Journal scientific and applied research, vol. 21, 2021
International Journal

Original Contribution

ISSN 1314-6289

BIOLOGICAL EFFECT OF THE ELECTROMAGNETIC FIELD

Dragomir I. Vasilev

DEFARTMENT OF COMMUNICATION AND COMPUTER TEHNOLOGIES, FACULTY OF TECHNICAL SCIENCES, KONSTANTIN PRESLAVSKY UNIVERSITY OF SHUMEN, SHUMEN 9712,115, UNIVERSITETSKA STR,

E-MAIL: d.vasilev@shu.bg

ABSTRACT: *In this paper presents biological effect of the Electromagnetic field. The human body consists of cells, tissues, organs with different electrical characteristics. When an electric current flows through the human body, cells and tissues prevent the movement of charged particles. The value of the resistance depends on the type and condition of the cells, the value and frequency of the applied voltage and the duration.*

KEY WORDS: *Electromagnetic field, Electromagnetic Environment, Body tissues, Induction values, EF Strengths.*

Introduction

The human body consists of cells, tissues, organs with different electrical characteristics. When an electric current flows through the human body, cells and tissues prevent the movement of charged particles. The value of the resistance depends on the type and condition of the cells, the value and frequency of the applied voltage and the duration. [1]

Exposition

Together with the resistance R, Ohm, the electrical properties of the fabrics are characterized by the specific volumetric electrical resistance, Ohm m3 and the specific electrical conductivity $\gamma = 1/\rho$, Cм / м.

When exposed to variable EMFs on the tissues of the human body, the free charges oscillate and the dipole molecules rotate with the frequency of the EMF. Both processes are accompanied by heat loss. The losses depend on the electrical conductivity of the tissues, the dielectric constant of the tissues and the frequency of the EMF. The relationship between these types of losses is expressed by the relatively complex dielectric constant

(1) $$\varepsilon_k = \varepsilon' - j\varepsilon'' ,$$

where ε' is the relative dielectric constant measure at the frequency f; $\varepsilon'' = \gamma/2\pi f\varepsilon_0$ – loss factor that takes into account the conversion of EMF into heat due to the presence of electrical conductivity; γ - active conductivity measured at frequency f; $j=\sqrt{-1}$, or on the tangent of the dielectric loss angle

(2) $$tg\,\delta = \frac{\varepsilon''}{\varepsilon'} = \gamma/2\pi f\varepsilon'\varepsilon_0 ,$$

where δ - the angle that complements the 90 ° angle φ between the vectors of the electric field strength and the total current density flowing through the dielectric.

Table 1

Relative dielectric constant of body tissues at 37 ° C

Body	Frequency, MHz					
	100	200	400	1000	3000	8500
Muscle	71-76	56	52-54	49-52	45-48	40-42
Heart muscle	-	59-63	52-56	-	-	-
Liver	76-79	50-56	44-51	46-47	42-43	34-38
Spleen	100-101	-	-	-	-	-
Kidneys	87-92	62	52-55	-	-	-
Lungs	-	35	35	-	-	-
Leather	65	-	46-48	43-46	40-45	36
Brain	81-83	-	-	-	-	-
Adipose tissue	-	4.5-7.5	4-7	5.3-7.5	3.9-7.2	3.5-4.5
Spinal cord	-	-	-	4.3-7.3	4.2-5.8	4.4-5.4

Table 2

Value of the resistance of body tissues at temperature 37° C, Ώ см

Body	Frequency, MHz					
	100	200	400	1000	3000	8500
Muscle	-	95-105	85-90	75-79	43-46	12
Heart muscle	-	95-115	85-100	-	-	-
Liver	154-179	110-150	105-130	98-106	49-50	15-17
Kidneys	-	90	85	-	-	-
Lungs	-	160	140	-	-	-
Leather	120-140	-	110-130	90-110	37-50	14
Brain	180-195	-	-	-	-	-
Adipose tissue	-	1050 - 3500	900 - 2800	670 - 1200	440-900	240-370
Spinal cord	-	-	-	100 - 2300	445-860	210-600

Tables 1 and 2 show the values of the relative dielectric constant ε' and resistance ρ, Ohm cm in the range from 100 MHz to 8.5 GHz. The tables show that fabrics containing a large amount of water (about 70%) and a relatively small mass are characterized by a relative dielectric constant of 50-70 and a resistance of about 100 Ohm cm. This group of tissues includes tissues of the liver, kidneys, heart, muscles and skin. Tissues with lower water content (adipose tissue, bone tissue) have significantly lower dielectric constants and higher resistance.[2], [4]

As the frequency increases from 100 MHz to 8 GHz, the dielectric constant and tissue resistance gradually decrease. The given dielectric properties of human tissues make it possible to calculate the absorption coefficients, the reflection coefficients of the boundaries between different tissues, the heating temperature of the tissues, the total amount of energy absorbed by the body, the scattering characteristics and to evaluate the effect of EMF on tissues of the human body.

EFFECT OF THE ELECTROMAGNETIC FIELD ON HUMAN

The entire population of the globe is to a greater or lesser extent systematically exposed to EMF. The ways of exposure to EMF in humans depend on the form of EMF, frequency, modulation. The action of an external electrostatic field on a person is accompanied by the appearance of unevenly distributed electric charges on the skin, including free and those introduced from the outside, which occur as a result of the phenomenon of electrostatic induction. On the side of the higher potential of the external ESP, negative electric charges are grouped, and on the opposite side of the human body - positive. ESP also causes polarization of tissue molecules because the molecules have a constant dipole moment and, in addition, the action of ESP leads to a change in the location of electrical charges in the molecule. The bound charges of polarized molecules are oriented in a similar way to the free ones.

