

Occupational Exposure to Power Frequency Fields in Some Electrical Transformation Stations in Romania

**Cristian Goiceanu
Razvan Danulescu**

Institute of Public Health, Iasi, Romania

The aim of this study is to investigate the levels of electric and magnetic power frequency fields at 8 electrical transformation stations in the North-East counties of Romania and to check their compliance with standards. Spot measurements were carried out on both electric and magnetic fields under overhead conductors of 110-, 220- and 380-kV installations. The magnetic field levels were several orders of magnitude below the reference level for occupational exposure set by ICNIRP (International Commission on Non-Ionizing Radiation) or by Romanian regulations. In contrast, the electric field levels were about the same order of magnitude as the reference levels. In 2 electrical stations the reference level of 10 kV/m was exceeded at specific locations within the outdoor installations area. However, the additional reference level for short-time exposure included in Romanian regulations, 30 kV/m, was not exceeded.

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1. INTRODUCTION

Electromagnetic fields represent physical agents that are most frequently encountered in the working environment. The extensive use of electric energy in various areas, from domestic and public facilities to industrial needs, have made power frequency fields the most widespread kind of electromagnetic radiation to which humans are exposed.

The European Union protection policy in the domain of occupational exposure to electromagnetic fields (EMF) has been stated in Directive 2004/40/EC [1]. The restrictions are based on the basic limits and reference values recommended by the International Commission on Non-Ionizing Radiation (ICNIRP) [2].

Current Romanian regulations on occupational exposure to EMF [3], adopted in 2002, are also based on the ICNIRP limits and reference levels [2], but several additional reference levels were

included. At power frequency, to allow short-time exposure to field levels higher than the 8-hr TWA (time-weighted average) value, ceiling reference levels were added for both electric and magnetic fields as recommended by the European Committee for Electrotechnical Standardization (CENELEC) [4] and the International Radiation Protection Association/International Non-Ionizing Radiation Committee (IRPA/INIRC) [5], respectively. To allow higher exposure than that for the whole body, additional reference levels indicated by IRPA/INIRC for the exposure of limbs to 50-Hz magnetic fields were also included.

EMF exposure at the workplace is strongly dependent on several factors, e.g., the domain of activity, the equipment and installations used, their working regime (duty), workplace setup, work tasks. The aim of this study is to investigate the level of power frequency fields in some workplaces where there might be high exposure levels. High

electric field levels are present in the case of power generation, transportation and distribution.

2. MATERIALS AND METHODS

The domain of the activity taken into account was the transportation of electric energy and, specifically, electrical transformation stations. In order to assess personnel exposure in some transformation stations located in the North-East counties of Romania (Moldavia region), measurement of 50-Hz fields was carried out. The measuring equipment we used consisted of an MSI-95 Gaussmeter with Magcheck-95 and E-100 single-axis probes (Magnetic Sciences, USA).

Spot measurements were carried out on both electric and magnetic fields of power frequency. The duty (load) of installations at the moment of the measurement was taken into account and measurements were carried out especially for installations working under normal conditions. A declaration of average time spent by workers in an installation area was required from shift leaders. The route of workers when inspecting the outside

installations of 110, 220 and 380 kV was also required to determine the investigation points.

All electric field measurements under outdoor installations were made at the height of 1.8 m above the ground. The level of the electric field at various points of interest was investigated, but the search for maxima was also carried out under or around important components of 110-, 220- and 380-kV installations. Most of the measurement points were situated under overhead wires and metal bars of these installations.

Magnetic field levels were also measured at the locations of electric field investigation, at the same height above the ground (1.8 m) or at the height of 1 m. Moreover, in several electrical transformation stations, measurement of magnetic field was also carried out close to transformers, searching for maxima, irrespective of the height above the ground.

