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ASPECTS REGARDING THE PRACTICAL EVALUATION OF THE EXPOSURE LEVEL IN ELECTRIC AND MAGNETIC FIELD FOR PUBLIC AND OCCUPATIONAL DOMAIN

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ABSTRACT: In the paper the authors present the results of experimental investigations on electromagnetic environmental assessment of public and occupational domain. In the first part of the paper were presented some theoretical considerations on risk management for specific activities of energy domain in general and electricity grids in particular, through a synthesis of information of the dedicated literature. For the occupational domanin were determined electric field strength and magnetic induction for operators in the energy sector. For the general population were determined the field sizes announced for high voltage overhead power lines and tram wagons. Is justified in the paper, the necessity to determine values for the electromagnetic field in order to assess the level of exposure of the human body and possible adverse effects generated by exposure. The authors have developed their own measure schemes just as they have done with representation and statistical analysis of data obtained from measurements.
Keywords: effects of electromagnetic field, exposure level, electric field strength, magnetic induction

1. INTRODUCTION

Exposure to electric and magnetic field are the subject of numerous studies at worldwide level. Some authors claim that there is not sufficient evidence that exposure to non-ionizing radiation to cause adverse effects on human health. These effects, according to the electric and magnetic field parameters, duration of exposure or the distance from the source are cataloged more than just "possible". They can be divided into two categories: thermal and non-thermal effects[2].

However, they mentioned in specialized literature and enough cases or situations that claimed that electromagnetic field exposure cause any health risks [1], [9], [13]. From researching of these bibliographic resources, as adverse effects of exposure to electric and magnetic field, we mention: heart problems, infertility, premature births, increase of the risk of various cancers, dizziness, insomnia, headache, anxiety, temporary loss of memory, lack of concentration, decreased immunity, etc. Even if there is many controversy among researchers, its worth unheeded the precaution measures based on exposure limit levels of the field parameters considered dangerous in national and international regulations [11][12][14].

2. RISKS RESULTING FROM EXPOSURE TO ELECTROMAGNETIC FIELDS

For employers, ensuring a safe working environment is regulated by law. Periodic measurements of electromagnetic pollution levels in the workplace is mandatory and must be taken to reduce it. Several state institutions in Romania, granted salary bonuses to employees in the working buildings where electromagnetic field exposure levels considered dangerous are exceeded. These bonuses are percentage values of 10-15% from basic salary. This cases include the Constanta, Prahova and Iasi County Councils, the city halls of the villages Braniştea from Dambovita County and Chirnogi from Călăraşi County or the municipalities of cities of Campia Turzii from Cluj County and Gura Humorului from Suceava County.

Interventions, working and checking of electric power installations require special training of personnel, selection and motivation of its work activities in relation to the risks inherent in particular that are human errors performer in terms of wrong actions and omissions. Risk factors of occupational environment can be classified as [5]: a. - risk factors of the production means: electrical risk, thermal risk, mechanical risk, etc.; b. - risk factors of work task; c - risk factors of the executor. To assess the health of exposed personnel and establish possible influences of electromagnetic fields generated within electricity networks in[5] indicated a protocol for medical examinations comprising: clinical examination, neuropsychological examination, functional investigation, laboratory tests on biological products by type of blood and urine tests performed in order to determine haematological and biochemical constants. As indicated in[2], for energy domain the risk analysis lends itself particularly to any subsystem where can appear the accidents or diseases of workers or any subsystem where there is a possibility that the occurrence of undesirable events to degrade the environment. Other risk analyzes done mainly refers to nuclear plants, power energy system as a whole as well at the relationship between vendor - consumer of electricity [2]. The most common accidents due to electromagnetic processes in electrical networks, are the electrocutions and the electric arc thermal actions [2]. Non-ionizing radiative actions of electromagnetic field can produce a particularly negative effects on long-term exposure of workers.

The Risk management in the workplace involves several steps [15],[16]. A model that pursues their succession is shown in the diagram from Figure 1.

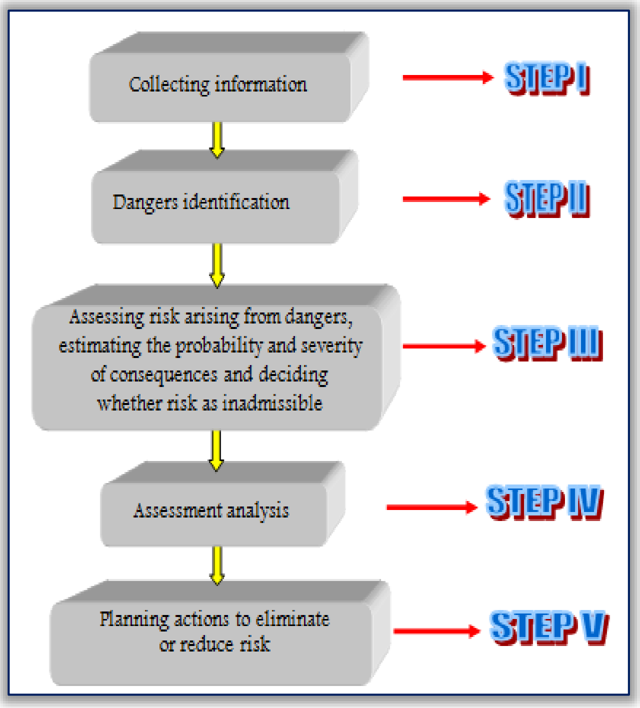

Figure 1. Stages for determining the risk in the workplaces(adapted by[15],[16])

The general population must take their own precautions measures but the knowledge of the effects of exposure and is based especially on thorough informing.

