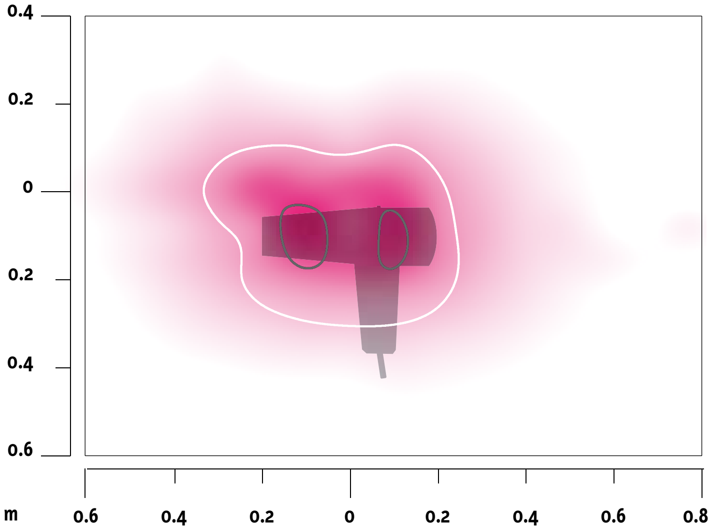
Electrical appliances in the household

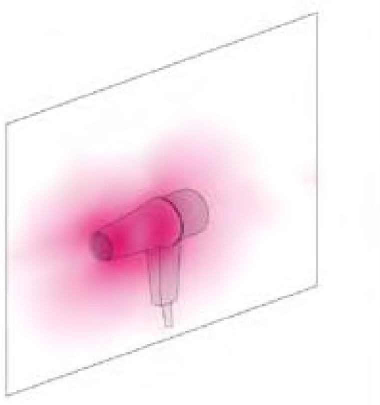
Appliance	Magnetic field (μT) Distance of 3 centimetres	Distance of 30 centimetres	Distance of 1 metre
Hairdryer	6–2000	0.01–7	0.01–0.3
Electric shaver	15–1500	0.08–9	0.01–0.3
Drill	400–800	2–3.5	0.08–0.2
Electric saw	250–1000	1–25	0.01–1
Vacuum cleaner	200–800	2–20	0.1–2
Washing machine	0.08–50	0.15–3	0.01–0.15
Clothes dryer	0.3–8	0.1–2	0.02–0.1
Clothes iron	8–30	0.1–0.3	0.01–0.03

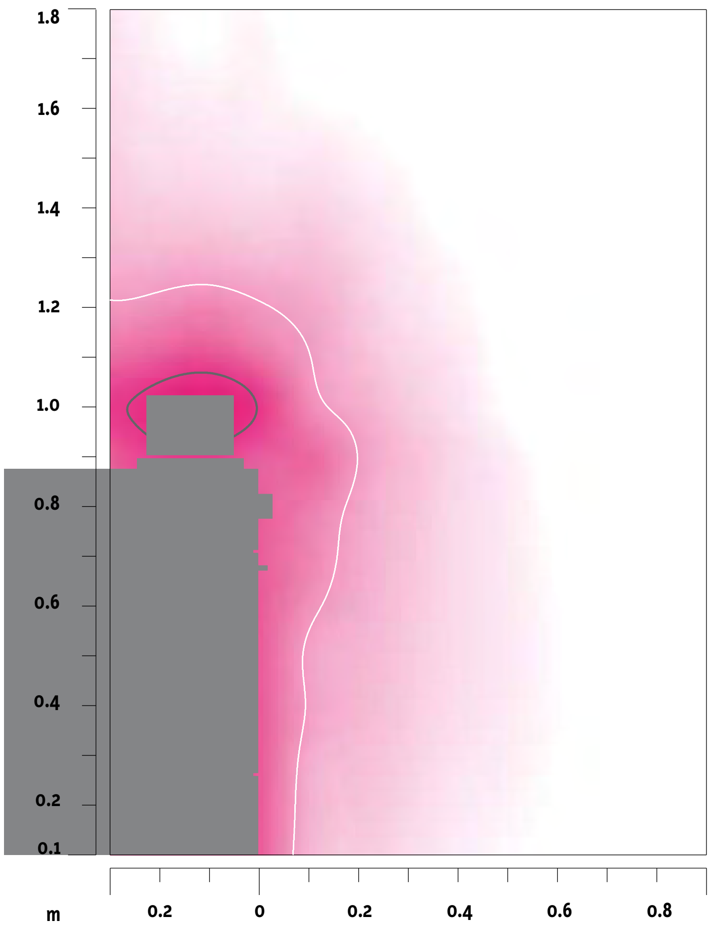
Kitchen appliances

Appliance	Magnetic field (μT) Distance of 3 centimetres	Distance of 30 centimetres	Distance of 1 metre
Electric cooker top	1–50	0.15–8	0.01–0.04
Microwave oven	40–200	4–8	0.25–0.6
Refrigerator	0.5–2	0.01–0.3	0.01–0.04
Coffee machine	1–10	0.1–0.2	0.01–0.02
Hand-held mixer	60–700	0.6–10	0.02–0.25
Toaster	7–20	0.06–1	0.01–0.02

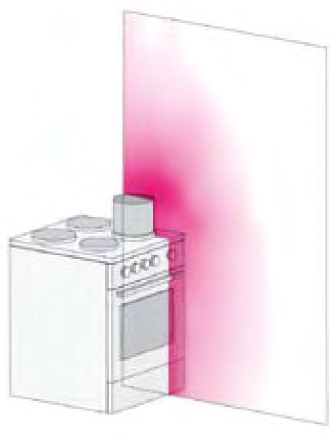


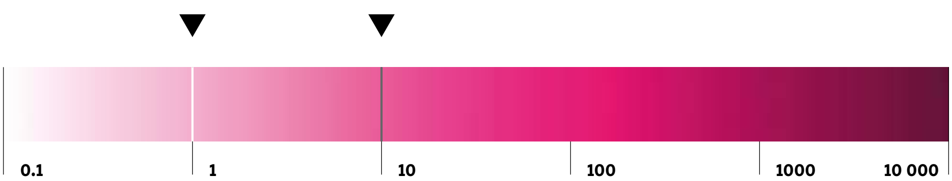
Magnetic field of a hairdryer. The most intensive fields occur close to the casing. The significance of the solid lines is indicated in the colour scale below.





Like all appliances that consume high levels of electricity to produce heat, electric cookers (hotplates) generate intensive magnetic fields. However, the exposure quickly diminishes with increasing distance.





Scale of magnetic flux density in microtesla (μT).

Reducing electrosmog in bedrooms

We spend about a third of our life in bed. In view of this, the situation in bedrooms is of particular importance. If we place electrical appliances in the wrong locations, we risk lengthy exposure to their electric and magnetic fields. For example, the magnetic field of a clock radio placed near the head of the bed can extend well into the bed, but at distance of 1 metre it is practically no longer detectable.
To reduce exposure to non-ionising radiation while we sleep, the following recommendations should be observed:

– Appliances such as computers and TV sets in the bedroom and in neighbouring rooms should be placed at a minimum distance of 2 metres from the bed. During the night, appliances should be switched off completely (not left in standby mode).
– Electrical appliances for monitoring babies and small children should also be kept at least 2 metres away from their bed.
– Mains powered clock radios should never be kept close to the head (minimum distance, 1 metre).
– Never sleep on electric cushions or electric blankets for lengthy periods if they are switched on.
– No extension cables should be placed beneath the bed.
– Beds should not be placed near electric risers or fuse boxes/panels.

