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EXPOSURE TO ELECTROMAGNETIC FIELDS IN OPERATORS OF BROADCAST RADIO STATIONS EMITTING AT 737 kHz TO 1602 kHz

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Abstract. In Poland, 28 AM radio stations operate at frequencies from 738 kHz to 1602 kHz with output powers ranging from 1 kW to 750 kW. Altogether 384 workers are employed at those radio stations. Levels of exposure to electromagnetic fields (EMF) were identified at 5 of those radio stations, separately for 3 groups of workers, i.e. operation, maintenance, and administration. Electric and magnetic field intensities: E (in V/m) and H (in A/m), and the effective time of individual worker's exposure to EMF were assessed. The assessments were carried out independently by the conventional (MEH-1 plus stop-watch) and computer-aided (Holaday Programmable Recorder) methods.

The study provided reliable data on the actual time of worker's exposure to EMF of exactly determined intensities.

The study indicated a wide range of different exposure levels between individual groups of workers, which depended rather on a particular AM broadcast station and the type of job performed by individual groups of workers' than on the transmitter power or the type of protective zones in the vicinity of transmitters.

INTRODUCTION

In Poland, 28 AM radio stations operate at frequencies from 738 kHz to 1602 kHz with output powers ranging from 1 kW to 750 kW. These stations employ 384 workers (351 men and 43 women) (1).

According to the health regulations currently in force the procedure used to assess exposure to electromagnetic fields (EMF) is limited to comparing the measurements of intensity of electric (E) and magnetic (H) fields with the limit values adopted for individual protective zones (2, 6).

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Radio transmitters, feeders (which conduct radio signals from the transmitter to the antenna), signal adding units and transmitting antennas (of the mast radiator type) are the main sources of EMF in AM stations.

Many operations performed in the broadcast radio stations are associated with exposure to high-strength electric fields. These operations include works on antenna masts and antenna system towers, and also maintenance and testing of the broadcasting units.

In the USA, Tell performed measurements at a FM radio station tower (operated at 40 kW output power) and found that the values exceeded 800 V/m at many measured sites (3).

During similar measurements in Sweden Mild found that at the height of radio antenna systems operated at 18 kW, the highest values were 400 V/m, while at the height of TV antenna systems operated at 6 kW, the corresponding values were within 10 V/m.

During the transmitter maintenance, at the site of power amplifier lamp, Mild obtained the equivalent power density value of the order of 100 W/m^2 (4).

The analysis of measurements performed during the years 1975–1985 by the State Radio Inspection at radio stations operated within the 0.1–100 MHz range showed that in the vicinity of 43% of transmitters, EMF intensity exceeded 70 V/m, and in 31% of the analysed instances the value of 70 V/m prevailed at distances greater than 1 m from transmitters. It was presumed that 70% of the engineering staff was probably exposed to EMF values in excess of 70 V/m. For 20% of the auxiliary personnel, the working conditions were classified as nonadmissible according to the national legal regulations (5).

The analysis of the protective zones indicated that, due to small widths of the zones (0.2–0.4 m) compared with the dimensions of the human body (0.2 m – thorax depth. 0.5 m arm width, 0.16 m head width), a worker may remain within several zones at one time (1).

Therefore, the procedure employed heretofore is univocal and more suitable for evaluation of EMF sources from the viewpoint of their effect on human health than evaluation of exposure of workers to EMF.

The objective of this study was to assess exposure to EMF among workers performing routine jobs associated with AM radio station operation.

MATERIALS AND METHODS

Five AM stations (denoted A, B, C, D, and E), employing 115 workers, were selected for detailed investigations. Based on our earlier studies, 3 groups of workers were identified, according to the type of the radio station operating jobs (1). The group of workers under study included 55 persons classified as operation and supervision workers – Group I, (they constitute approximately 30% of people of that group employed in all Polish AM stations), 8 classified as maintenance workers – Group II (25%); and 52 classified as administration and auxiliary workers – Group III (36%).

Electric (E) and magnetic (H) field intensities and the effective times of exposure to EMF were assessed.

During the measurements, operating conditions of EMF sources were taken into account, i.e. normal conditions of transmitter operation (visual control of transmitter parameters, register of transmitter operating parameters, correction of parameters); routine maintenance, repairs and simulated emergency situations were also considered. The measurements were performed with the aid of two independent (conventional and computer-aided) measurement techniques, using MEH-1 measuring set, completed with a stop-watch, provided by the Technical University of Wroclaw (Poland), and HOLADAY 3002 measuring set (made in USA), completed with a computerized recorder for recording durations of exposures to EMF at specified EMF levels. The specification of employed measuring sets are given in Table 1.

