Considerations on the Electromagnetic Pollution Produced by High Voltage Power Plants

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Abstract: - The paper presents a monitoring system for power quality and environment power facilities impact assessment. The high voltage installations' electromagnetic pollution is considered primarily within the analysis. The experimental results relate to substations within the Romanian Power Grid Company Transelectrica, Sibiu Subsidiary. The measurements have been performed for electric and magnetic field. The components of monitoring system and its advantages are also presented in the paper.

Key-Words: - electric field; environment; electromagnetic pollution; high voltage techniques; magnetic field; pollution measurement; power stations

1 Introduction

Electricity is one of the greatest discoveries of mankind. It is now used in almost all areas of activity: agriculture, industry, medicine, scientific research etc. In electricity, there are, among others, highly topical issues such as:

- sustainable use of energy resources;
- quality of electricity supplied;
- efficient use of electricity generated;
- reducing the environmental impact of energy facilities.

Evaluation of environmental impact of energy facilities involve quantification, monitoring and mitigating the effects of electrical installations on the environment, health and human safety and property of any kind.

Environmental influences relate to the presence and operation of the power transmission and distribution facilities: aesthetic pollution, noise pollution due to corona phenomena, electro-magnetic pollution due to low frequency electromagnetic field (induced effects and biological), field due to electromagnetic pollution high frequency (disturbance radio and TV), psychological pollution, environmental pollution (land occupation, ozone production, etc.).

Few of these issues have quantifiable character by measurement and computing methods. Others, such as visual impact, psychological or biological, cannot be assessed accurately enough.

For more than 30 years there are concerns both on the determination of the high voltage facilities' electric field and magnetic field intensity by measurement and computing. Also the consequences they of the electromagnetic fields on health and safety of persons is studied. Biological effects can be grouped into two categories:

- short-term effects that are incontrovertible. Worldwide there is a consensus regarding this issue, which is reflected by setting acceptable limits on public exposure;
- long-term effects (cancer, reproduction), but which are subject to controversy. Among the most important (but not single), international authorities dealing with regulations on the allowable limits for electric and magnetic fields are:
  - International Commission on Non-Ionizing Radiation Protection – ICNIRP;
  - European Committee for Electrotechnical standar-dization – CENELEC;
  - European Commission Directorate General V.

The first two authorities make the difference between the population and workers within the high voltage installations, while the third one refers only to the workers. All these authorities have made proposals for rules on acceptable limits of electric and magnetic field intensity, for different frequencies. But we cannot speak of a consensus on international level.

This paper presents a permanent power quality monitoring system. Also the impact of 110 kV, 220 kV and 400 kV power facilities on the environment can be studied.

2. Monitoring System of the Harmful High Voltage Power Facilities Electromagnetic Field Effects

Electromagnetic field secondary effects that request special protective measures to be taken are: radio emissions and receptions' disturbances and TV broadcasts, audible noise, public and facilities' safety to electrostatic and electromagnetic induced voltages.

The permanent power quality monitoring system and high voltage installations' electric and magnetic field consist of multiple devices and software presented synthetically in Table 1.

Table 1. Equipment Used for Measurements

No.	Equipment	Made by	Type
1	Electric field measurement equipment	ICEMENERG	Gradientmetru
2	Magnetic field measurement equipment	Conrad Electronic	Tesla Monitor
3	Portable computer	Fujitsu Siemens	Procesor Pentium 4
4	Power quality analyzer	Power Measurement Canada	7650 ION™
5	PSTN modem	US Robotics	Courier 56K Bussines
6	Data server	Hewlet Packard	Procesor Pentium 4
7	Software license	Power Measurement Canada	ION Enterprise 5.5

Electric field is determined by measuring the potential gradient (electric field intensity) in kV / m, using the ICEMENERG gradient meter. It is part of the floating potential measuring type apparatus, the detector being included within the measuring probe. The measuring probe is a plane parallel dipole and is therefore made as a parallel plate probes isolated from them according to the IEC Standard 833 – "Measurement of the industrial frequency electric fields". The ICEMENERG gradient meter, according to the IEC 61786/1998 Standard is part of the single axe sensor measuring instruments, for measuring the human body electric fields exposure.

Magnetic field is determined by measuring the maximum induction B in mT, for the points established using Tesla device monitor. The measuring device is part of the magnetic field measurement using a coil probe calibrated in a uniform magnetic field created by a solenoid with a suitable size to ensure the uniformity of the field. Measuring device complies with IEC 61786/1998 – "Measurement of electric and magnetic fields regarding the human exposure. Special requirements for measuring devices and rules".

The power quality analyzer is 7650^{TM} type, considering the current regulations and standards [1]-[9].

The PSTN modem is "U.S. Robotics Courier 56 K Business type for dial-up telephone line switchable. Selected communication speed is 19200 baud / s. This type of modem keeps its settings in case of accidental interruption of the supply voltage.

