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Induction hobs

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Induction hobs cook rapidly and save energy. They have long been used in commercial kitchens because of their advantages, and they are becoming increasingly common in domestic kitchens.

In an induction hob, the heat energy needed to cook the food is created by medium-frequency magnetic fields. These magnetic fields penetrate the base of the pan, where they create electric currents which heat the pan and its contents. Some of the magnetic fields are not absorbed by the pan, thus stronger magnetic fields may also occur in the immediate vicinity of the hob.

According to studies carried out on induction hobs the magnetic field exposure is in the range of the magnetic field threshold value that is intended to prevent risks to the population.

These magnetic fields can be reduced so as to fall below the threshold value by correct use of the induction hob. The following tips will help you to get the best results:

- Make sure that you have read and understood the operating and safety instructions in the operating manual and follow these correctly.
- Use the right size of cookware for the size of the cooking zone marked out on the glass ceramic surface; don't put a small pan on a large zone, but use a pan that covers the cooking zone completely. Always place the pan in the middle of the cooking zone.
- Don't use damaged pans with buckled or rounded bases, even if they can still be heated without difficulty
- Persons standing close to the hob or who touch the worktop with their body during cooking are advised to use the rear cooking fields, or the front cooking fields at reduced power.
- Exposure to magnetic fields can be reduced greatly by keeping a distance of 5-10 cm between your body and the hob.
- It is vital to use specially manufactured pans to ensure that energy is transmitted efficiently from the hob to the pan. They are labelled by the manufacturer as suitable for induction cooking.
- People with a cardiac pacemaker or an implanted defibrillator should talk to their doctor before using an induction hob. To prevent leakage currents from flowing through your body which could possibly interfere with these devices don't use metal cooking spoons.

