Energy-saving lamps

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Energy-saving lamps are also known as compact fluorescent lamps, compact fluorescent lights, energy-saving lights or energy-saving light-bulbs. Due to their design, energy-saving lamps generate electromagnetic fields and ultraviolet radiation in addition to visible light. If energy-saving lamps break then small amounts of mercury can be released. When used correctly energy-saving lamps are energy-efficient and comfortable lamps.

Figure 1: Top: Energy-saving lamp without an external glass or plastic envelope and with exposed fluorescent tubes. Bottom: Energy-saving lamp with an external envelope.

At a distance of 20 cm, the electromagnetic fields of energy-saving lamps are already well below the current limit values, such that according to our current state of knowledge no health risks are to be expected.

For lighting living rooms and private rest areas, which are occupied for longer periods in the evening, energy-saving lamps with a warm white light colour and colour temperatures of 3000 Kelvin are suitable.

Correctly used energy-saving lamps produce negligible exposure to ultraviolet radiation or to mercury. The following recommendations may be helpful:

- In order to minimise your exposure to UV radiation and electric fields stay at least 30 cm away from energy-saving lamps in rest, recreation or work areas where you spend lengthy periods.
- If you remain very close to energy-saving lamps for longer periods, then it would be advantageous to use energy-saving lamps with a second casing which emit only low amounts of ultraviolet radiation. If you are sensitive to low exposures of ultraviolet radiation, then a LED lamp can be advantageously used.
- Energy-saving lamps contain mercury. If a lamp breaks and the mercury escapes, there is no danger to health as there is only a small amount of mercury. The broken lamp can be best disposed of by picking up the glass shards and the dust with a moist piece of kitchen roll or with adhesive tape on carpets. Do not use a brush nor a vacuum cleaner. Put all the residues and the cleaning material in a plastic bag, make a knot and put it in the household waste. Before and after cleaning, thoroughly air the room in which the lamp broke.
- Defective energy-saving lamps with an intact glass bulb must not be disposed of in household waste. Return them to the shop where you bought them or to a specialised disposal centre.

1 Summary

An energy-saving lamp consists of a compact, gas-filled fluorescent light tube and an electronic ballast (starter). The ballast transforms low-frequency alternating current from the mains supply, from 50 cycles per second (Hertz, [Hz]), into medium-frequency alternating current at 25 000 to 70 000 Hz. The medium-frequency current flows through the tube and, with the aid of the mercury in the gas, produces ultraviolet (UV) light. A special coating on the inside of the tube transforms the UV light into visible light.

1.1 Low- and medium-frequency magnetic and electric fields

The electrical currents flowing in the lamp generate low- and medium-frequency magnetic and electric - fields. Low- and medium-frequency magnetic and electric fields can induce electrical currents in the - human body which, above a certain intensity, can stimulate the nerves and muscles. The currents - must not exceed the exposure limits in force to ensure that this type of stimulation does not occur in - people.

A Swiss study measured the magnetic and electric fields of eleven energy-saving lamps and calculated the current densities induced by these fields in humans. -
The study shows that medium-frequency electric fields are primarily responsible for these currents. - Depending on the type of lamp, the current densities in the immediate vicinity of the lamp reach between 10 and 55% of the exposure limit. The currents weaken rapidly with increasing distance from - the lamps, and are only between 2 and 10% of the exposure limit at a distance of 20 cm. -

By contrast, the low- and medium-frequency magnetic fields are small and do not cause any significant exposure. -

1.2 UV radiation

Energy-saving lamps with exposed fluorescent tubes may not be completely impermeable to UV radiation, so that a small amount may escape from the lamp. People who are less than 20 cm from these lamps for several hours may experience reddening of the skin as a result of excessive UV exposure. Very little or no UV radiation is emitted from energy-saving lamps with a second, light-bulb-shaped envelope (Figure 1).

1.3 Toxic substances

Energy-saving lamps do contain toxic substances, but nevertheless do not represent a health risk if some rules are respected; the rules can be found on the following website:

Energy saving lamps: Toxic substances

2 Technical data

Voltage: 230 Volts (V)
Frequency:
Low frequency: 50 Hertz (Hz) at the light fixture and on the primary side of the ballast. -
Medium frequency: 25-70 kiloHertz (kHz) on the secondary side of the ballast and in the fluorescent - tube.
Output: up to 23 Watts (W)

Construction and principle
Energy-saving lamps transform electrical energy into optical radiation in three steps. In the first step an electronic ballast (starter) transforms the low-frequency (50 Hz) alternating current from the mains supply into medium-frequency alternating current with a frequency of between 25 and 70 kHz. In the second step the accelerated electrons in this current excite the mercury atoms in the gas filling, causing them to emit photons and ultraviolet radiation. In the third step a special phosphor coating on the inside of the tube transforms the UV radiation, which is not visible to the naked eye, into visible light.

