity, dust particles and
- geometric and surface features of the objects.

Some discharge effects are familiar to us from our everyday lives. The best known are sparks when touching door handles, banisters or car bodies and the crackling or even sparks that occur when removing a synthetic garment.

Hazards posed by electrostatic fields

Generally speaking, electrostatic fields do not pose a hazard to humans. In fact, we do not even notice the charging process. However, there is a risk of people being startled and then reacting incorrectly when discharge suddenly occurs in people or mobile objects (such as chairs, trolleys or cleaning devices) after an electrostatic charge.

Humans notice electrostatic discharge when it exceeds approximately $5 \cdot 10^{-4}$ J, which is equivalent to a discharge voltage of 2,000 to 3,100 V with a typical human body capacitance of 100 to 250 pF relative to the earth. In office scenarios, the voltage level can be higher than that even when routine activities are being carried out (see Table 18).

To rule out the possibility of electrostatic discharge causing hazards, the energy transferred via the human body should not exceed 350 mJ or the charge transferred by the body should be no higher than 50 µC. When discharge occurs on electronic equipment, these levels of energy stored in humans are enough to destroy semiconductor components inside the equipment. In particular, a person with a charge of just a few volts can cause irreparable damage to a semiconductor component if they come into direct contact with the terminal for that component. For instance, a discharge voltage of

- 100 V is sufficient to delete a piece of information from a magnetic data storage medium,
- 50 V is sufficient to generate a spark that can ignite explosive gases and
- 5 V is sufficient to cause damage to the highly sensitive reading head of a hard disk.

In addition to this direct damage, electrostatic charge can cause particles to collect on smooth surfaces, resulting in such phenomena as grime on monitors or dust deposits.

Protection against static electricity

Experience has shown that electrostatic charges cannot be completely prevented in practice. Often they are so strong that circuit breakers in electronic devices cannot fully discharge them. It is therefore necessary to take precautions in order to reduce or discharge electrostatic charge, which can be done by the following means:

- Reducing contact areas:

  Electrostatic charges can be reduced if the contact surface is decreased or changed, e.g. by roughening (matting) it. This is a common course of action with films or film-based products, e.g. transparent document wallets.

- Earthing:

  If earthing is carried out correctly, any charge will be quickly discharged. It must be ensured that the bleeder is lower than 10^9 Ω. Correct earthing can be achieved by installing conductive or antistatic floor coverings, earthing any conductive furniture and work surfaces and fitting conductive rollers or wheels to chairs and carrying aids.

- Decreasing surface resistance and increasing relative humidity:

  Reducing surface resistance by ionising air or increasing humidity is seldom an option in indoor workplaces. Ambient air can only be ionised locally and it only takes effect once a minimum voltage level has been reached. This approach only makes sense in industrial workplaces where electrostatic charges have a disruptive effect. If the humidity is increased, the thermal environment requirements described in these recommendations (see Chapter 9) must be observed.

Static electricity protection requirements should be observed from an early stage, when selecting materials, as this reduces the need for action to be taken later.

10.2 Electric, magnetic and electromagnetic fields

In the modern world, humans are surrounded by natural and technically generated electric, magnetic and electromagnetic fields (EM fields). Examples of natural fields include the Earth's own magnetic field and electric fields arising from storms. Technically generated fields come about when electrical energy is produced, distributed and consumed.

Relatively high EM fields can occur in workplaces where they are used in accordance with the regulations for such things as part processing (in forging systems, furnaces, etc.). This section does not cover these types of workplace.

In indoor workplaces, EM fields can only occur in the immediate vicinity of electrical devices and systems operated there. It should be noted, though, that these fields are considerably weaker than those used to process parts. Nonetheless, it is a common concern that exposure to EM fields could have adverse effects in these workplaces too.

The frequency spectrum of EM fields ranges from static fields with a frequency of 0 Hz to alternating fields with frequencies of up to 300 GHz. Figure 14 shows examples of the different frequencies of EM fields and their applications and effects.

Static fields do not vary with time. Electric and magnetic static fields – two separate fields – have practically no relevance in indoor workplaces. However, active medical implants such as pacemakers, defibrillators, insulin pumps or cochlear implants can be affected by nearby permanent magnets.

The low-frequency EM field range covers all frequencies between 0 Hz and 30 kHz. Because of the low frequencies, the electrical field and the magnetic field are virtually disconnected and can be considered separately. Consequently, the electric field depends only on the voltage U and the magnetic field only on the current I. In systems and devices with high working currents, it is generally the magnetic field that is dominant. Conversely, high-voltage systems have a dominant electric field.