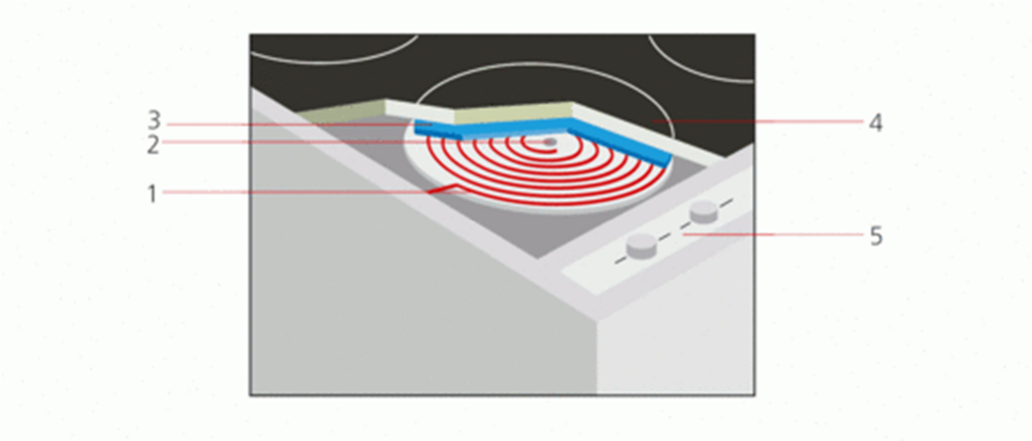
1 Situation

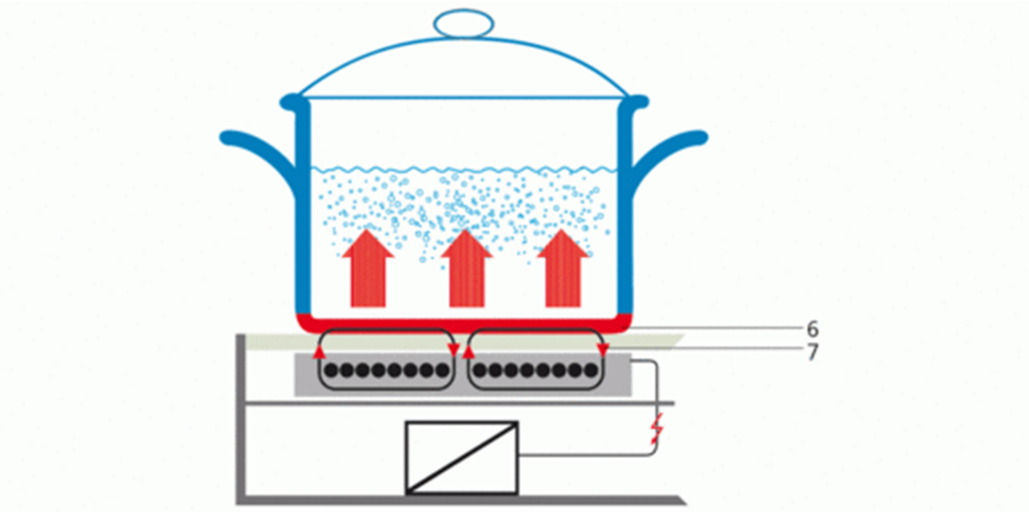
Electrical induction has been used for years in industry to heat electrically conducting components in a wide variety of applications. The primary use of this heating principle in the domestic setting is in induction hobs. Heat is generated directly in the pan and not, as with conventional hobs, conducted through the cooking zone to the pan. Induction hobs have a number of advantages: a rapid response time, rapid onset of cooking, shorter cooking times, energy-saving heat generation, no hot cooking zones and a correspondingly lower risk of burns and fire.

2 Technical information

Frequency: 20 – 100 kHz
Power: up to 7500 W

The principle of induction cooking
Beneath each cooking zone of the induction hob there is a coil through which a medium-frequency alternating current (20 - 100 kHz) flows. This creates a magnetic field of the same frequency which passes unobstructed through the ceramic cover of the hob and penetrates the pan sitting on the cooking zone (Figure 1). The magnetic field creates a circular current in the electrically conductive base of the pan (eddy current). This principle is called induction. The base of the pan is made of a material in which the heat-loss of the eddy current is as high as possible at the frequency being used. This happens in ferromagnetic materials. In these materials the alternating field is forced into the outer layer of the pan base (skin effect), which increases the resistance of the material to the current and produces intense heat. The alternating magnetic field within the base of the pan also repeatedly magnetises and demagnetises the material, and this creates additional heat (hysteresis loss) [1].





1 Induction coil	5 Indication of operation
2 Temperature sensor	6 Base of pan made of ferro magnetic material
3 Thermal insulation	7 Alternating electromagnetic field
4 Glass ceramic plate	

Stray fields

The magnetic field which is not captured by the induction in the pan is called a stray field. It is most likely to occur when the cooking zone is not completely covered by the pan [2]. Since the eddy current in the base of the pan creates a magnetic field that opposes the magnetic field generated by the hob and consequently the stray field are both weakened.

Leakage currents

The induction coil and the pan standing on the cooking zone form a capacitor. When the induction coil is switched on, the pan is charged electrically. If the pan is touched by a person, a small current (leakage current) may flow through that person's body [3].

Typical output

Appliances designed for use in the home usually have four cooking zones with different outputs ranging from 1200 to 3600 Watts. The total output of built-in units is approximately 7500 Watts. Cooking zones can be operated for a brief period at increased output (booster or power function) in order to start the cooking process rapidly or to heat water quickly.

Regulating heating power

Heating power can be regulated using various methods which affect the properties of the magnetic fields. Common methods include:

– Regulation using the frequency of the alternating current: The induction hob constitutes an electrical oscillating circuit which carries the maximum current at resonant frequency. If the frequency deviates from the resonant frequency, both current and output are reduced. (Example: full output at the resonant frequency of 17.5 kHz, output is four times lower at 41.7 kHz.)
– Regulation using pulse-amplitude modulation: Output is regulated by switching the magnetic field on and off periodically at lower cooking settings. One pulse every two seconds is typically used, with the duration of the pulse varying according to the selected output. The resulting magnetic fields are pulsed at a frequency of 0.5 Hz with varying pulse length.