3. STUDIED CASES

To establish the electromagnetic environment within professional and public domain the authors conducted measurements in several locations. For employees were considered energy entities bz type of hydroelectric power plants (HPP), thermoelectric power plants (TPP) and evacuation or distribution power substation (PS), belonging to Bihor Power System(BPS). For the general population were considered parts of a overhead power lines (OPL) on high tension in the city of Oradea passing through densely populated areas and the trams wagons from the electric urban traction system. The electromagnetic environment is complex and consists of many sources. Selecting only a particular source of electric or magnetic field in terms of their actual spread is almost impossible. Hydropower plants analyzed are: HPP Fughiu, HPP Săcădat, HPP Tileagd, HPP Lugaşu, HPP Munteni, HPP Remeţi. Thermal plant analized is CET I belonging by S.C Electrocentrale Oradea S.A. The electrical substations(Power Substations - PS) are the evacuation substations from power plants listed and distribution substation Scandic-Sudrigiu, Bihor. Specific areas of work endorsed and specific equipment of power substations and plants on which measurements were performed are: control rooms(CC), generators hall(GH), set transformers, power transformers, high and medium voltage cells, low voltage installations in alternative current (AC)and direct current(DC).

Within the system of urban electric traction there are three types of trams for which measurements were carried inside: Siemens ULF 151, manufactured in Austria, and Tatra T4 or TK4D by Czechoslovak production.

Some images of plants advised for occupational domain is shown in the following figures (Figures 2-5). The characteristics of the analyzed sources within a four HPP are presented in the following tables (Tables 1-4). For public domain the images with objectives analyzed are presented in the following figures (Figures 6-7). The technical specifications of trams analyzed are presented in the Table 5.

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Figure 2. Set transformer from HPP Tileagd

Figure 3. Excitation of HG from HPP Munteni

Figure 4. Control room of PS Sudrigiu

Figure 5. External devices from 110 kV of PS-CET I

Table 1. Specifications of HG and trafo from HPP Fughiu and Săcădat

Hydrogenerator	Set transformer
type HVS-426/66-26 production year: 1985 Producer: UCM Reşiţa S_n = 6400 kVA I_n= 676A $U_{n=}$ 6,3 kV Connection Y U_{exc}= 180 V Efficiency η = 96,8 % Speed n = 166,67 rot/ min cos φ = 0,86	type TTU-ONAF production year:1985 Producer: Electroputere Craiova, Romania S_n = 16 MVA U_1/U_2 =123/6,3 kV Connections Y_0D-11 U_{sc}=11% I_{nS} = 1468 A I_{nP} = 75,5 A Cooling mode: O.N.A.F.

Table 2. Specifications of HG and trafo from HPP Lugaşu and Tileagd

Hydrogenerator	Set transformer
type HVS-380/90-28 production year: 1985 Producer: UCM Reşiţa S_n = 10100 kVA I_n= 927 A $U_{n=}$ 6,3 kV Connection Y U_{exc}= 180 V Efficincy η = 97,3% Speed n = 214,3 rot/ min cos φ = 0,88	type TTU-ONAF production year: 1985 Producer: Electroputere Craiova, Romania S_n=25MVA U_1/U_2 =123/6,3 kV Connections Y_0D-11 U_{sc}=11% I_{nS} = 2250 A I_{nP} = 117,5 A Cooling mode: O.N.A.F.

Table 3. Specifications of HG and trafo from HPP Munteni

Hydrogenerator	Set transformer
type HVS-340/125-12 production year: 1982 Producer: UCM Reşiţa S_n = 31400 kVA I_n= 1754A $U_{n=}$ 10,5 kV Connection Y U_{exc}= 150 V Efficiency η = 97,6 % Speed n = 500 rot/ min cos φ = 0,85	type TTU-ONAF production year: 1985 Producer: Electroputere Craiova, Romania S_n = 40 MVA U_1/U_2 =123/10,5 kV Connections Y_0D-11 U_{sc}=10,5 % I_{nS} = 2199 A I_{nP} = 184,2 A Cooling mode : O.N.A.F.

Table 4. Specifications of HG and trafo from HPP Remeţi

Hydrogenerator	Set transformer
type HVS-340/125-14 production year: 1982 Producer: UCM Reşiţa S_n = 65000 kVA I_n= 3327A $U_{n=}$ 10,5 kV Connection Y U_{exc}= 180 V Efficiency η = 98,1 % Speed n = 428 rot/ min cos φ = 0,86	type TTU-FS production year: 1982 Producer: Electroputere Craiova, Romania S_n = 63 MVA U_1/U_2 =121/10,5 kV Connections Y_0D-11 U_{sc}=10,5 % I_{nS} = 3464 A I_{nP} = 300,5 A Cooling mode : O.N.A.F.

