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Cars, hybrid cars

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Relatively important low-frequency magnetic fields can occur in cars. The main sources are the magnetised steel belts in the tyres, which generate a low-frequency magnetic field when the car is moving. The ignition, the alternator, air conditioning system etc. also produce magnetic fields inside the car.

Hybrid cars have both an internal combustion engine and an electric motor. The drive system converts the excess kinetic energy from braking and idling into electrical energy. The electric motor uses this energy, thereby supporting the internal combustion engine to power the vehicle. The currents that flow through the circuits in the vehicle as a result of this generate magnetic fields.

Health effects

It is not known whether the long-term impact of low-frequency magnetic fields presents a health risk. No effects are expected from short-term exposure to the magnetic fields. People who wish to keep their exposure to magnetic fields low, as part of their own personal precautions, can have their tyres demagnetised at a few specialised garages in Switzerland.

The magnetic fields produced by the hybrid drive, as measured in the passenger compartment of two hybrid cars, were below the limit for known effects on health.

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1 Technical data

Cars

Various automobile components require electrical energy. While the car is stationary this is provided by the battery, and while travelling, by the alternator, which converts mechanical energy into electricity. This generates a low-frequency magnetic field in the cables and components that conduct the electricity. Since the chassis is used as a neutral conductor, electricity flows through it as well, generating a low-frequency magnetic field.

The steel beads and belts in tyres are magnetised, possibly as a result of the manufacturing process. The magnetised tyres generate a static magnetic field when the vehicle to which they are fitted is stationary, and a low-frequency magnetic field while it is in motion. The frequency of the magnetic field is dependent on the driving speed.

Table 1 gives an overview of the sources of electromagnetic fields in a car. In addition to the fundamental frequency shown, magnetic fields with higher harmonics (multiples of the fundamental) also occur. The threshold recommended by ICNIRP (International Commission on Non-Ionizing Radiation Protection) is given as a reference value. The threshold depends on the frequency of the magnetic field.

Table 1: Various sources of EMF in a car and their fundamental frequencies [1].

Source	Frequency (Hz)	ICNIRP-limit (µT)
Seat heater	0	40'000
Tyres (80 km/h)	10-12	500
Ventilator	~15	334
Ignition		143
Air conditioning	~500	6.25
Fuel pump	~600	6.25
Alternator	~1200	6.25

Hybrid cars

Hybrid cars have an internal combustion engine, which does the main work of propelling the car, and an electric motor, which provides support for the internal combustion engine.
In contrast to conventional cars, hybrid cars convert the energy that is not used when driving into electrical energy. Unused energy is produced during braking and when decelerating if, as the car goes along, a coupled drive can turn with the internal combustion engine.

In such cases, as the car goes along it supplies power to the electric motor which then acts as a generator. Thus, depending on the itinerary, the electric motor/generator continually changes from acting as a motor using energy to a generator producing energy. A battery stores the electrical energy. Since it is large, it is often installed in the boot, near the back seats.

The electric motor and the battery are connected together by an electric cable. The electric currents, which flow through the motor, cable and battery during the trip, generate magnetic fields. Since the cable and battery are near the passenger compartment, there is a possibility that some of the magnetic fields penetrate the passenger compartment

2 Exposure measurements

Cars

A study [1] determined the low-frequency magnetic field (5-2000 Hz) in all four seats of seven stationary cars with their engine and air conditioning running. The total body value was obtained by weighted aggregation of the measurements for ankle, knee, hip, chest and head. Since the measurements were performed while the cars were stationary, the tyres did not contribute to these magnetic fields.

Tabe Table 2: Magnetic field (5-2,000 Hz) averaged over the body [1].lla 2: campi magnetici (5-2000 Hz) ai quali è esposto il corpo [1].

Magnetic field (µT)	Car 1	Car 2	Car 3	Car 4	Car 5	Car 6	Car 7
Front left seat	0,11	0,12	0,15	0,22	0,14	2,6	3,2
Front right seat	0,15	0,13	0,33	0,37	0,11	1,1	0,78
Back left seat	0,04	0,06	0,03	0,03	0,06	2,4	4,0
Back right seat	0,1	0,11	0,04	0,04	0,03	1,3	1,5

In the cars with a battery situated at the front (cars 1-5), the measured magnetic fields were very small. Higher values were measured in cars 6 and 7. In these cars, the battery is situated in the boot or under the back seat, and the electricity from the alternator is thus conducted from front to back. This generates a relatively strong magnetic field, particularly on the left side of the car. At the left rear seat, a maximum magnetic field of 14 µT was measured at the level of the feet.

