UDC 004.932.75

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Electromagnetic screens application for population protection from electromagnetic fields and radiation

The results of the field measurements of electromagnetic radiation levels on the territory of the Odessa airfield are analyzed. It was established that it is necessary to develop and implement the system of electromagnetic monitoring, which will enable the detection of the sources of electromagnetic pollution at the facility.

Currently electromagnetic shielding is under detailed investigation, but technique and conditions of various shielding materials application, as well as optimal efficiency of shielding application are determined insufficiently.

These tasks are also urgent because of gradual implementation of the European Council Directive on electromagnetic safety and enactment of a range of European standards on electromagnetic safety and compatibility of technical facilities, which are stricter than Ukrainian national standards in most cases, according to the Decree of the Cabinet of Ministers of Ukraine (№ 1483 КМ 29.12.2014).

In the previous years a great number of studies on electromagnetic screens efficiency have been conducted [1-3]. The most of them have experimental character because theoretical studies in this area posses a bit abstractive character and they are not suitable for application [4, 5]. Study and development of modern protective materials [6, 7] prove possibility of protective properties management, i.e. production of screens with required shielding factor, in particularly, protective electromagnetic screens with regulated protective properties [8]. Studies of shielding efficiency have been conducted mainly in lab conditions and their results are not completely matched with measured results at real objects, which is conditioned, on our opinion, by both final dimensions of screens and external sources and overradiations impact. Our previous studies [9] have shown that shielding efficiency depends not only on chosen material properties, but also on the screen dimensions, its allocation relatively to the source of field and radiation, diffraction phenomenon etc. These aspects have not been studied enough yet.

The aim of study is the determination of electromagnetic screens application condition depending on frequency and amplitude of shielded field or radiation, their sources allocation and provision of practical guidelines on regulation of protective materials selection.

Electromagnetic shielding is the most urgent for the provision of standard electromagnetic environment in buildings and constructions (beside the certain objects, for example, civil aviation enterprises), i.e. for electromagnetic ecology of rooms. It is also necessary to take into account the presence of both internal and external sources of fields and radiations. External sources are generally radiotechnical objects of communication facilities with extremely low radiation wavelength (to 1 centimeter) and power supply objects – transmission facilities, transforming station and open switching centers with extremely wide wavelength (6000 kilometer). It's obvious that protective methods for different types of radiation must be different. The internal sources are power supply systems with powerline frequency electromagnetic fields and electromagnetic fields of industrial or domestic equipment, which have various and unpredictable frequency spectrum in many cases.

Technical approaches to the protection from these two categories of impact sources differ substantially. In many cases efficient protection from external impact sources can worse electromagnetic environment as a result of internal sources impact. The cause is that internal source radiation reflection from electromagnetic screen to the room increases electromagnetic background level. It is also partially applied to external sources. Our measurements have shown that reflection of base station electromagnetic radiation from well-shielded construction surfaces (metal decorative coats) significantly worsens electromagnetic environment on neighbor areas. Sometimes this worsening makes 70-80%. Partial reflection is observed even from concrete construction. It is important to note that this parameter depend substantially on weather conditions, for example, electromagnetic fields reflection index for construction roofs and surfaces changes significantly under precipitations. Neighboring buildings orientation in relation to incident and reflected waves is also important. Reflection phenomenon has unfavorable character in terms of human safety in any cases. Therefore, it is necessary to determine maximal permissible reflection coefficient at material selection for electromagnetic screen production, if the required general screening coefficient is known. Concerning separated premises their full shielding, even at minimal reflection coefficient, can cause certain inconveniences, for example, blocking of communication with base stations, experienced by citizens. It can block the activity of wireless computer net within certain building. Another problem is magnetization of ferromagnetic screen in external magnetic field, which may cause the field level increase at approaching. Our study have proved that ferromagnetic electromagnetic screens have to be applied as whole fully closed screens around high-power electrotechnical facilities or screens developed on the basis of reflection phenomenon, which is fundamental physical principle. Such screen is located from the source backside, instead of placing between the source and public zone. Decrease of powerline frequency and other low-frequence magnetic field level by 16-17% is achieved depending on relative distances in the public area, which is proved with the results of conducted experiments. The benefit of such shielding is that its efficiency can be accurately calculated [10]. The exception is ferromagnetic and magnetic screens made of soft magnetic amorphous alloys, but their application is limited with high cost of these materials due to complex production technology. The most efficient screens for protection from both external and internal sources impact are flexible metal-polymeric materials with managed protective properties. Determination of frequency and amplitude characteristics of radiation, to be shielded, must precede screen production, and required screen parameters are determined based on the developed dependencies (fig. 1).

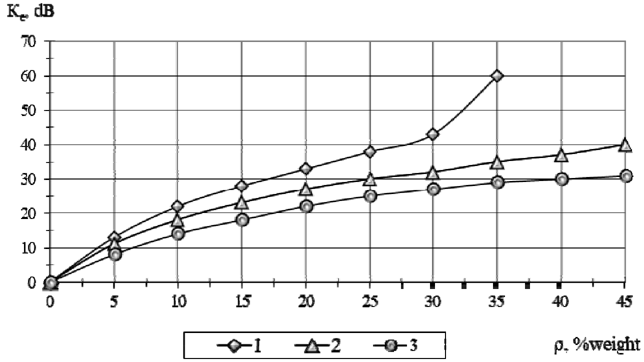

Fig. 1. Dependence of shielding coefficient of flexible protective material on conductive component content: thickness 1 – 5,0 mm; 2 – 3,0 mm; 3 – 1,0 mm

Reflection coefficients can be determined according to ratios at fig. 2.

