Electromagnetic interactions of metal detectors

European Journal of Medical Technologies
2017; 1(14): 33-40

www. medical-technologies.eu
Published online 20.04.2017

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Abstract

The article identifies the levels and ranges of electrical and magnetic fields generated by gate metal detectors. The identification systems surrounding us use the intentional propagation of the electromagnetic wave as a working medium, which affects humans and nature. Using the ESM-100 field meter, it was possible to determine the distribution of intensity values from several selected gate systems. The values were compared with the current permissible intensity limits.

Key words:

metal detector, electromagnetic emission

Introduction

In recent times, interest in anti-theft technologies and systems for identifying terrorist threats has increased. Some of these technologies use electromagnetic radiation to detect metals. Detectors, or metal detectors, were produced for military purposes – mines with metal construction could be found by means of detectors. Currently, hobby and industrial metal detectors dominate the market, with gates being used for metal detection in courts and airports. The industrial ones are mainly used to locate water, gas or power lines both in the ground and in the walls of buildings. A large group of detectors are installations that are used in public places, airports or other enclosed zones for protection purposes [1].

The multiplicity of uses and popularity raises the need for scientific studies on the effects of waves emitted by such devices on human organisms, and the results are related to the legislation specifying permissible levels of intensity.

Gate metal detectors

Gates for detecting metals at airports and other public places have become widespread. Currently, microprocessor-controlled metal-detection gates with specific detection and identification parameters are used at airports and in courts [2,3,4]. They have an extended detection area that includes several vertical and horizontal areas. Specific models can detect metal objects within more than 30 separate locations. The increased number of detection areas dramatically increases the throughput of a gate to several dozen people per minute, and precisely indicates where additional searches are needed. Various prohibited items are differentiated, and items that are allowed are ignored depending on the program selected and sensitivity settings. Detection range covers the area from the floor to the top of the detector (Fig. 1).

The metal detection gate must meet rigorous safety standards [4]. On the one hand, it is a group of EMD (Enhanced Metal Detector) requirements recognized

Fig. 1.
Typical inspection post – gate detectors at an airport [5]

by the Transportation Security Administration (TSA), NIJ-Standard 0601.02 for Gate Metal Detectors to detect weapons and smuggling and the 3-Gun FAA test (Federal Aviation Administration). On the other hand, the gate-detector, before being launched to market, must comply with EMC (Electromagnetic Compatibility) requirements, as well as with CSA, TEC, CB and ICNIRP (International Commission for Non Ionizing Radiation Protection) environmental and international directives. "Reference levels For general public exposure".

Two types of devices are used in public spaces of particular importance. People are inspected by electromagnetic gates and hand-held metal detectors. In contrast, luggage and objects carried by persons/passengers are screened in X-ray machines.

During the gate check, the person stands in an alternating electromagnetic field. Its value can only be compared with the norms in force. Thus, the intensity of both electrical and magnetic components cannot exceed the threshold applicable to people residing permanently within the field. However, the person passing through the gate is exposed to it incidentally, as he or she remains within the reach of the gate for several seconds.

Analysis of *E* and *H* intensity distribution

The analysis carried out in this paper is based on own research conducted with two types of detectors. Measurements were made in 2016. One of the detectors was located in one of the Lublin courts and the other gate may be used at airports. Because of safety regulations, little information on the operation of this type of equipment can be presented. Therefore, analyses of potential electromagnetic interactions of the above-mentioned systems on human organisms will be presented.

The typical principle of operation of the detector is based on changes in the value of magnetic induction. Determining the transmitter and receiver signals in the detector allows one to activate the appropriate operating conditions, including alarms. Detected changes in induction values can be caused by induced eddy currents in metal objects that are in the transmitter coil area (Fig. 2). The effect of the eddy currents will be the reaction of the magnetic field generated by the magnetic field with the receiving section field. Superposition of interactions causes deviations from the operating state, which results in an alarm.