Comparison with the limits recommended by the ICNIRP (International Commission on Non-Ionizing Radiation Protection) [2] is difficult, as the magnetic field measurement is composed of the individual magnetic fields, which have differing frequencies and limits (Table 1).

Car tyres

The FOPH commissioned a study in which the magnetic fields generated by car tyres were measured. Since the low-frequency magnetic fields are produced when the magnetic tyres rotate, measurements were made in cars travelling at 80 km/h. The magnetic fields were measured at frequencies of 5 to 2,000 Hz in 12 different cars (Table 3) [3].

Table 3: Peak values in the magnetic field spectrum at various positions in 12 cars travelling at 80 km/h [3].

Magnetic field (µT)	Driver's hip area	Driver's head area	Passenger's foot area	Back seat
Average	0.29	0.21	3.22	3.28
Standard deviation	0.18	0.10	2.53	2.55
Maximum	0.73	0.45	8.89	9.51
Minimum	0.12	0.10	0.76	0.65

High values were measured in the foot area of the passenger seat and on the back seat. In 2/3 of the cars, values above 2 µT were measured; in ¼ of the cars values above 6 µT.
The fundamental frequency of the magnetic fields is 10-12 Hz at a speed of 80 km/h. However, Figure 1 shows that higher harmonic frequencies were also measured.

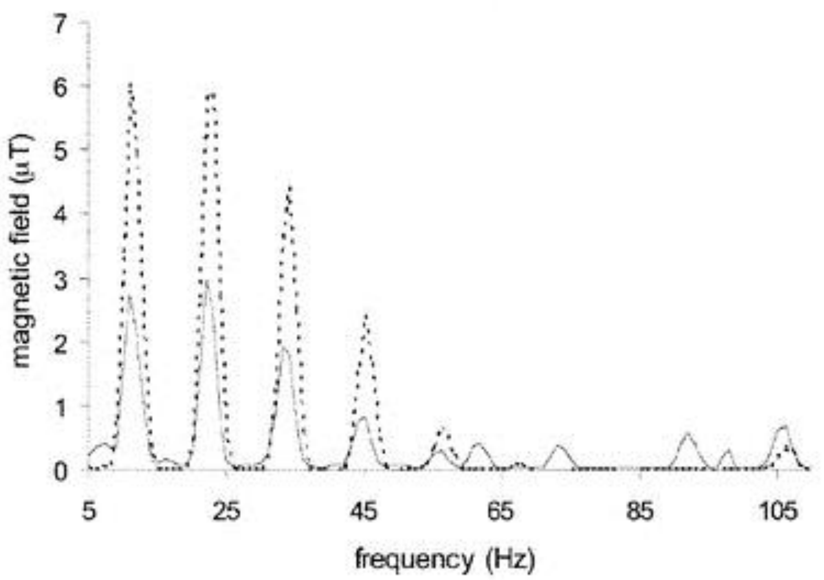

Figure 1: Typical magnetic field spectrum in car travelling at 80 km/h (magnetic field depending on the frequency). Dotted line: passenger seat foot area, solid line: back seat. Source [3]

A weighted aggregation of the spectral magnetic field parts between 5 and 100 Hz shows that in the back seat of the 12 cars measured, an average of 4%, maximum 6.9%, of the ICNIRP limits were attained (Table 4).

Table 4: Weighted aggregation of the spectral magnetic fields in the passenger compartment of 12 cars in motion, according to ICNIRP. The recommended limits of the ICNIRP are equivalent to 100% [3].

Proportion ICNIRP limits	Foot area passenger	Back seat
Average	4.6 %	4.0%
Maximum	14.3 %	6.9 %
Minimum	1.0 %	0.4 %

The same study also measured the magnetic fields of 32 tyres with different treads on a balancing machine. The frequency of the magnetic fields depend on the speed of the balancing machine. The magnetic fields between 5 and 2000 Hz were measured at a distance of 2 cm from the wheel (Table 5). The magnetic fields the tyres measured are broadly distributed between 0.8 and 97 µT.