Any low-frequency fields that occur are primarily determined by the location of the electrical wiring and equipment. Both the electric and magnetic field strengths decrease as the distance from the field source increases. Figure 15 shows how the magnetic field strength varies depending on the distance from and the shape of the field source.

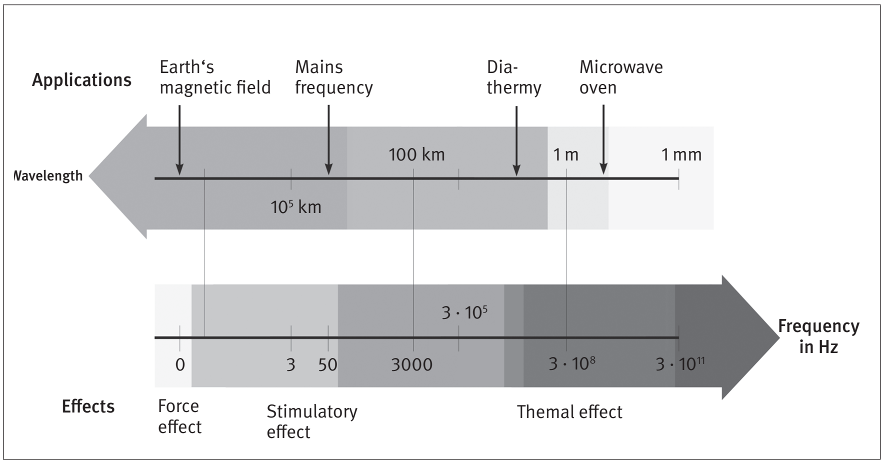


Figure 14:
Frequency spectrum of electromagnetic fields and their effects

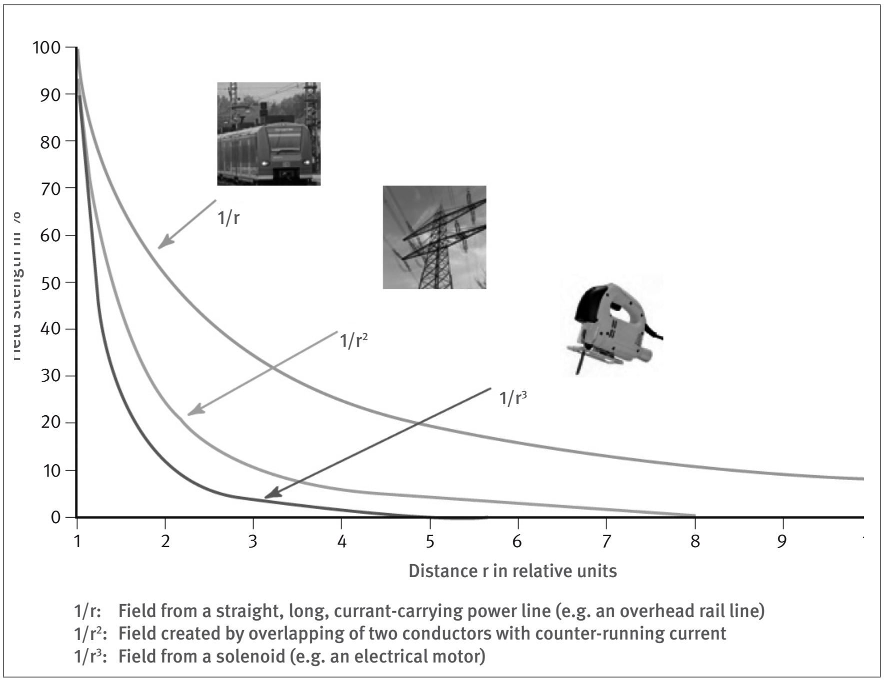


Figure 15:
Decline in the magnetic field strength of various sources in correlation with distance
(Source: Landesamt für Umwelt, Messungen und Naturschutz Baden-Württemberg. State Institute for Environment, Measurements and Nature Conservation Baden-Wuerttemberg [1], *Schutterstock*)

Electric fields can easily be altered by conductive materials, which have a distortive or shielding effect. By contrast, reducing magnetic fields is an extremely complex process because they are able to penetrate non-magnetic substances virtually unhindered [2].

The high frequency range starts at frequencies above 30 kHz and extends to the end of the microwave region at 300 GHz. It is not possible to consider the electric and magnetic field components separately in this frequency range because of the close connection between the two. The fields can detach themselves from their source, e.g. from an antenna, and spread across large distances. They are then referred to as electromagnetic waves. Unlike other waves, electromagnetic waves do not need a carrier or a propagation medium, which means they are also able to spread in a vacuum. Their propagation speed in this case is equivalent to the speed of light ($c = 3 \cdot 10^8$ m/s). Electromagnetic energy is transported in the direction of the propagation. Power flux density, expressed in W/m², can be used to quantify the energy flux. The term power flux density is used interchangeably with power density, energy flux density and radiation density.

