OCCUPATIONAL EXPOSURE TO POWER FREQUENCY ELECTRIC AND MAGNETIC FIELDS: RESULTS OF A SURVEY

M.Grandolfo[1], S.Onori[1], P.Vecchia[1], S.Battisti[2], and A.Serio[2]
1 - Physics Laboratory, Istituto Superiore di Sanità, Rome
2 - Medical Service, Ferrovie dello Stato, Rome

INTRODUCTION

The transmission of electrical power by high voltage a.c. overhead lines is well established and some of the associated problems such as noise, interference with radio and television transmission and the danger of flashover are well controlled. Reports[1] of the occurrence of subjective complaints such as increased headache, lassitude,nausea and loss of libido amongst Russian substations workers were published in 1966 and these were followed by other reports[2,3] from the USSR between 1967 and 1972. It was suggested that these symptoms were due to occupational exposure to high electric field strengths in substations.

In spite of the reassuring conclusions of numerous studies, the suspicion remains in some quarters that currents or charges induced by high electric fields, even though they are imperceptible, can be damaging to the health of exposed persons[4]. Four major epidemiological studies of occupationally exposed persons have been undertaken in the past seven years[5-8]; it should be noted however that in some studies the medical examinations did not coincide with the period of exposure, the control groups were not always closely matched and the field strength and exposure, expressed as kilovolt per meter hours, were estimated and not measured.

The aim of this paper is to report the preliminary results of measurements of power frequency electric and magnetic field strengths obtained in a survey of the power substations of the "Ferrovie dello Stato" (the Italian Railways, FS) in order to assess exposure levels and times of service of personnel during the working day. The present survey can be seen in the frame of a more general investigation[9] based on the coupling of environmental and medical data in order to verify the existence of possible relationships between the exposure conditions and the health state of people working in the substations.

TEST SITE AND INSTRUMENTATION

The measurement site was located in the outskirts of Rome, about 12 km northeast of center city. Measurements were made under the operating 220 kV, 50 Hz three-phase line entering the substation and in the area of the substation itself. The area was flat and nearly free from vegetative or geographic anomalies. On the days the measurements were taken, the weather was fair with temperature ranging between 20 and 25 °C.

For the measurements presented here two types of commercially available instruments have been used, the TE 307 model manufactured by Aeritalia, which has probes sensitive to the electric field in the frequency range 20 Hz-100 Hz, and the Hewlett-Packard 428 B model analog voltmeter equipped with a 3529 A model magnetometer probe able to measure magnetic flux density strengths up to 1 mT (10 G) in the frequency range 0-80 Hz with an accuracy of ± 3%. The Aeritalia sensor is an active isotropic and balanced antenna with full scale sensitivity selectable up to 10 kV/m with a calibration accuracy at calibration frequency of ± 0.5 dB and frequency sensitivity and isotropic response of ± 1 dB. The measurement procedure was the following.A 30 m profile line, perpendicular to the center phase of the transmission line, was established using a non-metallic 50 m tape measure. The observer-meteraxis was perpendicular to the transmission line, with

the observer's back toward the line. Tests were made positioning the instruments at 0.7 and 1.5 m above ground level and at least 3 m from the observer in the case of the electric field measurements.

EXPERIMENTAL RESULTS

Figure 1 illustrates the electric field strength profiles obtained at 0.7 and 1.5 m above ground level. Measurements of electric field strength were made with available instrumentation with a reproducibility of ± 10%.