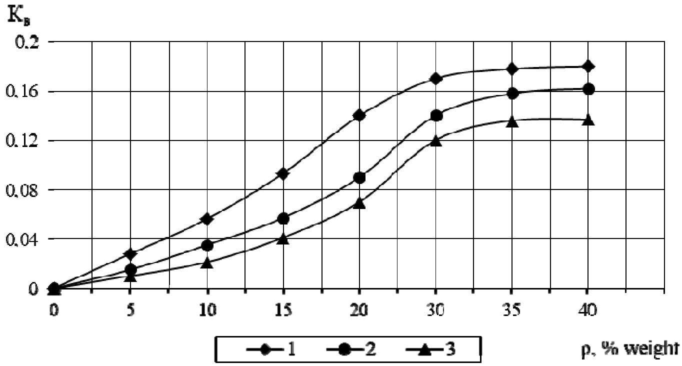

Fig. 2. Dependence of reflection coefficient of flexible protective material on conductive component content: thickness 1 – 5,0 mm; 2 – 3,0 mm; 3 – 1,0 mm

To determine the efficiency of electromagnetic screens for the provision of required parameters it is necessary to take into account a range of factors: reflection level, attenuation, caused by energy penetration through the screen material, and diffraction phenomena. The last issue is applied to perforated and latticed surfaces and screens with limited dimensions (length and width). Additionally it is important to take into account separately located big radioreflective surfaces and certain emitter, which sometimes increase field level in the radio shadow zone. The solution of these tasks will be efficient with application of both theoretical and experimental methods. Application of mathematic models with acceptable accuracy for the selection of protection methods provides significant reduction of time and costs used for the provision of required protection levels. To fulfill such work it is necessary to apply fundamentals of geometry [14]. The scheme for calculation of screen geometrical configuration accounting the diffraction phenomena is given at fig. 3.

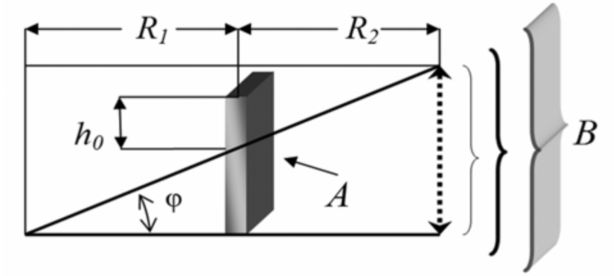

Fig. 3. Scheme of relative placement of electromagnetic screen *A* and field source. h_0 – distance between screen edge and source axis; R_1 – distance from source to screen; R_2 – distance from screen to protected zone *B*

To account the diffraction numerically it is useful to introduce the dimensionless parameter – screen efficiency factor η:

$$\text{з} = h_0 \cdot \cos \varphi = \sqrt{\frac{2}{\text{л}} \cdot \left(\frac{1}{R_1} + \frac{1}{R_2} \right)}$$

where h_0 – distance between the screen edge and source axis, λ – wavelength, R_1 – distance from the source to screen, R_2 – distance from screen to protected zone.

Conclusions

1. Assessment of electromagnetic environment has to be conducted prior to screen material and structure selection; it includes determination of frequency and amplitude parameters of electromagnetic fields and external and internal sources radiation.
2. It is necessary to choose reasonable correlation of attenuation and reflection screen parameters for maximal reduction of this physical factor impact on human. It is efficient to apply graphic dependencies given in this paper.
3. Ferromagnetic electromagnetic screens application is the most acceptable under condition of full blocking of field source or with accounting reflection effect that enables preliminary calculation of shielding efficiency based on geometrical issues exclusively.
4. Variability of shielding coefficients has to be taken into account at electromagnetic shielding application because of diffraction phenomena at the screen edges.
5. In all cases it is necessary to take into account the feasibility of screen production and installation, as well as its cost, which is provided by rationalization of shielding and reflection coefficients selection (i.e. with principle of reasonable adequacy).

References

1. Lynkov L.M., Bogush V.A., Borbotko P.V. et al.: Doklady NAN Belarusi, 2004, 3, 152.
2. Zaporozhets O.I., Lukianchikov A.V., Glyva V.A. et al.: Problemy okhorony praci v Ukraini, 2007, 14, 35.
3. Levchenko O.G., Levchuk V.K., Tymoshenko O.N.: Avtomaticheskaia svarka, 2011, 3, 49.
4. Rezinkina M.M.: Zhurnal tekhnicheskoi fiziki, 2007, 77(11), 17.
5. Model ekranirovania postoiannykh magnitnykh polei mnogosloinym tsilindricheskim ekranom / [V.T. Erofeenko, G.Ch. Shushkevich, S.S. Grabchikov, V.F. Bondarenko]. – Minsk, NPTs NAN Belarusi po materialovedeniu, 2012. – № 3 – P. 80 – 93.
6. Klapchenko V.I., Krasnianskii G.E., Glyva V.A., Aznaurian I.A.: Gigiena naselennykh mists, 2010, 56, 219.
7. Panova O.V.: Tekhnika budivnytstva, 2010, 24, 56.
8. Glyva V.A., Nazarenko M.V., Podobed I.M., Matvyeyeva O.L., Panova O.V.: Pat. 74857 Ukraine, МПК G12B17/00. Publ. 12.11.2912. Bul. № 21.
9. Glyva V.A., Panova E.V.: Tekhnologii technosfernoi bezopasnosti, 2014, 1 (53).
10. Panova O.V. Zakhyst pratsuuchykh vid vplyvu elektromagnithykh poliv ekranuvanniam: diss. … Cand. Tech. Sc.: 05.26.01 / Panova Olena Vasylivna – К., 2014. – 151 p.