PROBABILISTIC APPROACH OF STABILIZED ELECTROMAGNETIC FIELD EFFECTS

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Abstract - The effects of the omnipresence of the electromagnetic field are certain and recognized. Assessing as accurately as possible these effects, which characterize random phenomena require the use of statistical-probabilistic calculation. This paper aims at assessing the probability of exceeding the admissible values of the characteristic sizes of the electromagnetic field - magnetic induction and electric field strength. The first part justifies the need for concern and specifies how to approach it. The mathematical model of approach and treatment is presented in the second part of the paper and the results obtained with reference to 14 power stations are synthesized in the third part. In the last part, are formulated the conclusions of the evaluations.
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Keywords: electromagnetic field, exposure effects, statistical-probabilistic calculation.

1. INTRODUCTION

According to [1], the risk means "the possibility of reaching a danger, of having to face a trouble or suffered a loss, potential danger" (derived from the French risque). The notion of risk is used in many fields [2, 3, 4, 5], with different connotations, sometimes improperly. According to the defined notion [1], the risk is related to a random event (uncertainty) and to a specific hazard.

In the electro-energy area the risk theory had been developed, especially in relation to nuclear power plants. Are well known [3] the theories and methods of risk assessment in the nuclear area (Farmer, Otway, Rasmunsen). We believe that, with reference to technical systems, risk analysis is ideal for those cases where life, health or human comfort level may be endangered. In this sphere is also the risk of affecting living organisms, including humans, by the electromagnetic field.

The negative effects of the electromagnetic field (EMF) on humans are certain. Their most accurate assessment is the subject of numerous researches [6, 7, 8, 9, 10, 11]. On the basis of the results of the researches carried out, limitations of the EMF-characterizing quantities in areas where it interferes with human activity are currently established [12, 13, 14, 15].

The assessment of the risk of human involvement by EMF implies - among other things - the assessment of the probability of exposure to dangerous EMF. This is the subject of this paper. Many studies and research associate exposure to the electromagnetic field with the production of serious diseases on living organisms. Examples of these affections are [8, 9, 10]: dizziness, loss of memory or lack of concentration, anxiety, sleep disturbance, infertility and impotence, decreased vitality, brain tumors or other forms of cancer and others. These conditions are associated with certain parameters of the electromagnetic field, but also with the distance to sources or the duration of exposure.

Currently, the installations which generate the electromagnetic fields (GI - EMF) are diverse and can operate in a stabilized and / or transient regime. In the present paper we are considering only power GI - EMF - power stations, electrical grids, traction equipments etc. - which operate in a stabilized regime at the industrial frequency.

2. MATHEMATICAL MODEL

The effects of stabilized CELM against the persons which interferes with it, can be estimated by the cumulative total value of the consequence:

$$C = \sum_{j=1}^{M} p_{EV_j} \times c_j \qquad (1)$$

where:

p_{EV} – the probability of occurrence of the unwanted event (EVN);

c – unitary severity of the consequence;

j = 1...M – number of persons exposed in dangerous EMF(EMFd) into a time analysis interval (TA).

By EMFd is meant that EMF whose characteristic sizes B (magnetic induction) and / or E (field strength) exceeds the admissible values (Ba, Ea).

The unitary severity of the consequence (c) materializes by the degree of damage to the health of a person exposed to EMFd, which is in direct relation to the power Specific Absorption Rate SAR [14,15,16].

If we work with a mean (non-personalized) value of the consequence, according to current norms [14,15], it can be written:

$$C = c_{med} \sum_{j=1}^{M} p_{EV_j} \qquad (2)$$

In this case, the unit gravity of the consequence is considered a deterministic size and the analysis will focus on the random variable (p_{EV}), which can be expressed with the relation:

$$p_{EV} = p \cdot p_p \qquad (3)$$

Where, p – probability of simple event (EVS_1):"existence of EMFd in point M";

p_p – probability of simple event (EVS_2): "the human presence in area of EMFd"

For a certain person (j), the value (p_{pj}) will be estimated with relation:

$$p_{pj}=\sum_{j=1}^{k}\frac{t_{jk}}{T_A} \qquad (4)$$

Where t_{jk} – time domanin in which it is realizing EVS_2 with reference to person "j".

