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Electromagnetic fields' exposure to head, torso and limbs in office workplaces

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Abstract. The aim of this research was to investigate the electromagnetic fields in the modern office environment. Both low frequency and the high frequency electromagnetic fields were studied. The sources of elevated electromagnetic fields and the conditions under which they occur were identified. Measurements were performed by following a 14-point human body model, which characterizes the overall exposure of the sitting person.
The measurements analysis revealed the most typical sources of exposure to be loosely spread power wires and extension cables, but also power cables close to the worker's body on the floor or beneath the table. Standard office devices were also rising the exposure levels when situated in close proximity to the worker.

Key words: electromagnetic fields, radiofrequency, extremely low frequency, occupational exposure, office.

INTRODUCTION

Contemporary workplaces are increasingly being equipped with different technologies, because they help to optimize the workflow of the organization. At the same time as the number of electric and electronic appliances increases, the electromagnetic fields (EMFs) accompanied by such devices also show an increase in both the amplitude and frequencies. Wherever the electrical equipment is used it produces electromagnetic fields in some extent.

From the perspective of occupational health and safety, the spectrum of the electromagnetic radiation is broad – ranging from static fields to microwaves. By the health effects classification, the electromagnetic spectrum can be divided into:

- Static fields 0 Hz – 1 Hz;
- Low frequency fields: 1 Hz– 10 MHz;

– High frequency fields: 100 kHz – 300 GHz and 6–300 GHz. In the intermediate frequency range from 100 kHz to 10 MHz the effects are combination of low frequency fields and high frequency fields (European Commission, 2015).

The electromagnetic fields could pose a risk to both on human well-being and to society in general. Studies have shown that an adverse health effect of chronic exposure can be expressed at low levels of exposure.

EMF effects on the body may vary depending on the frequency. Experiments on animals have shown that low frequency magnetic field affects chemical and physiological changes in cells (Knave, 1992; Eglite, 2000; Rosenstock et al., 2004). Some researchers have shown that chronic exposure to weak EMFs (up to 1mT) affects the immune system, depriving body's defense capabilities (Nakagawa, 1997; Adey, 1988). Another possible EMF impact mechanism can be connected with changes at the genetic level (Goodman et al., 1989). Studies in UK have indicated that long-term exposure to power frequencies with the average level of 0.4 μT double the risk in development of leukemia for children below 15 years (Coghill et al., 1996; Binhi, 2002).

Some studies derived data about RF field effects on reproductive functions, effect of weight reducing to the newborn, RF field caused premature birth and congenital abnormalities, however other researches do not confirm such data. (Persson, 1989; Cohen, 1990; Knave et al., 1994; Artamonova et al., 1996).

There have been examples of the adverse effects on the reproductive system. Also, observed increase of body temperature, (Persson, 1989; Cohen, 1990; Knave et al., 1994; Artamonova et al., 1996).

Starting from the July 1st 2016 in all European Union member states the national legislation on the protection of workers from the electromagnetic fields must be implemented following the directive 2013/35/EU (The minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents – electromagnetic fields, hereinafter – the directive). The directive's specified limit and action levels (ALs) don't grant workers protection from long-term exposure to EMFs (Official Journal of the EU, 2013). Provisions mentioned in this Directive don't protect workers from low level long term effects, which, as suggested by some studies, may have an adverse effect in case of chronic exposure. Therefore, employers should follow best practices as common in occupational safety, i.e. reduce the risks to the minimum. The so-called precautionary principle prescribes the level of protection where safety at satisfactory level is guaranteed, i.e. risk factor does not cause illness or health abnormalities, neither in short-term or long-term. That requires different risk prevention measures, because each frequency band propagates differently and has different effects. Also, numerous electromagnetic field sources can generate a number of field types such as both low-frequency fields and the radio-frequency radiation. In the process of risk assessment it is therefore necessary to identify each electromagnetic field source and the frequency band. In risk prevention measures, each workplace must be assessed individually, as to take into account not only the EMF source characteristics, but also specifics of the workplace.