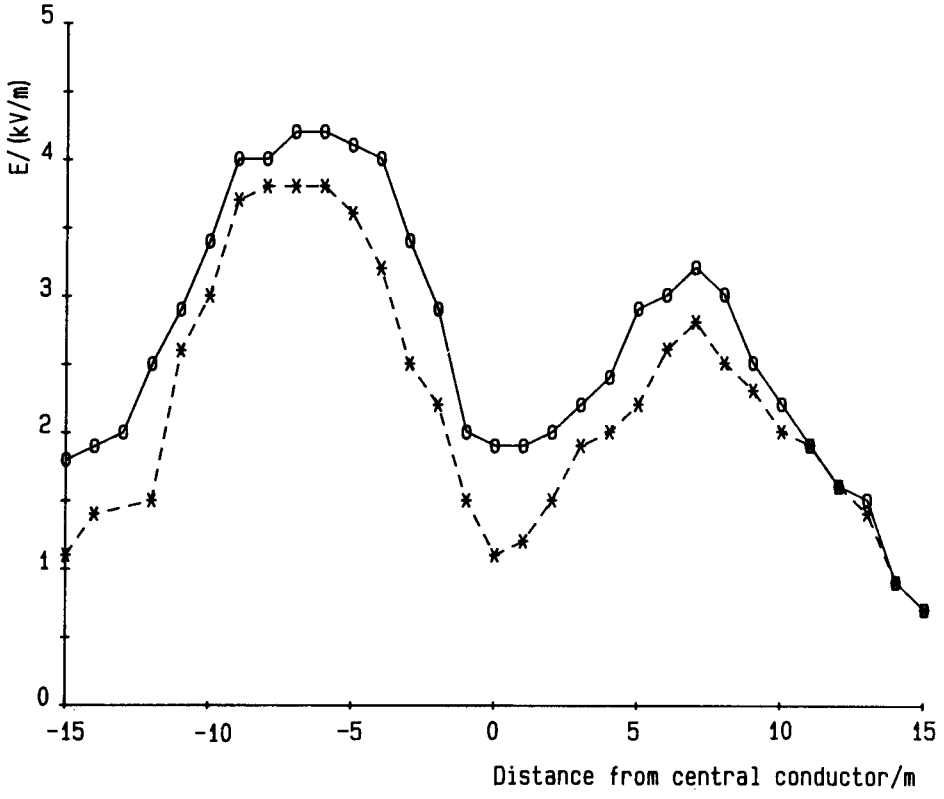

Fig. 1. Electric field measured under a 220 kV transmission line at 0.7 m (--*--) and 1.5 m (-0-) above ground level. Line height at the measurement point about 6 m.

Figure 2 shows a plot of each of the peak magnitudes of the three spatial magnetic flux density vectors. The different phase relations between the currents in the phase wires cause the magnetic field vectors to rotate in space to give rise to the three spatial components. Table 1 shows the typical electric field and magnetic flux density strengths measured at 1.5 m above ground level near different construction parts in a 220 kV substation.