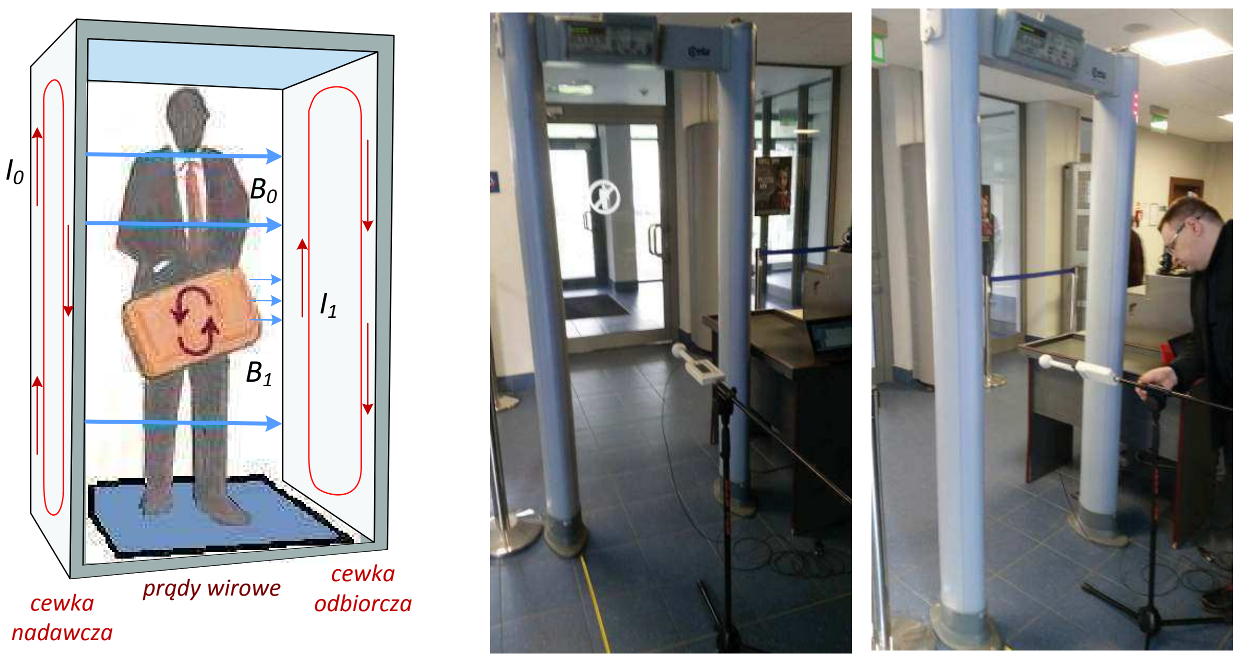


Fig. 2.
General working of the detection gate [6] and photographs of own research