2.1 Electric and magnetic fields

The electrical currents flowing in the ballast and fluorescent tube generate low- and medium-frequency magnetic and electric fields.

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 [1].

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. The following limits apply to energy-saving lamps:

Basic restrictions

- 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
- Low-frequency electric field: 5000 V/m
- Medium-frequency electric field: 87 V/m

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

2.1.1 Measuring exposure

The IT'IS Foundation was commissioned by the Federal Office of Public Health and the Federal Office of Energy to investigate eleven different energy-saving lamps and two different types of LED lamps, light-bulbs and fluorescent tubes with conventional inductive ballast [2].

2.1.1 Medium-frequency electric and magnetic fields and current densities

Figure 2: Liquid-filled phantom in the electrical field of the energy-saving lamp. The currents induced in the phantom are - measured using the - clip in the middle. There is a gap of 2 cm between the bulb and the phantom [2].

The medium-frequency electric and magnetic fields of the various lamps were measured at distances of 15 and 30 cm. The magnetic fields of all the lamps measured were between 50 and 100 times smaller than the reference value for magnetic fields. In contrast, the electric fields exceeded the reference value for electric fields by up to five times at a distance of 15 cm.

As mentioned above, reference values are only reliable if the body is exposed evenly. However, energy-saving lamps create small and inhomogeneous electric and magnetic fields in their vicinity, rendering a comparison of these fields with the reference values unsuitable. For this reason, the current densities created by energy-saving lamps must be measured in the body and compared with the basic restrictions.

The IT'IS Foundation has developed a new method for this purpose. In the first step a phantom filled with liquid is placed in the electric field of the energy-saving lamp (Figure 2). The liquid in the phantom has a similar electrical conductivity to the human brain. The electric field of the energy-saving lamp creates a current in the phantom which is measured using the clamp in the middle of the phantom (Figure 2).

In the second step, the measurements taken from the phantom are processed using computer models to calculate the currents induced in a human being. The calculations were carried out with four different models (man, woman, 6-year-old boy, 11-year-old girl) and for various body positions. It emerged that the differences between the people and the various body positions were not very large, with the results differing by a factor of 2 at most.

Table 1 shows the calculated maximum current densities in the human body for all eleven energy-saving lamps. In this scenario the distance between the person and the energy-saving lamp is only 2 cm. It is thus not a realistic situation but a worst-case scenario. The highest value was half the basic restriction. The energy-saving lamp in question (lamp number 4) is not available in Switzerland. Lamp number 3 is not available in Switzerland either. The other energy-saving lamps, which are all available in Switzerland, induce current densities which are between five and ten times lower than the exposure limit.

Table 1: Maximum calculated current densities in humans for the eleven energy-saving lamps investigated. The calculations assume a worst-case distance of 2 cm.

Lamp	Current density(mA/m2)	measured frequency (kHz)	% of basic exposure limit
1	10,4	46,5	11,2
2	14,6	43,6	16,8
3	13,2	37,7	17,5
4	52,5	47,1	55,7
5	13,4	36,9	18,2
6	8,5	37,7	11,3
7	21,4	48,8	21,9
8	10,4	47,1	11,0
9	5,1	26,2	9,8
10	7,3	41,5	8,8
11	15,3	40,2	19,0

The current densities decrease as the distance from the energy-saving lamp increases. Figure 3 shows current density as a function of distance from the energy-saving lamp. At a distance of 20 cm the current density is five times lower than at the worst-case distance of 2 cm

