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INFLUENCE OF THE ELECTROMAGNETIC RADIATION

OF MOBILE COMMUNICATION DEVICES ON THE ORGANISM

OF A HUMAN BEING

The paper considers elaborated methods of the calculation of the human organism radiation intensity by the aerials of the base stations of the cellular communication and the approximated calculation of the time of the safe usage of a mobile phone. The paper contains the examples of the calculations.

Key words: cellular communication, mobile radiophone, influence on human health.

Introduction

Nowadays mobile communication is one of the most rapidly developing telecommunication systems. In Ukraine more than 50 million users employ this type of mobile communication. National operators of mobile communication use systems of GSM-900 standard, range of operating frequencies of base station 925…965 MHz, mobile radiophones – 890….915 MHz, and GSM-1800 standard – 1805….1830 MHz, and 1710…1785 MHz correspondingly.

The operation of such a system is based on the principle of division of a certain area into zones in the nodes of which base stations of mobile communication system are located at the distance of 0.5- 1.0 km. one from another in settlements and at the distance of 10 km in other areas.

In Ukraine limiting admissible levels of electromagnetic radiation influence on people, according to the existing Sanitation Norms and Regulations is power flux density of 2,5 μWt/cm^2 for base station and 25 μWt/cm^2 for mobile radiophones. It should be noted that in Russia these values are 10 and 100 μWt/cm^2 correspondingly, whereas Western Europe these figures are several times greater than in Russia.

Aerials of base stations of mobile systems used by operators of the mobile communication in Ukraine emit power within the limits of 8….16 wt. These stations are installed on the roofs of buildings, chimneys, or on special masts at the heights of the 30 – 35 m over the earth surface. These aerials have circle horizontal directional patterns and sharp vertical directional pattern, which are inclined horizontally under the angle of 1…2 degrees, having the form of an umbrella or the cap of mushrooms. Mobile radiophone is a small dimensional transmitter-receiver. Its radiation power (in transmission mode) is within the range of 0,125 – 1 Wt. Power is a variable value and depends on the state of a communication channel "mobile radiophone – base station," i.e. the higher the signal of the base station is in the point of receiving, the less is the radiation power of a mobile phone. However, in real conditions, as it is known by the experience, it, on average, does not exceed 0,23 Wt, in case of operation in settlement in open air. In bus, taxi electric train and other shielded environments this power can reach maximum value.

Analysis of research and publications

Power flux density of electromagnetic field emitted Π by the aerial is computed, using the expression [2]:

$$\Pi = \frac{PG}{4\pi \cdot r^2} F(\theta) \cdot F(\varphi) \cdot k ,$$ (1)

where *P* – power of aerial radiation, *G* – aerial gain, *F(θ)* , and *F(φ)* – normalized function of the aerial orientation, *r* – distance in free space between the aerial and point of observation, located in

distant zone of the aerial field.

In accordance with international norms, radiation power of a cellular telephones is measured in SAR (Specific Absorption Rate) units – specific absorbed power, expressed for the unit of body mass or tissue. In CI units SAR is expressed in Wt/kg. Nowadays upper limits of SAR value in Europe is the value of 0.8 Wt/kg [3].

It is rather complicated to measure SAR value, because special equipment and precise simulator of human organism tissues are required. There is no also generally accepted technique of such measurements. That is why the results obtained by the different independent centers can differ considerably. Thus, the most reliable and realistic is the result of the evaluation of the evaluation of power flux density of mobile phone electromagnetic radiation, based on its power.

Two effects are distinguished for evaluation of any electromagnetic radiation [3], thermal and non-thermal (informational).

Thermal effect [3]. Human body, as it is well known, contains liquid, which by its electro physical properties is electrolyte (aqueous solution of a great number of acids, salts of microelements, etc.), that is, it is the environment with considerable dielectric losses of electromagnetic energy, which is consumed for heating. As the human brain is saturated with the liquid, then it is the medium, which is heated under the influence of electromagnetic radiation.

It should be noted that the aerials of a mobile phone is at the distance of approximately 5 cm from the human brain, exposed by electromagnetic radiation. It is quite a natural thing that the temperature of the corresponded sections of the brain increases. During the long conversations this effect can be felt by increased temperature of ear cavity. It has been calculated that if SAR value is 4 Wt/kg during 30 min. the temperature of tissue of an adult person increases by 1 C^0. this effect is harmful for any organ and it will result in dysfunction of this organ.

Another human organ, especially sensitive to electromagnetic radiation is an eye crystal. The body of the crystal is gel like mass that can become non-transparent under the action of radiation that is it can lead to eye cataract.