The separated free and polarized connected electric charges of tissue molecules create their own ESP, whose intensity vector is directed to the intensity vector of the external ESP. Inside the human body, the external ESP is weakened. The degree of shielding of the internal tissues of the human body largely depends on the amount of free charges. For comparison, in electrons all electrons are free. They provide good electrical conductivity and when the conductor is in an external ESP, they provide reliable shielding. The value of the current and the degree of exposure are determined by the frequency, intensity and homogeneity of the alternating electric field and the electrical characteristics of the body tissues.

At operating frequencies, the absolute dielectric constant of the tissues of the human body is $\varepsilon_0 \approx 4\pi.10^7$, F/м, and the specific conductivity - γ = 0.1/0.2 См/м.

The oscillating motion of charged particles and dipoles in an alternating electric field is accompanied by the formation of heat and physicochemical processes. The absorption of field energy is due to ionic conductivity and dielectric losses. The movement of charged particles (ions) in the human body is accompanied by the formation of heat, the amount of which is directly proportional to the square of the vibration frequency, the square of the induction of MF and the conductivity of the tissues. In this case, more heat is generated in tissues with good electrical conductivity, ie in liquid media (blood, lymph) and in tissues with good blood supply (muscles, liver, etc.).

MF of any nature freely penetrate into living tissues and act on charged particles (electrons, ions, dipole molecules) moving in parts of the body with the Lorentz force, H,

$$F = qvB\sin\alpha \,, \tag{3}$$

where q is the charge of the ion, Cl; v is the velocity of the ion, m / s; B magnetic flux density, Tl; and α the angle between the vectors V and B.

In the same MF, the free charged particles move in circles with radius

$$r = \frac{m}{q}\frac{v}{B}\,, \tag{4}$$

where m is the mass of the particle.

The period of rotation, c, is

(5) $$T = \frac{2\pi}{B}\frac{m}{q}.$$

If the angle α lies in the interval 0 < α <0,5π, then the particles move in spirals, the step of which is equal to

(6) $$h = \frac{2\pi m v \cos\alpha}{Bq}.$$

In inhomogeneous MF with a change in induction, the motion parameters change. In real conditions, the movement of charged particles in the human body will be determined not only by the Lorentz force, but also by the presence of EF, biocurrents, electrical properties of tissues and a number of other factors. Given the possible effect of external PMF on the tissues of the human body, it should be noted that the molecules and structures of the human body have di- and paramagnetic properties. Their magnetic permeability is close to one and natural MF have practically no force effect on them. At the same time, numerous observations show the body's reactions to natural MF, the mechanisms of action of which are still insufficiently understood. At low frequencies the value of the current density j, A/м2, is calculated by the formula

(7) $$j = \pi r f \gamma B,$$

where γ = 0.1 – 0.5 is the specific conductivity of the human body, Cm / m; f – current frequency, Hz; r - radius on contour, м; B is the induction of MF, Tl.

The increase in dielectric loss and frequency is confirmed by experimental data, according to which the losses associated with the relaxation of water molecules in tissues with a frequency of 1 GHz are about 58% of total losses, at 10 GHz - about 90%, and at 30 GHz - about 98%.

When the human body is exposed to EMF from the specified frequency ranges, part of the energy is reflected from the surface of the body, putting pressure on it

(8) $$P = \frac{F}{c}(1 + R),$$

where - 3 x 10^8, м / s; R is the reflection coefficient. The rest of the EMF energy is absorbed. The depth of EMF penetration into the human body depends on the wavelength. It is generally accepted that the depth of penetration into the human body is one tenth of the wavelength. Due to the fact that different tissues absorb energy in different ways, they are heated to different temperatures. The degree of heating of parts of the human body also depends on the value of PES. At low values of PES, the heat energy released in the human body, due to the functioning of thermoregulatory mechanisms, can be released into the surrounding space without a noticeable increase in body temperature. The local effect of EMF on homogeneous areas of the body under conditions of natural cooling of the body surface leads to the strongest heating of the outer layers of tissue. The indoor areas heat up less under these conditions. If there is a forced cooling of the body surface, then the maximum increase in temperature takes place in the internal tissues at some distance from the surface of the human body, which is greater the longer the EMF wave and the more intense cooling of the body surface .[2], [3]

Conclusion

A noticeable thermal reaction of the human body to the EMF effect occurs when the value exceeds 10 mW / cm2. At lower values, the human body temperature does not rise, but EMF has an adverse effect on the human body. When EMF acts on a heterogeneous tissue structure (for example, the presence of a layer of fat on the muscle layer), the temperature distribution is complex. Due to the lower absorption of EMF by adipose tissue, heat dissipation in the adipose layer is lower than in the muscle layer. Therefore, when the layered system is irradiated, a more significant increase in temperature occurs in the muscle layer than in the fat layer located closer to the radiation source. This phenomenon is particularly pronounced in decimeter waves. [4]

Reference:

[1]. Ellis, F. P. et al., Physiological Responses to Hot Environments; special report, Series No. 298. Medical Research Council, London

[2]. Code of Practice – Masts and aerials, B5248 UK Dept. of the Environment.

[3]. Adair, E. R., Thermophysical Effects of Electromagnetic Radiation; IEEE Engineering in Medicine and Biology Magazine, March 1987

[4]. Buzov AL, Kolchugin Yu. I., Paltsev Yu. P. Ecological aspects of EMI of mobile stations of mobile communication systems // Occupational medicine and industry. ecology. - 1996