3 Exposure limits

Electric and magnetic fields can induce electrical currents in the human body which, above a certain - intensity, can acutely stimulate the nerves and muscles. To avoid effects of this kind, the European - exposure limits are defined, such that the currents flowing in the body shall be 50 times lower than this - value. [4]. -

The underlying limits, known as basic restrictions, limit the current density, a term which describes the - flow of current through an area. The permissible current density is 50 times lower than the level at - which the nerves and muscles are stimulated. -

Current densities cannot be measured directly in the body. They can be calculated with considerable - experimental effort using body phantoms and numerical simulations. -
These difficulties are overcome by using values known as reference values. They are derived from the - basic restrictions and can be measured as the strength of an electric and magnetic field in the absence of a body. Reference values ensure that the associated basic restrictions are not exceeded. - They are particularly useful in cases where the whole body is exposed evenly. -

In cases where the electric or magnetic fields of an appliance exceed the reference threshold value - then a more detailed investigation step must be undertaken to determine whether the fundamental - basic threshold values are respected. -

The following limits apply to induction hobs: -

Basic threshold values

– Low-frequency fields at 50 Hz: current density of 2 mA/m^2
– Medium-frequency fields: the permissible current density depends on the frequency and ranges from 50 mA/m^2 at 25 kHz to 140 mA/m^2 at 70 kHz.

Reference values

- Low-frequency magnetic field: 100 µT
- Medium-frequency magnetic field: 6.25 µT

These exposure limits do not take account of the possible longer-term effects of electric and magnetic fields.

4 Exposure of the user to stray magnetic fields

In a study commissioned by the FOPH in 2006, the stray magnetic fields of two integrated models with four cooking zones (hob 1 and hob 2) and a professional high-performance mobile unit with one cooking zone (hob 3) were measured [2].

The current standard for induction hobs [5] stipulates that the unit must comply with the reference value of 6.25 microtesla (µT) [4] at a distance of 30 cm from the cooking field when one cooking zone is operated with a suitable pan that is large enough and centred on the cooking zone. All the units measured complied with this requirement.

However, in everyday use persons may use the induction hob in such a way that these conditions may not be met. The effect on the stray field of several cooking zones being used at the same time or unsuitable pans being used or the pans not being centred on the cooking zone was therefore also investigated. The magnetic fields were measured between 1 cm and 30 cm away from the edge of the glass ceramic cooking field since in practice it is not always possible to keep at least 30 cm away from the hob. This applies particularly to pregnant women, children and people of small stature.

Using several cooking zones at the same time

The measurements showed that the stray fields produced in front of the hob by simultaneous use of several cooking zones are not much larger than those created by a single cooking zone.

Appropriate vs. inappropriate pan

The measurements were carried out using appropriate and inappropriate pans which were centred over the cooking zone.

- **Appropriate pans:** Pans which are suitable for induction hobs AND / OR whose diameter is the same as that of the cooking zone.
- **Inappropriate pans:** Pans which are not suitable for induction hobs OR whose diameter is not the same as that of the cooking zone.

The stray fields measured with inappropriate pans were up to 3.5 times larger than those measured with appropriate pans (Figure 2).

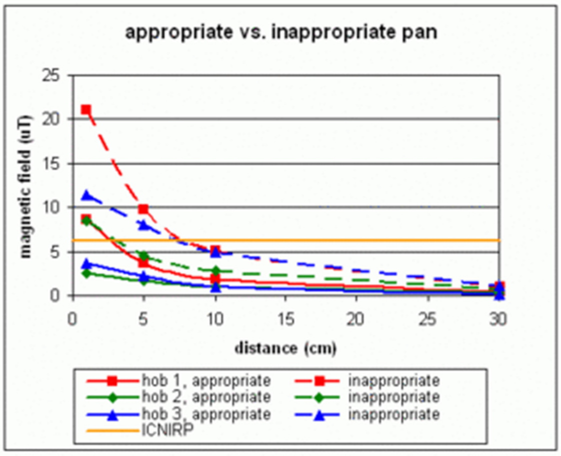


Figure 2: Stray fields were measured at a distance between 1 and 30 cm using appropriate and inappropriate pans centred over the cooking zone.

Centred vs. not centred position on the cooking zone

An induction hob switches off automatically when the pan is removed from the cooking zone. The stray-field measurements compared suitable, exactly centred pans with suitable pans which were only so far off-centre that the hob did not switch off. Figure 3 shows that positioning the pan off-centre increases the stray field for the same pan by a factor of up to 5.

