

PUBLIC PROTECTION FROM ELECTROMAGNETIC FIELDS OF INDUSTRY FREQUENCY

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Summary Lithuania introduced normative of public protection from 50 Hz frequency electric field. It proposed permissible intensity of this field – 0,5 kV/m inside buildings and 1 kV/m in their territory. Separate normative is prepared for industry frequency electric and magnetic fields in work places. Permitted values of fields depend on exposure duration, but cannot exceed 25 kV/m and 5,1 kA/m. Russian, Swedish and American scientists declare that long time exposure of 50 Hz magnetic field with intensity more than 0,2-0,3 μT is dangerous for carcinogenic risk. International Agency for research on Cancer (IARC) initiated a program to evaluate the carcinogenic risk of low frequency electromagnetic fields to humans and till 2002 year collected a lot of information for different countries with quantitative analysis of epidemic data. Standardized incidents ratio (SIR) was proposed for evaluation of leukaemia in humans and especially children. Exposure of children in magnetic fields $> 0,4 \mu\text{T}$ showed a twofold SIR increasing. Data concerning the subject of an evaluation did not disclose inadequate evidence in humans and experimental animals for the carcinogenicity of magnetic fields of industry frequency, but they are classified as “possibly carcinogenic to humans”.

1. INTRODUCTION

High voltage electricity power lines are used for ages. Their electromagnetic fields are associated with electric power systems, industrial, electric and electronic appliances and well investigated, but accurate conclusions about dangerous on humans health are not done till today. Low frequency 50 or 60 Hz fields differ from microwaves and have small energy to increase temperature of body if intensity of electric field is smaller than 1 MV/m. At frequencies this low the electric and magnetic fields act independently of one another. Any device connected to an electric outlet, even if the device is not switched on, will have an associated electric field that is proportional to the voltage of the source to which it is connected. Magnetic field depends on current which flows in circuit. Both electric and magnetic fields of 50 or 60 Hz exist close to the lines or appliances and drops off with move away from source. Protection from fields of high voltage electricity overhead transmission lines in Lithuania is described below. Normative are prepared for electric field because it is constant for concrete voltage line. In the paper is taken humans exposure from domestic appliances also.

In 1996 the World Health Organization established the International Electromagnetic Fields project with reviewing results and conducting risk assessment for exposure to static and extremely low frequency fields [1]. They planed to evaluate all health effects on human of this fields' exposure in 2002-2003.

In 2002 expert scientific working group of IARC reviewed studies [2] related to carcinogenicity of low frequency electric and magnetic fields. The main attention is taken for investigation of industrial frequency electromagnetic fields relevant to children carcinogenicity.

2. PUBLIC PROTECTION FROM ELECTROMAGNETIC FIELDS OF OVERHEAD ELECTRICITY LINES

All states of Europe have prepared normative with limitation of electromagnetic fields level near to high voltage electricity transmitting lines. These limitations depend more on policy than technical and medical substantiation. We partly described situation in Lithuania in papers [3, 4]. The great influence for our country normative had standards of Russia. Hygiene's normative [5], prepared by Lithuanian Ministry of Health Care, directs that electromagnetic fields caused by industrial frequency transmitting lines must be limited and verified only if voltage is 330 kV and more. It restricts only electric field intensity and proposes these permissible values:

- inside of residence and public purpose buildings – 0,5 kV/m and in their territory -1 kV/m without time limitations,
- in urbanized territories and suburban green zones – 5 kV/m without time limitations,
- in automobile highways and country roads – 10 kV/m, if transport stays under electricity line no longer 2 h,
- in uninhabited residences, where transport can move and agriculture fields are – 15 kV/m with limited time of exposure 1 h.

The new 330 kV or more voltage electricity transmission lines must be designed at distance more than 250 m from residence buildings. Only at special cases the distance can be reduced till 20 m according special permission of public health service, if electric field intensity under wires is less than 5 kV/m.

We can have impression about levels of electric field near to 330 kV overhead power lines on Fig.1.

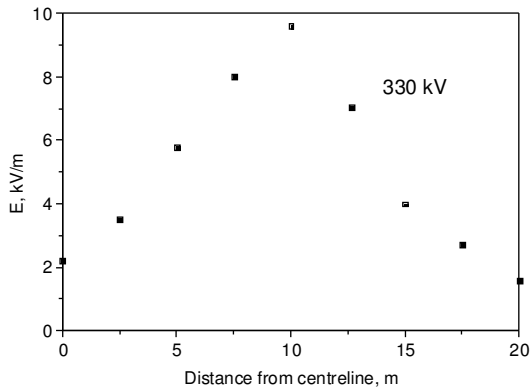


Fig. 1. Electric fields from high voltage overhead power lines

Population health is preserved from action of electricity lines due establishing of sanitary protection zones (SPZ). In the SPZ territory is forbidden or limited economy activity, in spite of plant growing or exploitation of former built buildings, if mentioned field levels are not exceed.