Effects of EM fields

EM fields can have direct and indirect effects. Direct effects of low-frequency electric fields are displacement currents induced in the human body and electric fields in the tissue. In strong electric fields, other effects can be a tingling sensation or hair standing on end on the skin's surface. Low-frequency magnetic fields induce eddy currents in the human body and electric fields in the tissue. If the currents and/or fields induced in the body/tissue exceed certain threshold values, they can excite nerve and muscle cells. Table 19 (page 60) shows examples of the effects on the human body as a function of flux density.

Current scientific knowledge indicates that induced electrical field strengths of 50 mV/m and electrical flux densities of less than 10 mA/m² are not likely to cause adverse effects on the human body [3 to 5].

High-frequency electromagnetic fields, on the other hand, can cause heat build-up in the human body. When electromagnetic waves hit the human body, a portion of them is reflected and another portion penetrates the body and is absorbed by it. The depth of penetration depends on the type of tissue and the frequency of the electromagnetic field. The energy from the radiation absorbed in the body is converted into heat, which brings about an increase in body temperature – initially at the site of absorption. However, heat conduction and the body's temperature regulation system can cause the temperature to rise in other areas of the body as well. The temperature regulation system endeavours to maintain the core body temperature at a constant 37 °C. A high increase in core body temperature can cause damage; an increase to above 42 °C is fatal. To prevent damage, the extent to which electromagnetic fields are absorbed by the human body must be restricted to ensure that any resulting temperature increase is no higher than 1 °C.

Table 19:
Effects in the body as a function of flux density

Flux density in mA/m²	Effects
‹ 1	No substantiated biological effects
1 to 10	No confirmed effects; unsubstantiated reports of discomfort in specific individuals
10 to 100	Well-substantiated effects; visual sensations; effects on the nervous system; reports of accelerated healing of bone fractures
100 to 1,000	Potentially harmful to health; discomfort thresholds; confirmed change in the excitability of the central nervous system
› 1,000	Potential damage; heart contractions possible, ventricular fibrillation

One unit for measuring the extent to which the body absorbs energy from high-frequency electromagnetic fields is the specific absorption rate (SAR), which is expressed in W/kg.

Apart from these scientifically substantiated direct effects of EM fields, there is public debate about other possible, though as yet unproven, effects. They range from such phenomena as malaise to headaches, sleeping disorders, influences on the hormonal system and even cancer. There are frequent calls for the permissible values for electromagnetic fields to be lowered, citing these suspected effects. In most cases, the term electrosmog is used rather than electromagnetic field – the intention being to make it clear that electromagnetic fields are present everywhere in our normal environment and are considered a potential risk.

The Strahlenschutzkommission (German Commission on Radiological Protection) constantly monitors the latest findings and publishes them on its website [6] and elsewhere. In terms of causal links between exposure to EM fields and the incidence of certain effects, the Commission distinguishes between what it refers to as hints, suspicions and proof. There are hints for numerous effects and a suspicion for two effects caused by low-frequency EM fields. But there is no scientifically substantiated proof apart from for the direct effects outlined above.

The indirect effects include force effects exerted on ferromagnetic materials and effects on electronic devices. Force effects occur, for example, in the immediate vicinity of MRI scanners. However, such effects do not play a role in indoor workplaces. A further indirect effect is interference with active medical implants.

Electric, magnetic and electromagnetic fields can cause interference with other electronic devices as well as with active medical implants. In the past, magnetic fields often caused faults in cathode ray tube (CRT) monitors but this no longer happens with TFT display screen equipment, which is mostly used today.

EM field occurrence in indoor workplaces

Most appliances in or near indoor workplaces generate electric and magnetic fields with a mains frequency of 50 Hz. High-power electrical appliances create quite substantial magnetic fields. In addition, magnetic fields occur in the immediate vicinity of small transformers. The electric field strengths of appliances in indoor workplaces are very low and can therefore be disregarded.

Table 20 shows examples of low-frequency field sources and their emissions measured at various distances. These values can be used to assess the relevance of potential field sources in indoor workplaces and to distinguish between significant and insignificant sources.

Indoor workplaces can also be located close to power supply and distribution systems (see Figure 16, page 62). Measurements of various systems have produced results considerably lower than the permitted values in the DGUV regulation 15 [9]. This is also true of the electrical wiring in buildings. However, distribution systems located in offices can interfere with IT systems.