The data server is an HP personal computer Intel P4, 3 GHz. Due to large volume of data recorded for processing into various statistical forms, capacity is 1024MB RAM, 120GB SATA HDD. Auxiliary power is provided by UPS. Data Server has an LCD monitor 19", a multi color print A4. Fujitsu Siemens notebook communication with the server system is achieved by connecting the external modem described above, to the analogue telephone circuit.

Microsoft Windows NT operating system is used. On request, the data transmitted by the portable computer are automatically saved in a dedicated database. The system allows the external archiving of transmitted data by the DVD RW and also their security.

The entire database saved on the server can be accessed on demand to generate the own primary data processing programs, data listing, graphical plots, reports.

The implementation of the system requires the measurement of magnetic and electric field within the substations. It is followed by the transmission and storage of the measurements reports at the central point.

3. Experimental Results

Experimental results from each measuring point will present:

- normal operating scheme for the substation;
- reports that measure the electric and magnetic field, containing the following information: test location test, test name, test date, technical requirements, test results in tabular form;
- checking of measured values within the admissible limits.

Measurements have been performed in seven substations (see Fig. 1) belonging to the Romanian Power Grid Company Transelectrica, Sibiu Subsidiary:

- Alba 220/110/20 kV;

- Brasov 400/110 kV;
- Darste 400/110 kV;
- Fântânele 220/110/20 kV;
- Gheorgheni 220/110/20 kV;
- Ungheni 220/110/20 kV;
- Iernut 400/220/110 kV.

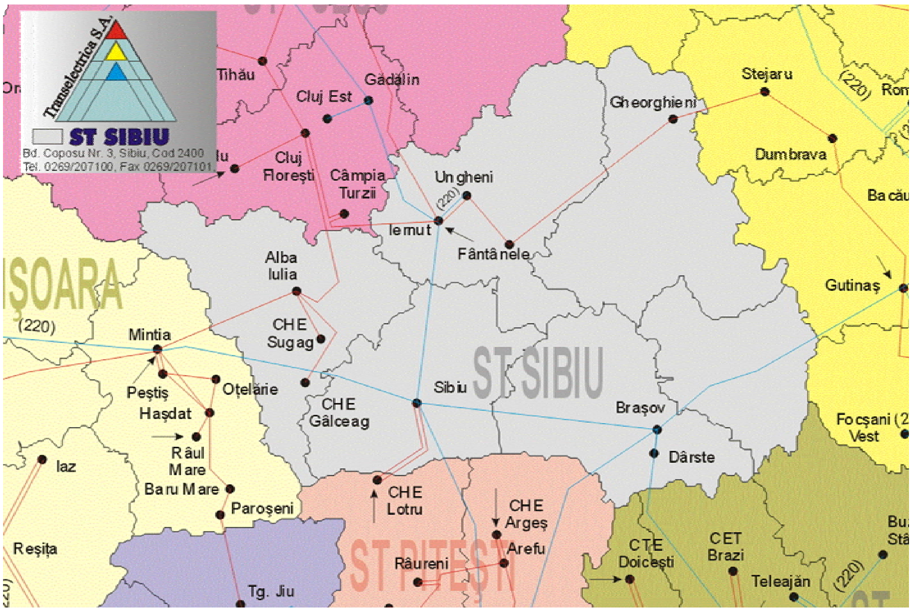

Figure 1. Substations within C.N.T.E.E. Transelectrica S.A., Sibiu SubsidiaryIn the following only the measurements performed at Darste 400/110 kV and Iernut 400/220/110 kV substation are presented.

The results of the magnetic field measurements, for the case of the 400/220/110 kV Iernut substation, are given in Table 2. All values measured induction B are much lower than the maximum allowable B = 0.5 MT and therefore are not necessary measures to protect personnel action against the magnetic field.

TABLE 2. MAGNETIC INDUCTION B (MT). MEASUREMENTS PERFORMED WITHIN 400/220/110 KV IERNUT SUBSTATION

No.	Measuring point	Magnetic field B [mT]		
		R	S	T
1.	Blocking inductance BI cell 5	0.018	0.020	–
2.	MOP-10 Mechanism cell 5	0.015	0.017	0.013
3.	DRV cell 5	0.013	–	0.011
4.	Voltage transformer cell 5	0.016	0.019	–
5.	Circuit-breaker IO cell 3	0.025	0.030	0.030
6.	Blocking inductance BI cell 3	0.028	–	0.022
7.	Circuit-breaker IO cell 2	0.015	0.018	0.013
8.	Circuit-breaker IO cell 1	0.019	0.014	0.014
9.	Relays cell 2	0.02		
10.	Relays cell 1	0.02		
11.	Voltage transformer cell 1	0.016	0.018	0.014
12.	Current transformer cell 1	0.012	0.014	0.011
13.	DRV cell 1	0.016	0.019	–
14.	At the autotransformer vat	0.3	0.3	0.45
15.	Command room	0.002		

Results of electric field measurements on the 400/220/110 kV Iernut substation are given in Table 3. They conducted measurements in the 92 points and 66 points were found values of the intensity of the electric field from 10 kV / m. In these areas with E> 10 kV / m necessary measures to protect staff in accordance with international and domestic rules.