Under these conditions, the analysis will focus on size "p". Given the character (p, c) - random and imprecise levels - the subject can be treated by applying probabilistic or fuzzy modeling. Probabilistic treatment was justified and applied by the authors of this paper in [4,5], with reference to the EVS_1 probability calculation, for one of the characteristic sizes of the EMF (B or E), where appropriate with one of the relations [5]:

$$H_1:\ p_{1X}=\frac{1}{\sqrt{2\pi}\cdot\sigma_{Xm}}\int_{X_a}^{\infty} e^{-\frac{(X_m-m_{Xm})^2}{2\cdot\sigma_{Xm}^2}}\,dX_m,\ X=\{E,B\} \qquad (5)$$

$$H_2:\ p_{2X}=\frac{1}{\sqrt{2\pi}\cdot\sigma_{Xm}}\int_{X_i}^{\infty} e^{-\frac{(X_m-m_{Xm})^2}{2\cdot\sigma_{Xm}^2}}\,dX_m + \frac{1}{\sqrt{2\pi}\cdot\sigma_{Xa}}\int_{-\infty}^{X_i} e^{-\frac{(X_a-m_{Xa})^2}{2\cdot\sigma_{Xa}^2}}\,dX_a,\ X=\{E,B\} \qquad (6)$$

where, X_m – the measured values of the characteristic sizes;

X_a – the admissible values of the characteristic sizes;

X_i – the coordinate of the intersection point of the two distributions (admissible values, measured values).

Hypothesis 1(H_1): The admissible values are fixed, indicated in a normative;

Hypothesis 1(H_2): The admissible values are, in fact, the mean values of some (E, B), random variables.

The two relationships are expressions of probability (p), with reference to each size (B, E). In fact, the two characteristic sizes coexist in EMF formation. In this paper we will evaluate the probability EVS_1 in real conditions: „ B or/and E exceed the admissible / supportable values"(B_a, E_a). So:

$$\begin{cases} p_1 = p_{1B} + p_{1E} - p_{1B}p_{1E} \\ p_2 = p_{2B} + p_{2E} - p_{2B}p_{2E} \\ p_{EV1} = p_1 \cdot p_p \\ p_{EV2} = p_2 \cdot p_p \end{cases} \qquad (7)$$

3. APPLICATION RESULTS FOR POWER STATIONS OF BIHOR POWER SYSTEM

The evaluation methodology presented was applied to 14 power stations (PS) from the Bihor PWS. The measurements were made in several phases between 2012 and 2015 using the EMF detector SPECTRAN 5035 manufacturing device Aaronia, Germany. The measurements were made for the medium and high voltage levels of the stations on the operators' runways at measuring heights of 1 m and 1.7 m. For each PS, voltage level and characteristic sizes, have been performed a total number of 200 measurements. The values obtained were entered into a specially created database using the Excel program in the Office package.

In Figures 1÷ 8, we exemplify distributions of the two random variables ≡ characteristic sizes (E, B).