Table 5: Peak values of spectral magnetic fields of car tyres, measured on a balancing machine at 2 cm from the tyre's surface [3].

Magnetic field (µT)	Total (n=32)	New tyres (n=13)	Used tyres (n=19)	Aluminium rims (n=25)	Steel rims (n=7)
Average	25.2	22.4	29.2	21.5	38.1
Standard deviation	22.3	7.8	34.0	18.8	29.9
Maximum value	97.0	33.9	97.0	97.0	71.9
Minimum value	0.8	10.1	0.8	0.8	6.4

Demagnetising car tyres

A study commissioned by the FOPH also developed a method to demagnetise car tyres [4]. A 50 Hz field is produced by a coil close to the car wheel, which is rotating on a balancing machine. The coil is slowly moved away from the car tyres, which reduces the 50 Hz field in the car tyres and demagnetises them. This method was able to reduce the magnetic fields in the car tyres strongly and permanently [3] (Table 6). Even after five months' use, the magnetic fields were still greatly reduced.

Table 6: Peak values of the spectral magnetic fields of four car tyres, measured on a wheel balancing machine at 2 cm from the tyre's surface. Monitoring after 1 and 5 months' use of the tyres. Source [3]

	Magnetic field (µT)
Before demagnetisation	11.7 ± 3.1
After demagnetisation	1.5 ± 1.6
Check after 1 month	1.1 ± 0.9
Check after 5 month	1.4 ± 1.

Hybrid cars

Biel Technical University was commissioned by the FOPH to measure the magnetic fields in the passenger compartments of two hybrid cars. The measurements were done whilst the cars drove through the town of Biel and in the laboratory under defined driving conditions. The measuring equipment was placed on the front passenger seat, in the driver's foot well and in a child's seat attached to the back bench. The tyres were de-magnetised, to rule out any effect of magnetic tyres on the results.

Hybrid cars generate a mixture of magnetic fields, at frequencies of 5 to 500 Hertz (Figure 2). The strength of the magnetic fields changes constantly as the car travels along, and is greatly dependent on the way the car is advancing or braking (Figure 3). The strength of the magnetic fields was similar for both vehicles. During driving, the magnetic fields on the child's seat were between 0.1 and 3 µT, which correspond to one to four percent of the threshold values. The magnetic fields on the front passenger's seat and in the driver's foot well are of the same order as those on the child's seat.

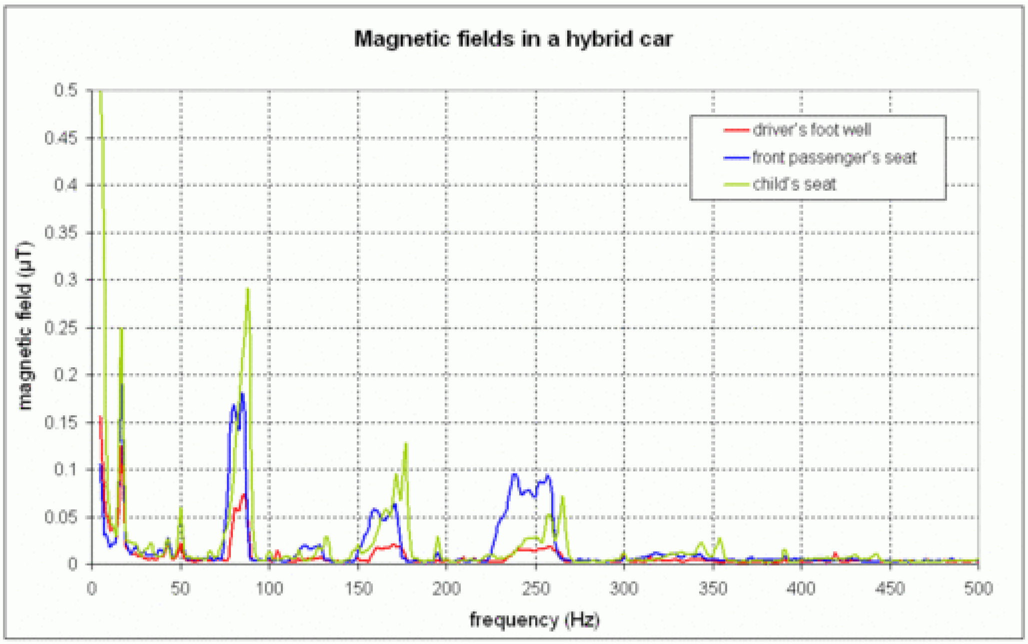

Figure 2: Frequency dependence of low frequency magnetic fields in the passenger compartment of a hybrid car, shown in relation to the threshold value. Measurements were made at one point in time during a drive around town, and were done in the driver's foot well, on the front passenger's seat and on the seat back of a child's seat attached to the back bench.