Generally speaking, the electric and magnetic field values recorded near low-voltage and medium-voltage underground cables are much lower than the permissible values as the underground location of the cables means the workplaces are a certain distance away from the cables.

Near overhead lines, the electric and magnetic fields depend on the distance from the line, the voltage level and the current. The electrical field strengths and magnetic flux densities are much lower than the permissible values. This is due to the height of the power line systems and the minimum distance from the lines specified in electrical safety requirements. Electrical field strengths of several kV/m are possible directly below overhead lines (where there are no buildings). Magnetic flux densities of up to 20 mT have been observed where the current level was 1 kA. By way of comparison, the lowest values permitted in the DGUV regulation 15, formerly BGV B11, "Electromagnetic fields" [9], are 6.6 kV/m for electric fields and 424 mT for magnetic fields. In public areas, the values permitted by the 26th Bundesimmissionsschutzverordnung (BImSchV; Federal Immission Control Ordinance) [12] are 5 kV/m and 100 µT respectively.

Furthermore, buildings, trees, bushes and any conductive materials distort and shield electric fields, making electric and magnetic field strengths that pose a hazard to humans unlikely in indoor workplaces located beneath overhead lines.

Table 20:
Examples of low-frequency electric and magnetic fields from electrical appliances [7; 8]

Appliance	Frequency in Hz	Distance in cm	Electric field strength in V/M	Magnetic flux densitiy in µT
Drill	50	3 30 100	- - -	400 to 800 2 to 3.5 0.08 to 0.2
Computer	50	3 30	- -	0.5 to 3.0 < 0.01
Slide projector	-	3 30 100	- - -	240 4.5 0.15
Television	15 k 50	30 3 30 100	1 to 10 - 60 -	0.2 2.5 to 50 0.04 to 2 0.01 to 0.15
Dishwasher	50	3 30 100	- - -	3.5 to 20 0.6 to 3 0.07 to 0.3
Halogen lamp (low voltage)	-	3 30	- -	25 to 80 0.6 to 1.7
Fan heater	-	30	-	10 to 20
Space heater	-	3 30 100	- - -	10 to 180 0.15 to 5 0.01 to 0.25
Coffee maker	50	3 30	- 60	1 to 25 0.1 to 0.2
Kitchen stove	-	3 30 100	- - -	1 to 50 0.15 to 0.5 0.01 to 0.04
Refrigerator	50	3 30 100	- 120 -	0.5 to 1.7 0.01 to 0.25 < 0.01
Base station for handsets	50	30	-	1.5
Fluorescent lamp	-	3 30 100	- - -	40 to 400 0.5 to 2 0.02 to 0.25
Humidifier	-	30	-	10 to 20
PC monitor	-	3 30 100	- - -	0.5 to 10 0.45 to 1.0 < 0.01 to 0.3
Radio (portable)	-	3 100	- -	16 to 56 < 0.01
Vacuum cleaner	50	3 30 100	- 50 -	200 to 800 2 to 20 0.13 to 2
Immersion heater (1 kW)	-	3 30 100	- - -	12 0.1 < 0.01
Desk lamp (60 W)	-	3 30	- 5	0.1 to 0.2 0.01
Clock (mains powered)	50	3 30 100	- 30 -	300 2.25 < 0.01
Video recorder	-	3 30 100	- - -	1.5 < 0.1 < 0.1
Kettle (1 kW)	-	3 30 100	- - -	5.4 0.08 < 0.01

Figure 16:
Example of a power distribution system

High-frequency fields occur in indoor workplaces where, for example, radio systems are in use. Examples of high-frequency electromagnetic field sources and the respective permissible values are listed in Table 21.

EM field emission from selected appliances

- Monitors
  PC monitors generate, among other things, low-frequency and high-frequency electromagnetic fields. However, the field emission is so low that it is significantly lower than the values permitted by DGUV regulation 15. Consequently, there is no hazard for people who work with PC display screens.

- Wireless LAN systems
  Wireless Local Area Networks (WLANs) are local data networks for wireless data transmission between devices such as PCs, servers and printers, primarily inside buildings. In Germany, these devices operate in the 2.4 and 5 GHz frequency bands. Depending on the frequency band, transmission power levels of up to 100 mW (2.4 GHz) or 1 W (5 GHz) are allowed. As a result, even at a distance of just a few centimetres from the antenna, the values recorded are lower than those permitted by DGUV regulation 15.