Table 1. Specifications of the employed measuring set

Type of Meter	Range of Frequency	Range of Field Strenghts		Measurement error
		E-field	H-field	
MEH-1a				
– probe AE-1, directional	100 kHz – 300 MHz	2–1000 V/m		+/–30%
– probe AM, directional	100 kHz – 10 MHz		0.5–250 A/m	+/–30%
HOLADAY HI 3002				
– probe STE 1247 HR, isotropic	0.5 MHz – 6 GHz	10^2–10^7 V^2/m^2		+/–30%
– probe LFH 72–22, – isotropic	0.5 MHz – 10 MHz		0.005–1000 A^2/m^2	+/–30%

RESULTS

Conventional method

The analysis of E field strength at workplaces in Group I indicated the presence of the highest values in station B, both at stationary (Control Room – 110 V/m) and non-stationary (transmitter parameters readout – 550 V/m) workplaces. These values indicated intermediate and hazardous zones. The fields corresponding to those zones could also be found at station A, however, the values of the field intensities were several times smaller. Detailed data for individual stations are given in Table 2.

The analysis of exposure time in Group I at stationary (ranging from 5 h to 12 h) and non-stationary (ranging from 0.2 h to 0.45 h) workplaces together with the analysis of E field intensities in the individual stations enabled us to conclude that neither Maximum Admissible Intensities (MAI) nor exposure time were exceeded in any of the investigated stations. It was revealed that at stations C and E exposure was negligible, at station D – admissible and at stations A and B – admissible under certain conditions.

The Polish Health and Safety Regulations require that for the 100 kHz – 10 MHz frequency range, assessment of exposure to magnetic (H) fields be also performed. H-field strength values at non-stationary workplaces in Group I ranged from 0.03 A/m (station C) to 1.6 A/m (station A). According to the Polish Health and Safety Regulations, those fields belong to the safe zone, i.e. the exposure is negligible.

Table 2. Results of conventional and computer aided-tests of workers' exposure to EMF in AM broadcast station

Test Station (f [MHz])	Transmitter output power	Maximum Values of E field Strength [V/m] Assessed by using MEH – 1a METER					Exposure dose (Vh/m) Assessed by using HOLADAY 3002 SET		
		Transmitter room	Control room	Manager room	Office room	Radio station premises	Operation and Supervision Workers (group I)	Administration Workers (group III)	Radio Station Manager
A (1.482)	20 kW	176	26.40	26.40	26.40	3–198	98	232	177
B 1.503)	300 kW	550	110.00	13.00	11.00	20–1000	161	–	–
C (738)	300 kW	3.10	1.50	11.00	14.00	6–1000	0.31	156a	–
D (1 305)	30 kW	55	9.90	24.40	<2.00	8–1000	1.00	32	96
E (1 305)	30 kW	12	<2.00	<2.00	<2.00	7–50	0	0	0

a – for the guard

The analysis of EMF measurements in Group II showed that in this group risk of exposure to EMF was highest due to the character of jobs, which required a longer stay in areas of extreme EMF intensity values, particulary in cases of emergency. The highest E-field intensity values (> 1000 V/m) in an emergency case occurred at station B during the lamp neutralization. The neutralization took about 300 seconds. E-field intensities associated with running and routine transmitter maintenance ranged from 6 V/m to 66 V/m. With defective earthing of the serviced transmitter, workers may be exposed to several times higher E-field strength being not aware of that: that was demonstrated by the measurement results at station A, where the highest E-field strength values of 253 V/m occurred as a result of a defective service ground. The detailed results of the measurements are presented in Table 3.

Table 3. Results of the measurements of electric fields strength in AM broadcast station during radio transmitter maintenance

Exposure of Maintenance Workers (Group II) Assessed by using MEH – 1a METER		
Radio Station (P [kW])	Maximum Values of E Field Strength (V/m) Inside Radio Transmitter	
	Transmitter Circuit Earthed	Transmitter Circuit Unearthed
A* (20)	66.0	253.0
D (30)	6.0	66.0
E (30)	33.0	20.0

* – 83 V/m was measured in front of the transmitter (with door of the transmitter unit closed)

Relatively high E-field strengths were also found to occur at workplaces of Group III. For example, in the room of the station manager, the highest E-field strength values of 26.4 V/m and 24.4 V/m were found to occur at stations A and D, respectively. In the remaining office rooms, E-field strengths ranged from non--measurable (stations D and E) to 26.4 V/m (station A). In Group III, it was sufficient to limit the assessment of the EMF exposure to E field only, as the workers were exposed solely to EMFs emitted by antennas of the mast radiator type. This type of antennas are known to be mainly electric sources with negligible magnetic component. The analysis of the results showed that in Group III workers were exposed to intermediate and safezone E-fields. Accordingly, the exposure of workers at stations E and C was negligible except the guard, for whose exposure was admissible under certain conditions; at stations B and D – admissible; and at station A – admissible under certain conditions.

