1. Electricity and Health

Leena Korpinen
Professor, M.D., D.Tech.
Tampere University of Technology
Laboratory of Electrical Engineering and Health

University gets inquiries about the health effects of electric and magnetic fields

People often inquire through email and phone about electric and magnetic fields. This article presents the most common questions.

During one year Laboratory of Electrical Engineering and Health has received 23 inquiries, i.e. one inquiry every other week. In addition, 7 journalists contacted our laboratory, leading to various media dealings with electromagnetic fields.

There were mainly two kinds of inquiries. Most of the inquirers were people from technology branches wanting to pay attention to potential health effects of electric and magnetic fields when developing new products. Also, the contactor can be an aware customer wanting to receive information about a product's potential electric and magnetic fields and their health effects.

The second group consists of people who are worried about their own health or their children's health. One of the most typical questions was whether one can buy a house near a transmission line. Apart from these, the health related questions concerned the fields caused by various devices.

Electric and magnetic fields – some background information

The Finnish electric system consists of electric power stations, transmission-, regional, and distribution networks and devices that use electric power. To put it simply, electricity is first transmitted from electric power stations to a nationwide transmission network (main grid) that has a voltage of 110, 220 or 400 kilovolts (kV). The transmission network connects to distribution network at substation, from which electricity is transmitted in medium voltage network with a normal voltage of 20 kV. The electric

power is transmitted from the medium voltage networks to customers in low voltage cables.

A live cable or device generates an electric field around it. Electric field strength is measured in volts per meter (V/m). The current in the electric cable generates a magnetic field around it. Magnetic field is depicted for example with a variable called magnetic flux density, the unit of which is tesla (T). In practice, the values are given in microteslas (μT), which is a thousandth part of tesla.

There are electric and magnetic fields near transmission and distribution systems of electric power, and also near electric devices when they are functioning. People are exposed to electric and magnetic fields both at work and in their leisure time. Potential health effects have been studied extensively.

One of the recognized effects of low frequency magnetic fields (e.g. transmission lines) is the reaction of nerve and muscle cells due to electric current. In addition, sight sensations are possible. Very strong low frequency electric fields bring about skin-deep effects, that are caused by a minor spark discharge and moving hair.

IARC, the International Agency for Research on Cancer in WHO (The World Health Organization), noted that a lengthy residence within a magnetic field of over 0,4 μ may cause cancer in children (leukaemia). IARC has classified the low frequency magnetic fields to class 2B, that is, possibly causing cancer. For example, coffee and exhaust gas belong to class 2B.

"The fields caused by power lines are fairly insignificant and research shows that they do not have any health effects."

However, it has not been possible to prove the increased risk with scientific certainty. Nor do we know a biological mechanism that could explain the magnetic fields' potential ability to cause cancer.

There has been a lot of public discussion about electric devices, mobile phones, computer screens and transmission lines possibly causing hypersensitivity to electricity. However, no connection between the exposure to the fields and the symptoms has been found in scientific research.

Those who consider themselves hypersensitive to electricity have a

multitude of different symptoms like tingling, vertigo, weariness, headache, powerlessness and skin symptoms. These symptoms feel real to the people in question although as yet there is no scientific proof of the electric and magnetic fields causing them.

Based on research, limitations have been set as to exposure to these fields. In Finland, the Ministry of Social Affairs and Health gave a new decree 'on the limitation of public exposure to non-ionizing radiation' in 2002 (294/2002)[1]. The decree enforces binding limits for exposure to ultraviolet radiation, radiofrequency radiation and laser radiation. In addition, the decree gives recommendations for maximum exposure limits for low frequency electric and magnetic fields. However, the decree applies only to public exposure. According to the decree, the recommended value for public exposure to the electric fields of a transmission line (50 Hz) is 5 kV/m and to the magnetic fields 100 μ, if the exposure is of a significant length.

On April 4, 2004 a directive came to force in the European Union (2004/40/EU) on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields).[2] The directive includes the maximum values for employee exposure to low frequency electric and magnetic fields. Presently, the directive is being adapted to the local legislation. The directive's action values for exposure to 50 Hz electric field are 10 kV/m and 500 μT for magnetic fields. The exposure limit value for exposure to low frequency fields is given in current density (10 mA/m2).