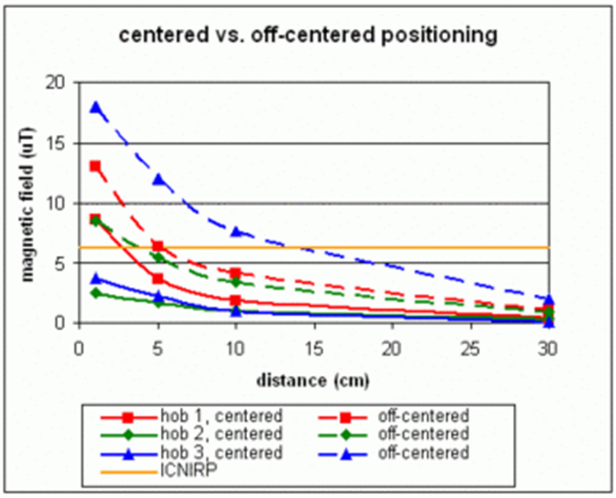


Figure 3: Stray fields were measured at a distance between 1 and 30 cm using centred and off-centre appropriate pans.

Appropriate pan, centred vs. inappropriate pan, off-centre

Figure 4 compares the stray fields from an appropriate, centred pan and an unsuitable, off-centre pan (worst case). The stray fields in the worst case are up to 9.5 times larger than the stray field generated by the use according to the standard.

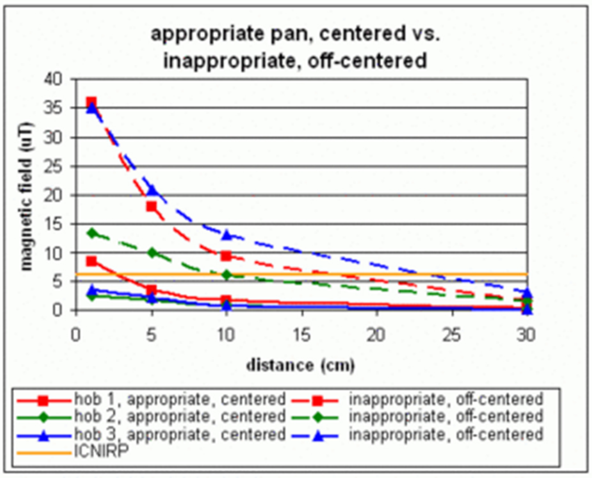


Figure 4: Stray fields were measured at a distance between 1 and 30 cm with appropriate, centred pans and inappropriate, off-centre pans.

The impact of distance on stray fields

Stray fields are larger the closer to the cooking field they are measured (Figures 2-4). At a distance of 30 cm, all models comply with the reference value of 6.25 microtesla (µT). In most cases the stray field measured 1 cm in front of the edge of the cooking zone exceeds this reference value. With an off-centre placing the stray field reached the reference value at a distance of < 1 cm to 12 cm with appropriate pans and < 1 cm to 20 cm with inappropriate pans. All measurements were carried out with the hob at the highest setting. A distance of 1 cm is unlikely to occur in normal daily use and represents a worst-case scenario. None of the measurements exceeded the reference value at a distance of at least 5 - 10 cm, the distance most likely to occur in practice, when the pans are used correctly (suitable cookware, centred over the cooking zone).

5 Exposure of the user to induced body currents

The stray fields originating from induction hobs lead to electrical currents running through the body of a person standing in front of the hob. In order to avoid acute reactions such as nerve or muscle stimuli, these currents may not exceed the European reference values for the exposure to currents flowing in the body and in particular in the central nervous system [4].

As the stray fields described in chapter 2 have partly exceeded the reference value, a further investigative step was undertaken in order to determine whether the currents generated in the body by these stray fields respect the threshold values for exposure to currents.