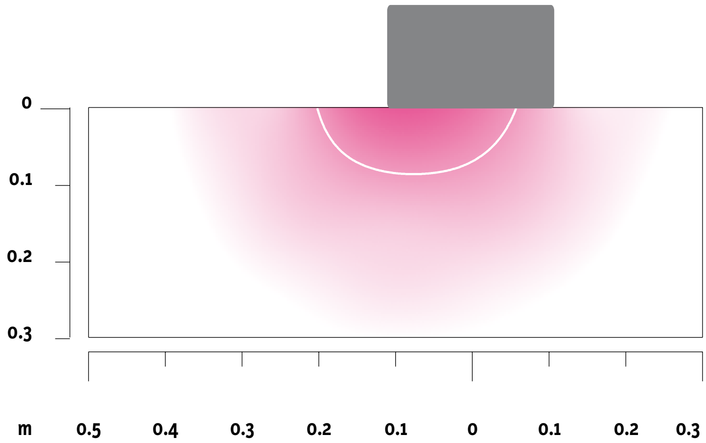
Screens

Cathode ray monitors for computers and TV sets generate different types of fields and radiation: electrostatic fields, low-frequency electric and magnetic fields, high-frequency non-ionising radiation and weak X-rays. To reduce exposure from screens and monitors, the following recommendations should be observed:

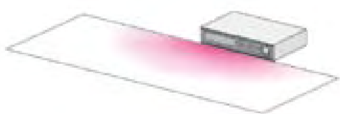
– **TCO label:** when buying a new screen, look for the TCO label (originally from Sweden). Labels like TCO 99 or TCO 03 indicate low-radiation computer screens.

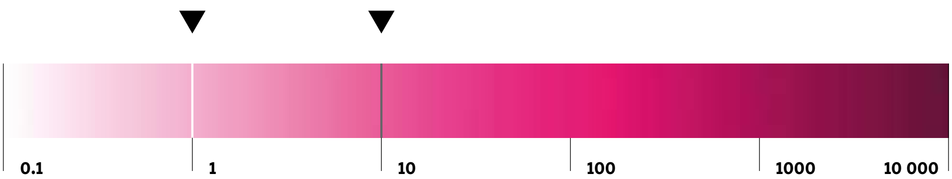
– Maintain an adequate distance: maintain a distance of at least 50 centimetres from computer monitors, and a minimum distance of 2 metres from TV screens (also applies in adjacent rooms).
– **Flat screens produce less electrosmog:** since they consume electricity, flat screens also generate low-frequency electric and magnetic fields, but otherwise they are free of radiation.

Appliance	Magnetic field (µT) Distance of 3 centimetres	Distance of 30 centimetres	Distance of 1 metre
Clock radio	3–60	0.1–1	0.01–0.02
Electric blanket	Up to 30		
TV set	2.5–50	0.04–2	0.01–0.15
Monitor with TCO label		0.2 (50 cm)	
Electric floor heating		0.1–8	
Stove	10–180	0.15–5	0.01–0.25



Magnetic field of a clock radio. To avoid long-term exposure while asleep, permanently operated electrical appliances like clock radios should be kept at least one metre away from the bed. The significance of the solid lines is indicated in the colour scale below.





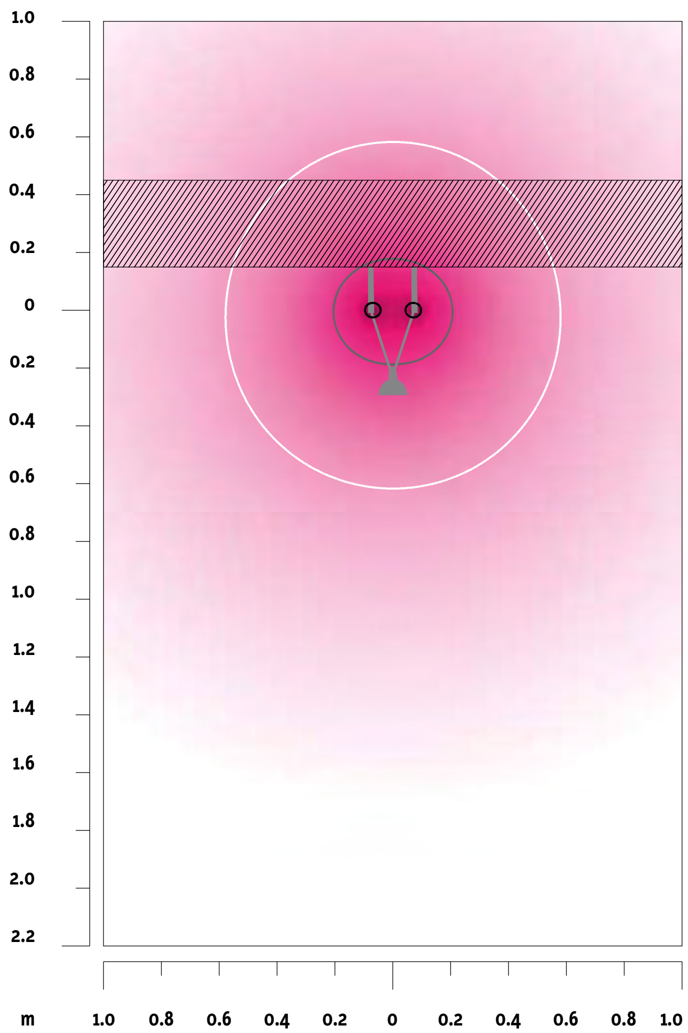
Scale of magnetic flux density in microtesla (µT).

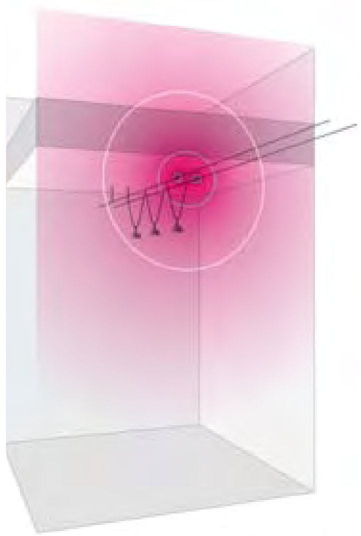
Lighting

Lighting systems such as low-voltage halogen lamps produce relatively intensive magnetic fields. These originate partly from the transformers that reduce the normal voltage in the household from 230 to 12 V, and partly from the current-bearing wires. In order to yield the same light output, the current in the cables of lamps operated with low voltage has to be higher than is the case in conventional lighting systems, and this means that the magnetic fields are also stronger. In addition, if the current conductors are not close together, the field intensifies and can also be measured on the floor above.
To reduce exposure, the following points should be observed when buying lighting equipment:

– **Filament bulbs.** These produce the lowest magnetic fields of all forms of lighting, but in view of their poor light efficiency they require significantly more electricity than energy-efficient lamps.
– **Energy-efficient lamps.** These produce slightly stronger fields than filament lamps due to the choke in the base, but the fields disappear already at a distance of around 50 centimetres. Thanks to their lower electricity consumption and longer service life, these lamps are more ecological than filament bulbs.
– **Fluorescent tubes.** Since their fields are more intense than those from energy-efficient lamps, a distance of at least 1 metre is recommended.
– **Low-voltage halogen systems.** These produce the strongest magnetic fields of all forms of lighting. It is recommended to install transformers and conductors at a distance of at least 2 metres from frequently occupied areas.

Appliance	Magnetic field (μT) Distance of 3 centimetres	Distance of 30 centimetres	Distance of 1 metre
Filament bulb (60 W)	0.1 – 0.2		
15-watt energy-efficient lamp (with electronic choke)	1	0.1	
Halogen table lamp	25 – 80	0.5 – 2	Up to 0.15
Low-voltage halogen lighting			Up to 0.3





Low-voltage halogen lighting systems produce the strongest magnetic fields of all forms of electric lighting. If they are installed on the ceiling, they can also cause considerable levels of exposure in rooms located directly above.

Highly fluctuating magnetic fields along railway lines

The magnetic fields from the catenary system (railway contact and feeder lines) fluctuate considerably. When locomotives accelerate or brake, they increase the flow of current and this intensifies the magnetic field. The busier the route, the higher the exposure levels.

