Part 5

DECREASE IN PHYSICAL FACTORS IMPACT FROM POWER OBJECTS ON ENVIRONMENT

5.1. Decrease in impact of electric and magnetic fields of the industrial frequency on the person

5.1.1. Biological impact of electric and magnetic fields of the industrial frequency

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A question concerning the probable adverse EF impact on the person was put for the first time by the Soviet researchers in the early sixties of the XX century. It was connected with complaints of the personnel, maintaining substations (SSs) and ALs under voltage of 400 and 500 kV, to a headache, slackness, undue fatigability, irritability, drowsiness, infringements of activity of cardiovascular system and gastrointestinal tract. All this served as a base to start regular studying of a state of persons' health, exposed to industrial impact EF of industrial frequency (EF IF). And at the initial stage of researches the basic attention was given only to EF IF, and the possible influence of MF IF on a human body was completely ignored.

Regular studying of a state of persons' health, exposed to impact by EF and MF IF, started in our country in 60-ties when investigations of personnel, maintaining substations under voltage of 220, 330, 400, 500 kV [1, 2, 4, 6—8, etc.] were for the first time carried out. In these works, executed by experts of the Kharkov Research Institute of Occupational Hygiene, Kiev Research Institute of the Common and Municipal Hygiene, LIOT, a number of adverse changes of a state of personnel health has been noted. People, working at SSs voltage of 400, 500 kV, were complaining of neurologic character disease (a headache, slackness, undue fatigability, drowsiness), and also of infringements of cardiovascular system and gastrointestinal tract activity. The specified complaints were accompanied by some functional frustration of nervous and cardiovascular systems in the form of vegetative dysfunction, propensity to a tachycardia or a bradycardia, an arterial hypertensia or a hypotonia. There were also marked the increase in time of visually-motor reaction, increase in limits of olfactory sensitivity, decrease in memory, attention, and pulse lowering. Changes in structure of peripheral blood were expressed in a moderate thrombocytopenia, neutrocytosis, lymphocytosis, monocytosis, tendencies to retikulopenie, decrease in haemoglobin and erythrocytes number, blood sedimentation rate reduction. The similar data has been received in researches at volunteers.

However, in these researches influence of intensity and time characteristics of EMF IF on the specified deviations in a state of health was not analyzed. Electric component levels were controlled only in single instances, magnetic ones were not controlled at all.

The first domestic publications have formed the basis for carrying out of some similar researches in the USA, Canada, Spain, France and other countries, also carried out without a hygienic estimation of factors of the industrial environment, affecting the workers. In these researches significant changes of a state of health were mostly not found in persons, professionally connected with operation and service of electric grid objects.

Nevertheless, the executed in 80-90-ties of the XX century in the State Institution the Research Institute of the Occupational Health of RAMS a complex of researches on clinic and physiological analysis of a state of cardiovasculare, nervous, immune systems of the persons, operating electric grid objects, with an estimation of their exposition loading to EF and MF IF, allowed to prove with enough high degree of probability the raised risk of breakdown [6, 13]. In 1991 this data formed a basis for retiring of some categories of personnel, maintaining electric grid objects (electricians of line service, wiremen operating open switchgear of SHV and test operators of high-voltage equipment) on pension.

Despite the majority of the western researchers till now deny a probable risk of health infringement in persons, exposed to professional EMF IF influences, the last 20—25 years in the literature of Great Britain, the USA, Sweden and other countries there were publications, in which possibility of occurrence of oncological diseases at the persons, exposed to EMF IF influences both in conditions of production, and in places of their residing [15—18, 20—23, etc.] was marked. And in these researches the basic attention was given to possible prevailing influence of magnetic, but not electric component of EMF. Since the first publication of American scientists Wertheimer & Leeper [23] in 1979 in which attention to the question on possible cancerogenic influence of industrial and non-industrial EMF IF influences has been put, mainly, it concerned MF IF impact on the person, there have been published the data of more than 100 works bringing an attention to the question on possible risk of leucosis progress (leukaemias) at persons of the so-called "electric occupations" (Tab. 5.1). Recently in the foreign literature there was also data about probability of progress of the separate forms of neurodegenerative diseases at the working personnel [19, 21].

The problem on possible adverse (up to cancerogenic) impact of magnetic component of EMF IF, created by constantly operating sources, on population, mainly, on children is now becoming ever more urgent. At the same time, if in one group of works the raised risk of leucosis progress in children is marked, the data of other epidemiological researches testifies about an absence of correlation between non-industrial impact of MF of the lowest levels and development of diseases of the oncological nature (Tab. 5.2).