- Mobile network transmitters
  In recent years, a system of fixed and mobile transmitters (Figure 17) has been set up in the Federal Republic of Germany to facilitate use of today's information and communication technologies. Table 22 gives an overview of the various mobile networks and the characteristics of their fixed-site transmitters.

Operators of mobile network fixed-site transmitters (base stations) must be in possession of a “site certificate”. These are issued by the Bundesnetzagentur (Federal Network Agency) provided it has been ensured that the site in question complies with the values permitted by the 26th Bundes-Immissionsschutzverordnung (BImSchV) [12], which are intended to protect people in electromagnetic fields. The Bundesnetzagentur specifies the minimum distances (safety distances) to be kept from the transmitters, taking into account the field strengths at the site, and indicates them in the site certificate. Suitable measures must be taken (e.g. fencing or barriers) to ensure that unauthorised persons adhere to the required safety distance.

Table 21:
Examples of exposure from high-frequency electromagnetic fields in indoor workplaces and the maximum permitted values (exposure area 2 as defined in DGUV regulation 15) [10; 11]

Field source		Distance	Typical exposure values	Permissible values
Anti-theft device		In the area under surveillance	‹ 2 mW/m²	4.5 W/m²
Microwave oven		5 m from appliance	0.62 W/m²	10 W/m²
Mobile telecommunication	Base station	50 m	0.06 W/m²	4.45 to 10 W/m² depending on frequency band
	Mobile phone	3 cm from antenna	‹ 2 W/kg	2 W/kg
High frequency exposure in dwellings near mobile network transmitters		None given	3 µW/m² to 5.2 mW/m²	2 W/m²

Figure 17:
Mobile network transmitter

Table 22:
Mobile telecommunication networks and characteristics of their fixed-site transmitters (basestations)

Mobile network	Carrier frequency in MHz	Antenna input power	Notes
D-net	890 to 960	10 W typical 50 W possible	Digital Pulsed 217 Hz
E-net	1,710 to 1,880	10 W	Digital Pulsed 217 Hz
UMTS	1,920 to 2,170	20 to 40 W	FDMA[2]) and TDMA[3])
Tetra (BOS)	380 to 395	Up to 40 W ERP[1])	TDMA[3]) (four time slots per carrier)
Tetrapol	70 to 520	Up to 50 W	FDMA[2])
City call	470	100 W	Regional call display
Analogue trunked radio Public access	410 to 430	Up to 200 W ERP1)	Closed user groups
Digital Mobile Radio (DMR)	136 to 174 403 to 470	Up to 40 W	TDMA[3]) (two time slots per carrier)
Wireless LAN (WLAN)	2,400 to 2,480 5,100 to 5,800	‹ 100 mW EIRP [4]) ‹ 1 W EIRP [4])	-

1) ERP: Effective Radiated Power
2) FDMA: Frequency Division Multiple Access
3) TDMA: Time Division Multiple Access
4) EIRP: Effective Isotropical Radiated Power

Since access to fixed transmitters is restricted and the safety distance is larger, indoor workplaces near mobile network base stations are certain to comply with the maximum values permitted by the 26th Bundes-Immissionsschutzverordnung (BImSchV). It is therefore unlikely that mobile network transmitters will pose a hazard to people who work in indoor workplaces.

- Mobile communication devices

  Mobile communication devices (e.g. mobile phones) have variable transmission power levels. In-vehicle devices work with transmission power levels of up to 8 W; mobile phones' transmission power levels go up to 2 W.

  Some of the high-frequency energy produced in mobile communication is absorbed by the mobile phone user's head. The actual amount depends on the phone's design, the way in which it is used, the antenna type, the position of the antenna in relation to the head, the frequency and the transmission power.

The current requirement is that mobile communication devices must not exceed a specific absorption rate (SAR) of 2 W/kg [3]. Based on current scientific knowledge, adverse effects on health are not likely if this value is complied with.

- DECT systems

DECT (Digital Enhanced Cordless Telecommunications) is a mobile telephony standard for access to mobile communication networks. In practice, however, it is actually a standard for cordless telephones. It describes a mobile communication system comprising at least one transmitter station (base station) and one mobile communication device, i.e. a cordless telephone. DECT systems enable several base stations/repeaters (Figure 18, see page 64) and cordless telephones to be used, which means that, for example, a relatively large area (e.g. building complex) can be covered and/or several telephone conversations can be conducted simultaneously.

In Europe, the system has been defined for the 1,880 to 1,900 MHz frequency range. Theoretically, the transmission power level of a DECT system is a maximum of 250 and on average approximately 10 mW. The criteria for cordless telephone use are the same as for mobile phone use but the transmission power level of cordless telephones is considerably lower than that of mobile phones. DECT systems do not present a hazard to people in indoor workplaces.