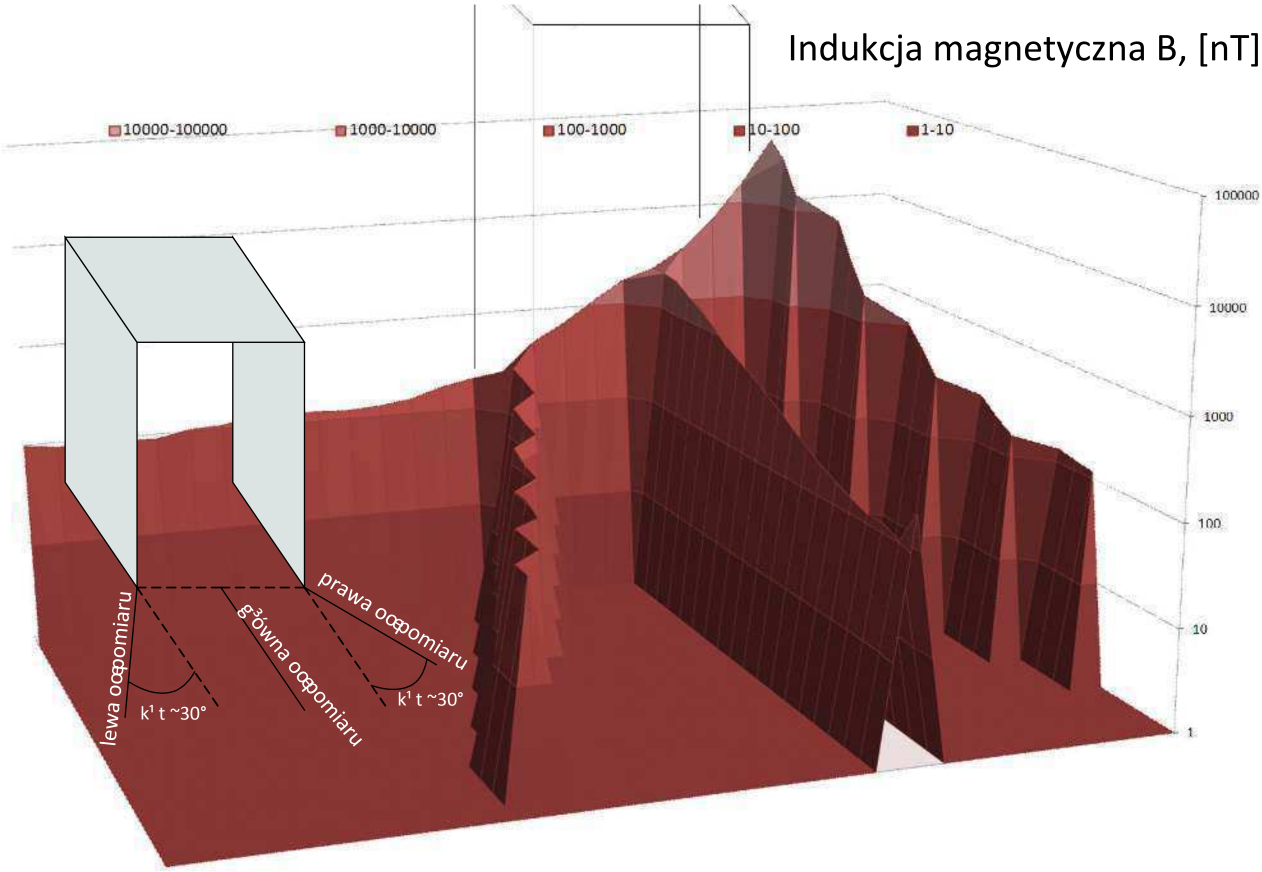


Fig. 3.
Spatial distribution of the B magnetic induction in nT around the detection gate

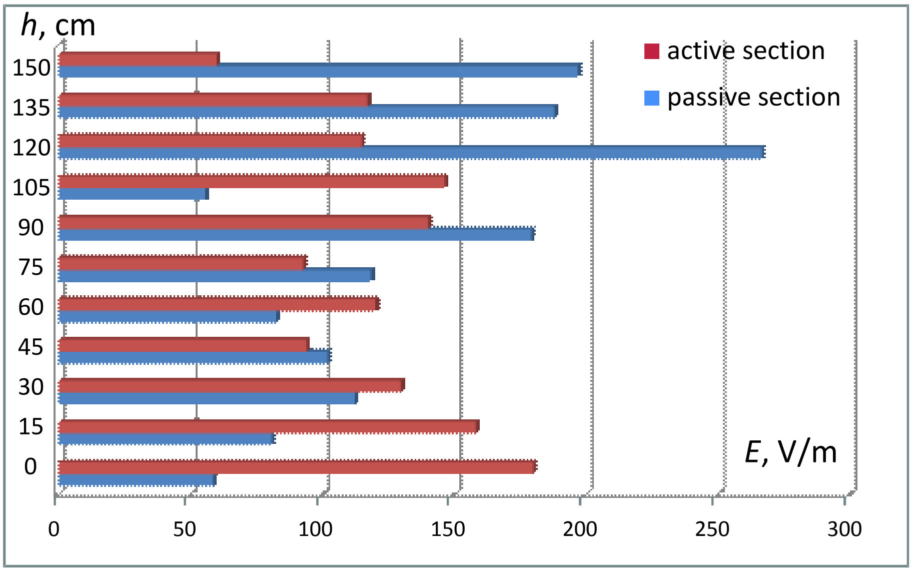


Fig. 4.
Changes in the value of the E electric component in the height function at the detector walls, the color of the detector shows the active and passive side of the detector

End solutions are by all means different, often backed up by patented systems and configurations.

The ESM100 meter, which was used for research in this paper, is equipped with an isotropic electromagnetic field sensor to measure both the electric field and the magnetic component in the 5 Hz to 400 kHz frequency range. Because of the metal elements of the meter, it was necessary to maintain a special measurement procedure requiring long-time measurement, so as not to trigger the alarm.

Measurements were carried out in two stages. In the first cycle, the spatial distribution of the electrical and magnetic components' intensity was determined. By removing the meter at specified (every 10 cm) steps from the gate walls, both the values and trend of intensity changes were established. The test was performed on three measuring axes – the main axis in the center of the gate, with two lateral axes angled 30 degrees outside the left and right wing of the gate. Geometry of measuring axes and values are presented in Figure 3. The clearly-observed trend of decreasing magnetic induction (magnetic field intensity) decreases markedly, as the distance from the active section of the detection gate gradually increases. Measurements were made at a height of one meter from the ground.