Contents

Electric fields from catenaries

Most railway services in Switzerland are operated with alternating current with a frequency of 16.7 Hz. This means that electric and magnetic fields occurring alongside railway lines also have this frequency.
The strength of the electric field directly beneath the catenary (e.g. at a level crossing) is around 1,500 volts per metre (V/m), and it decreases with increasing distance. The applicable exposure limit value in Switzerland for 16.7 Hz electric fields – 10,000 V/m – is therefore easily complied with. And since the voltage in the catenary remains fairly constant, independently of the level of operation, the electric field also does not vary – unlike the magnetic field.

Large fluctuations of the magnetic field

Since the catenaries do not always carry the same current, the magnetic fields in the vicinity of railway lines can fluctuate considerably. Whenever locomotives and railcars accelerate or feed electricity back into the network when braking, the current increases, and so does the magnetic field. And locomotives also require more electricity when they are travelling uphill or pulling heavy goods trains.
Typically, current is fed into the contact line at points 25 to 30 kilometres apart. If there is no train travelling along a section between two feed points, no current is flowing and therefore no magnetic field is created. In the example depicted here, this is the case between 1 a.m. and 4.30 a.m. But if there are trains in operation, the magnetic field exists along the entire section in which the locomotives are being supplied with electricity. The exposure alongside the railway line varies according to the amount of traffic along each supply section, the current location of each train and the fluctuating electricity demand of the locomotives.
Since the magnetic fields of the public electricity network and the railway supply network have different frequencies, their intensities cannot be directly compared. Depending on the frequency, the threshold of the magnetic field strength for eliciting health effects is different. The exposure limit values specified in the ONIR and aimed at protecting against short-term effects are 100 microtesla (μT) for 50 Hz magnetic fields, but 300 μT for 16.7 Hz fields.

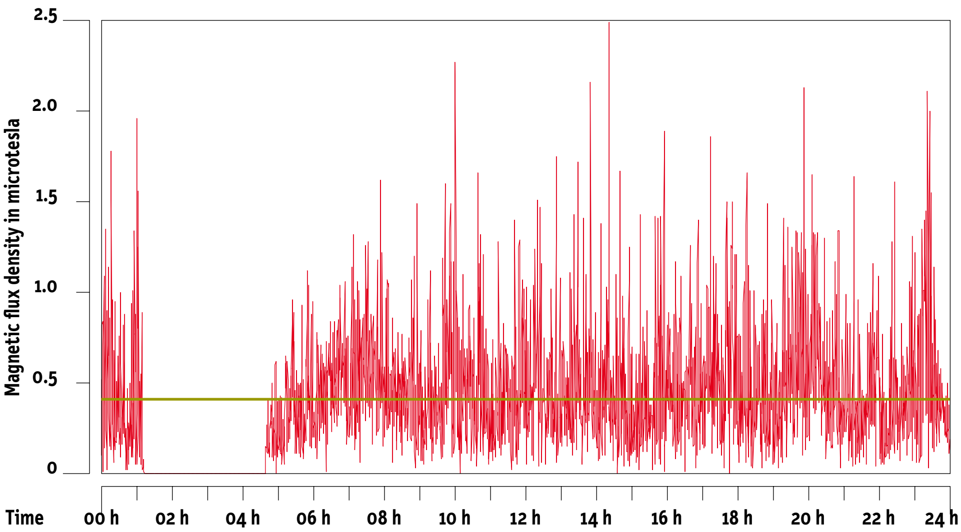
Special characteristics of the railway power supply

Like the public electricity supply network, most railway lines in Switzerland are operated with alternating current. Despite this common factor, however, there are certain significant differences that also affect magnetic fields in the vicinity of railway power supply systems:

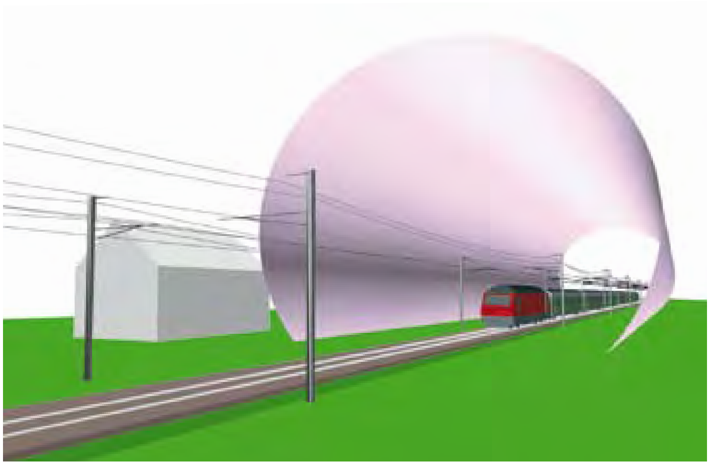
Lower frequency: The railway power supply has a frequency of 16.7 hertz (Hz), whereas the frequency of the public electricity supply is 50 Hz. This difference can be attributed to the fact that the earliest electric motors for trains required the lowest possible frequency in order to function reliably. In view of this, at the beginning of the 20th century a number of European countries (including Switzerland) agreed, after various trials, to adhere to the frequency of 16.7 Hz, which is still used today. This decision called for the construction and operation of a separate electricity supply network for railways, and as a result, major railway operators like the SBB (Swiss Federal Railways) possess their own power plants and own transmission lines. But in addition, they also use 50 Hz alternating current from the public grid, which has to be converted to 16.7 Hz by means of frequency changers. Electricity generated in power plants is fed to the railway sub-stations via separate high-voltage transmission lines at 132 kilovolts (kV). The voltage is then reduced to 15 kV, the level required by locomotives.

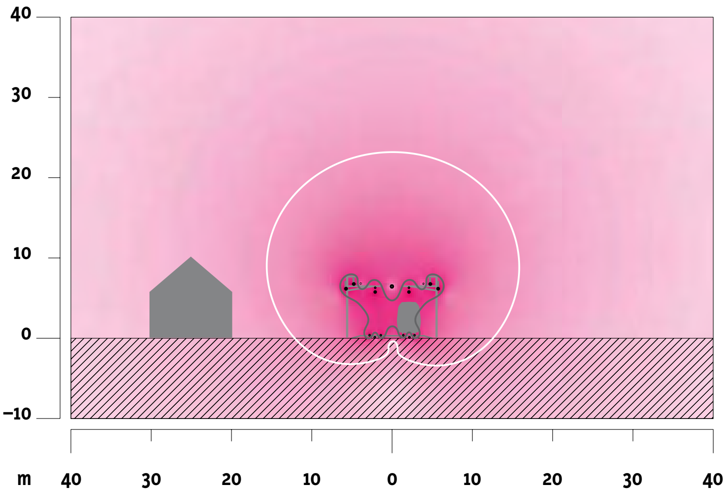
Fewer current conductors: The public electricity supply is a three phase system – here the circuit comprises three phase conductors. By contrast, the transmission network for the railway electricity supply uses only a feed and a reverse conductor, both of which are live. Along the railway line itself, the power required by locomotives is fed only via the contact line, while the reverse current passes through the rails, the return wire and the soil.

Mobile power consumers: As a rule, electrical appliances and machines are used at a fixed location, but locomotives fed by the railway supply network are constantly on the move. They can even generate current themselves when applying electric brakes: here the engine becomes a generator that converts brake energy into electricity which it feeds back into the supply network.

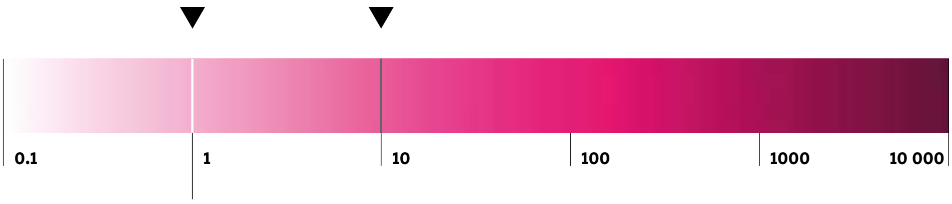


16.7 Hz magnetic field on the double track railway line between Lucerne and Basel near Nottwil, measured at a distance of 10 metres from the centre of the rails: the exposure level fluctuates depending on traffic volume. If there are no trains on this stretch, there is no exposure. The 24-hour average level (green line) is 0.41 microtesla. This is of relevance for comparison with the installation limit value, which (again averaged over a 24-hour period) is 1 microtesla, and is therefore complied with in this example.