Body currents cannot be measured directly; they have to be calculated with computer simulations using virtual model persons. On behalf of the FOPH, the IT'IS research foundation in Zurich undertook such simulations for models standing directly by the worktop in front of the three tested induction hobs and who are cooking with properly positioned pans suitable for induction hobs. In addition to the magnetic currents, the simulations also took into account gender, age, build, anatomy, tissue characteristics and posture of the following virtual persons:

- Woman, age: 26, height: 1.60 m, weight: 58 kg, not pregnant
- Woman, age: 26, height: 1.60 m, three/seven/nine months pregnant
- Foetuses in the third/seventh/ninth month
- Girl, age: 5, height: 1.08 m, weight: 18 kg
- Boy, age: 6, height: 1.17 m, weight: 20 kg
- Boy, age: 14, height: 1.65 m, weight: 50 kg
- Man, age: 34, height: 1.74 m, weight: 70 kg
- Man, age: 37, height: 1.78 m, weight: 120 kg

The body currents were simulated for peripheral parts of the body as well as for the central nervous system (brain and spinal cord) (Figure 5).

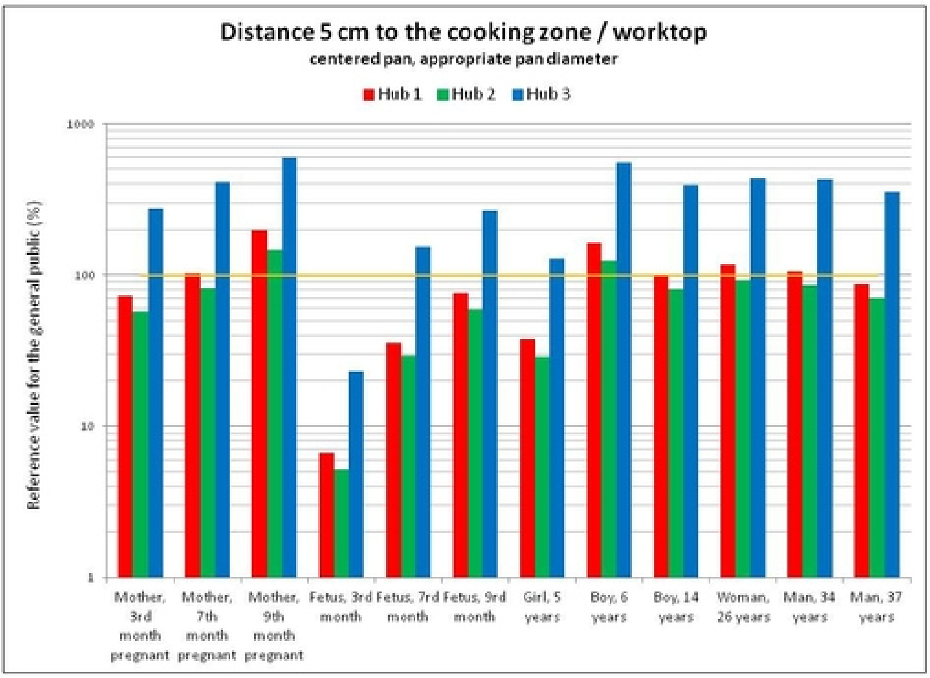


Figure 5: Body currents measured throughout the entire body of models standing directly by the worktop of induction hobs, as a ratio of reference value. 100% corresponds to the reference value for the general public. Hob 1 and hob 2 are built-in units; hob 3 is a professional mobile unit.