The next step involved identifying the intensity at the nearest distance from the gate walls in the altitude function. Measurements were carried out every 15 cm, starting from the floor of the inner walls of the gate. The values obtained clearly indicate the existence of two "active" sites having sections of transmitting coils, and "passive" sections having a receiving section.

In addition to the intensity detection during the tests, electromagnetic wave identification was performed. The spectral form obtained using the Rigol E102 digital oscilloscope showed both frequency and amplitude modulated signal characteristics of the detector signal. We detected harmonic components from the 4kHz to 48kHz range in the signal.

The second detection system is a typical system working in special zones, such as airports. The system is generally larger (longer) and is built to increase the flow of scanned people by extending the detection lines of personal items and luggage with the X-ray system. The working of the detection system is shown in Figure 6.

Fig. 5.
Changes in the value of the E electric component in the height function at the detector walls, the color of the detector shows the active and passive side of the detector

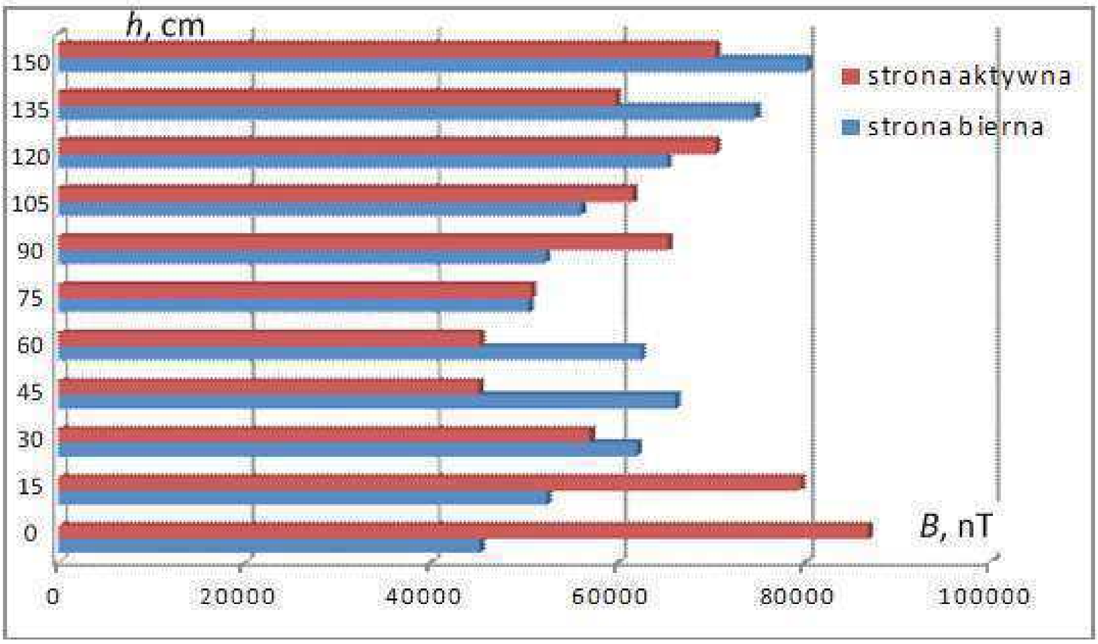
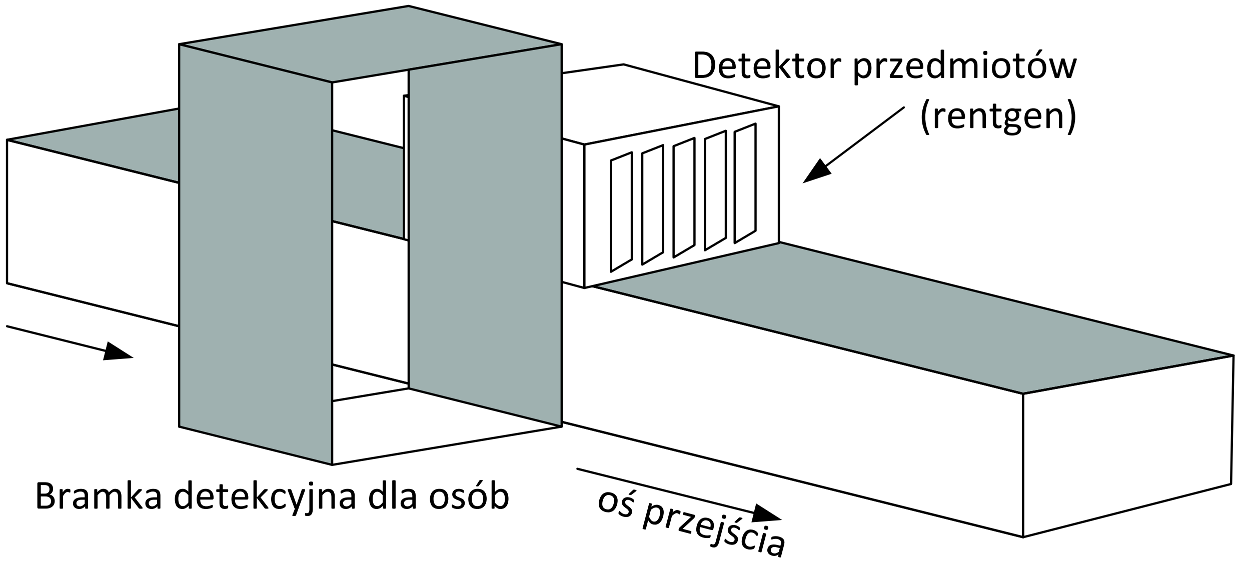