Table 5.1. **A risk of leucosis progress as a result of industrial influences of EMF in the USA (according to the data, generalized by J. Goldsmith [17])**

Occupation	Relative risk (RR)	95 % confidence interval
Operators of telegraph, radio- and radar-tracking stations	1,8*	1,4…2,6
Technicians and electronics engineers	1,3	0,9…1,8
Electric and electronics engineers	1,2	1,0…1,5
Electricians	1,1	0,9…1,2
Collectors of electric equipment	2,4	1,0…4,8
Operators of electric substations	1,6	0,8…3,0
Line personnel	1,3	1,0…1,6
Repair and phone installation personnel	0,9	0,6…1,3
Workers of the aluminium industry	1,9*	1,2…2,9
Drivers of municipal transportation, tram	1,7	0,7…3,3
Lighters of film studios	1,1	0,5…2,2
Welders	0,9	0,7…1,2
Totally	1,2*	1,1…1,3

* Probability $p < 0,05$.

Table 5.2. **A risk of leucosis progress at children and adults at non-industrial influence of EMF IF**

Author, year	Group	Method	RR/IR (95 % CI)*
Wertheimer & Leeper, 1979	Children, 344 cases, control group — 344 persons Residing near to electric systems with a difficult configuration	Case—control	3,0 (1,8…4,9)
Fulton et al., 1980	Children	the same	1,1 (0,7…1,6)
Tomenius, 1986	Cancer Register, Sweden, 716 cases of cancer, residing near to MF IF sources	»	1,1 (0,3…4,6)
McDowall, 1986	Residing near to electrosending devices, death rate, adults	»	1,0 (0,4…2,2)
Savitz et al., 1988	Children, residing near to electric systems with a difficult configuration	»	2,8 (0,9…8,0)
Severson et. al., 1988	Residing near to AL, adults	»	1,0
Coleman et al., 1989	Residing near to transformer SSs, children, 84 cases, control group — 141 persons, adults	»	1,6 (0,3…9,8) 1,3 (0,8…2,0)
London et al., 1991	Children, Los-Angeles, residing (measurements)	»	2,2 (1,1…4,3) 1,7 (0,6…3,3)
Youngson et al., 1991	Residing near to AL, adults	»	1,2 (0,6…1,9)
Feychting & Ahlbom, 1993	Sweden, residing (measurements)	»	2,7 (1,0…6,3) 0,65 (0,2…1,9)
Olsen et al., 1993	At magnetic induction of 0,4 μT the risk increase is more substantial (reliability is unknown)	—	—
Verkasalo et al., 1993	Chronic influence, constitutional cancer, at the magnetic induction of 0,3 μT and higher, the risk is 1,5 (confidential interval is not resulted)	—	—
Tikhonova et al., 1999	Population, residing near to power object; 1971—1990. All cohort members: 50 460 man-years	Retrospective cohotr	1,3 (0,2…7,0)
Tikhonova et al., 1999	Children of the parents, exposed to industrial impacts of EMF IF, 208 cases, control group — 319 persons	Case—control	1, 9 (statistically insignificant)

* RR — relative risk; IR — index of risk; CI — confidence interval.

Despite the relative discrepancy of this data, IARC in 2002 referred MF IF to a category 2b — "reference carcinogens" for the children's population that formed a basis for the World Health Organization (WHO) within the limits of memorandum of the program "Electromagnetic fields and health of the person" to propose maximum (to a level of technical accessibility) restriction of MF IF levels, created by its constantly operating sources, in places of population residing "in connection with probability of their cancerogenic influence and an insufficient level of scrutiny of a question" [24].

For revealing a degree and a character of EMF IF influence on the person, biological objects and environment, electric and magnetic components can be separately considered. It is connected with the length of a wave (for frequency of 50 Hz — 6000 km). For the person, placed near to EMF IF source, a distance from a source to the point of supervision is not enough in comparison with the length of a wave. In this case EFs and MFs practically do not depend on each other. Electric field is generated only by charges, and MF — only by currents. Thus, in every moment of time in each point of the space, meeting the condition of $R << \lambda$, the instant value of EF (MF) intensity corresponds to the instant value of distribution of charges (currents). They are the same size and direction as though distribution of charges (currents) was constants. Fulfilling this condition, it is said that the observation point is in the nearest zone. In the considered case there is practically no electromagnetic radiation, and there are quasistatic EF and MF variables being independent from each other. Therefore, the object being in this EMF, is exposed as it was separate influence of EF and MF. As physical mechan-

isms of EF and MF interaction with the body, placed in the fields, is different, the only way of a proper solution of the question at estimation of electromagnetic conditions near to EMF IF sources is separate definition of electric and magnetic components of intensity.