Table 3. Electric Field Intensity E (kV / m). Measurements Performed within 400/220/110 kV IERNUT Substation

No.	Measuring point	Electric field E [kV/m]		
		R	S	T
Cell 5 Gadalin				
1.	IO-MOP Mechanism	18	16	16
2.	SL Line separator	10	7	9
3.	IO Bracker	12	10	12
4.	BB Blocking inductance	9	11	–
5.	VT Voltage transformer	13	9	11

No.	Measuring point	Electric field E [kV/m]		
		R	S	T
6.	DRV discharger	13	9	11
7.	BS 1 Bars separators 1	13	10	13
8.	BS 2 Bars separators 2	11	8	9
9.	B1 Under bars 1	16	16	16
10.	B2 Under bars 2	11	9	11
11.	VT-B1 Voltage transformer	12	10	12
12.	VT-B2 Voltage transformer	9	7	9
T: 35p-21p>10kV/m				
Cell 1				
13.	VT Voltage transformer	13	12	16
14.	CT Current transformer	16	13	15
15.	Under bars B	12	10	12
16.	DRv Discharge	13	13	16
17.	BS Bars separator	12	10	13
18.	IO-MOP Bracker Mechanism	16	14	16
T: 18p-16p>10kV/m				

The results of magnetic field measurements at 400/110 kV Darste substation are given in Table 4. All induction B measured values are much lower than the allowable maximum B = 0.5 mT and therefore necessary measures to protect staff against the magnetic field action are not necessary.

Table 4. Magnetic Induction B (mT). Measurements Performed within 400/110 kV Darste Substation

No.	Measurement point	Magnetic induction B [mT]		
		R	S	T
1.	Voltage transformer	0.055	0.038	0.045
2.	TCCb Current transformer	0.014	0.019	0.017
3.	Current transformer Brasov OHL	0.012	0.014	0.019
4.	Current transformer Brazi OHL	0.013	0.016	0.020
5.	Protecting relays cabin 1	0.02		
6.	Protecting relays cabin 2	0.03		
7.	Protecting relays cabin 3	0.035		
8.	Control room	0.03		

The electric field measurement results for 400/110 kV Darste substation are given in Table 5.

Table 5. Electric Field Intensity E (kV / m). Measurements Performed within 400/110 kV Darste Substation

No.	Measurement point	Magnetic field intensity E [kV/m]		
		R	S	T
Cell Brasov OHL				
1.	SB 1 Isolator	10 V/m	8 kV/m	11 kV/m
2.	SB 2 Isolator	7 V/m	7 kV/m	7 kV/m
3.	IO-MOP mechanism	12,5 kV/m	11 kV/m	16 kV/m
4.	IO circuit-breaker	11 kV/m	11 kV/m	12,5 kV/m
5.	SL Line Isolator	9 kV/m	8 kV/m	10 kV/m
6.	ST_f Isolator	18 kV/m	13,5 kV/m	18 kV/m
7.	TC Current transformer	11 kV/m	8 kV/m	9 kV/m
8.	TT Voltage transformer	11 kV/m	9 kV/m	11 kV/m
9.	DRV surge arrester	11 kV/m	9 kV/m	11 kV/m
T: 27p-15p>10 kV/m				

Measurements were performed in 92 points; for 66 of them electric field strength values have been recorded above 10 kV / m. In those areas with E > 10 kV / m are necessary protecting measures in accordance with international and national staff.

4. Conclusion

The monitoring system presented allows:

- Measurement of electric field intensity for specific job activity operating and maintenance personnel for overhead lines (OHL) and 110 kV, 220 kV and 400 kV electric substations;
- Magnetic induction measurement for specific job activity operating and maintenance personnel for overhead lines (OHL) and 110 kV, 220 kV and 400 kV substations;
- Electric, respectively magnetic, field distribution numerical analysis determination, for the 110 kV, 220 kV and 400 kV OHL case, starting from a limited number of points;
- Electric and magnetic field induced and biologic effects evaluation and risk factor assessment of working and maintenance staff professional disease within the 110 kV, 220 kV and 400 kV substations;
- Establishment of concrete protecting measures to protect the operating personnel from 110 kV, 220 kV and 400 kV install-lations against the electric and magnetic fields, based on the literature study.

Based on the experimental determinations performed within the 7 substations, magnetic induction values within the admissible limits have been obtained. Regarding the electric field intensity values, in case of 400/220/110 kV Iernut substation and 400/110 kV Darste substation there have been recorded values greater that 10kV/m. For these areas (E>10 kV/m) personnel safety protection measures have been taken: screens for reducing the electric field and working time interval mitigation for within the critic areas.

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