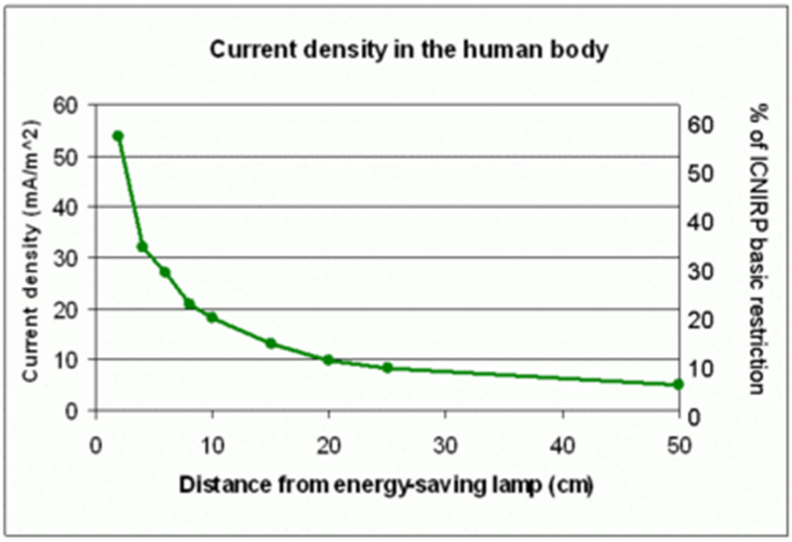

Figure 3: Relationship between distance and current density and relationship between measured values and exposure limit using the example of the lamp with the strongest fields (lamp number 4).

Figure 4 shows the calculated current densities (current per area) in a person whose head is close to an energy-saving lamp. The person is earthed, allowing the current to be discharged through the feet. Since the ankles are the narrowest part of this route, the greatest current density occurs in the Achilles tendon.

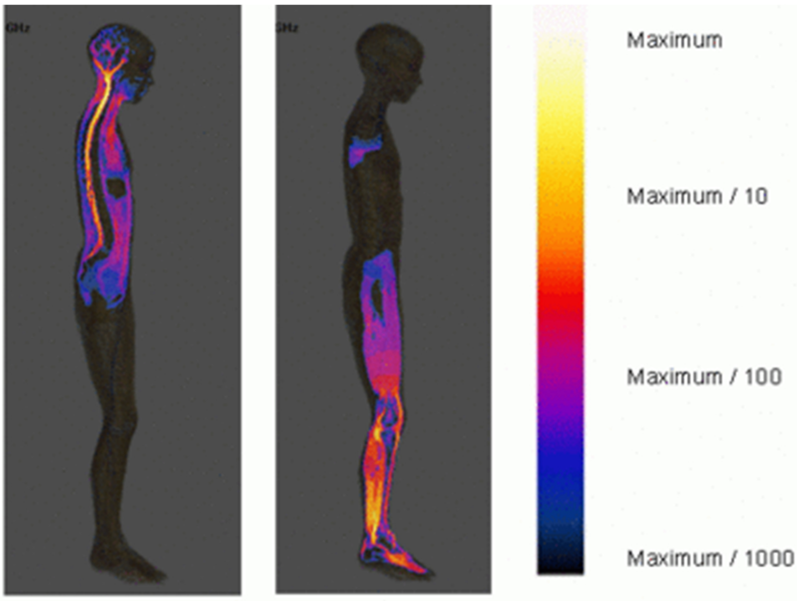

Figure 4: Distribution of calculated current densities in the model of a person (11-year-old girl) with a simulated energy-saving lamp suspended above her head. The currents are induced by the medium-frequency electrical field of the energy-saving lamp. Left picture: Cross-section at spine level. Right picture: Cross-section at Achilles tendon level. High values are shown in yellow, low values in black and blue. The highest current density occurs in the Achilles tendon [2].

The current densities measured for the light-bulbs, LED lamps and fluorescent tubes with conventional inductive ballast were so low that they were below the working range of the measuring equipment.

2.1.2 Low-frequency magnetic fields

The low-frequency magnetic fields were measured 15 cm below and 15 cm to the side of the lamp and compared with the reference value. Energy-saving lamps, LED lamps and light-bulbs all generated very small low-frequency magnetic fields. All the values measured were below 0.5 µT and are thus at least 200 times lower than the reference value. The fluorescent tubes with conventional ballast induce slightly larger low-frequency magnetic fields of up to 4 µT. These values are 25 times lower than the reference value.

3 Impact on health

3.1 Low- and medium-frequency electric and magnetic fields

Low- and medium-frequency magnetic and electric fields induce electrical currents in the human body which, above a certain intensity, can acutely stimulate the nerves and muscles. Since the fields of energy-saving lamps are below this level, acute stimulation is unlikely to occur. The longer-term impact on human health of the electric and magnetic fields generated by energy-saving lamps has not been investigated to date.

Few studies have been performed of the medium frequency range (300 Hz - 100 kHz), in which energy-saving lamps and other devices such as computer monitors work. Most of the laboratory and animal studies carried out so far have focused on the question of whether exposure to fields of this type, e.g. those generated by computer monitors, can affect foetal development or reproduction. The results of studies carried out so far are inadequate to permit any conclusions. Carcinogens, genotoxic and toxic effects and effects on the nervous system cannot be evaluated because the number of studies available is too low [3].