3. RESULTS

Eight electrical transformation stations were included in the present study. Field levels were measured under the overhead conductors of 110,

TABLE 1. Measured Electric Field Levels in Transformation Stations

Station	Electric Field Strength E (kV/m)		
	110-kV Installation	220-kV Installation	380-kV Installation
1	1.3–4.3	2.9–6.4	—
2	1.6–6.6	1.3–7.5	—
3	1.3–4.9	2.4–11.3	—
4	0.6–4.0	1.8–7.0	—
5	1.8–7.9	1.5–11.5	4.0–26
6	2.0–3.6	2.3–6.6	—
7	0.5–5.7	2.5–7.4	—
8	2.4–4.2	4.4–8.0	—

TABLE 2. Measured Magnetic Field Levels in Transformation Stations

Station	Magnetic Flux Density B (μ T)		
	110-kV Installation	220-kV Installation	380-kV Installation
1	0.3–3.6	0.7–1.4	—
2	0.7–4.4	0.5–2.5	—
3	0.5–4.8	1.3–8.5	—
4	0.4–2.5	0.4–1.6	—
5	0.9–8.4	2.7–10.5	1.8–5.8
6	0.7–7.2	2.4–8.8	—
7	0.2–0.5	0.7–2.6	—
8	1.0–4.8	2.4–5.9	—

220- and, when present, 380-kV installations. The range of the measured values of the electric and magnetic field levels, within each electrical transformation station, is given in Tables 1 and 2, respectively.

We tried to determine whether the field levels exceeded or not the reference levels of the ICNIRP guidelines [2]. In the case of exceeding the ICNIRP reference levels, we checked if the additional reference levels for short-time exposure—included in Romanian regulations—in terms of ceiling values, were also exceeded.

For two of the inspected stations (No. 3 and No. 5), the electric field in several measurement points exceeded the ICNIRP reference level of 10 kV/m. However, the additional ceiling reference level of 30 kV/m allowed by Romanian legislation for short-time exposure was not exceeded.

In the case of station No. 3, the electric field level exceeded the reference level of 10 kV/m only for

one measurement point, the second highest level being close to the reference level: 9.5 kV/m. Due to the measurement uncertainty, i.e., about 10% for the electric field, it is difficult to conclude if the reference level was exceeded for this second point or not.

Within the area of station No. 5, several measured field levels exceeded the level of 10 kV/m at the 220- and 380-kV installations as shown in Figures 1 and 2. These values represent maxima at each specific location. At the 220-kV installation, the reference level was exceeded for three measurement points and at a fourth location the electric field level reached the value of 10 kV/m. In the case of the 380-kV installation, electric field strength exceeded 10 kV/m at 7 of the investigated locations, but the highest values were recorded off workers' route when inspecting outside installations (at locations where we expected high field values).

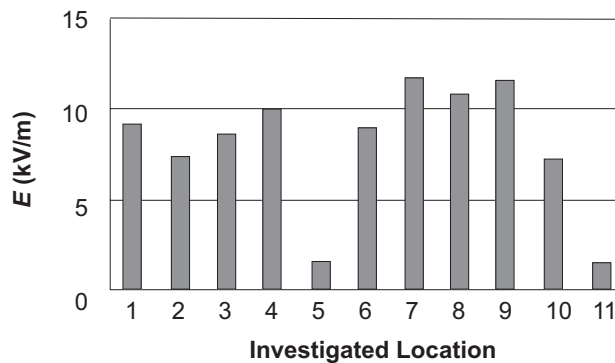


Figure 1. Measured electric field levels under overhead conductors of a 220-kV installation at station No. 5. Notes. E —electric field strength.

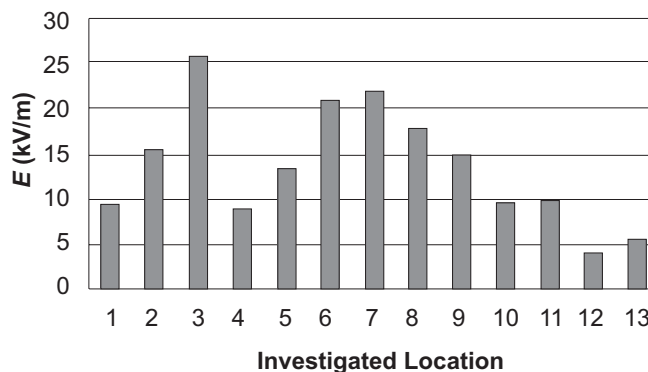


Figure 2. Measured electric field levels under overhead conductors of a 380-kV installation at station No. 5. Notes. E —electric field strength.