As humans can't perceive electromagnetic fields, often employees do not know if they are exposed to strong levels of EMFs or not. As discussed earlier, one of the important risk mitigation measures is workers training and so that people know under which circumstances they may get exposed to high levels of EMFs. The worker, if knowledgeable about safe working methods and EMF related risks, are often capable of organizing their working environment and processes in a risk minimizing way. Often risk associated with the electromagnetic fields can be reduced by very simple methods and techniques (Vilcane, 2015).

The aim of this study is to determine the electromagnetic fields' levels at office workplaces and to discriminate these based on the body region (head, torso, limbs).

MATERIALS AND METHODS

In this study electromagnetic fields at computer equipped offices were investigated. The office workstations consisted usually of a desktop or laptop PC, with nearby peripheral devices (i.e. printers, scanners). There were also other office equipment, such as desk lamps, telephones, extension cords and sometimes lock-boxes, server cabinets i.e. are also encountered.

In this study we used instruments from Gigahertz Solutions: 1) HF59B radiofrequency analyzer, connected to a directional antenna HF800V2500LPE174 (Germany) and 2) low-medium frequency analyzer NFA400 from the same manufacturer. The high frequency meter measured frequencies from 800 to 2,500 MHz whereas the low frequency meter measured from 50 Hz to 400 kHz. High frequency (HF) readings were taken in RMS (root mean square) mode.

The measurements followed Koppel's 14-point model (Figs 1 & 2). For each workplace 14 readings were taken for each of the three field types: measurement rounds were taken for 1) extremely low to intermediate frequency electric field, 2) extremely low to intermediate frequency magnetic field and 3) radiofrequency field. 14-point model gives a comprehensive view of the exposure situation across the workers body. For each of the 14 points the area where the worker could be was scanned with the meter and the highest reading recorded. The measurements were taken where the human body can be situated in the workplace. The results indicate the maximum possible exposure level that the worker could be exposed to. The measurements indicate the resultant field (Koppel & Tint, 2014).

It was also attempted to identify the source for elevated electromagnetic fields, when encountered. This was done by switching on and off electrical appliances, till the field level was reduced.

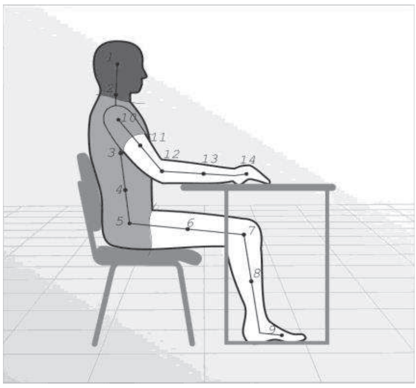


Figure 1. 14-point model of a sitting person (Koppel & Tint, 2014).

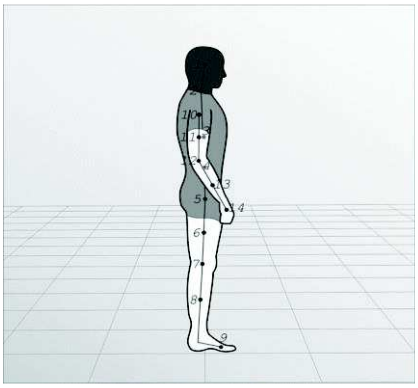


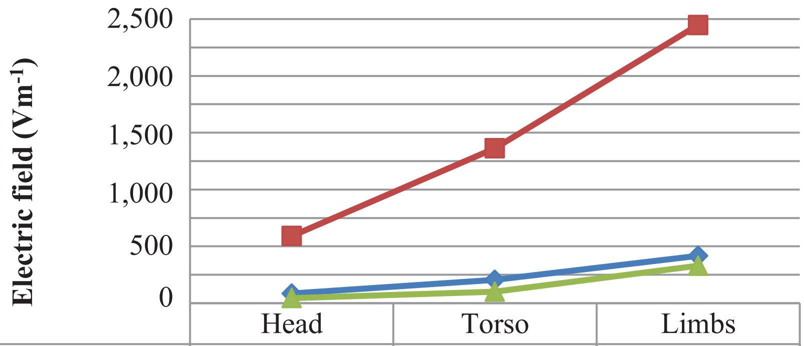
Figure 2. 14-point model of a standing person (Koppel & Tint, 2014).