Figure 18:
Access point for DECT systems

- Microwave ovens

  Microwave ovens use high-frequency energy (typically 2,455 MHz) to heat food. The energy is absorbed by the food and converted into thermal energy. Shielding ensures that the values permitted outside the appliance are complied with.

  According to research by the Bundesamt für Strahlenschutz (Federal Office for Radiation Protection), the leakage radiation from domestic microwave ovens, measured as power density, is equal to 1% of the permissible emission limit value [13]. The emitted power density decreases as the distance increases (at a distance of 30 cm, only roughly 5 to 10% of the power density measured on the oven's surface has any effect). Consequently, microwave ovens in indoor workplaces will not exceed the 10 W/m² permitted by DGUV regulation 15 for category 2 exposure areas, assuming the oven is intact. However, if there are obvious defects in the shielding (e.g. faulty door seals), this cannot be guaranteed. It is therefore important to ensure that faulty microwave ovens are not used.

10.3 Regulations and limit values

Germany has regulations to provide protection against electric, magnetic and electromagnetic fields in both the public domain and the workplace.

26th BundesImmissionsschutzverordnung (BImSchV)

The public domain is regulated by the 26th BImSchV [12] which was enacted in 1997. It lays down requirements concerning the protection of the general public and neighbouring communities against harmful environmental effects caused by EM fields.

The Ordinance applies to the installation and operation of low-frequency and high-frequency systems for commercial use or use in connection with business undertakings. As per the Ordinance definition, low-frequency systems are stationary installations for transforming and transmitting electricity, i.e.:

- Overhead lines and underground cables with a frequency of 50 Hz and a voltage of 1,000 V or higher
- (Overhead) traction current lines, including transformers and switchgear, with a frequency of 16.67 or 50 Hz
- Electrical transformers, including switchgear bays, with a frequency of 50 Hz and a high voltage of 1,000 V or more

As defined by the 26th BImSchV, high-frequency systems are stationary transmitters with a transmission power level of 10 W EIRP (Effective Isotropical Radiated Power) or higher in the 10 MHz to 300 GHz frequency range. Transmitters with power levels of › 10 W are commissioned on the basis of the "Gesetz über Funkanlagen und Telekommunikationsendeinrichtungen" (Act on Radio Equipment and Telecommunications Terminal Equipment). The commissioning procedure is described in the "Verordnung über das Nachweisverfahren zur Begrenzung elektromagnetischer Felder" (Ordinance concerning the Controls for the Limitation of Electromagnetic Fields). Such systems must always be installed and operated in such a manner that the fields they emit do not exceed the threshold values.

The 26th BImSchV also defines the areas to be examined, primarily areas in buildings or on land in which people are not only intended for temporary human presence. However, the Ordinance is also applied to areas requiring a particularly high level of protection, which include hospitals, schools, nurseries, playgrounds and similar facilities. It does not apply to employed work, i.e. the field covered by occupational health and safety requirements.

"Electromagnetic fields" accident prevention regulation

Where health and safety requirements apply, the DGUV regulation 15 – the accident prevention regulation on "Electromagnetic fields" [9] – should be used. Its content is explained in more detail in the German Social Accident Insurance Institutions' rule that accompanies it, DGUV rule 103-013 [14]. DGUV regulation 15 applies wherever employees are exposed to electric, magnetic or electromagnetic fields in the 0 Hz to 300 GHz frequency range.