Figure 6. Inside the tram Siemens ULF151

Figure 7. PL 110 kV Oradea South- Oradea West

Table 5. Technical specifications of trams from Oradea

Comparative characteristics trams	TATRA tractor wagon	TATRA trailer	SIEMENS ULF 151
Number of seats places	22	22	42
Number ofstanding places	80	80	153
Supply voltage on grid	600 V.c.c	-	600 V c.c.
Starting current	380 A	-	250 A
Rated current	240 A	-	528 A_{max}
Lenght	14	14	24,21
Widht	2,20 m	2,20 m	2,4 m
Gauge	1435 mm	1435 mm	1435 mm
Weight	14 000 kg	12 000 kg	30 300 kg
Facilities	-	-	a.c.
Traction engine	TE022 D	-	MAS
No.engines/wagon	4	-	6
Engine voltage supply	300 V. .c.c	-	3x397 V/54 Hz
Engine power	43 kW	-	35 kW
Normal current of engine	160 A	-	88 A
Rated speed	1700 rot/min	-	1604 rot/min
Lighting	35x40 W	35x40 W	11x40 W
Mitigation device	-	-	3x11 kW +1x4

In the city of Oradea, are located seven routes of OPL on the level of 110 kV and one route on 400 kV level. These Power Lines are operated by S.C. Electrica S.A. and S.C. Transelectrica S.A.

4. SCOPE AND METHODOLOGY

In Romania there is increased interest in evaluation of quantities of electric and magnetic field in lucrative areas, especially those belonging to the energy system such as afferent installations of power stations or high voltage overhead power lines. [3],[6],[7],[8],[10].Measure schemes, based on indications of regulations often differ from author to author, but their role is to best capture of the spatial distribution of field sizes. To that fact shall be extended the measurements duration and the establishment of representative measuring points.

The values of representative sizes of electromagnetic field practically must be assessed for comparison with normative permissible limit values indicating exposure level that is dangerous to health, and if overcome them to appropriate actions to limit human exposure.For static regime of electric and magnetic field until industrial frequency, the limit values are[10],[11],[12],[14]:for the general population B_{lim} = 100 μT and E_{lim}= 5000 V/m; for the workers in electricity gridsc B_{lim}=500 μT and E_{lim}= 10000 V/m.

For each space or category of people will be able to make a hierarchy based on the level of exposure given the measured values or the averages calculated for electromagnetic field sizes.As a basis instruments for measurement of the electromagnetic field quantities were used the electric and magnetic field detectors CA 42, isotropic type, model Chauvin Arnoux, produced in France and ME3030 B, monoaxially, production Gigahertz, Germany.As auxiliary instrumentation for quota setting, horizontal distances and gauges of PL conductors, were used 2m graded rules with markings from 50 to 50 cm built by authors from PVC and rangefinders laser BOSCH PLR 500 and ultrasonic type SupaRule 600 E, by german production.

Measure schemes are set as shown in Figures 8-11. The values obtained were noted in the sheets of measurements.

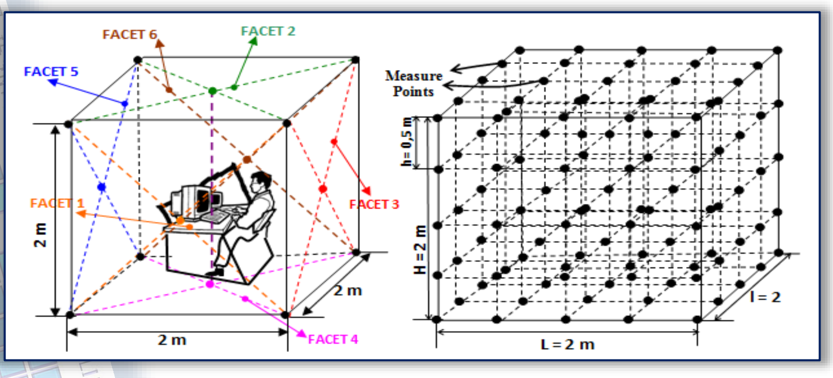


Figure 8. Measuring cubic scheme:
a – operator's location; b – measure points formed

Case of the scheme from Figure 8 is similar manner as described by the authors in [4] and refers to the exposure assessment operators in control rooms (CC) of the hydro power plant, for thermoelectric plant and distribution substation analyzed. Quotas measuring points were determined using graded rulers.Analyzing the figure 8 can be seen formation as elementary cubes with side h of 0.5 m, in number of 64 and distribution or the total number of measurement points. For power transformers of HPP measure scheme as it is shown in Figure 9. For each objective were measured the magnetic flux density in μT and electric field strength expressed in V/ m.

In the case of measurements taken along the patrols routes of the operators from HPP the odds were chosen as H_1 = 1 m and H_2 = 1,7 m. Step measure considered as measure distance between two measuring points p_i, is Δp = 2m.