Living near transmission lines

It is important to know the voltage or current and the distance to the transmission line when we evaluate the fields of the transmission lines. In general residences are situated so far from the transmission lines that exposure levels in the yard and inside the house are at the same level as normal background fields. In other words, a transmission does not in practice have any importance to the field exposure of the residents.

Tampere University of Technology has measured and evaluated quite a few transmission line fields. Figures 1 and 2 present the measurement findings of TUT. The recommended maximum values in the EU recom-

mendation ‘On the limitation of public exposure to electric and magnetic fields (0 Hz – 300 GHz)’ are 5 kV/m and 100 μT.

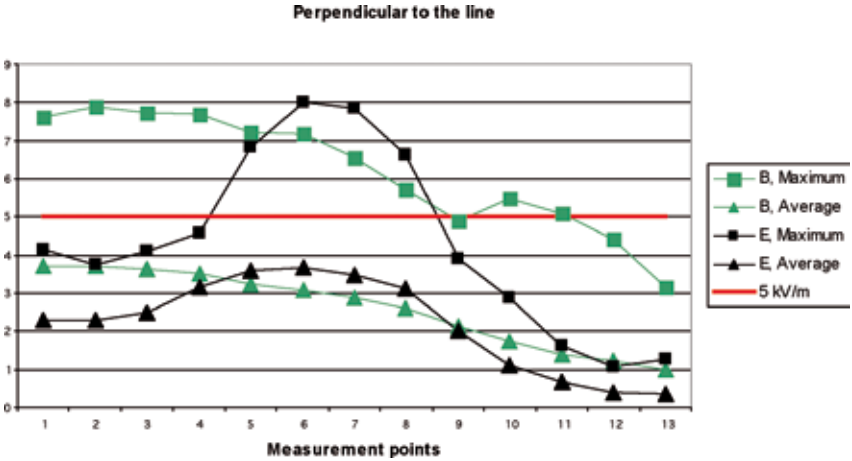

Figure1. Combined maximum and average values for the strength of electric and magnetic fields, measured perpendicular to the line (n = 21). The voltages in the ends of the measured lines varied between 391,1 - 407,5 kV during the measuring.[3]

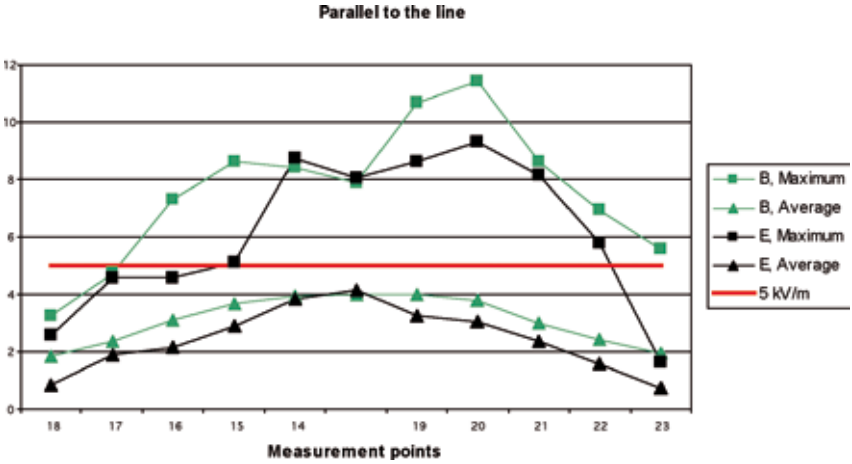

Figure2. Combined maximum and average values for the strength of electric and magnetic fields, measured parallel to the line (n = 21). The voltages in the ends of the measured lines varied between 391,1 - 407,5 kV during the measuring.[3]

As for fields in substations, measuring has focused on the exposure of employees, i.e. measurements were taken inside the station. Due to the inquiries addressed to TUT, we have also measured the outside area that people have access to.

Figure 3 shows an example substation, outside of which, and from there towards the road the measurements were conducted.

Figure 3. A photo from outside of the substation.

Figures 4 and 5 show the results.