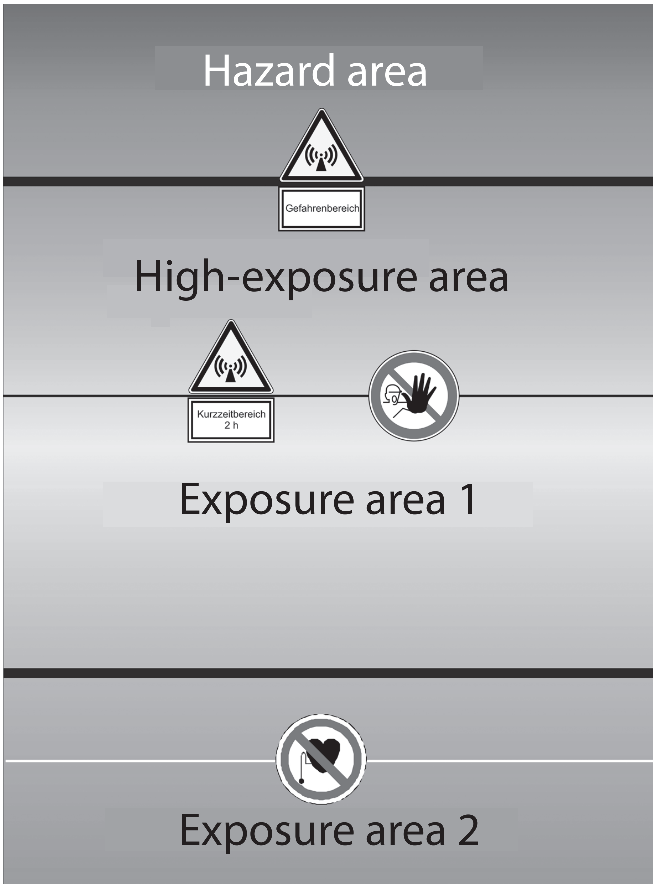
When checking workplaces for possible exposure to electric, magnetic or electromagnetic fields, the employer must define exposure areas, determine the electromagnetic fields that occur and compare them with the permissible values. The exposure levels must be determined by a properly qualified person and can take the form of calculations, measurements, consideration of information supplied by the manufacturer or comparison with other systems.

DGUV regulation 15 makes a distinction between exposure area 2, exposure area 1 and high-exposure areas (Figure 19).

Exposure area 2 covers all areas for which there is no special access control. Generally accessible indoor workplaces therefore fall into this category, which is subject to the lowest permissible workplace values. Higher values are permitted in exposure area 1, which comprises all controlled-access areas.

In addition to the two areas mentioned above, there are high-exposure areas, where the values permitted for exposure area 1 may be exceeded temporarily provided special precautions have been taken.

Figure 19:
Exposure areas as defined in DGUV regulation 15 [9]



Values permitted by DGUV regulation 15

Permissible values have been specified at the international level in such a way as to rule out any biologically relevant effects that might cause damage, hazards or other unwanted phenomena. Since the effects of electromagnetic fields are frequency-dependent, the permissible values have also been defined based on frequency. They are given as basic values and values derived from those basic values.

The basic values are the current density in A/m², the specific absorption rate (SAR) in W/kg, power density in W/m² and the field strength in the body tissue in V/m. They (see also DGUV regulation 15 [9]) stem from physical, biological and medical findings and are internationally recognised and recommended [4].

Since measuring these basic values is an extremely complex process, permissible values for the field sizes (the electric field strength and the magnetic flux density/field strength) have been derived from the basic values for use in the workplace. Compliance with these derived values ensures that the basic values are also adhered to within the body. The values for electric field strength and magnetic flux density permitted by DGUV regulation 15 are shown in Figures 20 and 21.

Table 23 lists the permissible values for whole-body exposure at 50 Hz (a common mains frequency). The permissible values for exposure area 2 are generally not exceeded in indoor workplaces.

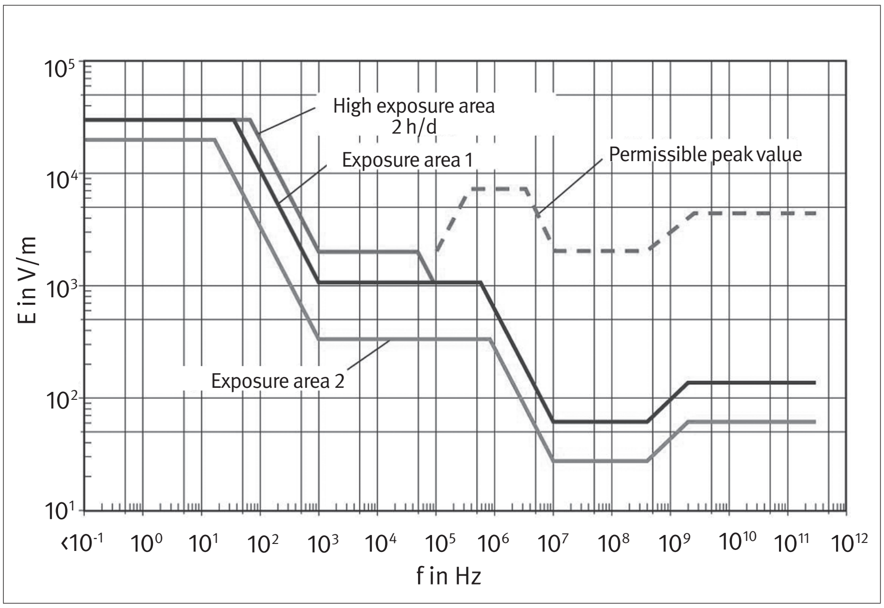


Figure 20:
Permissible values for electric field strength *E* in exposure areas 1 and 2 and high-exposure areas, as specified in DGUV regulation 15 [9]