Fig. 6.
Single integrated control system including a detector gate for people and a detection system for objects and luggage



As with the previous gate, the test consisted of several parts. The first step was to determine the parameters of the magnetic and electric fields along the axis of the transition along the entire length of the inspection system. The measurement step was set every 20 cm, measured at a height of one meter from the ground. The values obtained are shown in Fig. 7.

The next step in the study was to measure the magnetic induction distribution between the detector gate walls at one height. The values obtained are presented graphically in Fig. 8.

Obtained results compared to acceptable intensity

With regard to the analysis of human exposure in the low-frequency electrical and magnetic fields (ELF and VLF – working frequencies of metal detectors), magnetic fields are of particular interest.

The maximum observed electrical and magnetic field values for the first gate were 86.9 μT (70 A/m) and 554 V/m. In the case of the second test object, the highest observed field values were 41μT (33,4 A/m) and 254 V/m, respectively. The values obtained do not exceed the admissible exposures of the revised Regulation [7] of 2016. (Table 1). As far as manual scanners are concerned, their emissions are even lower. The measures of the Terascan ESH-10 handheld scanner are several hundred times smaller – the magnetic induction is about 100 nT and the electrical component is 40 V/m.

The situation with the compatibility of medical electronic devices is completely different. As reported by the industry, the disturbance that incidentally occurred with pacemakers was the transition of this device into the so-called steady-state frequency, which is safe for the patient. Neurostimulators and automatic defibrillators show no undesirable response to the field. However, the working of the Holter monitor is disrupted.

The observed levels and short exposure times are safe for people who rarely deal with detectors, such as those at airports. But the ever more widespread detection systems in many public institutions and anti-theft systems in stores increase the intensity of the impact.

Conclusions

In the vast majority of manufactured and used equipment, there is no need to perform measurements and assess the exposure to electromagnetic fields. Research confirms the existence of the safe zone [1,8]. Nevertheless, independent research is a manifestation of the concerns of detector users and bystanders, as well as the remarks and conclusions of many

Fig. 7.
Changes in the value of the E electric component and the B magnetic induction in the axis of the person passing through the whole inspection system (500 cm)