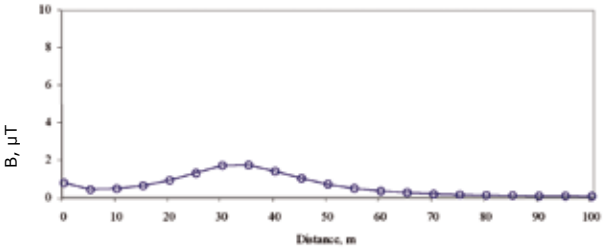

Figure 4. Results of the magnetic field measurements outside the substation starting from the fence.

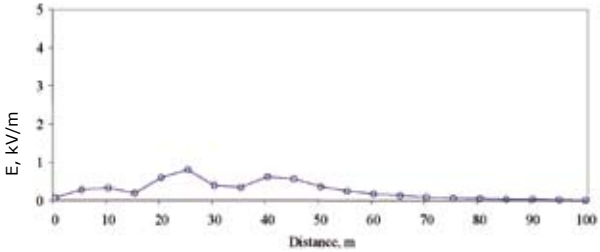

Figure 5. Results of the electric field measurements outside the substation, starting from the fence.

Based on these measurements, it seems the fields are quite weak outside the substation.

Fields caused by various devices

The health related questions often concern devices and their fields. Table 1 shows different measurement results by TUT of the magnetic fields generated by various devices. Electric fields around the devices are of insignificant value.

Table 1. Examples of magnetic fields generated by certain devices (B50 is the magnetic flux density at 50 Hz frequency and Bm is the maximum value for the magnetic flux density). The devices were measured at five points, from a distance of 25 cm from the device surface, the background field measuring 0,02 µT.[4]

Device (number,pcs)	Average B_{50} / µT	Maximum value B_{50} / µT
Fan	4,3	8,1
Drilling machine	3,0	5,5
Electric soldering iron	1,1	1,9
Mixer	0,4	0,7
Hairdrier	0,4	0,5
Radio (3)	0,1-0,3	0,1-0,5
Radioclock	0,2-0,3	0,2-0,6
Toaster (2)	0,1-0,2	0,1-0,2
Water cooker (3)	0,1-0,2	0,1-0,2
Waffle iron	0,1	0,4
Warm-air heater	0,1	0,1
Lamp (2)	0,1-0,1	0,1-0,2
Coffeemaker (3)	0	0,1
Curling iron	0	0

Fields in residential buildings

One of the most central sources for magnetic fields in apartment buildings is the indoor distribution substation of the building. In this case magnetic fields that are stronger than normal may appear in the premises above the indoor distribution substation. These fields can cause disturbances in the devices in the overhead space, and this is why TUT often receives inquiries about how to reduce the fields of indoor distribution substations. For practical experiments to reduce the magnetic fields of indoor distribution substations see research report.[5]

Figure 6 shows how the fields of the space above the indoor distribution substation are measured at TUT and table 2 lists some measurement results at TUT for this space. Measurements do not take wide band exposure to magnetic fields into account.

For further information on measuring the fields of indoor distribution substations, see the guide by Radiation and Nuclear Safety Authority

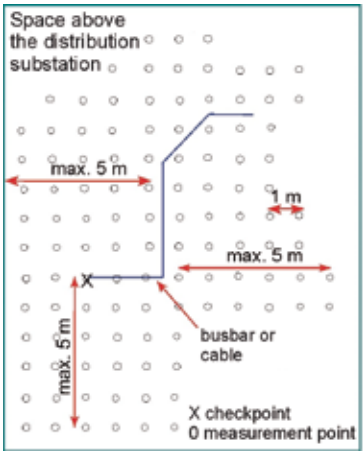

Figure 6. An example of the measurement points when measuring the fields of the space above the indoor distribution substation (X is the checkpoint, 0 is the measurement point).[4]

Table 2. Average values (avg.) for magnetic fields in the measurements of premises near indoor distribution substations.[4]

Distribution substation number	Capacity, KVA	Current, A	Position to the distribution substation	From floor 0 m, avg., µT	1 m avg., µT	2 m avg., µT
1	800	730	Above	4,25	1,30	0,72
2	1000	331	Above	1,13	0,46	0,29
3	800	382	Above	4,41	1,67	0,90
4	800	975	Above	6,54	1,84	1,03
5	1000	428	Beside	0,15	0,15	0,18
6	700	505	Above	2,14	0,83	0,49
7	500	138	Above	0,52	0,33	0,27
8	500	511	Above	2,44	1,29	1,31
9	500	356	Above	2,25	1,17	0,91
10	800	246	Above	0,74	0,26	0,13
11	* 800+ (1000+500)	652	Above	1,90	0,77	
12	800	355	Above	0,81	0,42	0,29
13	2H1000	251+588	Above	5,74	2,20	0,97