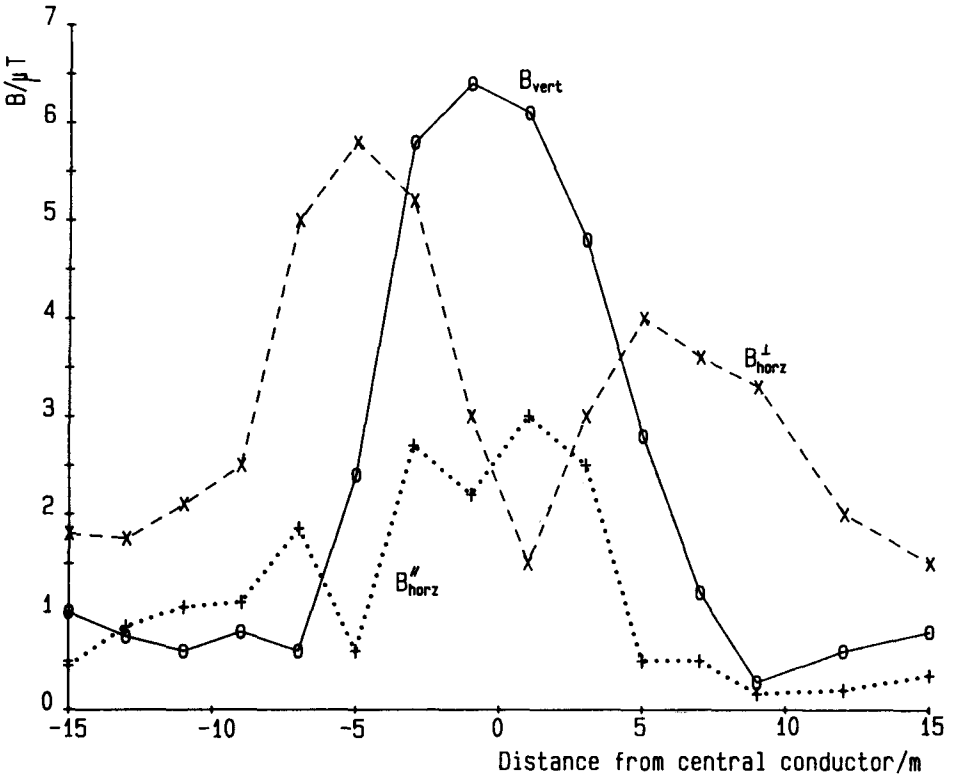

Fig. 2. Profile of three magnetic flux density components under a 220 kV line. Line height at the measurement point about 6 m.

Table 1 - Typical electric field and magnetic flux density strengths in a 220 kV substation measured at 1.5 m above ground level

Construction part	E/(kV/m)	B/μT
Disconnector busbars	1.2 - 4.6	4 - 12.5
Circuit breakers	3 - 4.6	7 - 10.8
220 - 132 kV transformers	1 - 4.2	6 - 15

CONCLUSIONS

Electric field and magnetic flux density strengths have been measured in areas in which access was limited to employees or was normally forbidden for everybody, except in emergency situations. In these areas maximum field strengths ranged between 1 and 5 kV/m for the electric field and between 4 and 15 μT for the magnetic flux density. Workers can be categorized as attending personnel and are exposed

for an average of 3 hours per working day.

On the basis of available experience and these preliminary results it can be concluded that electric and magnetic fields caused by electric power FS substations do not seem to constitute a danger to human health. Due to the chronic,long-term exposure, however, an epidemiological investigation to obtain a final assessment of possible hazards is now under way[9].

REFERENCES

1) T.P.Asanova, and A.I.Rakov, The state of health of persons working in the electric field of outdoor 400 and 500 kV switchyards, Gig.Trud.Prof.Zabol. 10:50 (1966).
2) T.E.Sazonova, Physiological assessment of the work conditions in 400-500 kV open switchyards, Scient.Publ. of Institute of Labor Protection 46:34 (1967).
3) V.P.Korobkova, Yu.A.Morozov, M.S.Stolarov, and Yu.A.Yakub, Influence of the electric field in 500 and 750 kV switchyards on maintenance staff and means for its protection, in "Conference Internationale des Grands Reseaux Electriques à Haute Tension (CIGRE)", Paris (1972).
4) World Health Organization Environmental Criteria Document, "Extremely low frequency (ELF) electric and magnetic fields (up to 300 Hz) with particular reference to power frequencies (50/60 Hz)", WHO Publisher, Geneva (Draft April 1983).
5) E.Malboysson, Medical control of men working within electromagnetic fields, Rev.Gen.Elec. 7:75 (1976).
6) P.F.Roberge, "Study on the state of health of electrical maintenance workers on Hydro-Quebec's 735 kV power transmission systems", Hydro-Quebec (1976).
7) G.J.Stopps, W.Janischewsky, "Epidemiological study of workers maintaining HV equipment and transmission lines in Ontario", Canadian Electrical Association Research Report (1979).
8) B.Knave, F.Gamberale, S.Bergstrom, E.Birke, A.Iregren, B.Kolmodin-Hedman, and A.Wennberg, Long-term exposure to electric fields. A cross-sectional epidemiologic investigation of occupationally exposed workers in high-voltage substations, Scand.J. work environ. and health 5:115 (1979).
9) A.Checcucci, An epidemiological investigation of HV substations workers: study design and preliminary results, in: "Biological Effects and Dosimetry of Static and ELF electromagnetic fields", M.Grandolfo, S.M.Michaelson, and A.Rindi,eds., Plenum Press, New York-London (in press).