For each workplace, the results from 14 points were averaged differentiating body regions into three: head (measurement points 1–2), torso (measurement points 2–5) and limbs (measurement points 6–9 and 10–14 points). Based on all the workplaces, three subsamples were formed, which characterize the exposure levels in offices (Koppel & Tint, 2014).

RESULTS AND DISCUSSION

The study covered 85 office workplaces; most of them were computer work stations. Workplaces were equipped with typical office equipment: printers, copiers, various external hard drives, stationary and radio phones, local lighting lamps, and other potential sources of exposure to electromagnetic fields, depending on the specifics of job content and the company profile. Measurements were also made in atypical office workplaces, such as security guard workstations. Latter workplaces are equipped with computers, but the nature of the job also requires equipment to perform specialized duties e.g. security camera monitoring station, walkie-talkies. Consultation room measurement data was also included in this group (Vilcane, 2015).

Based on the three subsamples, the following Figes (Figs 3, 4 & 5) show EMF exposure levels in different body areas (head, torso and limbs) (Vilcane, 2015).



	Head	Torso	Limbs
SD	85	204	417
Maximum	590	1,362	2,448
Average	44	101	330

Figure 3. Electric field exposure to different body regions in office working environments (Vilcane, 2015).

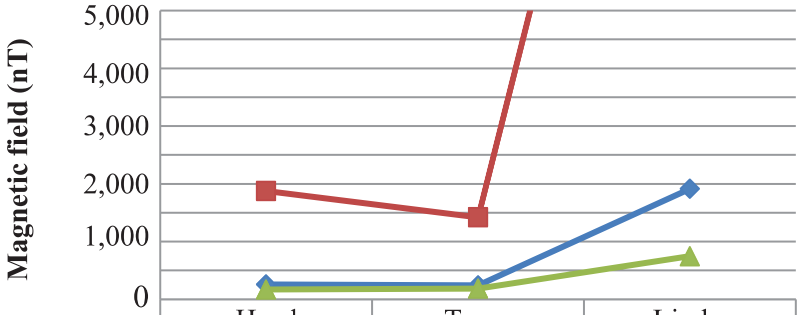
The maximum exposure case for electric field was encountered in a workplace with a badly designed electric wiring. The conductive materials in the walls and working surfaces radiated the 50 Hz electric field. In other cases, elevated electric fields were also encountered due to poor workplace layout, placement of electrical devices such as printers, computers, extension cords etc. These pheripheral devices were usually located too close to the worker's position. Comparing the average readings with standard deviation, we see that background electric field is not repetitive, however most of average readings differ from the standard deviation directly to the limbs (Vilcane, 2015).

It is important to remember that monitors and other electrical appliances should be grounded for the electric field reduction to have any effect (Sandström, 2006).

Exposure to the magnetic field to different body areas, is shown in diagram 4. From all studied workplaces, the maximum magnetic field was encountered at guardman's workplace, that was equipped with a computer and job specific appliances. The source of maximum exposure was a powerful trancievers' power supply unit. Standard deviation also showed that background exposure in surveyed workplaces, in comparison with the average reading is quite large.

Measurements also showed that portable computers' power converters also created higher than average exposure (462 nanoTeslas – nT). In latter case the exposure level was related to the distance in between the power converter and the worker's body.