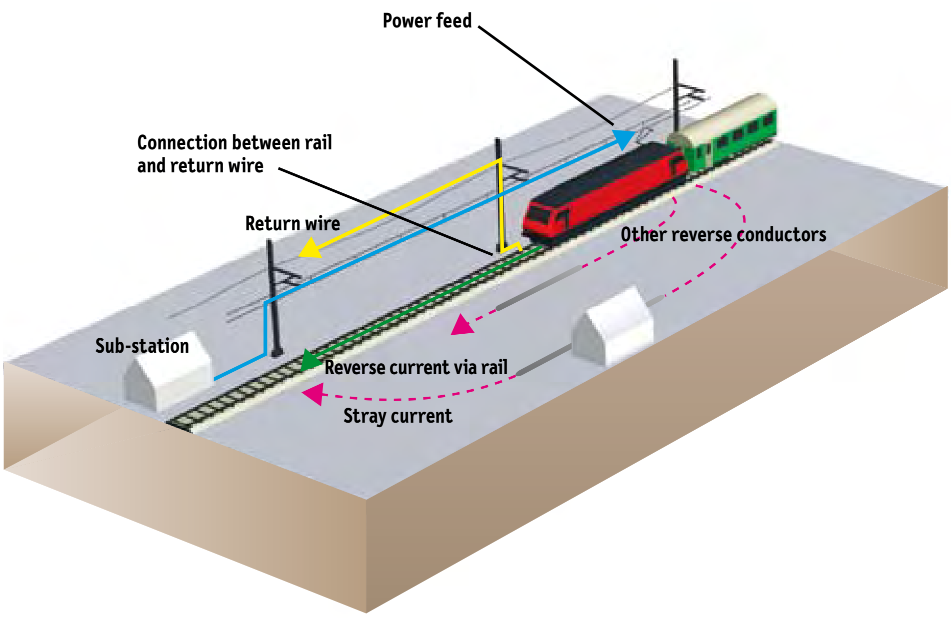




Magnetic field on a typical double track railway line. The magnetic flux density at the perimeter of the tunnel-like area (perspective view, left) is 1 microtesla (average over a 24-hour period). The cross-section of the magnetic field vertical to the railway line (right) shows how exposure diminishes with increasing distance from the contact line. The grey line represents a 24-hour average level of 10 µT, and the white line depicts a reading of 1 µT.



Scale of magnetic flux density in microtesla (µT).



Power is fed from the sub-station to the locomotive via the contact line (blue arrow). The current then flows back to the sub-station via the rails (green arrow), the return wire (yellow arrow), the soil and other reverse conductors in the ground (red arrows). The spatial extension of the magnetic field of a railway catenary is relatively broad due to the distance between the power feed and reverse currents.

Focusing the reverse current

The fact that the feeds and reverse currents are fairly far apart is another factor that is of significance with respect to the intensity of magnetic fields from railway catenary systems. Electricity is fed via the contact line, whereas the reverse current flows via the rails and the return wire. Due to the contact between the rails and the ground, however, some of the reverse current flows through the soil or via underground metal pipes (e.g. those used for gas or water supply). Stray currents of this sort can propagate over considerable distances and only return to the railway line in the vicinity of the sub-station.
The further apart the feed and reverse currents are, the greater the reach of the magnetic field (at the same current). To reduce this, the best solution is for the largest possible fraction of reverse current to flow via the return wire, since this is closest to the contact line.

Precautionary regulations of the ONIR

The precautionary emission limitations for catenary systems specified in the ONIR vary according to whether the installation is new, to be modified or old.

- **New installations:** These include catenary systems for new railway lines and for lines that are to be re-routed. At places of sensitive use they are required to comply with the installation limit value of 1 microtesla (µT). This is measured as a 24-hour average. On a double track line, for example, the specified installation limit value is normally complied with from a distance of between 10 and 25 metres from the contact line, depending on the traffic volume. In certain exceptional circumstances, the relevant authorities may allow the installation limit value to be exceeded.

– **Installations to be modified:** In the ONIR the term "modified" refers to the addition of tracks to an existing railway line. At places of sensitive use at which the installation limit value was already exceeded prior to the implemented changes, the magnetic field intensity must not be increased. At all other places of sensitive use, the installation limit value must be complied with. As with new installations the specified requirements may be eased in certain circumstances.

– **Old installations:** This term refers to catenary systems that are not being modified or that are renewed on existing lines. If the installation limit value is exceeded at places of sensitive use, these systems have to be equipped with a return conductor (earth wire) placed as close to the contact line as possible. This is already the case on most railway stretches today. The ONIR does not require any further measures for old installations.

Exposure inside trains

We are also exposed to magnetic fields when we are inside a train. These fields are produced partly by the currents in the catenary system and the rails, but also by the on-board power supply that is required for lighting, heating and air-conditioning purposes. This internal power supply consists of a special cable that is fed by the locomotive and runs beneath each coach right along the entire length of the train.

Measurements carried out in a double-decker train on the stretch between Bern and Zurich have shown that the magnetic fields fluctuate considerably throughout the journey, and can also vary greatly in different parts of the train. The magnetic field was found to be at its strongest on the lower level near the locomotive. At seat level, the mean reading for the journey was 4 μT, and short-term peak levels of up to 10 μT were recorded. At this position the main source of the magnetic fields is the supply cable running beneath each coach, whose importance diminishes with increasing distance from the locomotive. On the upper level of the first coach behind the locomotive, and on both levels at the other end of the train, the magnetic field intensity was approximately the same (average level for the full journey, around 0.7 μT, with short-term peaks of up to 3.5 μT).

Since trains are not included in the definition of places of sensitive use, no precautionary limitation applies inside railway coaches for the magnetic field.

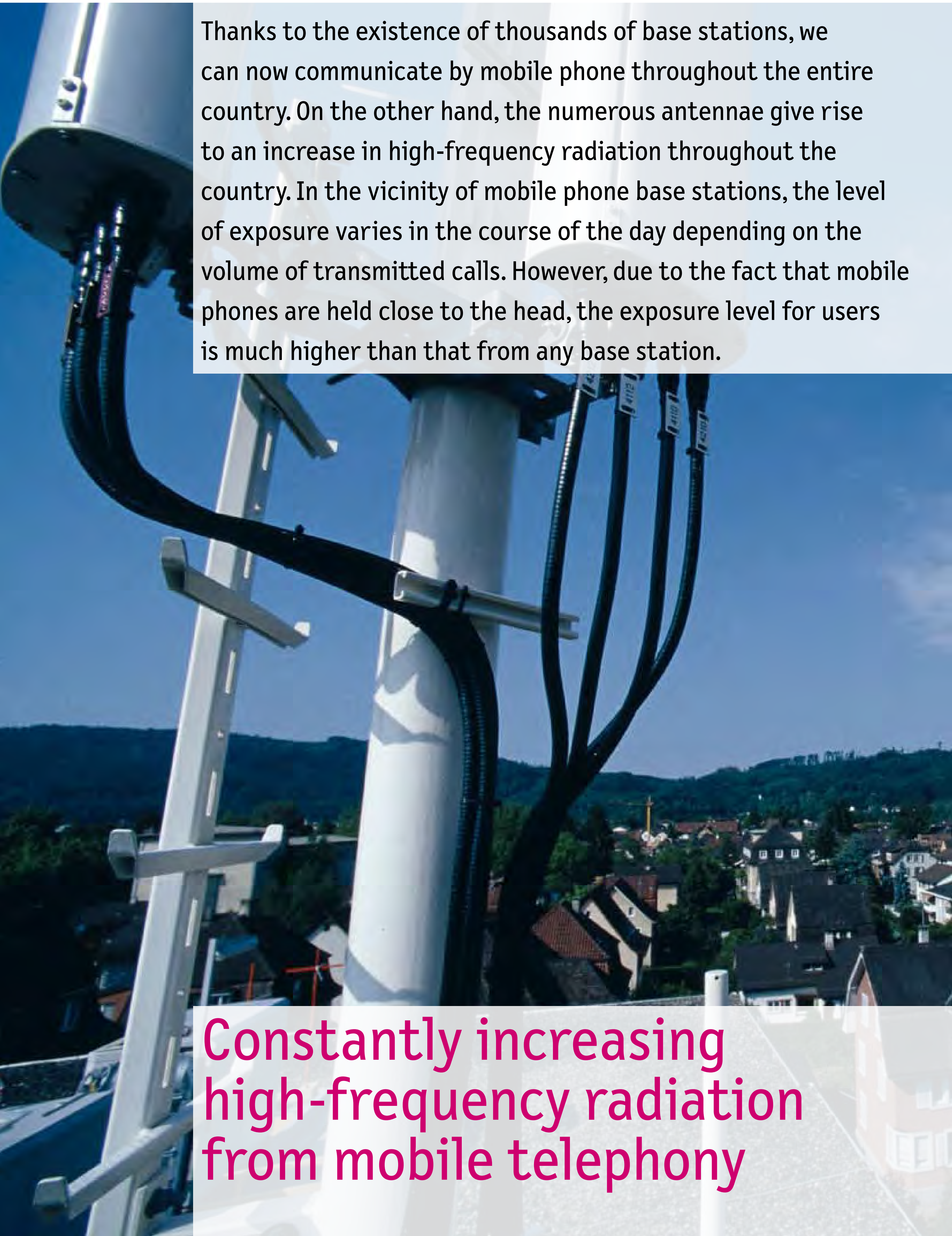
We are also exposed to magnetic fields when we are inside a train. The level of exposure varies according to the part of the train we are in.