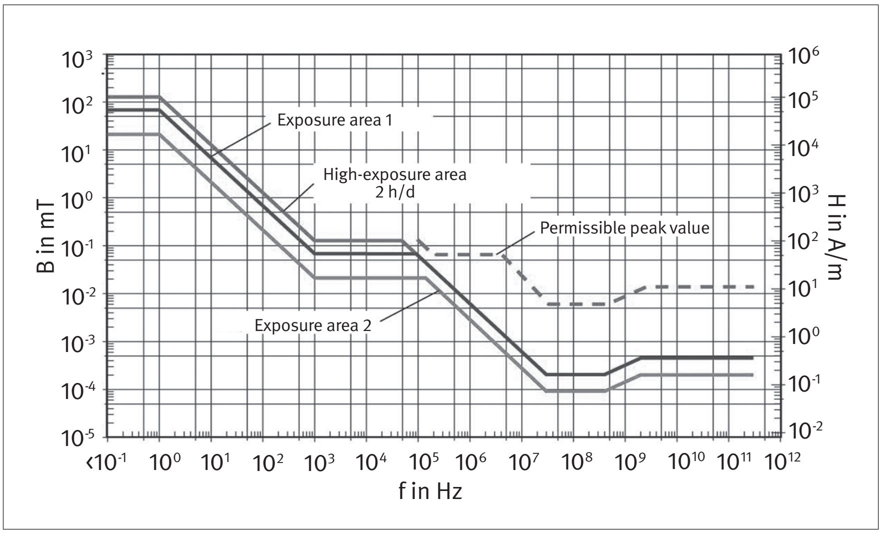


Figure 21:
Permissible values for magnetic flux density *B* in exposure areas 1 and 2 and high-exposure areas, as specified in DGUV regulation 15 [9]

Table 23:
Values permitted by DGUV regulation 15 [9] at a frequency of 50 Hz

Exposure area	Permissible electric field strength in kV/m	Permissible magnetic flux density in mT
Exposure area 2	6.7	0.42
Exposure area 1	21.2	1.36
High-exposure area	30.0	2.54

Measures required by DGUV regulation 15

No measures are required in the case of indoor workplaces where the values permitted for exposure area 2 are not exceeded. The equipment typically used for office communication and work (particularly display screen equipment) has such low emission values that they fall below the permissible values for exposure area 2 (see section on "EMF occurrence in indoor workplaces"). This is also true of electrical tools, domestic appliances, electrical systems within buildings and engines, drives, etc. with low connected loads.

However, at sites located in the immediate vicinity of industrial installations with high electrical power levels, it is not possible to rule out values exceeding those permitted by DGUV regulation 15. In accordance with this regulation [9], measures are required if this does happen. These measures include, for example, drawing up operating instructions, conducting briefings, marking and implementing access controls.

Permissible values for people with active medical implants

Even though the values in indoor workplaces lie below those permitted for exposure area 2, active medical implants such as pacemakers can be influenced by electromagnetic fields. In such cases, a special risk assessment must be carried out and, if appropriate, the area must be marked accordingly (Figure 22).

Influences on active implants depend on various parameters, such as the sensitivity setting, the design and installation of the electrodes and the implants' immunity to interference. Assessments at workplaces must therefore always be on a case-by-case basis, taking into consideration the settings (entered in the pacemaker ID card) and the information supplied by the manufacturer. The potential effects of EM fields on medical implants and the risk assessment required are described in DGUV information 203-043, formerly BGI/GUV-I 5111, "EM field influence on implants – A guide for the workplace" [15].

Figure 22:
"No pacemakers" sign

10.4 Summary

Though electrostatic charges can occur in indoor workplaces, the electrostatic fields they generate do not generally pose a hazard for employees. However, discharge processes can potentially result in startle responses as well as damage to electronic components. Electrostatic charge should therefore be avoided as far as possible in indoor workplaces. Possible ways of doing this are choosing appropriate materials, reducing contact areas and earthing.

Indoor workplaces can also be subject to electric, magnetic or electromagnetic fields. In office workplaces, they are generated by the (electrical) equipment typically found there. However, the electric, magnetic and electromagnetic fields emitted by such equipment are small. The maximum permitted values for these fields are generally complied with in offices and hazards to humans are unlikely.

Values above the permissible values can also be ruled out for indoor workplaces near power supply and distribution units. Individual risk assessment may be necessary for people with active medical implants (e.g. pacemakers).

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