Non-thermal (informational) effect. The problem is that [3] mobile phones of GSM standard perform transmission of the information by pulses combined in block. Each block consists of 8 pulses. Each user has only one out of eight pulses. The rest of the pulses belong to other seven users they can communicate at the same frequency at the same time. Duration of one GMS-block is 4,616 ms, thus the pulse frequency of a mobile phone is 1/4,616 ms = 217 Hz. Generation of each eight pulse results in proportional energy release. If rated power of a cellular phone in accordance with the instruction equals 2 Wt, then the power which has to be released at each pulse will be 2/8 = 0.25 Wt. blocks of the above mentioned pulses between a mobile phone and a base station are grouped in multi blocks consisting of 26 repetitions.

Hence, the second frequency which is to be emitted by a cellular phone is the frequency: 217/26 = 8.35 Hz. Moreover, some types of cellular phones, operating in energy-saving mode, are able to generate the third frequency – 2 Hz. This set of low-frequency radiation is a dangerous feature of mobile communication. The problem is that the above mentioned frequencies of cellular phones coincide with the frequencies of a natural bioelectric frequency of the human brain activity registered by encephalogram. Frequency of the 217 Hz coincides with so called gamma-rhythm of the brain; 8.35 Hz coincides with the alpha–rhythm; 2Hz coincides with the delta-rhythm.

Hence, signals which are able to interact with human brain bioelectric activity (for instance, by means of resonance), and distort its functions, are transmitted to human brain from outside. Such changes are seen at encephalogram and remain for a long time after the conversation is over. It must be noted that alpha waves are especially individual, directly connected with mental activity of a person and are considered to be reflections of inner images of conscience scanning. Abstract thinking is namely connected with alpha-rhythm of the brain. During sleeping delta-rhythm prevails, whereas gamma waves dominate during human physical activity. Is the action of pulsing sources of energy really harmful for human organism? Medicine knows such an example when the influence of pulsing illumination with frequency of 15Hz on human organism provokes an attack,

because such a frequency has implicit form of photosensitive epilepsy.

Some people have a habit to put a mobile phone nearby, using it as an alarm-clock It is also dangerous. A mobile phone does not "sleep" at night and it constantly operates in pulse mode.

More information regarding harmful impact of radiation for young people contains the research carried out among 11 000 users of cellular phones by National Working Life Institute (Sweden) and SINTET Unimed (Norway) by the request of Norway Radiation Protection Board. The research showed that people who used the phone less than two minutes felt discomfort and side effects. Health problems grow if phones are used longer. Half of the users involved in the survey told that they felt unpleasant heat in head region near the ear. Young people are especially subjected to risk. Often people under 30 feel the side effects in three, four times stronger.

Children are especially sensitive to high frequency radiation of mobile phones, because the formation of their immune system has not been completed yet and protective reactions of the organism are not developed. It should be noted that radiation of mobile phones is very harmful for pregnant women, because the radiation can be fatal for human embryo.

The main symptoms of the harmful influence of a mobile phone on health are the following:
− headache;
− memory disorder and disturbance of attention;
− constant fatigue;
− depression;
− pain and gripes;
− vision impairment;
− pulse and arterial pressure liability (research showed that after the conversation over the mobile phone arterial pressure can raise 5….10 mm. mercury column);
− a risk to get a brain tumor increases to 50 % after 6 years of mobile phone usage.

Problem setup

Suggested methods are intended for computation of the actual value of the radiation intensity of a human being by the aerials of the base stations of the cellular phone systems in large cities and approximate calculation of the safe tine to use mobile phones, assuming that orientation and structure of an aerial field of a mobile phone in studied intermediate zone practically will not differ from their character in the radiation zone.

Prove the obtained results by the practical examples. Make conclusions and give practical recommendations.

Main materials of the paper

Calculation of the base stations' electromagnetic influence on a human organism

Let's make use of the expression (1) introducing two coefficients *k1* and *k2*, in this case density of the electromagnetic field power flux radiated by the aerial of the base station and its influences on the human organism can be calculated by the formula:

$$\Pi = \frac{PG}{4\pi \cdot r^2} F(\theta) \cdot F(\varphi) \cdot k_1 \cdot k_2 , \qquad (2)$$

where *k1* − is a modulus of the reflection factor on the border "air-wall of the building", *k2* − is a modulus of a refractive index on the border "wall of the building or floor between stories - air".

Values of these coefficients depend on the angle of an incidence of the radio beam on the wall or floor and on the electro physical parameters of the materials the wall or the floor are made of. I known that these coefficients by modulus as well as functions *F(θ)* and *F(φ)* cannot exceed one.

Proceeding from the formula (2) we see that selected conditions are the worst for human selected conditions are the worst for human health. For convenience of a formula (2) usage, we will express *P*-in µWt, *r*- in cm, *П* – in µWt/cm² and rewrite the formula in the following form:

$$\Pi = \frac{25PG}{\pi \cdot r^2} \tag{3}.$$

Having solved the equation (3) relating r, we obtain the formula:

$$r = 5\sqrt{\frac{PG}{\pi \cdot \Pi}}, \tag{4}.$$

Applying the obtained formula we can determine minimal distance from the aerial where radiation intensity will be equal Π μWt/cm^2 if radiation power equals P Wt and gain factor G of a base station aerial.