3.2 UV radiation

Studies show that energy-saving lamps are not fully impermeable to UV radiation, probably due to defects in the coating, and emit UV-A, UV-B and sometimes even highly energetic UV-C radiation [4,6]. Because of the lamps' feeble heat release, a person may place himself very close to an energy-saving lamp, i.e. less than 20 cm away, and the radiation exposure to the eyes and skin may possibly exceed the current threshold limits. Consequently, health effects such as skin reddening are not to be excluded [5,7]. Energy-saving lamps with a double envelope tend to emit less UV, although this statement is not always true [4].

In some circumstances energy-saving lamps represent a risk for persons with skin diseases, such as e.g. chronic actinic dermatitis, who react sensitively to UV radiation or blue light [5,8,9]. Such people should not use single envelope energy-saving lamps if they work for longer periods near to the lamp. As double envelope energy-saving lamps also emit UV radiation, sensitive persons can avoid the UV by using low-radiation LED lamps [5].

3.3 Visible light

Visible light can affect physiological processes in the human body. The photoreceptor melanopsin occurs in the retina, where it absorbs light in the blue part of the spectrum. One of its functions is to adjust the "internal clock" which produces a circadian (day/night) rhythm in the body. The internal clock affects sleeping and waking and other parameters such as body temperature, hormones, such as melatonin, tiredness and cognitive performance.

As the visible light emitted by energy-saving lamps and conventional light-bulbs contains blue and other colours of light, the Institute of Chronobiology of Basel University, supported by the FOPH, investigated whether and to what extent conventional light-bulbs and energy-saving lamps affect sleep and circadian, hormonal and cognitive processes in humans [10,11]. The analysis of the results suggests that those energy-saving lamps that have a warm white light colour or colour temperatures of 3000 Kelvin are particularly suitable for evening lighting of the household.

FOPH research projects: Energy-saving lamps

3.4 Mercury

Energy-saving lamps contain only a very small amount of mercury - usually less than 5 milligrams. This mercury is hermetically sealed in the fluorescent tube, but it may be released if the glass breaks. If this happens, the air in the room will contain a low level of mercury for a short time, but the amount is so small that it poses no risk to health.
If an energy-saving lamp breaks, we recommend disposing of the fragments as described previously and airing the room. There is no risk of chronic exposure to mercury in the room air because there is not a large amount of liquid mercury which could persist in the room and contaminate the air over a longer period.

Defective energy-saving lamps must not be disposed of with household refuse because they contain mercury and other components which could affect the environment.

FOPH fact sheet: Quecksilber

4 Legal situation

4.1 Electric and magnetic fields

Energy-saving lamps are low-voltage devices and as such must comply with the requirements of the Regulation concerning electrical low-voltage devices (SR 734.26)[12]. Low-voltage devices must not pose a danger to either people or objects, and may only be brought into circulation if they comply with the fundamental health and safety requirements of the European (EC) Low-voltage Directive [13]. The basic requirements governing electromagnetic fields are specified in European standards. Lighting equipment is regulated in standard IEC 62493 issued by the International Electrotechnical Commission [14] and in the standard of the same name EN SN 62493: 2010 [15] in the EU and Switzerland.

The permissible electric and magnetic fields are in line with the recommendation of the European

Council on the limitation of exposure of the general public to electromagnetic fields [1]. The manufacturers are responsible for ensuring that their equipment complies with these conformity criteria; there is no comprehensive control 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.

4.2 Optical radiation

The permissible optical radiation is defined in European standard EN 62471:2008 [16]. This standard has the status of a Swiss standard and is a generally recognised code of practice in Switzerland.

4.3 Mercury and disposal

Energy-saving lamps are governed in Switzerland by the Chemical Risk Reduction Regulation (ChemRRV) [17]. This regulation refers to European Directive 2002/95/EC, which restricts the use of certain hazardous substances in electrical and electronic equipment [18]. The European Directive stipulates that an energy-saving lamp may contain no more than 5 mg of mercury.

Energy-saving lamps and fluorescent tubes are subject to the provisions of the Regulation on the return, acceptance and disposal of electrical and electronic equipment (VREG) [19]. Among other things, the Regulation requires illuminants and lamps to be returned to the dealer, manufacturer or importer. These entities, in their turn, are obliged to accept the old material at no charge - provided that their range includes devices of this kind - and to dispose of it in an environmentally compatible manner.

5 Literature

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18. Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment
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