Motor cars are not an alternative

The presence of magnetic fields inside trains is not a reason for changing the means of transport, however: magnetic fields also occur in motor cars. These are partly attributable to on-board electrical systems, but can also be produced from magnetised wheel rims and steel belts in tyres. Measurements carried out inside moving cars showed that the highest exposure occurs in the area around the passenger's feet and on the rear seat. Readings varied greatly from model to model, and covered the same range as fields inside trains.

Direct current (DC) transport systems

Trams, trolley buses and some narrow-gauge railways are operated with direct current, and these systems produce static (DC) electric and magnetic fields. For DC magnetic fields, the ONIR specifies an exposure limit value of 40,000 μT, and this level is always complied with by a very large margin. Research has not yielded any indications of potential health risks associated with DC fields encountered in everyday life, and for this reason the Ordinance does not specify any installation limit value for DC transport systems.



Thanks to the existence of thousands of base stations, we can now communicate by mobile phone throughout the entire country. On the other hand, the numerous antennae give rise to an increase in high-frequency radiation throughout the country. In the vicinity of mobile phone base stations, the level of exposure varies in the course of the day depending on the volume of transmitted calls. However, due to the fact that mobile phones are held close to the head, the exposure level for users is much higher than that from any base station.

Constantly increasing high-frequency radiation from mobile telephony

Contents

The fact that we hold a mobile phone so close to our head when calling means that the level of exposure is much higher than that from a base station antenna.

Mobile communication boom

The majority of the population of Switzerland now own a mobile phone, and more than 9,000 base stations ensure that we can make calls with them from almost anywhere in the country. After 1993, the GSM mobile communication standard gradually replaced the existing Natel C network and thus contributed towards the boom in mobile telephony. In 2002 the implementation of UMTS—a third generation network—was initiated. But the constantly expanding range of services and growing demand in the area of mobile communication are also resulting in increasing exposure to high-frequency electromagnetic waves. By contrast with electricity supply, in which radiation is an undesirable by-product, in the area of mobile communication it is used deliberately as a means of transmitting data without wire.

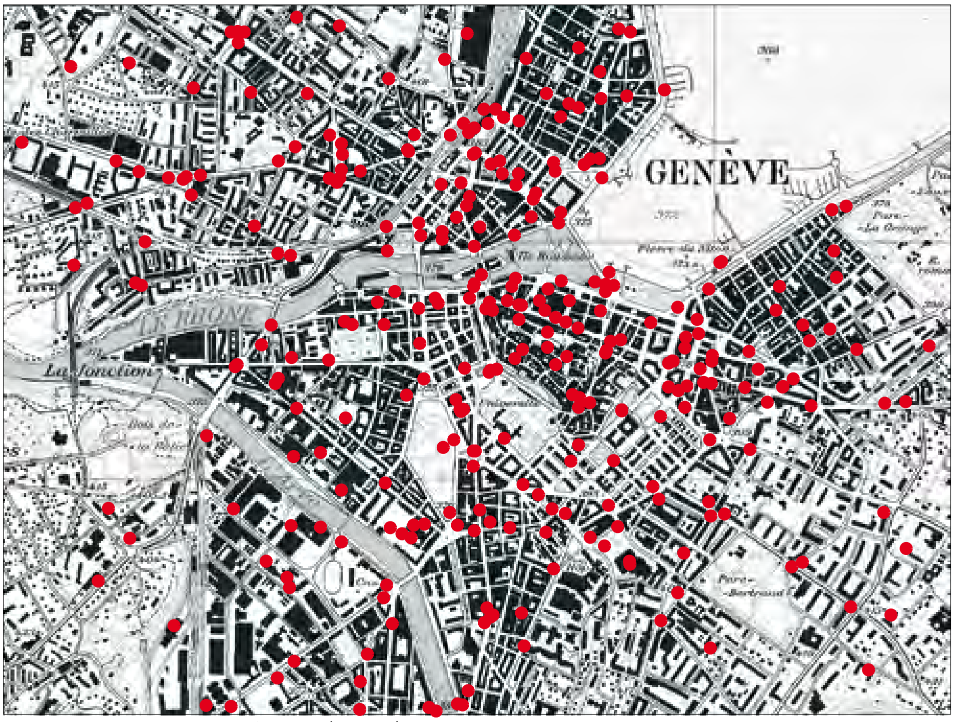
Structure of the network

A mobile communication network comprises multiple cells. Each cell has an antenna that establishes a wireless connection to the mobile phones in its vicinity. Normally a number of cells are supplied from a given location, and all the antennae at this location form a base station.
Base stations are linked to a network switching centre via standard cable connections or via point-to-point microwave links. From here they receive calls that they have to pass on to mobile phones in their cells. And vice versa, they also transmit calls to this switching centre that are being made with a mobile phone in their supply area.
Each base station can only transmit a limited number of calls. The range of each cell is thus determined by the intensity of utilisation. In rural areas with low mobile phone density, cells can have a radius of several kilometres, whereas in urban centres they only have a range of a few hundred metres. And the micro-cells frequently used in town centres are even

GSM: the GSM (Global System for Mobile Communications) standard has been in use in Switzerland since 1993. GSM networks operate in two frequency ranges: 900 MHz (GSM900) and 1,800 MHz (GSM1800).

UMTS: UMTS (Universal Mobile Telecommunications System) is the standard for the third generation of mobile communication. The UTMS network, for which implementation began in 2002, operates in the 2 gigahertz frequency range (1,900 to 2,200 MHz). It is able to transmit much higher volumes of data than GSM, and thus enables the transmission of moving images.

smaller. These are used in areas where call volumes are particularly high, or coverage is difficult due to building density. Finally there are also pico-cells, which have a radius of only a few dozen metres and are used for providing connections within buildings.
The transmitting power of an antenna has to be so high that the signals to be transmitted also reach the mobile phones at the perimeter of the cell. On the other hand, they must not be too intensive, otherwise they would interfere with signals in other cells. Since antennae in small cells operate with a lower transmitting power, they produce a lower level of radiation exposure. Although more antennae are required, the overall power radiated by all base stations is lower, not higher – at least in urban areas. A fine-meshed network can even transmit more calls with an overall lower transmitting power.