Aerial of the base station has circle horizontal directional pattern and narrow directional pattern (7° by half power) in vertical plane. It has also a small slope (2°) of maximum radiation relatively the earth surface.

Example 1.

Let us consider typical case, for instance, when $P = 8$ Wt, $G = 17$dB and height of the aerial light over earth surface h = 32. If we substitute the given values in the equation (3), and Π is taken as equal 2.5 μWt/cm^2 – limiting acceptable by the medical norms value, then the distance r in the direction of the main lobe of the aerial directional diagram will be equal 35.8m. Thus, at the distance of 36 m from the aerial in the direction of the most powerful beam radiation becomes safe for human organism. It is quite obvious that at the same distance from the in another direction the safety will be even greater. Lateral lobes of the diagram act directly under the aerial where the intensity of the aerial radiation decreases by the order, points with accepted values of power flaw density will be located at the distances which do not exceed 10 m from the aerial. If, for example, the aerial of the base station is located at the roof of a block of flats at the height of 5 m, then the inhabitants of the upper story, being protected by the reinforced concrete floor, will be radiated with the intensity of the order lower than admissible norm. Regarding the inhabitants of the neighboring houses, it is sufficient that upper stories were on the lower level than the aerials and the distance to the aerial being not less than 30 m.

This condition is observed if the norms regarding the distance between blocks of flats are observed in the process of construction.

Pedestrians automatically find themselves in safe zone, even when they observe the aerial of the base station from the pavement, because the distance to the aerial increases by the value of height of the building where the aerial is installed. People are exposed even to less radiation inside the building or in the street when they are influenced by the wave reflected from the wall of the building.

Calculation of the safe time of the mobile radiophone usage

If the power of a mobile radiophone aerial is denoted by P_M, amplification factor of the mobile phone aerial – G_M, distance to radiation point - r, then approximately to intermediate and directionally to the neighboring zones average value of the power flux density Π_M, radiated by radiophone can be calculated by the formula:

$$\Pi_M = \frac{P_M \cdot G_M}{4\pi \cdot r^2}. \tag{5}$$

Having divided Π_M by maximally admissible value of the power flux $\Pi_{ДОП} = 25$ μWt/cm^2, we obtain number k that shows how man times Π_M – actual intensity of the radiation exceeds admissible value:

$$k = \frac{\Pi_M}{\Pi_{ДОП}}. \tag{6}$$

Such an excess would take place, if the object of radiation was located in the power flux the

whole day.

Thus, to determine maximum admissible time t of the safe operation of a mobile phone during a day is sufficient to divide 24 hours (duration of the day) by the excess coefficient k:

$$t = \frac{24}{k} \qquad (7)$$

Having substituted value of Π_M from (4) into (5) and the new value k in (6) we obtain:

$$t = \frac{96\pi \cdot r^2 \cdot \Pi_{ДОП}}{P_M \cdot G_M} . \qquad (8)$$

For convenience of the application of the given formula we convert hours into minutes, power Π_M we will express in microwatts, distance r – in centimetres, after that by the final formula we will obtain the result in minutes:

$$t = \frac{5{,}76\pi \cdot r^2 \cdot \Pi_{ДОП}}{P_M \cdot G_M \cdot 10^3} . \qquad (9)$$

Example 2.

We select practically average value of the mobile phone radiation power $P_M = 2 \times 10^5$ µWt; $r = 5$ cm (distance from the aerial of a mobile phone to the head of the user); $\Pi_{ДОП} = 25$ µWt/cm^2; $G = 1$ (assuming that the nearest zone the aerial has practically single direction). Having substituted these values in the formula (8) we obtain: $t = 56.52$ min.

Rounding off the obtained result in favour of user's health, it should be noted that total time of the mobile phone usage must be limited by 50 min a day. If a mobile phone is used in the shielded location constantly (in the cabin or in the car), this time should be reduced in four or five times.

Conclusions and recommendations

1. Radiation of the base station aerials practically does not influence the human health.

2. An adult person can operate a mobile phone in the open air safely only 50 min a day.

3. Children aged under16 can safely operate a mobile phone not longer than 20 min. a day.

4. The usage of the mobile phones by small children must be prohibited.

5. Time of the constant usage of the mobile phones by adult persons in the shielded locations (cabin, car, van) must be reduced to 15 min a day.

6. You should remember that your mobile phone is constantly in the active mode. That is why, do not put it in the pocket or on the breast as a locket, especially it concerns young people, pregnant women and children.

7. Using a mobile phone, do not put the palm or fingers on the rear cover of the mobile phone. our body absorbs an electromagnetic wave reducing signal from the base station that makes the phone operate with the increased power.

8. Do not use a mobile phone driving the car, because it diverts driver's attention.

9. Do not buy mobile phones second hand without corresponding technical documentation, remember SAR – index.

10. Use a mobile phone in case of necessity.

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