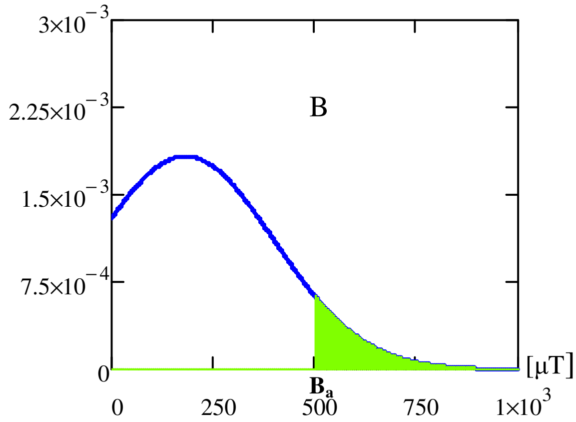

Fig. 1. Distribution of B for PS Mecanica

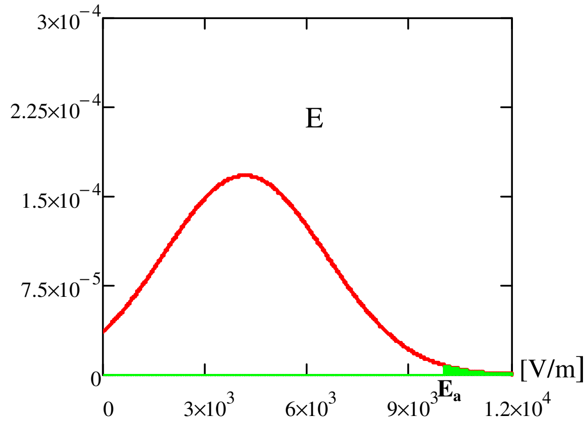

Fig. 2. Distribution of E for PS Mecanica

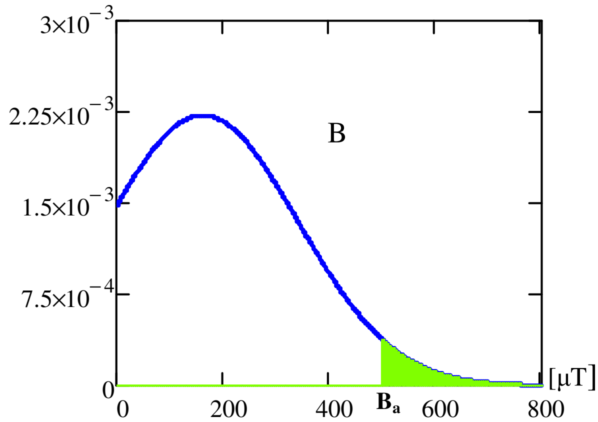

Fig. 3. Distribution of B for PS Oradea Vest

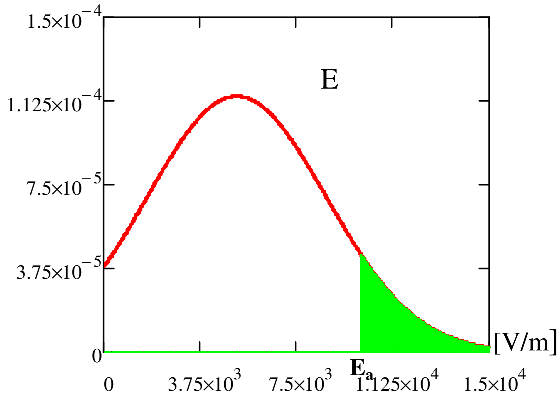

Fig. 4. Distribution of E for PS Oradea Vest

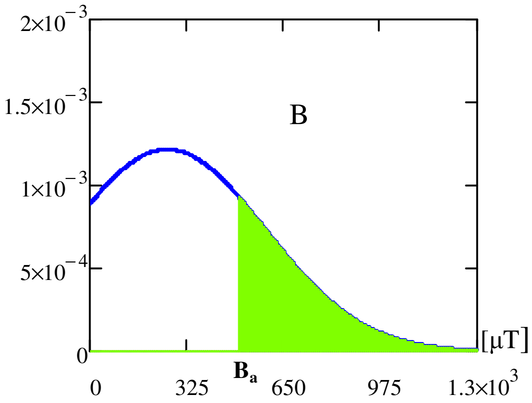

Fig. 5. Distribution of B for PS Oradea Center

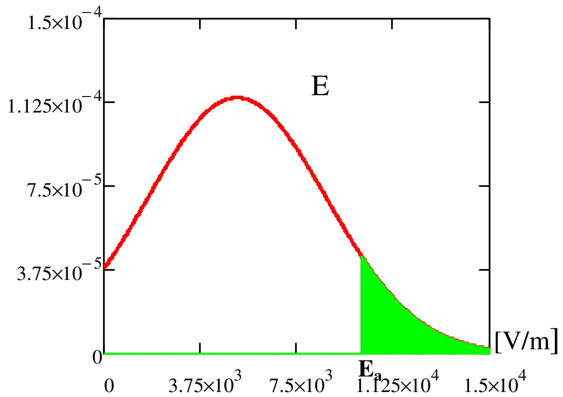

Fig. 6. Distribution of E for PS Oradea Center

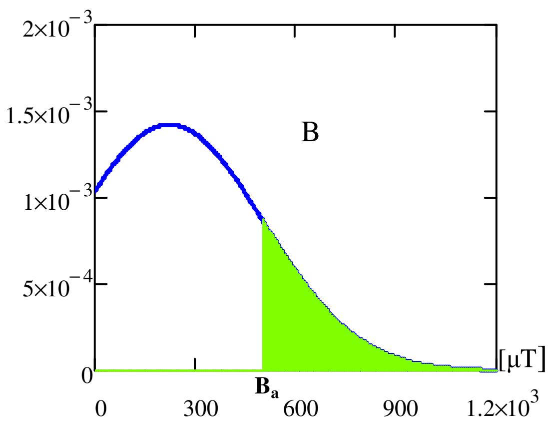

Fig. 7. Distribution of B for PS Velenţa

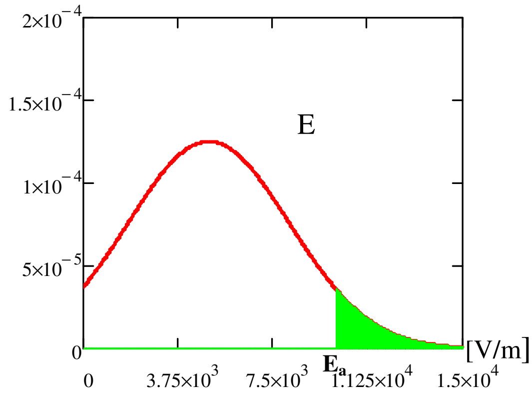

Fig. 8. Distribution of E for PS Velenţa

Table 1 summarizes the results obtained for the probability of exceeding the admissible values, with reference at the two characteristic sizes (E, B), under the conditions of the two working hypotheses.

Table 1 - Obtained values for probability of existence of EMFd into PS of Bihor PWS

Crt no.	Power station	p_{1E}	p_{1B}	p_1	p_{2E}	p_{2B}	p_2
1	Velenţa	0,0346	0,0154	0,049	0,0646	0,0258	0,089
2	Oradea Centru	0,0252	0,0169	0,042	0,0552	0,0254	0.079
3	Crişuri	0,1034	0,0225	0,124	0,1205	0,0326	0,149
4	Oradea Sud	0,2076	0,0145	0.219	0,3195	0,0284	0,339
5	Oradea Vest	0,1175	0,0265	0,141	0,1815	0,0372	0,212
6	Salonta	0,0879	0,0175	0,104	0,0939	0,0298	0,121
7	Eurobussines	0,0465	0,0154	0,061	0,0525	0,0263	0,077
8	Ioşia	0,0567	0,0264	0,082	0,0867	0,0387	0,122
9	Palota	0,0925	0,0269	0,117	0,1025	0,0472	0,154
10	Mecanica	0,0784	0,0165	0,094	0,0684	0,0255	0,092
11	Beiuş	0,0335	0,0195	0,052	0,0477	0,0349	0,081
12	Era park	0,0196	0,0126	0,032	0,0319	0,0194	0,051
13	Vaşcău	0,0353	0,0226	0,057	0,0554	0,0317	0,085