Reproduced with the kind permission of swisstopo (BA056863)

Reproduced with the kind permission of swisstopo (BA056863)

The higher the demand for phone services, the greater the density of the mobile communications network, as we can see from a comparison between the city of Geneva and the small country town of Bière (canton of Vaud). Each red dot represents a mobile phone base station. The two maps depict the situation as of 1 June 2004. The locations of all transmitters in Switzerland can be viewed at www.funksender.ch.

Mast with mobile communication antennae (top) and antennae for point-to-point transmission (round). The latter link base stations to the switching centres.

Units and dimensions

Mobile phone antennae transmit high-frequency electromagnetic waves or radiation – also referred to as high-frequency non-ionising radiation.

Frequency: This refers to the number of oscillations of an electromagnetic wave per second, and it is measured in hertz (Hz), megahertz (MHz) or gigahertz (GHz).
1 Hz = 1 oscillation per second
1 kHz = 1,000 Hz
1 MHz = 1,000,000 Hz
1 GHz = 1,000,000,000 Hz
Mobile communication networks in Switzerland operate at 900 MHz (GSM900), 1,800 MHz (GSM1800) and between 1,900 and 2,200 MHz (UMTS).

Transmitting power in watts (W): This indicates how much energy is supplied to an antenna per time unit. Typical levels per direction are between a few thousandths of a watt and 40 to 50 watts. Fluctuations occur in the course of each day due to variable loads of mobile communication systems.

Equivalent radiated power (ERP) in watts: ERP is another means of indicating transmitting power, and is also expressed in watts. It is used for calculating exposure and in Switzerland it is also of relevance for the licensing of mobile phone base stations. ERP levels are significantly higher than those of the transmitting power. For a typical base station antenna, they may be around 30 times higher. They take account of the fact that the radiation from an antenna is not emitted uniformly all round, but rather is focused within a sector. By contrast with the transmitting power, ERP describes the conditions within the main radiation cone. Here the situation may be compared to that of a spotlight. Due to its directional nature, its light is much brighter than that of a normal filament bulb with the same output. In this example, the ERP would correspond to the power required to be fed into a conventional light bulb in order for it to produce the same brightness as the spotlight in its radiation cone.

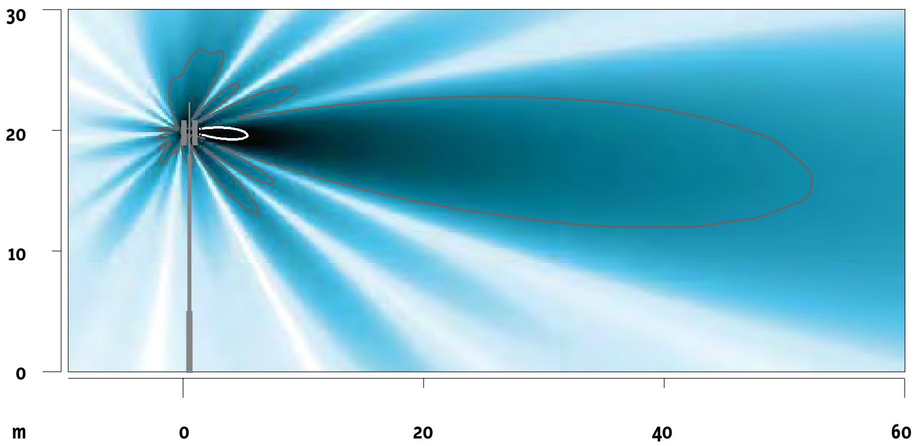
Electric field strength: This indicates the radiation intensity and is measured in volts per metre (V/m).

The antennae installed at base stations establish contact with mobile phones within their range.

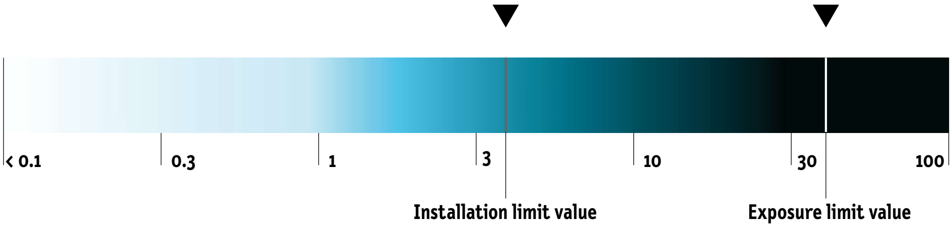
Power flux density: This, too, indicates radiation intensity. It measures the energy flux per unit time through a perpendicular reference area, and is indicated in watts per square metre (W/m^2) or microwatts per square centimetre ($\mu W/cm^2$).
The power flux density can be calculated from the electric field strength, and vice versa. The power flux density is proportional to the square of the electric field strength. Both field parameters are in direct correlation with the transmitting power of an antenna:

– The power flux density is directly proportional to the transmitting power. If the transmitting power is doubled, this means that the power flux density is also doubled.
– By contrast, the field strength only increases by the square root of the transmitting power. If the transmitting power is doubled, the electric field strength therefore only increases by the factor $\sqrt{2}$, which is equivalent to an increase by 41 percent. This physical law is also of significance if two antennae radiate towards the same location from different locations with the same transmitting power. Here, too, the overall field strength is not doubled, but merely increases by 41 percent. In order for the field strength to double, four antennae of the same power would have to transmit to a given location, and 100 antennae would be required for the field strength to increase tenfold.

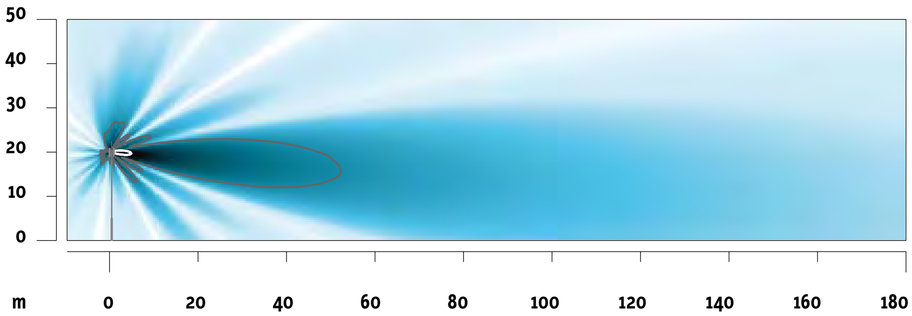
Electric field strength	Power flux density	
(V/m)	W/m^2	$\mu W/cm^2$
61.4	10	1000
33.6	3	300
19.4	1	100
10.6	0.3	30
6.1	0.1	10
3.4	0.03	3
1.9	0.01	1
1.1	0.003	0.3
0.6	0.001	0.1
0.3	0.0003	0.03
0.2	0.0001	0.01



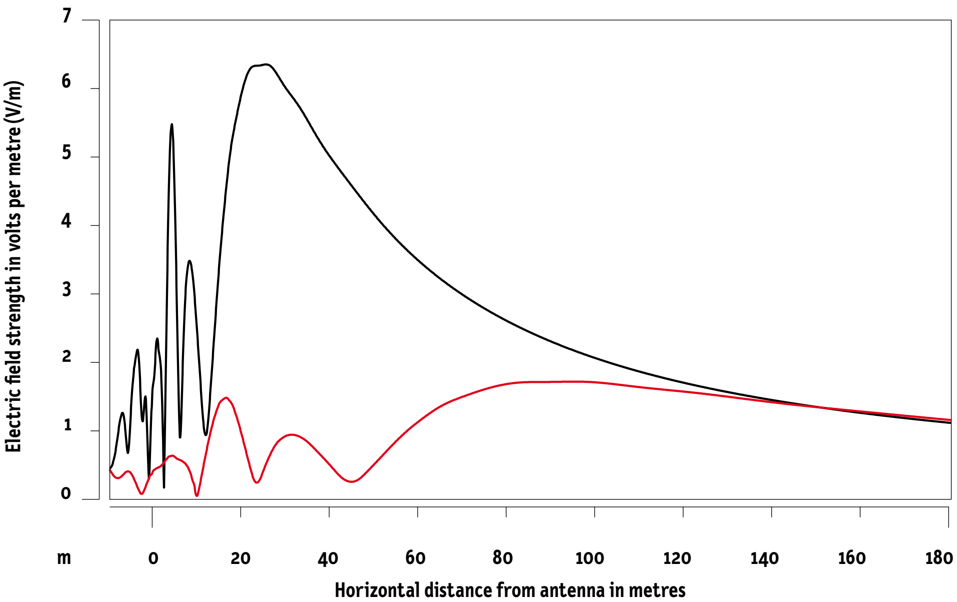
Radiation in the vicinity of a base station antenna with an equivalent radiated power of 1,000 watts in the 900 MHz frequency range (GSM900). The antenna is located on a 20-metre mast and has a slight downward orientation. The significance of the solid lines is indicated in the colour scale below.