Interaction of external EMF with biological objects is carried out by inducing the internal fields and electric currents, the size and distribution of which in a body of the person depends on variety of parameters, such as a size, a form, an anatomic structure of a body, electric and magnetic properties of fabrics (electric/magnetic permeability and electric/magnetic conductivity), orientation of the object with respect to the body polarization, and also EMF characteristics.

According to the state-of-the-art understanding at the heart of a mechanism of EMF biological action (50 Hz) lies the influence of electric current, induced under their impact, on the excitable structures (nervous, muscular fabrics). A parameter, defining a degree of the influence is density of the vortical current, induced in a body. Thus, for EF of the considered range of frequencies weak penetration into a body of the person is characteristic, for MF the organism is almost transparent. Density of the induced current j can be estimated under equations [25]: for EFs

$$j = kfE,$$

where f — frequency; E — EF intensity; k — a factor, depending on the type of a fabric; for MFs

$$j = \pi R \sigma f B,$$

where B — magnetic induction; R — radius of the critical organ; σ — conductivity of the fabric.

Estimation of the currents, induced by MF IF, considering their three-coordinate distribution in a body and presence in its model of about 100 thousand elements (from positions of variability of conductivity) allows to specify a general equation, characterizing a relationship between the density of the current, induced by MF, and the mentioned above parameters. This relationship with the account of an ellipse form of the person's body model will be the following [26]:

$$j = \mu_0 \pi f \sigma H \frac{2ab}{a+b},$$

where μ_0 — magnetic permeability; f — frequency; σ — conductivity of the fabric; H — intensity of MF; a and b — a length of the minimum and maximum axes of an ellipse.

There is data on degree and expressiveness of various reactions of a human body on EF and MF action, depending on a density of the vortical current [17, 27, etc.] — from threshold reactions of a nervous fabric to cardiac arrest and tetanic contraction (Tab. 5.3).

Besides, rough thresholds of sensory perception of EFs by frequency of 50 Hz and their dependence on individual parameters and orientation of the person in space and in relation to a source of the operating EF (tab. 5.4) are established.

From the researches at volunteers, the data, testifying either about absence, or about presence of insignificant and, mainly, nonspecific reactions of a human body at single and rather short influences of EFs and MFs by frequency of 50 Hz, is also obtained (tab. 5.5).

Table 5.3. **Levels of density of the vortical currents, induced in a body of the person by EFs and MFs, and organism reactions**

Current density, $\mu A/cm^2$	Biological effects
0,1	No reactions of the nervous system at cellular level
about 1	Phenomenon of electric and magnetic phosphenes. Presence of reaction of brain fabrics. Production of the membrane potential of 0,1 mV (tiny potentials)
10…50	Thresholds of stimulating touch receptors, nervous and muscular cells. Possibility of harmful action
more than 100	Probability of heart ventricle fibrillation. Possibility of cardiac arrest, tetanic contraction

As a whole, the data presented above, testifies that it is impossible to deny a risk of progressing the adverse changes of a state of health as at the persons, exposed to industrial influences by EMF IF, and at the population.

Table 5.4. **Presence of sensations and irritation of the person, staying in EF with frequency of 50 Hz (researches at volunteers) [30]**

EF intensity, kV/m	Presence of the referred sensation, % of the test group			Irritation, % of the test group		
	A	B	C	A	B	C
5	4	8	20	0	0	1
10	7	20	40	0	0	1
15	15	35	60	0	1,5	1,5
20	25	55	80	1	2	3
25	50	80	95	3	3	3

Note. A — both hands along a body; B — one hand is located horizontally; C — the same over a head.

Table 5.5. **Human body reactions at influence of EFs and MFs with frequency of 50 Hz (researches at volunteers) [29]**

Intensity		Time of impact, h	Reactions
EF, kV/m	MF, mT		
1; 15; 20	—	До 2	Change of reaction time (within physiological norm). CR change (within physiological norm)
20	0,3	3	No influence on reaction time of and BW
1; 15	—	2	No influence on CR, AP
20	0,3	2	No influence on AP, CR, ECG
20	—	to 8,5 h and 60—90 min after 4 h of a rest	AP, CR change

Note. CR — cardiac rate; BW — brainwave; AP — arterial pressure; ECG — electrocardiogram.

For an adequate estimation of levels of electromagnetic factors, affecting the personnel, operating electric network objects, estimation and instrumental methods can be used.