Examples of Variation in Measured ELF Electric Fields under 400 kV Power Lines

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Abstract— The paper presents how the measured extremely low frequency (ELF) electric fields (EFs) fluctuate in the same measurement place when the humidity varies. EF measurements were performed at three places near 400 kV power lines. In Place A (nine measurements), the EFs varied from 6.8 to 12.5 kV/m when relative humidity was from 70.5% to 86%. In Place B (five measurements), the EFs were 5.1–8.2 kV/m when relative humidity ranged from 67% to 76%, and in Place C (two measurements), the EFs were 0.90–0.92 kV/m when humidity was 68–76%. The measured EFs varied significantly.

1. INTRODUCTION

The physiological effects and public exposures of electromagnetic fields have been studied at Tampere University of Technology (TUT). Parts of the earlier projects have also measured the electric fields in the same place under 400 kV power lines [4, 5].

Humidity is not expected to significantly influence the electric field (EF). However, laboratory tests have demonstrated that it can influence EF measurement systems when humidity is sufficient to cause condensation on the sensor and on the supporting structure (tripod) [1]. It has been found during these laboratory tests that EFs measured in high humidity conditions are always higher than the correct values. According to the previous considerations, accurate EF measurements cannot be performed under rainy conditions [1].

The aim of the work was to investigate how the measured ELF electric fields fluctuate in the same measurement place when humidity varied. When we compare the measured values to the recommendations (e.g., guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [3] or Directive 2013/35/EU [2]), it is important to know how humidity influences the measured results.

2. MATERIALS AND METHODS

During three days, the EF measurements were performed at three places near 400 kV power lines in Finland. Figures 1–3 show the measurement places.

Figure 1: Measurement Place A, near 400 kV power line.

Figure 2: Measurement Place B, near 400 kV power line.

Figure 3: Measurement Place C, near 400 kV power line.

Table 1: Electric field measurement results at different places.

Date and time	Meter	Measurement place	Electric field strength	Relative humidity (Measurement time)
12.08 08:39	EFA-300	A	12.5 kV/m	86.0% (08:42)
12.08 08:58	EFA-3	A	10.5 kV/m and 10.9 kV/m	79.0% (09:00)
12.08 20:20	EFA-300	A	7.5 kV/m	70.5% (20:21)
12.08 20:24	EFA-3	A	6.8 kV/m and 7.2 kV/m	70.5% (20:21)
27.08 13:05	EFA-300	B	5.05 kV/m	67.0% (12:59)
27.08 13:13	EFA-300	C	0.92 kV/m	68.0% (13:20)
28.08 10:32	EFA-300	C	0.9 kV/m	76.0% (10:31)
28.08 11:01	EFA-300	B	7.3 kV/m and 7.8 kV/m	76.0% (11:04)
28.08 11:05	EFA-300	A	10.2 kV/m	76.0% (11:04)
28.08 11:09	EFA-3	A	10.8 kV/m and 11.0 kV/m	76.0% (11:04)
28.08 11:12	EFA-3	B	8.0 kV/m and 8.2 kV/m	76.0% (11:04)

Details of the measurement places have been published earlier [3, 4]. The EF strength was measured with two 3-axis commercial electric meters: EFA-3 meter (accuracy ±5%, RMS) and EFA-300 meter (accuracy ±3%, RMS).

In Place A, nine electric field measurements were performed, in Place B, five measurements, and in Place C, two measurements.

3. RESULTS AND DISCUSSION

Table 1 shows the EF measurement results at Places A, B, and C.

In Place A, the EFs varied from 6.8 to 12.5 kV/m when relative humidity was from 70.5% to 86%. In Place B, the EFs were 5.1–8.2 kV/m when relative humidity ranged from 67% to 76%, and in Place C, the EFs ranged from 0.90–0.92 kV/m when humidity was 68–76%.

In Place A, the EFs varied from 6.8 to 12.5 kV/m when relative humidity was from 70.5% to 86%. In Place B, the EFs were 5.1–8.2 kV/m when relative humidity ranged from 67% to 76%, and in Place C, the EFs were 0.90–0.92 kV/m when humidity spanned 68–76%. The measured EFs varied significantly. For example, in Place A, the lowest EF (6.8 kV/m, relative humidity 70.5%) was only 54% of the maximum value (12.5 kV/m, relative humidity 86.0%). In the example, the difference in relative humidity was 15.5%. In Finland the voltage is always same on 400 kV power lines. Therefore, the changes of the voltage cannot explain our results.

4. CONCLUSION

The measurement material is quite limited; however, it is possible to find examples where the measured EFs were quite different when the humidity also varied. In the future, humidity is important to take account in EF measurements.

REFERENCES

1. CIGRE (International Council on Large Electric Systems), "Technical guide for measurement of low frequency electric and magnetic fields near overhead power lines," Working Group C4.203, CIGRE, Paris, France, 2009.
2. European Parliament and Council of the European Union, "Directive 2013/35/EU of the European Parliament and of the council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)," *Official Journal of the European Union,* 21, 20th Individual Directive within the Meaning of Article 16(1) of Directive 89/391/EEC) and Repealing Directive 2004/40/EC, 2013.
3. ICNIRP, "Guidelines for limiting exposure to time varying electric and magnetic fields (1 Hz–100 kHz), *Health Phys.*, Vol. 99, 818–836, 2010.
4. Korpinen, L., H. Kuisti, J. Elovaara, and V. Virtanen, "Cardiac pacemakers in electric and magnetic fields of 400-kV power lines," *Pacing Clin. Electrophysiol.*, Vol. 135, 422–430, 2012.
5. Korpinen, L., H. Kuisti, J. Elovaara, and V. Virtanen, "Implantable cardioverter defibrillators in electric and magnetic fields of 400 kV power lines," *Pacing Clin. Electrophysiol.*, Vol. 37, 297–303, 2014.