** three transformers, one of which is a indoor distribution station*

‘”Rakennusten magneettikenttien mittaaminen, STUK tiedottaa 1/2003” (‘Measuring the magnetic fields of buildings’ STUK report 1/2003) which can be found at the end of the 2003:12 guidebook by Ministry of Social Affairs.[6]

Conclusions

Basically we can say that the fields of electric devices and cables are normally so weak that public exposure remains below various recommendations.[1,2] In spite of this, there is a small group of people who feel they are oversensitive to even the weakest electric and magnetic fields, even though this cannot be scientifically proven.

The health effects of these fields are being researched around the world and hence our knowledge is being updated all the time. For those who are interested, there is a lot of updated information on the subject on the homepage of WHO (World Health Organization) at www.who.int/peh-emf.

References:

1. STMa 294/2002. 2002. Asetus ionisoimattoman säteilyn väestölle aiheuttaman altistumisen rajoittamisesta. Sosiaali- ja terveysministeriö. Helsinki. pp. 47

2. 2004/40/EY. 2004. A directive on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields). European Parliament and Council The official journal of the European Union, 159. 26 p.

3. Korpinen L., Isokorpi J., Keikko T. 1998. Kartoitus pientaajuisista sähkökentistä elin- ja työympäristössä. Tampereen teknillinen korkeakoulu, Sähkövoimatekniikka, Raportti 6-98, Tampere, pp. 35

4. Korpinen, L. 2000. Laitteiden ja elinympäristön sähkö- ja magneettikenttien mittaaminen. Kauppa- ja teollisuusministeriön tutkimuksia ja raportteja. 9/2000, pp. 134

5. Keikko T., Kuusiluoma S., Menonen P., Korpinen L. 2000., Käytännön kokemuksia kiinteistömuuntamoiden magneettikenttien pienentämisestä. Tampere University of Technology, Electric power engineering, Report 4-2000, Tampere, pp. 106

6. Korpinen, L. 2003. Yleisön altistuminen pientaajuisille sähkö- ja magneettikentille Suomessa. Sosiaali- ja terveysministeriön oppaita 2003:12, pp. 64

Interview
Ulla Vehmasaho / Professor Leena Korpinen, M.D., D.Tech.

Mobile phones do not have negative health effects - using a hands-free reduces exposure

Electricity – that divine power found before the time of Christ but tamed only in 1740 – has caught our interest right from the first applications. The first uses of electricity had to do with electricity as a source of health. Today we are worried about the electromagnetic fields around the cables and appliances. How does continuous exposure to the electromagnetic fields of transmission lines, mobile phones and wireless networks affect people? And what will happen to the environment as the amount of electronic scrap increases? All this is being studied all over the world.

Professor Leena Korpinen, Doctor of Medicine and Doctor of Technology, thinks the user has the responsibility for using a mobile phone or other mobile devices. She encourages us to find information to support our decisions since makes people worry and that is not good for one's health.

- Most often people are worried about whether the nearby transmission lines have any health effects. Another thing that worries them is the increasing use of mobile phones. The health effects of strong electromagnetic fields are quite well known already. The effects of weak fields, generated by mobile phones, have also been studied before and are being studied at the moment. The present belief is that they do not have any health problems, Leena Korpinen, the head of the Laboratory of Electrical Engineering at Tampere University of Technology, sums up.

Electric and magnetic fields are everywhere. They are generated by, e.g. earth, sun and lightning. Even people themselves, through their biological processes, create electric and magnetic fields around them.

- The strongest electric and magnetic fields result from human activities. At home we find fields around domestic appliances that are on, e.g.

vacuum cleaner, whisker, hairdryer, TV, computer and microwave oven, Korpinen explains.

- Normally the fields around domestic appliances are weak and exposure time is minimal. There are no harmful effects.