For transformers were obtained by measuring four sides, location of the points to be made for the eight directions indicated by the red arrow in Figure 9. We considered three measuring distances to the transformer d_1, d_2, d_3, and for each point were considered by three odds, h_1, h_2, h_3. Measurement directions were noted with D_{1-8} and measuring points with P_{1-8}.

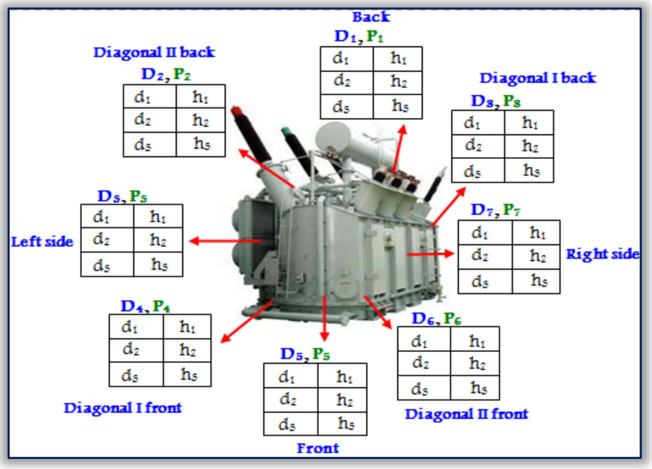


Figure 9. Measuring scheme for set and distribution power transformers

At trams measurements were performed in the interior of the wagon into the alveoli above or in the vicinity of the traction motors, on the distance between two successive stations, both when stationary and with engines started that during the start-up and movement. Measuring heights considered are 1 m and 1.7 m from the floor. Recordings were performed every 5 seconds for the same stretch of route. The number of people was different and was not recorded in the sheets of measurements. The location of the meter operator in Siemens ULF151 tram type, shown in Figure 10.

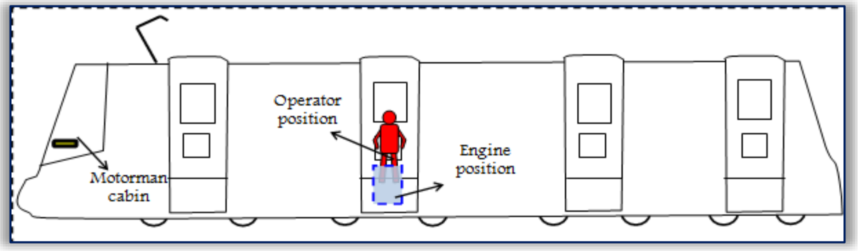


Figure 10. Measurement scheme for tram type Siemens ULF 151

For the top of the HG hall the magnetic flux density measurements B [μT], were placed around their excitation system according by a radial - circular scheme whose model is presented in Figure 11.

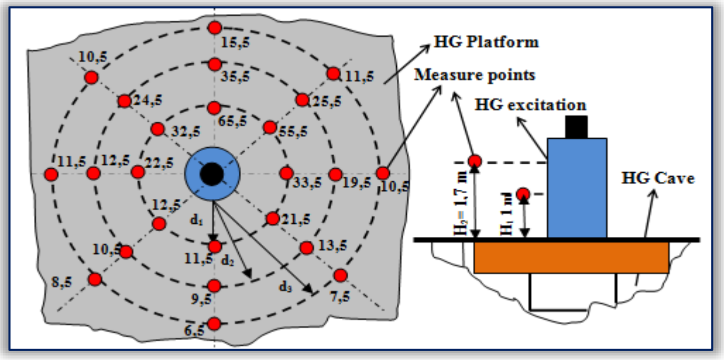


Figure 11. Measuring scheme for HG excitation system inside HPP(H_2= 1,7 m). Case of HG Munteni

The measurement points are indicated by the red color and are positioned on 8 radius around the carcass of the excitation system of hydrogenerators (HG). For each 8 radius, were established by measure three points so that for each circumference was also obtained 8 measuring points. As distances from the exciter carcass of HG, they were considered d_1 = 0.5 m, d_2 = 1 m, d_3 = 1.5 m. The values of B are indicated in the same figure (at odds H_1 = 1 m).

The measure odds chosen also in this case are H_1= 1 m and H_2= 1,7 m, above HG platform as shown in the scheme of Figure 11. Total number of measure points will result equal to 24. For inside of power plants and substations measurements were performed on route patrol of staff with tasks in their electrical installations. So, for a HPP, these professional categories are: shift operator - electrician, sfift chief – foreman electrician, plant head – power engineer. The following table shows the lengths of routes made by shift electrician and arithmetic mean values obtained from actual values measured for HPP Munteni. Patrol routes also include all voltage levels.