Scale of electric field strength in volts per metre (V/m).



Close-up of the radiation pattern of the same antenna as above.



Radiation in the vicinity of a mobile phone base station

The intensity of radiation in the vicinity of a mobile phone base station depends on a variety of factors. All these parameters are taken into account by the licensing authorities for the purpose of calculating exposure due to a planned facility:

- **Equivalent radiated power (ERP):** The higher the radiated power of an installation, the higher the radiation intensity in the vicinity.
- **Spatial radiation pattern of the antenna:** Antennae at base stations do not radiate uniformly in all directions. Instead they focus their radiation – rather like a spotlight – and steer it in the desired main direction. Outside this cone, radiation is still present, but it is greatly reduced. Besides the main direction, we can also identify side lobes.
- **Distance from the antenna:** The electric field strength is halved at twice the distance from the antenna. This applies especially along the main beam. On the ground, however, the situation is more complicated. Exposure in the immediate vicinity of the antenna mainly originates from the side lobes. Outside their range of influence, the field strength gradually increases with increasing distance, since here it is the radiation from the main beam that predominates. In the above example, it reaches its peak at around 90 metres, and only then does it gradually diminish.
- **Attenuation thanks to walls and roofs:** Walls and roofs attenuate radiation that reaches a building from the exterior. This also applies to a building on which an antenna is located. If there are no skylights in a concrete roof, most of the radiation is shielded. However, radiation easily passes through tile and timber roofs and through windows with uncoated panes.

Electric field strength at increasing distance from the antenna depicted above, shown at two different heights above the ground. The black curve shows the exposure along the direction of the main beam at 15 metres above the ground, while the red curve shows exposure 1.5 metres from the ground.

How mobile phones and base stations function

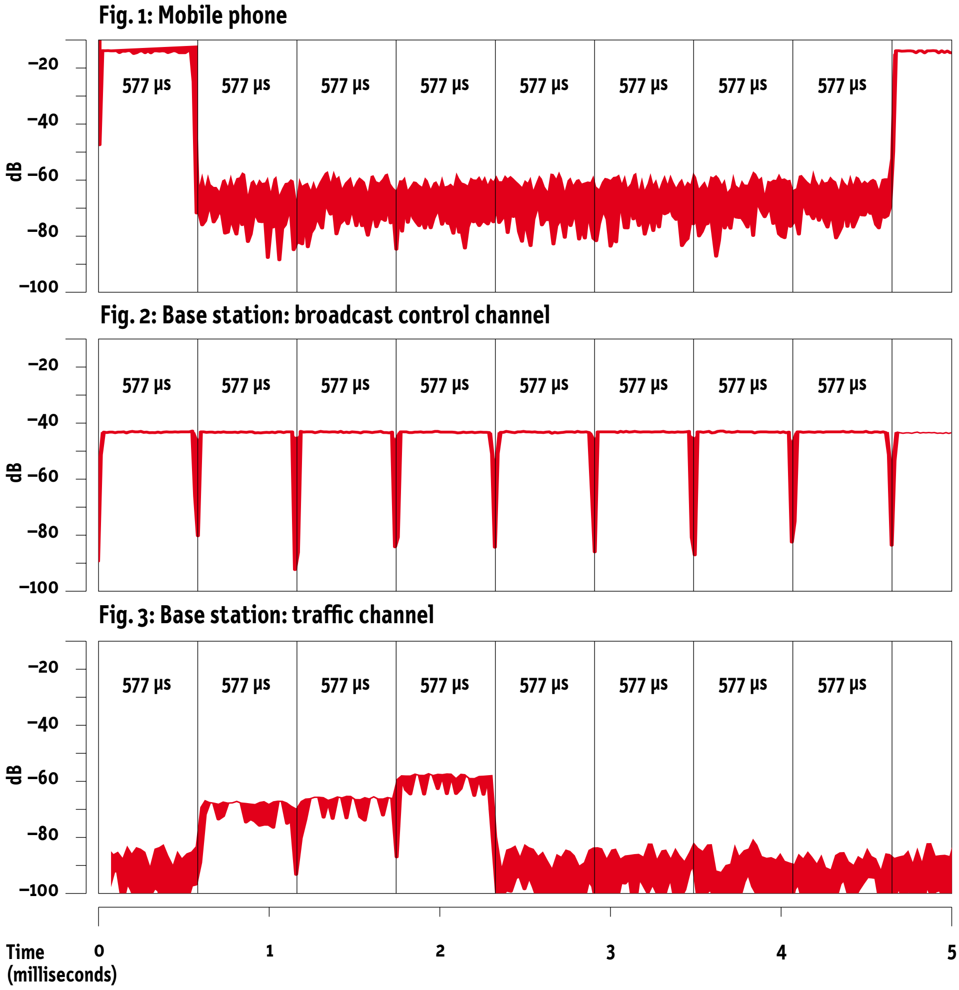
In order to allow a number of people to make phone calls at the same time in a given cell, with GMS up to eight users share the same frequency channel. Each of them is allocated an eighth of the time (time slot) for the transmission. The data are partitioned in separate packages with a duration of 577 microseconds (µs) that are sent at intervals of 4.6 milliseconds (ms) – see Fig. 1. For this reason, mobile phones emit a pulsed radiation with a repetition rate of 217 pulses per second.

GSM mobile phones are equipped with a dynamic output control. When a connection is being established, the phone transmits at maximum output. This level is then reduced until it is just sufficient to maintain an adequate connection with the base station.

In its turn, the base station transmits on a broadcast control channel and on traffic channels.

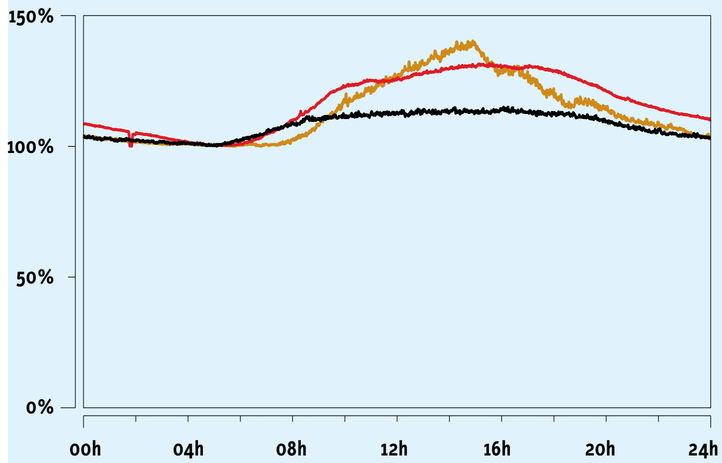
The broadcast control channel transmits all eight time slots with full transmitting power (Fig. 2). A brief blank out takes place between each time slot. In one time slot, technical data are transmitted that, for example, are required for establishing or maintaining connection. The other time slots on the broadcast control channel are used for transmitting calls or are artificially filled with blank data.