14	Vârfurile	0,0229	0,0133	0,036	0,0325	0,0214	0,053

5. CONCLUSIONS

The omnipresence of artificial EMFs implies that there is a potential risk of harm to exposed people, both in the professional and civil environments.

The identification of EMF generated by power plants is a very topical issue for the proper protection of people who may enter their area of existence. F or this purpose, it is essential to assess as accurately as possible the severity of the consequences of exposure of individuals in EMF. The sizes that characterize the EMF and their effects on random variables with imprecise levels for accurately assessing the risk of EMF exposure are appropriate probabilistic or fuzzy modeling. This paper presents the methodology proposed and applied by the authors for the modeling and probabilistic evaluation of the EMF effects generated by the power installations in stabilized operating regime using two working hypotheses, following the characteristic quantities (E, B), taken separately and in combination. It is noted that for all 14 analyzed power stations there is a risk of exceeding the admissible values in both working hypotheses and with reference to both characteristic sizes, hypothesis 2 being covert against hypothesis 1, for each characteristic size, and for their combination. For all PE, the impact of the electrical component of EMF is more pronounced than the magnetic component. The hierarchy of the 14 PSs in terms of the probability aspect of staff affecting by exposure to EMF can be done on three levels: big (4,5), medium (3,6,8,9) and small (1,2,7 , 10, 11, 12, 13, 14).

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