Using a hands-free set reduces exposure

- There has been exponential growth in the number of mobile phones and their use. This brings up important issues and health effects will have to be researched thoroughly. The limits for maximum radio frequency fields have already been set, Korpinen says.

- One of the known effects of exposure to radiofrequency fields is the thermal effect. Safety regulations have been built on the idea that tissue must not warm up. In a normal case the intensity of the field is clearly under this level.

- The Finnish sauna is a perfect example of the thermal effect. We sit in a temperature of 100 degrees and our entire body gets warm. That is not considered dangerous, quite in the contrary in fact. However, we can not compare these situations as such, because exposure, for example when we are holding a mobile phone at our ear, is directed at a certain part of our brain. So far, mobile phones have not been shown to have any harmful effects and their power is very low too.

On the other hand, we haven't been able to prove without doubt that using a mobile phone is absolutely safe. Especially the effects of long-term use are unknown. This is why Korpinen recommends using a hands-free if you want to minimize your exposure.

- Using a hands-free is handy even elsewhere than when driving. It is better ergonomically, too.

The long-term effects of using a mobile phone are still unknown. The Radiation and Nuclear Safety Authority recommends the use of a hands-free and text messages especially for children.

The Radiation and Nuclear Safety Authority in Finland advises children to be careful with their mobile phone use and recommends a hands-free and text messages. Exposure is always stronger if the phone is right on your ear.

Wireless networks will be the next new concern

Exposure to electric and magnetic fields will go up in the near future as wireless communication increases. Field sources like this are of minor importance though and almost insignificant if compared to the total exposure.

- The Finnish Radiation and Nuclear Safety Authority doesn't see wireless Internet as a health risk. Research activities should thus be targeted on more significant sources of electromagnetic fields, Korpinen says.

- On the other hand, it is no wonder that the wireless network and the fields worry people. It is easy enough to locate the transmission lines and base stations but much harder to recognize the places where one gets exposed to fields from wireless networks. This makes people even more worried.

- The users themselves have the responsibility for using a mobile phone or any other mobile device. It is worth being self-initiative and hunting out information to support one's decisions. Doubt makes people worry for nothing and all the worrying can make people ill. According to Korpinen, The radiation and Nuclear Safety Authority is one of the objective sources of information.

Not all electronics scrap is scrap

Growing amounts of electronic scrap are one of the health or better, environmental, effects of electricity. According to the Statistics Finland, the share of electricity and electronic scrap amounted to 16,000 tons of separately collected municipal waste. 90 percent of it was reclaimed.[1]

- The situation is getting better though, as the designers of new products now pay more attention to material choices and the reusability of the products. Users are also becoming more aware of environmental issues and new technology is being developed for collecting scrap and recycling it, Korpinen informs us.

- But the choices and deeds of the consumer have a major influence here. It is worth considering whether you really need all the appliances and whether you always need to acquire the newest model of a mobile phone or computer. Wouldn't it be great if having the skills to reuse the old things instead of buying new things would be given the high status label?

- There are many ways to use cast-off electronic appliances. You can recycle them as such, i.e. you can take them to flea market, recycling center or to stores that resell them. Or you can take them to a scrap dealer or to the collecting places of manufacturers or importers from where they will then be taken to be further processed, Korpinen tells us.

- The dumping ground is the absolutely worst place for electronic scrap. Only the kind of waste that can not be recycled and which is not problem waste should be taken to a dumping ground.

Electricity contributes to health

The health effects of electricity have been discussed as long as we have known electricity. In the beginning the emphasis was on the positive effects of electricity while today the discussion centers on the harmful effects of electric and magnetic fields.

Man only learned to control the power called electricity in 1740's. Its power was tested first in medicine. Electricity was considered a divine power offering an answer to all the questions of mankind and all its diseases. As it was possible to kill with electricity, people believed it could also restore life. The first cardiac resuscitation devices were developed as early as in the late 18th century. There seemed to be endless possibilities in medicine for electricity. By the 1860's an electric treatment had been developed for almost any disease.

Electricity is still used successfully as both a medical treatment and an energy source for the constantly developing health technology. In other words, the potential of electricity in medicine still seem unlimited. ■

Reference

[1]Tilastokeskus
http://www.tilastokeskus.fi/til/jate/2005/jate_2005_2006-12-13_tie_001.html
(Accessed 20.9.2007)