Table 6. Rond trails for shift electrician from HPP Munteni

Location	Duration (min)	Lenght/dimension of route/space [m]	Mean value of magnetic induction [μT]	Mean value of electric field strenght [V/m]
110 kV Substation	20	210	0,86	2250
20 kV Substation	10	23	1,24	850
Trench cables MT+LT	10	33	1,43	550
Trafo TSI 3-4 20/0,4 kV	10	61	0,82	950,5
Instl LT 0,4kV	20	346	0,22	65,5
Instl LT (bays)	20	24	0,15	20,6
Instl. D. C.	10	54	0,09	11,5
Diesel Group	10	53	0,03	10,5
Total timeof service patrol(round)	110 x 3 = 330 min			

For apertures of OPL were chosen two measure routes.The type of the OPL selected for measurements is on 110 kV voltage level, with double circuit and make connections between PS Oradea South and PS OradeaWest.The first route corresponds to the central axis of line projected on the ground between two three-phase circuits.The second route correspond to axis of single circuit of power line.The three apertures considered are distributed within the Food Market West (D_1) in the territory of the university campus, next to the sport hall (D_2) respectively in the territory of automotive market (D_3).Measure step considered this time is $\Delta p = 3$ m. The measure odds in this case is $H_1 = 1$m şi $H_2 = 1,7$ m, too.Minimum conductors gauges for the three openings are: for $D_1 \rightarrow G1_{min} = 11,2$ m, for $D_2 \rightarrow G2_{min} = 11,4$ m respective for $D_3 \rightarrow G3_{min} = 13,2$ m. Total number of apertures for this OPL between the two substation is 58.

5. RESULTS AND DISCUSSIONS

The measurement results are summarizes, spreadsheet, graphics and differentiated for each category of equipment or objectively analyzed. Following measurement procedures submitted for all investigated areas will calculate arithmetic averages of instantaneous values for the two size categories of electromagnetic field. The following are some representative examples considered by the authors.

a. For the cases of HPP, TP and PS

For a control room will present the results of measurements for the two cubic facets of the scheme shown in Figure 12.Meaning notations in Figure 12 is as follows: T_1-T_5=measuring routes for each facet; P_{1i}– P_{5i}, with i=1...5, are the measure points on facet 1 and N_{1j} – N_{5j}, with j=1...5, represent the measure points on facet 4. For CC of HPP Remeţi the measuring results in cases of two considered facets, are summarized in Tables 7 and 8.

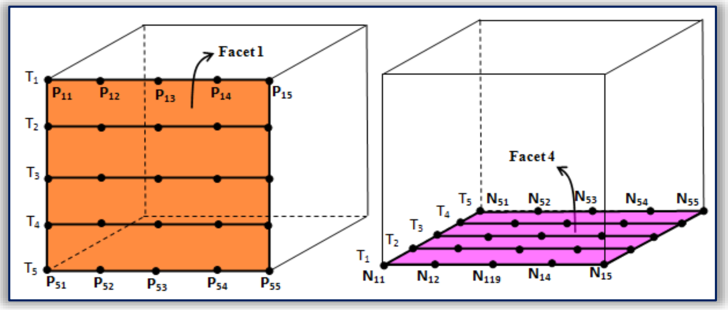


Figure 12. Points of measurement into the cubic scheme: a - on facet 1; b- on facet 4. Case of CC from HPP Remeţi

Table 7. Values of magnetic induction for measure points related facet F_1

Nr. crt	T_1 - F_1 P	T_1 - F_1 B[μT]	T_2 - F_1 P	T_2 - F_1 B[μT]	T_3 - F_1 P	T_3 - F_1 B[μT]	T_4 - F_1 P	T_4 - F_1 B[μT]	T_5 - F_1 P	T_5 - F_1 B[μT]
1	P_{11}	0,18	P_{21}	0,23	P_{31}	0,29	P_{41}	0,63	P_{51}	1,84
2	P_{12}	0,22	P_{22}	0,25	P_{32}	0,28	P_{42}	0,67	P_{52}	1,81
3	P_{13}	0,18	P_{23}	0,21	P_{33}	0,32	P_{43}	0,58	P_{53}	1,79
4	P_{14}	0,19	P_{24}	0,22	P_{34}	0,31	P_{44}	0,63	P_{54}	1,83
5	P_{15}	0,17	P_{25}	0,24	P_{35}	0,33	P_{45}	0,61	P_{55}	1,85

Table 8. Values of magnetic induction for measure points related facet F_4

Nr. crt	T_1 – F_4 N	T_1 – F_4 B[μT]	T_2 – F_4 N	T_2 – F_4 B[μT]	T_3 – F_4 N	T_3 – F_4 B[μT]	T_4 – F_4 N	T_4 – F_4 B[μT]	T_5 – F_4 N	T_5 – F_4 B[μT]
1	N_{11}	0,31	N_{21}	0,35	N_{31}	0,36	N_{41}	0,47	N_{51}	1,84
2	N_{12}	0,35	N_{22}	0,32	N_{32}	0,37	N_{42}	0,51	N_{52}	1,81
3	N_{13}	0,39	N_{23}	0,46	N_{33}	0,47	N_{43}	0,54	N_{53}	1,79
4	N_{14}	0,45	N_{24}	0,34	N_{34}	0,42	N_{44}	0,59	N_{54}	1,83
5	N_{15}	0,48	N_{25}	0,35	N_{35}	0,54	N_{45}	0,62	N_{55}	1,85