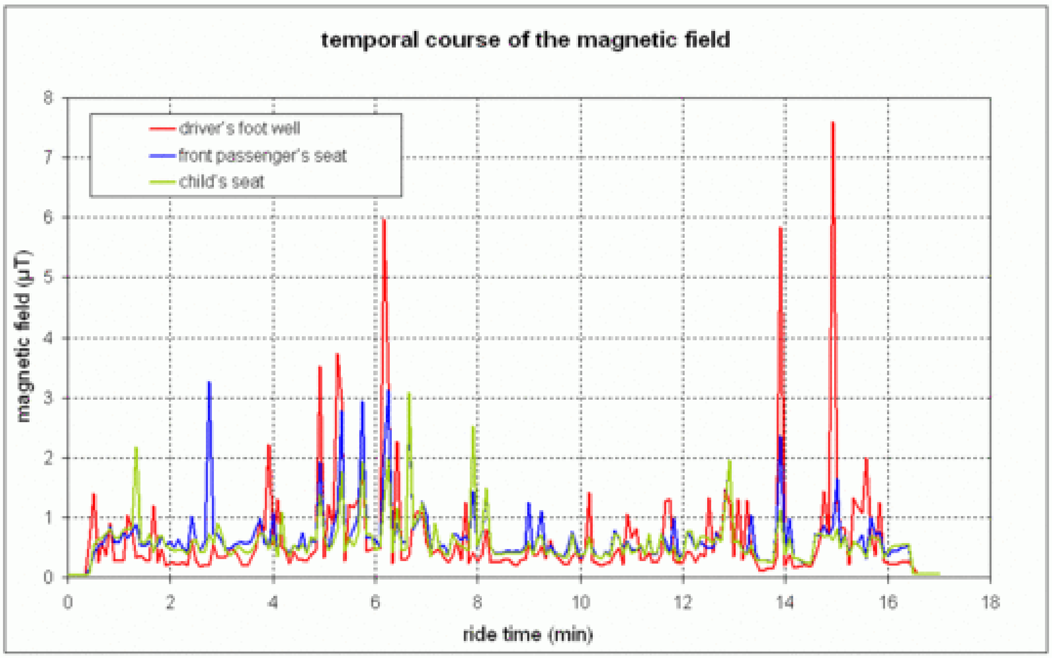

Figure 3: Low frequency magnetic felds in the passenger compartment of a hybrid car as it drives around town. Points of measurement: driver’s foot well, front passenger’s seat, seat back of a child’s seat attached to the rear bench.

3 Effects on health

So far, no specific studies have been carried out on the effects on health of magnetic fields in cars and hybrid cars. Low-frequency magnetic fields can penetrate the body and produce electrical currents in it. If the currents are too great, then under some circumstances nerves of the central nervous system could be briefly excited. The ICNIRP (International Commission on Non-Ionizing Radiation Protection) recommended limits permit magnetic fields to be only so great that the electrical currents produced are at least a factor of 50 below the excitability threshold of the central nervous system. The magnetic fields in the passenger compartment of cars and hybrid cars are, according to information that we have so far, much weaker than these recommended threshold values. Consequently, short term health effects are not to be expected.

In 2002 the International Agency for Research on Cancer (IARC) classified static and low-frequency magnetic fields as possibly carcinogenic (Group 2B) [5]. This was based on epidemiological studies that suggest that long-term and durable exposure to magnetic fields in the low-dosage area of 1 µT or even lower (< 0.4 µT) could increase the risk of Alzheimer's disease [6, 7] or of childhood leukaemia [8, 9].

It is not yet possible to estimate to what extent low-frequency magnetic fields in cars contribute to such long-term exposures.

4 Legal regulations

There is no regulation for electromagnetic fields in in cars. Logically, the ICNIRP limits [2] mentioned above can be taken as a reference. All the magnetic fields measured lie below these limits.

5 References

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