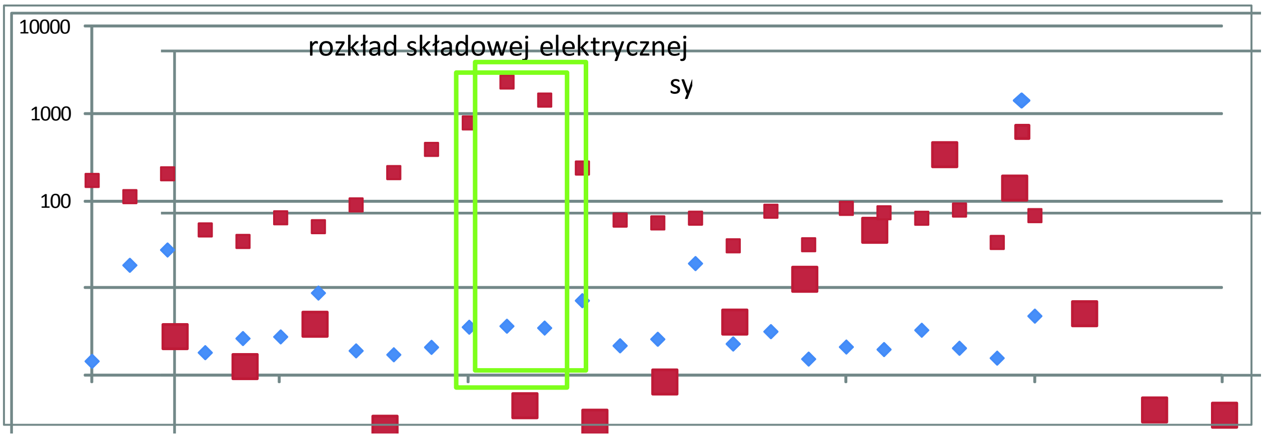


Fig. 8.
Distribution of magnetic induction intensity between gate walls

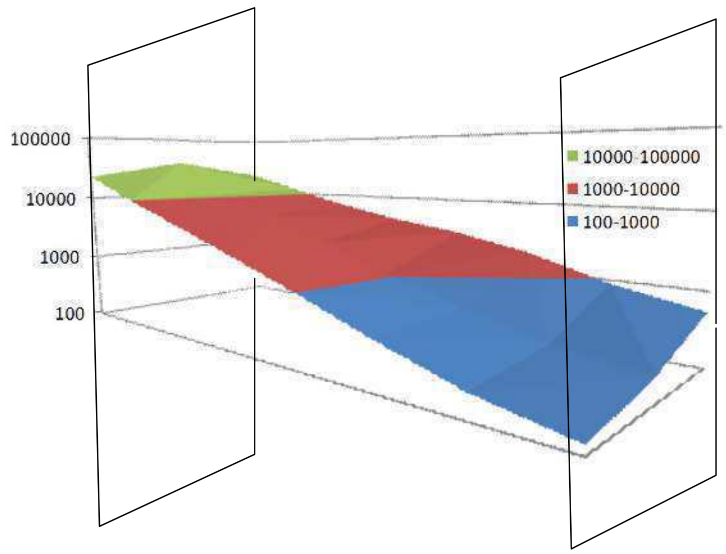


Table 1.
Juxtaposition of intervention limits for exposure to magnetic fields [57]

Lp.	Częstotliwość	Limity IPN dotyczące natężenie pola-M[1), 3), 4)]					
	f	IPNog-H[1)]	IPNob-H[1)]	IPNod-H[1)]	IPNp-H[1)]	IPNk-H[1)]	IPNm-H[3)]
	Hz	A/m (WR)	A/m (WR)	A/m (WR)	A/m (WR)	A/m (WR)	A/m (P)
1	$f < 5$ (w tym pole magnetostatyczne)[4)]	$3{,}2\times10^5$	$1{,}6\times10^5$	$2{,}4\times10^3$	4×10^2	8×10^5	Nie określono
2	$5 \le f < 50$	$3{,}2\times10^3$	$1{,}6\times10^3$	$1{,}6\times10^3/3$	60	8×10^3	
3	$50 \le f < 10^3$	$1{,}6\times10^5/f$	$0{,}8\times10^5/f$ 100mT / f	$0{,}8\times10^5/(3\times f)$	$3\times10^3/f$	$4\times10^5/f$	
4	$10^3 \le f < 20\times10^3$	$1{,}6\times10^2$	80 100µT	80/3	3	4×10^2	
5	$20\times10^3 \le f < 3\times10^6$	$3{,}2\times10^6/f$	$1{,}6\times10^6/f$	$1{,}6\times10^6/(3\times f)$	$6\times10^4/f$	$8\times10^6/f$	80
6	$3\times10^6 \le f < 10\times10^6$	$3{,}2\times10^6/f$	$1{,}6\times10^6/f$	$1{,}6\times10^6/(3\times f)$	2×10^{-2}	$8\times10^6/f$	80
7	$10\times10^6 \le f < 300\times10^9$	0,32	0,16	0,16/3	2×10^{-2}	Nie określono	Nie określono

research studies, which continue to show the potential for chronic conditions occurring even within relatively weak fields.

In the human body within the electromagnetic field, the electric current, whose effects depend on the frequency of the field, is induced. For example, in the fields of small and medium frequencies, nervous or muscular tissue may be stimulated, and in the radiofrequency and microwave frequencies, the tissue temperature increases within the organism or at the surface of the skin [9]. Induced currents can interfere with the natural electrophysiological processes in the nerve or muscle cells, causing their agitation.

The researchers have obtained the consent of the competent institution to carry out the research, but some restrictions have been introduced with regard to the disclosure of sensitive information, which is related to security.

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