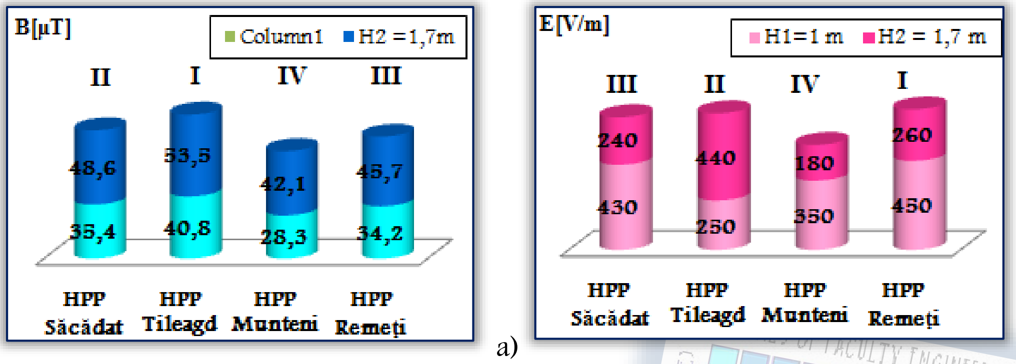
The results obtained in case of electric field intensity E measuring in the vicinity of the evacuation transformer from the HPP Tileagd, is summarized in Table 9.From the point of view of the HG and evacuation transformers technical specifications, there are two twin two each, thus the Fughiu

HPP are similar to those of the HPP Săcădat and from HPP Tileagd are similar to those of HPP Lugaşu.

Table 9. Electric field strength values E[V/m] for set trasformer(trafo) of HPP Tileagd

Measuring high [m]	Distancefrom trafo [m]	Electric field intensity [V/m]	Distance from trafo [m]	Electric field intensity [V/m]	Distance from trafo [m]	Electric field intensity [V/m]
$h_1 = 0{,}5$	$d_1 = 0{,}5$	2700	$d_2 = 1{,}0$	2200	$d_3 = 1{,}5$	890
	$d_1 = 0{,}5$	2650	$d_2 = 1{,}0$	2300	$d_3 = 1{,}5$	780
	$d_1 = 0{,}5$	2800	$d_2 = 1{,}0$	1890	$d_3 = 1{,}5$	650
	$d_1 = 0{,}5$	2800	$d_2 = 1{,}0$	1600	$d_3 = 1{,}5$	500
	$d_1 = 0{,}5$	2750	$d_2 = 1{,}0$	1900	$d_3 = 1{,}5$	600
	$d_1 = 0{,}5$	2900	$d_2 = 1{,}0$	2100	$d_3 = 1{,}5$	980
	$d_1 = 0{,}5$	2680	$d_2 = 1{,}0$	2000	$d_3 = 1{,}5$	850
	$d_1 = 0{,}5$	2700	$d_2 = 1{,}0$	1950	$d_3 = 1{,}5$	0,22
$h_2 = 1{,}0$	$d_1 = 0{,}5$	2900	$d_2 = 1{,}0$	1800	$d_3 = 1{,}5$	800
	$d_1 = 0{,}5$	3100	$d_2 = 1{,}0$	1600	$d_3 = 1{,}5$	900
	$d_1 = 0{,}5$	3250	$d_2 = 1{,}0$	1760	$d_3 = 1{,}5$	1100
	$d_1 = 0{,}5$	3200	$d_2 = 1{,}0$	1860	$d_3 = 1{,}5$	1250
	$d_1 = 0{,}5$	2980	$d_2 = 1{,}0$	1740	$d_3 = 1{,}5$	1050
	$d_1 = 0{,}5$	3400	$d_2 = 1{,}0$	1600	$d_3 = 1{,}5$	1300
	$d_1 = 0{,}5$	3500	$d_2 = 1{,}0$	1800	$d_3 = 1{,}5$	1250
	$d_1 = 0{,}5$	3200	$d_2 = 1{,}0$	1700	$d_3 = 1{,}5$	1350
$h_3 = 1{,}7$	$d_1 = 0{,}5$	4100	$d_2 = 1{,}0$	2600	$d_3 = 1{,}5$	1400
	$d_1 = 0{,}5$	4200	$d_2 = 1{,}0$	2700	$d_3 = 1{,}5$	1250
	$d_1 = 0{,}5$	3800	$d_2 = 1{,}0$	2700	$d_3 = 1{,}5$	1300
	$d_1 = 0{,}5$	3700	$d_2 = 1{,}0$	2500	$d_3 = 1{,}5$	1270
	$d_1 = 0{,}5$	3600	$d_2 = 1{,}0$	2450	$d_3 = 1{,}5$	1250
	$d_1 = 0{,}5$	3400	$d_2 = 1{,}0$	2500	$d_3 = 1{,}5$	1400
	$d_1 = 0{,}5$	3800	$d_2 = 1{,}0$	2360	$d_3 = 1{,}5$	1350
	$d_1 = 0{,}5$	4250	$d_2 = 1{,}0$	2670	$d_3 = 1{,}5$	1140