If the capacity of the broadcast control channel no longer suffices to handle all calls, the traffic channels are activated. These only emit radiation in the actually required time slots and are adjusted so that their power output is kept as low as possible (Fig. 3). The temporal transmission pattern of a traffic channel varies according to the number of transmitted calls and the quality of the connections. In the example shown here, time slots 2 to 4 each operate at a different transmitting power, and time slots 1 and 5 to 8 are not activated.



Temporal transmission patterns of a mobile phone (top) and base station (middle: broadcast control channel; bottom: traffic channel). The levels in dB are given in logarithmic units: a difference of 20 means factor 100 in the transmitting power and factor 10 in the field strength.

Electric field strength near base stations in the course of a day



24-hour profile of radiation exposure from three different base stations.The graph shows the electric field strength during a 24-hour period in percentage of the minimum level. At the minimum level of 100 percent, only control channels are transmitting.

In the vicinity of a mobile phone base station, the level of exposure varies in the course of the day depending on the volume of transmitted calls. During the night, exposure practically comes from the control channel only. Then in the course of the morning the level increases with the volume of calls and activated traffic channels, and reaches its peak in the course of the afternoon or towards evening.

When averaged over time, and especially during the night, the actual level of radiation exposure is lower than indicated with mathematical predictions and approval measurements, since these are based on the maximum possible load, which seldom occurs.

Precautionary regulations of the ONIR

At places of sensitive use, mobile phone base stations are required to comply with the installation limit value specified by the ONIR. This applies to residential dwellings, schools, hospitals, offices and playgrounds. An installation comprises all mobile phone antennae on the same mast, on the same building or those that are otherwise located closely together. The specified installation limit value must be complied with at full capacity – i.e. at maximum call and data volume with maximum transmitting power. The following installation limit values apply:

- 4 V/m for GSM900 installations
- 6 V/m for GSM1,800 and UMTS installations
- 5 V/m for a combination of GSM900 and GSM1,800/UMTS installations

In the main transmission direction and without attenuation by building structures, these requirements call for the following distances from an antenna:

ERP per direction	Distance for compliance with the installation limit value (in main transmission direction)	
	GSM 900	GSM 1800 UMTS
10 W ERP	5.5 m	3.7 m
100 W ERP	18 m	12 m
300 W ERP	30 m	20 m
700 W ERP	46 m	31 m
1000 W ERP	55 m	37 m
2000 W ERP	78 m	52 m

Outside the main beam or if the radiation is attenuated by a building shell, these distances are significantly shorter – in the mathematical prediction in the site data sheet down to one-thirtieth.

Licensing and supervision of mobile phone base stations

A building permit is required for most mobile phone base stations. This procedure may vary in terms of content or implementation, depending on the canton, but the basic principles are the same everywhere.

- **Application for building permit, submission of site data sheet:** Operators of mobile phone base stations are obliged to submit an application for a building permit to the authorities of the municipality concerned. The required documentation includes a site data sheet in which the operator provides details such as transmitting power and main transmission directions of the antennae, and calculates the anticipated radiation in the vicinity of the facility. The building legislation of the canton concerned also specifies whether a structure profile of the planned antenna mast has to be erected at the intended location.
- **Publication of application, objection options:** The municipality concerned is obliged to publicly disclose the application for a building permit. In most cantons, residents have the opportunity to examine the application and raise objections. The site data sheet indicates up to which distance between place of residence and site of the facility the residents concerned are entitled to object.
- **Material examination of application and objections:** The relevant authorities examine the application and if necessary call on the assistance of the cantonal consulting office for non-ionising radiation. All calculations and details contained in the site data sheet are examined, and this sometimes requires on-site inspection. Objections also have to be evaluated, and a decision is taken concerning the building permit after hearings have been completed.
- **Building permit and appeal options:** If a planned mobile phone base station complies with the limit values specified by the ONIR and meets the applicable building regulations, it then has to be approved by the relevant authorities. The decision regarding the building permit is then communicated to the applicant and to any residents who may have raised objections. The latter then have the option of lodging an appeal against this decision with the relevant cantonal courts, up to the Federal Tribunal as final instance.

  In the event that 80 percent of the installation limit value is reached or exceeded, the relevant authorities require an approval measurement of the radiation level of the facility after start-up. In this way the authorities examine whether the facility complies with the installation limit value both on paper and in practice.

Hints for users of mobile phones

Mobile phone users can reduce their exposure to radiation by observing the following recommendations:

- **Low-radiation mobile phones:** Use a low-radiation device where possible. The lower the specific absorption rate (SAR), the lower the radiation that is absorbed by the head during a call. Details concerning the specific absorption rate of mobile phones can be found in the related operating instructions or at **www.topten.ch** and **www.handywerte.de** (in German).
- **Hands-free device:** With a hands-free device, the distance from the antenna of the mobile phone is increased, and this reduces the level of radiation that can enter the head. To protect other sensitive parts of the body, when using a hands-free device the mobile phone should not be kept in a pocket near the heart or in a front trouser pocket.

Comparison of exposure from base stations and mobile phones

Mobile phones have a considerably lower transmitting power than antenna systems, but exposure to radiation from a mobile phone when making a call is much higher than that from the most powerful base station. The reason for this is that we hold a mobile phone very close to our head, whereas we hardly ever come within a few metres of an antenna of a base station.
In view of the large distance from the base station, our entire body is uniformly exposed to an equal level of radiation, whereas with a mobile phone, the radiation is concentrated primarily on the head.
Another difference here is that a base station radiates permanently, whereas a mobile phone only does so during a call. If no call is being made – i.e. the device is in ready or standby mode – a mobile phone that is switched on receives control signals from the nearest base station, but it only sends a short signal every few minutes in order to report its whereabouts.
In the case of GSM, there are also different forms of signals. The radiation from a mobile phone is pulsed at a repetition rate of 217 Hz. The broadcast control channel of the base station transmits continuously with only short blank outs. If traffic channels are also activated, this results in a complicated and varying overall signal of the base station, since the signals of traffic channels vary according to the number of calls.

Base station	Mobile phone
Stronger transmitters	Weaker transmitters
Considerable distance away from people	Very close to head
Uniform exposure of entire body	Local exposure of head
Low absorbed power	High absorbed power in head region
Radiation permanently present	Radiation only present during calls
Radiation has a complicated signal form (applies to GSM)	Radiation regularly pulsed at 217 Hz repetition rate (applies to GSM)

Specific absorption rate for mobile phones

An international guideline applies in Switzerland for mobile phones, recommending a limit value for the specific absorption rate (SAR) of 2 watts per kilogram of body weight. The specific absorption rate indicates how much radiation the body absorbs and converts into heat during a call. The lower the SAR, the weaker the level of radiation.

**Example of the calculation of radiation exposure of the head when using a mobile phone: the model concerned has an SAR of 0.61 W/kg. The highest exposure is in the white/yellow zone in the outer layers. The exposure diminishes rapidly towards the interior. In the black zone it is 100,000 times weaker than in the outer layers.
(Original image from IT'IS Foundation, Federal Institute of Technology, Zurich)**

- **Quality of reception:** If the quality of the connection to the base station is good, the mobile phone transmits at low power. The level of exposure can therefore be reduced by making calls from locations where the level of reception is good (i.e. sealed rooms, cellars, etc. should be avoided).
- **Avoid phoning from a car:** Reception inside a car is poor, since the vehicle body strongly attenuates the radiation. Mobile phones should - if at all - only be used inside a car if the vehicle is equipped with an external antenna. Various studies have demonstrated that the use of a mobile phone when driving increases the risk of an accident because the driver no longer concentrates fully on the road. For safety reasons, making calls in a moving car is only permitted with the aid of a hands-free device.
- **Establishing a connection:** A mobile phone transmits at the highest power when establishing a connection. After dialling, the mobile phone should be kept away from the head until the connection has been made. In this way, exposure can be reduced.
- **Keeping calls short:** The shorter the call using a mobile phone, the lower the exposure.