Normative [5] requires to measure electric field intensity for installed new electricity lines or built new buildings by accredited laboratory's personal.

Technical means can be used for population protection due reducing electric field intensity by special screens and their grounding, mowing away buildings from electricity lines, planted trees and etc. Buildings attenuate electric fields considerably and their strength may be one to three orders of magnitude less inside a building than outside it. Electric fields to which people are exposed inside buildings are generally produced by internal wiring, appliances and not by external sources.

Russian standards and Lithuanian normative requirements are very similar. In spite of the world opinion that magnetic field is more dangerous for population health, the electric field limitations were involved in the normative. In Russian sanitary normative and rules „Population defence from electric fields of overhead electricity lines of industrial alternative current” № 2971-87 the same limits are 0,5 kV/m inside buildings and 1 kV/m in their territory. There are calculated SPZ sizes (Tab.1) according criterion for electric field -1 kV/m.

Tab.1. Sizes of sanitary protection zones around electricity transmission lines according normative № 2971-87

Voltage of electricity transmission line, kV	Size of sanitary protection zone, m
330	20
500	30
750	40
1150	55

Greater values of electromagnetic fields during long time (months-years) can damage health of sound man and have influence on heart and nervous systems or

cause oncological disease. Allergic people are sensitive to smaler electric fields with shorter action. Russian scientists with independent Swedish and American specialists opinion declare that long time non dangerous for carcinogenic risks exposure of 50 Hz magnetic field flux density not exceed 0,2-0,3 μT. Ministry of Health Care of Lithuania Republic prepared new normative for evaluation of electromagnetic fields permitted levels of occupational exposure [6]. They depend on existence time at work places. The extract from normative in Tab.2 demonstrates the main features.

Tab.2. The greatest permitted values of industry frequency (50 Hz) electric and magnetic fields in work places from exposure duration

Time of exposure, min	Permitted intensity of E, kV/m	Permitted H, kA/m
10	25,0	5,1
120	14,3	3,5
240	9,1	2,3
360	6,7	1,4
480	5,3	1,0
More 480	5,0	0,9

It is forbidden to work in place where intensity of electric field exceeds 25 kV/m and magnetic field is more than 5,1 kA/m.

Normative are very strict and correspond to EU Council recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz).

Many European countries have electrified transport systems that operate at 16,6 Hz. On Swedish trains typical daily exposures were in the range of 2-15 μT. The average magnetic fields to which workers are exposed for various jobs in the electric power industry have been reported [7] as follows: 0,18-1,72 μT for workers in power stations, 0,8-1,4 μT for workers in substations, 0,03-4,57 μT for lines and cables and 0,2-18,48 μT for electricians.

3. DOMESTIC APPLIANCES MAGNETIC FIELD

The highest magnetic flux densities to which most people are exposed in the home arise close to domestic appliances that incorporate motors, transformers and heaters. The flux density decreases rapidly with distance from their, varying between the inverse square or inverse cube of distance. Flux density at distance of 1 m is similar to background levels. Tab. 3 gives values of magnetic field from domestic appliances in use in the United Kingdom [8]. It reported that whole body can be exposed between 1 and 3 μT.

Tab.3. Magnetic field's intensity at 50 cm distance from the surface of appliances

Appliance type	Magnetic field, μT
Vacuum cleaner	0,78
Central heating pump	0,51
Dishwasher	0,80
Electric shower	0,44
Portable fan	0,50
Hand blender	0,97
Food mixer	0,69
Fish-tank pump	0,32
Tin / can opener	1,33
Electric shower	0,84
Video display terminals	0,21

4. INVESTIGATION OF CANCER IN HUMANS AND ANIMALS

Studies of cancer in humans have aim to find correlation between intensity of low frequency electromagnetic fields and carcinogenic risk. The main attention is taken into childhood leukaemia. If there would be a known biophysical mechanism of interaction for carcinogenesis, it would be possible to identify the critical parameters of exposure. Ascertained the fact that most dangerous for humans is low frequency magnetic field. The typical average magnetic fields intensity in homes appear to be about 0,05-0,1 μT . Pooled analyses of childhood leukaemia and magnetic fields have used $>0,4 \mu\text{T}$ as high-exposure category.

The IARC monographs [2] represent very wide review and quantitative evaluation of epidemiological data. The most typical examples of assessment we present below.

The cohort study of childhood cancer and magnetic fields was conducted in Finland [9]. The study examined the risk of cancer in children living from 1970-89 within 500 m of overhead 110-400 kV power lines with calculated magnetic fields to be $> 0,01 \mu\text{T}$. The cohort comprised 68300 boys and 66500 girls till 20 years. During the 17 observation years 140 patients with cancer (35 children with leukaemia, 39 with a tumour of the central nervous system, 15 with a lymphoma and 51 with other malignant tumours) were identified by the Finnish Cancer Registry. Historical magnetic fields during this time were estimated by Finnish power company. Cumulative exposure defined as the average exposure per year multiplied by the number of years. The high exposure was $> 0,2 \mu\text{T}$ for average and $> 0,4 \mu\text{T}\cdot\text{years}$ for cumulative exposure. Standardized incidence ratio (SIR) is 1,0 (baseline) if $< 0,01 \mu\text{T}$.