In these cases the measurements were geared only towards the plants of the same type. Distribution equipment in control rooms or even their type in retrofitting situations are different, however. Figure 13 shows a hierarchy based on the level of exposure in the vicinity of the HG and the set transformer based on average values of magnetic induction and electric field strength.



a) b)

Figure 13. The HPP Hierarchy by mean values of magnetic induction from HG hall (a) respectively by mean values of electric field strength from vicinity of power transformer(b) at $d_2 = 1$m.

b. For the case of trams

At odds on 1 m from the floor trams, the values of magnetic induction and electric field strength are shown in Tables 10 and 11.

Table 10. The values of magnetic induction B[µT], for10 measure moments inside trams

Tram type.	ST1 [µT]	M1 [µT]	M2 [µT]	M3 [µT]	M4 [µT]	M5 [µT]	M6 [µT]	M7 [µT]	M8 [µT]	ST2 [µT]
T4	0,76	0,95	1,323	1,521	1,725	1,015	1,155	1,224	1,025	0,96
KT4D	0,66	0,85	1,123	1,325	1,625	1,215	0,955	1,135	1,125	0,75
ULF	0,85	0,95	1,023	1,221	1,225	1,371	1,055	1,175	1,025	0,92

Table 11. The values of electric field strengthE[V/m], for 10 measure moments inside trams

Tram Type	ST1 [V/m]	M1 [V/m]	M2 [V/m]	M3 [V/m]	M4 [V/m]	M5 [V/m]	M6 [V/m]	M7 [V/m]	M8 [V/m]	ST2 [V/m]
T4	210	160	110	115	130	145	150	155	170	200
KT4D	180	160	100	120	110	130	150	170	175	190
ULF	240	110	160	155	165	190	185	210	220	230

The ranking of the three categories of trams by the average level of exposure from the inside to the population traveling with them, for two categories of sizes field is shown in Figure 14, a and b.

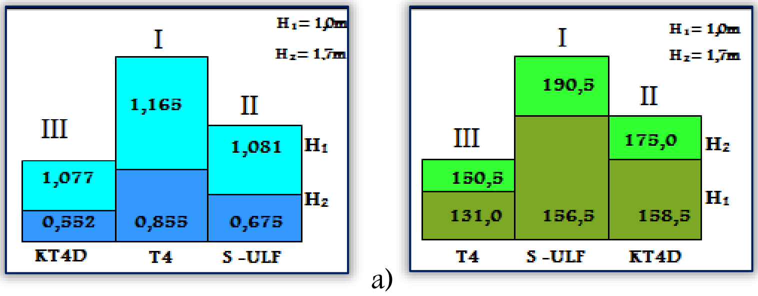


Figure 14. Trams hierarchy by mean values of field siyes: a - case of B_{med}, b – case of E_{med}

c. For the case of OPL

Some measuring points (P1 - P12) representative of the aperture inside the territory of the Oradea university campus with a ranking of the three apertures considered as mean values of sizes of the field, is shown in Figure 15, by the magnetic flux density, respectively in Figure 16 for electric field intensity equivalent to two chosen measure odds.

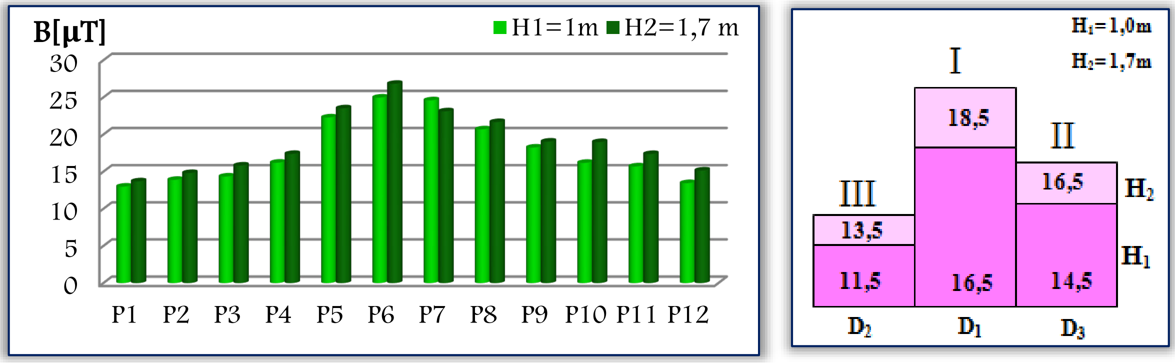


Figure 15. Magnetic induction distribution to the ground in case of aperture D_3 and apertures ranking

For Inside of tram, increasing the value of magnetic induction is more pronounced at H_1 quota, reducing to the H_2 quota. Increase the intensity of the electric field is to quota H_2 toward the contact line or by sources located on the tramc ceiling. This inversion is normal because the electric traction motors are located under operator.