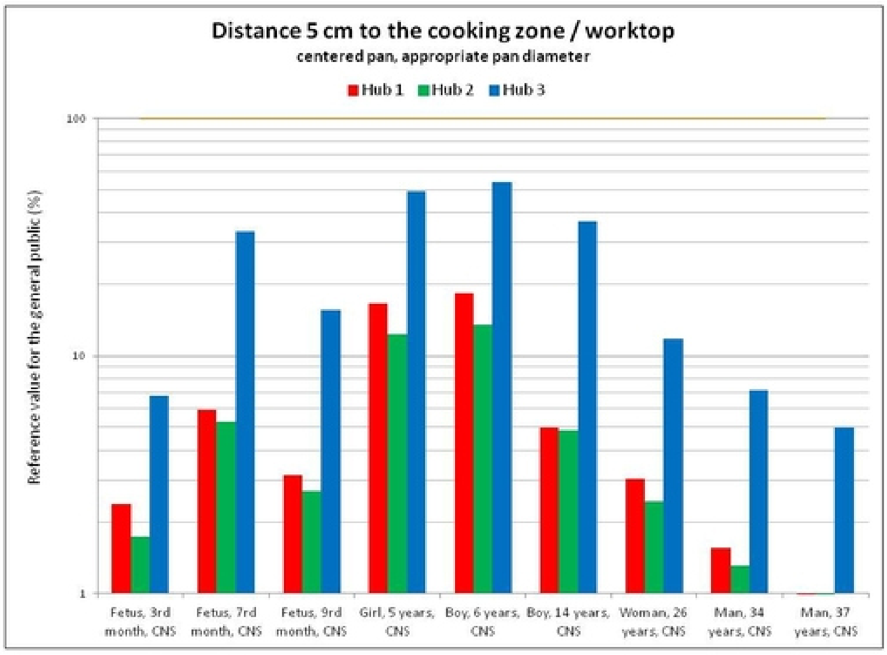


Figure 6: Body currents measured in the central nervous system of models standing directly by the worktop of induction hobs, as a ratio of reference value. 100% corresponds to the reference value for the general public. Hob 1 and hob 2 are built-in units; hob 3 is a professional mobile unit. CNS = Central nervous system

The results show that the body currents emanating from the two built-in units fall below or right on the reference value for most models, with the exception of the woman who is nine months pregnant and the six-year-old child, both of whom show body currents above the reference value. The body currents generated by the professional high-performance mobile unit are mostly above the reference value (figure 5). The central nervous system currents, which are all-important for the health evaluation [4], are below the reference value for all models, however (Figure 6).

6 Effects on health

6.1 Magnetic fields

To date no specific studies of the effect of induction hobs on health have been carried out.

According to the World Health Organization (WHO), there is no compelling evidence of medium-frequency magnetic fields having long-term effects on health. [6]. However, it notes that relatively few studies investigating this frequency range have been published. It is not possible to draw any conclusions from the small number of animal studies that have been carried out in the medium-frequency range. The human studies, most of which have looked at the risks posed by computer monitors, have not identified any impact on health. The extent to which these results can be extrapolated to induction hobs is not clear, since these appliances are different in terms of both the radiation which they emit and the size of the magnetic fields.

Magnetic fields can penetrate the human body and induce electrical currents in it. If these currents exceed a certain value they can directly stimulate the central nervous system. To avoid effects of this kind, the European exposure limits for magnetic fields are defined, such that the currents flowing in the body shall be at least 50 times lower than this value. [4]. By following the hints listed under "Health risks and Precautions" you can ensure that these threshold values are respected.

6.2 Effect on implanted electronic devices

Some studies have looked at the way induction hobs affect implanted electronic devices [3,7-9]. The possibility cannot be excluded that stray magnetic fields generated by induction hobs may affect implanted electronic devices at short range; this has been demonstrated for unipolar cardiac pacemakers [3]. Also the effect of leakage current on unipolar cardiac pacemakers has to be borne in mind. People with unipolar pacemakers are advised not to touch pans for extended periods and not to use metal spoons for cooking [3]. It is vital for people with implanted electronic devices to read the safety advice provided by the manufacturer and talk to their doctor before using an induction hob. The Rechtliche Regelung

7 Regulation in law

Induction hobs are low-voltage appliances which are regulated in Switzerland by the Regulation concerning electrical low-voltage appliances [10]. This regulation requires low-voltage appliances not to endanger either persons or objects when used correctly, where possible when used in a foreseeable incorrect manner, and when foreseeable faults occur. It also states that low-voltage appliances may only be marketed if they comply with the essential health and safety requirements of the European (EC) Low Voltage Directive.

Manufacturers of low-voltage appliances must obtain a Declaration of Conformity for a product before it can be brought onto the market; this declaration states that the product complies with the essential requirements. The essential requirements for individual products are specified in technical standards; the requirements that the electromagnetic fields created by domestic appliances have to meet are specified in SN EN 62233: 2008 [4]. The corresponding conformity criteria correspond to the limit recommended by the EU [4].

Manufacturers are responsible for ensuring that their appliances comply with the conformity criteria; there is no comprehensive oversight of the market in Switzerland. The Swiss Inspectorate for High Current Installations (www.esti.admin.ch) checks compliance with the regulations by inspecting random samples of products on the market.

8 References

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