SIR = 1,5 for average exposure and 1,4 for cumulative exposure. Significant increasing of risk was not noticed.

It is made [10] a pooled analysis of studies that examined the relation between childhood leukaemia and residential magnetic fields. The greatest

emphasis was placed on the geometric mean of measured child's exposure in the bedroom in the home inhabited before or at diagnosis. Exposure was categorized into four groups: $<0,1 \mu\text{T}$, 0,1-0,2 μT , 0,2-0,4 μT and $>0,4 \mu\text{T}$. The study comprised 3247 children with leukaemia, of whom 2704 had acute lymphoblastic leukaemia and 10400 controls, all under the age of 15 years. Results of investigation are shown in Tab. 4.

Tab.4. Pooled analysis of total leukaemia in children

	0,1-0,2 μT	0,2-0,4 μT	$>0,4 \mu\text{T}$
Country of study	SIR	SIR	SIR
<i>Measurement studies</i>			
Canada (1999)	1,3	1,4	1,6
Germany (1998)	1,2	1,7	2,0
United Kingdom (1999)	0,84	0,98	1,0
USA (1997)	1,1	1,0	3,4
<i>Summary of measurement studies</i>			
<i>Calculated field studies</i>	1,6	0,79	2,1

While the relative risks for intermediate exposure categories were 1,1, it for the highest exposure category $> 0,4 \mu\text{T}$ showed a twofold increase.

Studies of adults have looked primarily at occupational exposure, but some have investigated residential settings.

Verkasalo in Finland investigated adults' cancer [11] in similar conditions as for children [9]. In a nationwide cohort study of 383700 adults he investigated cancer risk and exposure to magnetic fields in homes within 500 m of power lines between 1970 and 1989. Of 196 patients with leukaemia 10 controls were selected and several exposure measures in intervals 0-4, 5-9 and > 10 years were used. SIR was 0,96 at $<0,20 \mu\text{T}$, 1,1 for 0,2-0,4 μT , 0,87 for 0,4-1,0 μT , 0,81 for 1,0-2,0 μT and 0,71 at $> 2,0 \mu\text{T}$. No association was seen between the risk for leukaemia and highest annual exposure. The working group noted the lack of information of residential exposure might have resulted in substantial exposure misclassification.

The last investigations in the USA [12] whether appliances may be associated with adult brain tumours showed that there was little evidence of association between brain tumours and curling iron, heating pad, vibrating massager, electric blanket, heated water bath, sound system, computer, television, microwave oven and etc. Ever use of hair dryers was associated with glioma (SIR=1,7), but there was no evidence of increasing risk with increasing amount of use. Conclusion was made that low frequency electromagnetic fields from commonly

used household appliances are unlikely to increase the risk of brain tumours.

On another hand, it is worried about health of great number of woman working with computers. Epidemiological studies showed that 50-60 Hz electromagnetic fields increase risk of breast cancer. There is information that mortality from breast cancer was 40% greater for woman long time exposed by strong electromagnetic field. The greatest health care organization in United States-Kaiser Permanente HMO found 73% greater number of abortion cases for woman working with CRT monitors with kinescope lamps.

In the absence of adequate data on humans, it is biologically plausible and prudent of carcinogenicity in experimental animals as they presented a carcinogenic risk to humans. Groups of animals were continuously exposed to magnetic field strengths of 2 μ T, 200 μ T or 1000 μ T during two years. Another researchers [13] exposed rats till 5000 μ T, but results of exposure's influence on carcinogenicity were generally negative.

5. CONCLUSIONS

1. Lithuania, Russia and European countries have very strict normative with limits of electric fields' level near to high voltage electricity power transmitting lines. These limitations are 0,5 kV/m in buildings and 1 kV/m in territory. Normative does not describe limitation of magnetic field, but it is known that magnetic field exposure is more dangerous than electric field and flux density must be smaller than 0,2 – 0,4 μ T.

2. Low frequency magnetic fields are possibly carcinogenic to humans, but there is limited evidence in humans for the carcinogenicity of these frequencies magnetic fields in relation to childhood leukaemia and other cancers. A consistent association between residential exposure and adult leukaemia and brain cancer has not been established. Cancer risk increased for occupational intermediate or high magnetic field exposure categories. It is noticed that long work of woman with CRT computer monitors increase risk for breast cancer and abortion. Experiments with animals showed inadequate evidence for carcinogenicity of industrial frequency magnetic fields.

3. Studies results of cancer risk evaluation were not very reliable, because cases of human illness were registered and electromagnetic situation in their living place was recreating after long time.

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