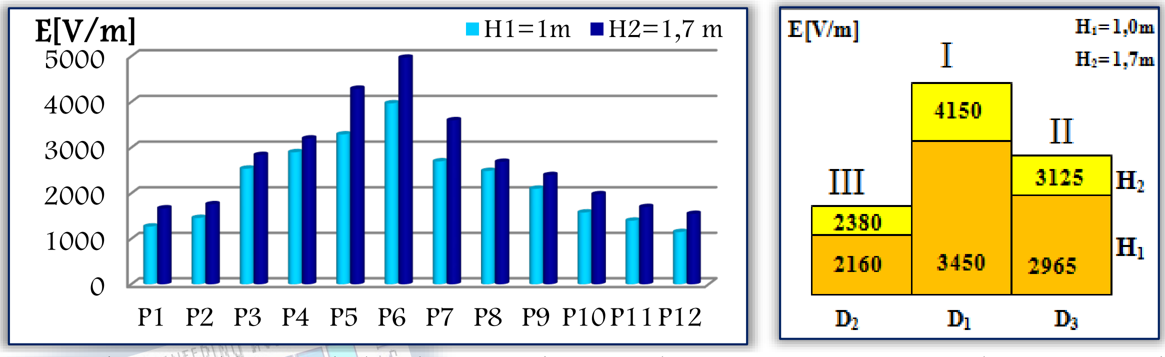


Figure 16. Electric field strength distribution to the ground in case of aperture D_3 and apertures ranking

For other types of installations, the increased of electric and magnetic field sizes is larger to quota H_2, what it signifies the sources proximity. For trams were recorded maximum values of the electric field intensity between 190 and 240 V/m and magnetic induction between 1,371 and 1,725 μT as maximum values for each type of tram. Loading trams with people is different from day to day and hour intervals during a day. These variations must be surprised by accurate identifying those intervals so as to be captured maximum values for field sizes that give exposure level.For apertures of OPL considered the maximum recorded values for magnetic flux density was 54,5μT in sector point with minimum gauge of line conductors inside WEST Market Oradea. At the same point was measured for intensity of electric field the value of 6200 V/m.Climatic conditions at the measurements moments in case of OPL was:season – summer, temperature 26°C, relative humidity – 30 %, nebulosity 0 – clear sky, time slot: 10.30-11.30 a.m., year 2016.In case of evacuation transformers from HPP, the maximum values of electric field strength have reached in range 3700 – 6500 V/m and magnetic induction was framed between 25,5and75,5 μT. The lowest values of the electric field intensity were recorded at transformers placed insulated in a space shielded with wire mesh fence and not inside the stations with high voltage cells.For excitation systems of synchronous generators in HPP maximum values ranged between 55.5 and 75.8 μT.In the case shown in Figure 11, for HG of HPP Munteni, maximum value registered of 65.5 μT at height of 1.7 m above platform indicates that the measuring point is closest to the conductors providing the generator excitation current.The cubic type of measure schemes, allow appreciation of field sizes in a large number of points around the operator and their traceability by identifying the location of sources in the control room.In other words, based on magnetic induction values can appreciate the proximity to a current-carrying conductor. In other words, based on magnetic induction values can appreciate the proximity to a current-carrying conductor. Contribute to this process and the characteristics of the measuring apparatus. Such a device with internal memory isotropic, type CA 42 allows display of maximum, minimum and average values of field sizes and also their values on the three axes of 3D measurement plan. Can be identifiedand in this case the sources location or making correlations of voltage and current values with those of the electric field intensity and magnetic induction, especially since the device holds oscilloscope function. For example, if the measurement results of Remeţi HPP control room, measuring points on two sides with maximum values of magnetic induction between 1,79 and 1,85 μT, suggests the proximity to conductors with intense currents compared with other points. This is confirmed by reality because the beds cable throughput control room are located under the floor where the operator exercising his service duties, along the route T_1 respectively T_5 of the measure facets. Also, by storing a large number of data, with extended time for the entire day, permit assessment of the operating regime or operational status of surrounding equipment that are sources of electric and magnetic field.

6. CONCLUSIONS

The essential difference between employees and the public is that the first category is subject to inevitable action of the electromagnetic field generated by the installations and equipment in the workplace and for the second category exposure is voluntary and is due to use household appliances or proximity to public sources of electromagnetic field, or while traveling in them. The High values of field sizes measured indicate that the operators are near of bus bars, high voltage terminals or power cables with intense currents. A correlation as accurate as possible between electromagnetic field quantities and generating sizes of these, as type of voltages and currents is possible only by knowing operative state of installations or charging degree with people of trams or their drive speed. For these processes are necessary the installation of additional meters and recording or storing data tracking installations as S.C.A.D.A type. It is also possible that environmental conditions contributing to modify the sizes of electric and magnetic field. Special attention should be paid to overstraining regimes of the power grids marked by the presence of overvoltage and short circuit or overload currents. These regimens that lead to amplification of electromagnetic field quantities should last as little by adjusting the optimal protection systems. Exceeding the limits normally considered dangerous implies taking measures to protect persons exposed to electromagnetic fields.

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