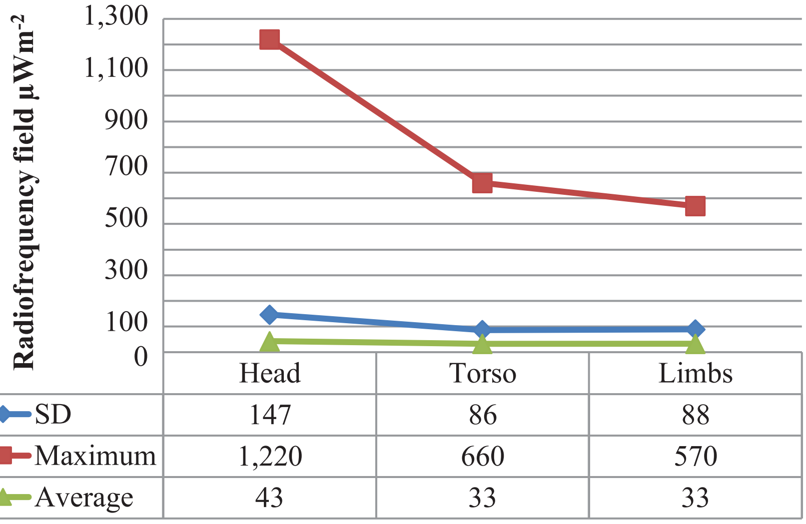
In general, elevated magnetic fields were generated by powerful office equipment – computers can generate exposure up to several thousand nanoTeslas. In one of the surveyed workplaces the largest magnetic field was from a poorly designed speaker set placed on the table (699 nT). Some workplaces are confronted with nearby transformers. In one of such workplaces, with a transformer in an adjacent room, the average background magnetic field was 491 nT across the room (Vilcane, 2015).



	Head	Torso	Limbs
SD	260	243	1,913
Maximum	1,874	1,420	16,000
Average	171	186	748

Figure 4. Magnetic field exposure to different body regions in office working environments (Vilcane, 2015).

Diagram 5 represents radiofrequency exposure in offices to various body areas. Radiofrequency radiation poses different risk specifics as compared to the low-frequency fields. If the RF radiation enters the room through the windows, generally the maximum exposure occurs in the upper body region. In this sample, mostly the RF source was from outside of the working premises, entering the room mainly through the windows (Fig. 6), (Vilcane, 2015).



	Head	Torso	Limbs
SD	147	86	88
Maximum	1,220	660	570
Average	43	33	33

Figure 5. Radio frequency exposure to different body regions in office working environments (Vilcane, 2015).

Figure 6. The source of radio frequency exposure for the highest exposure case –a cell phone base station on the adjacent building.

Often high level RF sources were cell phone base stations residing outdoors. But elevated levels were also encountered from wireless networking transmitters within the premises (Wi-Fi routers, cell phone repeaters etc), radiotelephone stations etc. In one case, a poorly selected placement for the radiotelephone network tranceiver elevated the entire office's RF levels, but was worse for the person working right half a meter away from it. The standard deviation compared with the average shows that surveyed workplace background exposure is nearly uniform.

CONCLUSIONS

This study presents results from electromagnetic fields' measurements from office environments. The measured EMF levels were below the occupational safety limits and far from levels present in some industrial processes. The aim of this article was to determine the average EMF levels at office workplaces, and to identify the sources where levels are elevated.

Based on the measurement results, there is no mandatory need for the employer to mitigate the exposure levels. However, as discussed earlier, the regulation based on the EU directive 2013/35/EU is for the protection from short-term effects, i.e. the effects from long term exposure are yet not accounted for. Some studies have shown that prolonged exposure at levels below the current safety limits may indeed have some effects (Hinrikus at al., 2005; Hardell, Sage, 2008).

This study determined that in case of extremely low frequency fields, most elevated exposure cases are due to poorly arranged electric and electronic equipment or poor workplace layout. In the majority of the cases the exposure could be reduced by rearranging the equipment and the workplace, with minimal effort from the employer's side. In general, the exposure could be reduced by creating more distance in between the worker and the equipment that is the source of the elevated levels. No conclusion can be drawn, which type of equipment should be distanced away from the worker: depending on the model, the same type of equipment could create low or high levels due to the different electrical design. Measurements are a helpful tool for the employer to determine which equipment generates high levels, so that EMF risk management plan could be implemented.

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