As expected, magnetic field levels under outdoor installations are several orders of magnitude below the reference level set by ICNIRP (500 μT). The maximum levels of magnetic fields close to transformers, even higher than under overhead conductors, are also below the ICNIRP reference level [2], by about one order of magnitude. The highest level of a magnetic field around transformers was recorded at station No. 5 and it was about 34 μT .

Measured electric fields inside buildings within the perimeter of transformation stations are well below the values presented in Tables 1 and 2 and, consequently, below the ICNIRP reference levels.

4. DISCUSSION

The spot measurements of field levels in electrical stations are not exhaustive and were carried out only at specific locations, but the maximum field level was searched at places where high values of field level were expected. Consequently, the values presented in Tables 1 and 2, and in Figures 1 and 2 should not be regarded as a distribution of field values, but only as an indication of the maximum levels at the main points of interest. However, the results of electric and magnetic field measurement make it possible to check compliance with Romanian regulations [3] or with ICNIRP reference levels [2].

Magnetic field levels within inspected electric transformation stations are below Romanian reference levels for whole-day exposure [3], which is the same as the ICNIRP single reference level for power frequency magnetic field, i.e., 500 μT . Consequently, according to current national regulations and to ICNIRP guidelines [2], too, occupational exposure to magnetic fields in the investigated electrical transformation stations is very low.

In the case of exposure to electric fields, the situation is very different. When people work inside building(s) within station perimeter, exposure to an electric field is low. But when workers inspect outdoor installations or have to work outside (e.g., repairing), the electric field in some points reaches levels higher than the ICNIRP

reference level for power frequency fields, which is the same as the Romanian reference level for whole-day exposure, i.e., 10 kV/m. Compliance with Romanian regulations is still achieved for field levels of 10–30 kV/m if time of exposure is lower than the ratio $80/E$, where the electric field strength E is in kilovolts per metre. As the additional ceiling level of 30 kV/m is not exceeded and the declared period of time spent in those specific points is short, being lower than the ratio $80/E$, all measured levels of the electric field comply with Romanian regulations [3].

According to ICNIRP guidelines [2], higher electric field levels are allowed, up to twice the reference level for power-frequency electric fields, provided that “adverse indirect effects from contact with electrically charged conductors can be excluded” (p. 510) [2]. When indirect effects are excluded, ICNIRP guidelines allow field levels up to 20 kV/m. However, the measured field level exceeded the level of 20 kV/m for several points. For these points, there seems to be no compliance with the EU Directive [1].

A question arises as to whether in practice additional reference levels for short-time exposure to power frequency electric fields are really necessary.

Electric field levels in electrical stations are quite constant in time, excepting the moments of temporary disconnection of some elements or a slight variation related to season and weather conditions. Electric field levels are mainly produced by the voltage used by installations and the exact design of installations.

Only for two of the eight investigated electrical stations, the reference level for whole-working day exposure to electric fields was exceeded. At first sight, it seems that installations could be modified to reduce the electric field levels. On the other hand, to redesign and rebuild installations in order to reduce field levels is expensive. In contrast, including in regulations additional ceiling levels to protect against short-time exposure to power-frequency electric fields is a non-cost solution.

The reference level of 30 kV/m and the associated exposure time limitation to periods shorter than $80/E$ were meant to limit the discomfort of personnel when perceiving sensations like hair

vibration or tingling between body and clothes [6, 7]. As there are no known significant health consequences of exposure to electric fields of 30 kV/m, allowing short-time occupational exposure to fields up to this level seems to be reasonable.

5. CONCLUSIONS

Magnetic field levels in the inspected electric transformation stations were much below the reference levels for occupational exposure set by ICNIRP [2] and by Romanian regulations [3]. In contrast, electric field levels, even though generally lower, were relatively close to the ICNIRP single reference level for a power frequency electric field. Moreover, in two electrical stations this reference level was exceeded at specific locations within the outdoor installations area. However, the additional reference level for short-time exposure included in Romanian regulations was not exceeded. Electrical transformation stations represent specific cases where additional ceiling levels for short-time exposure are very useful to limit personnel exposure without imposing more severe restrictions that would imply the high cost of reducing field levels.

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