Computer-aided measurement method – an attempt at individual dosimetry

Individual dosimetry is one of the methods used to assess exposure to EMF fields. The Holaday HI 3002 Meter which, in addition to field intensity probe, is

provided with a computerized field intensity, duration recorder and a printer, offers the possibility of assessing exposures to EMF under conditions similar to those used in dosimetry. The results of the dosimetric measurements are given in Table 2.

The analysis of results showed that, in emergency situations, workers in Group II could be subjected to dangerous exposure (MAI values). Excessive exposure (exceeded admissible time of work in the hazardous zone) could also occur in that group during routine maintenance of the transmitter (e.g. service of transmitter with improper earthing). It was found that the actual measured duration of exposure to EMF for Group I was by one order of magnitude lower than reported. In Group I the measured dose received when reading the transmitter parameters (non-stationary workplace) was usually greater than the dose received at stationary workplaces. At station B, the situation was reverse. The dose at the stationary workplace (Control Room) was by one order of magnitude higher than that at the nonstationary workplace (Transmitter Room). The comparison of doses received by workers in Group I and Group III revealed, in general, greater exposure than in Group I. At station D, however, the dose received by workers in Group III during the whole working shift, was higher than in Group I even by two orders of magnitude. The situation was similar at station C, where greater doses were found to occur for the guards than for the workers performing jobs associated directly with the radio station operation.

DISCUSSION

The study revealed that AM station workers were exposed to EMF of widely differing magnitudes which depended neither on power of the radio station nor on the rating of protective zones in the vicinity of transmitters. At station C, where the power of one transmitter was 150 kW, the exposure was negligible, while at station A it was admissible under certain conditions although transmitter power was 7 times lower. On the contrary, at stations C and E, where the radio station power was the same (150 kW), the exposure to EMF was admissible under certain conditions in the first one and negligible in the other. Therefore, a global assessment of exposure to EMF in the group including all workers was not feasible, and must be carried out individually for each station.

The regulations on the assessment of exposure to EMF are different in individual countries and depend on the adopted concept of biological effects of EMF. The concept, in turn, determines the adopted measurement method. The present state of our knowledge does not make it possible to establish which of the concepts is most feasible. Therefore, the use of various methods for assessment seems to be a reasonable approach. Each of the currently available methods for exposure assessment has its own advantages and disadvantages. Therefore, individual dosimetry based on the integration of the product of field intensity and duration should not be overestimed, as it may fail to discriminate between short-term exposure to high-intensity EMF and long-term exposure to low-intensity EMF. It is known that the biological effects and damages are related rather to dose rate than to simple total dose. For example, exposure to a 2000 W/m^2 EMF for 10 minutes (thermal effects) is not equivalent to exposure to a 10 W/m^2 EMF for 2000 minutes (non-thermal effects). The problem can be solved, to some extent, by separate recording of

exposure to extremely high-level EMF and long-term exposure to low-level EMF. The possibilities for such separate recording of the exposure are offered by the Holaday HI 3002 Meter provided with a computerized recorder and a printer. The results of measurements performed with the aid of the set are presented in this work and serve to supplement the data on the actual exposure of workers employed at the AM station.

CONCLUSION

1. The exposure of workers to EMF at AM broadcast radio stations depends on radio station operating conditions (for example source screening) and the type of job performed by individual worker groups rather than on maximum transmitter output power.

2. The measurements indicated the highest exposure to EMF in Group II.

3. Routine tests were performed rather in view of the assessment of EMF sources than in view of evaluation of workers' exposure. The assessment should be performed, therefore, in all AM broadcast radio stations. The revision will identify workplaces at which special EMF conditions prevail, and enable to take suitable preventive measures.

4. It was found that currently used measurements should be updated, and individual dosimetry should be included in the assessment. It is particularly important to apply dosimetry in broadcast radio stations for operation and supervision (Group I) because of the mobile character of workers' jobs, and for antenna servicemen performing their jobs at the time when other antenna systems operate.

REFERENCES

1. Aniołczyk H. The analysis of exposure of the population to electromagnetic fields with special reference to the composite electromagnetic fields produced by radiocommunication stations. Expert's Report The Nofer Institute of Occupational Medicine, Lodz 1990 (in Polish).
2. Mild KH. Occupational exposure to radio-frequency electromagnetic fields. Proc IEEE 68 (1): 12–17, 1980.
3. Mild KH. Radiofrequency electromagnetic fields in Swedish radio stations and tall FM/TV towers. Bioelectromagnetics 2: 61–69, 1981.
4. Ordinance of the Ministry of Labour, Wages and Social Security and the Ministry of Health and Social Welfare of 19 January, 1977 on Work safety and hygiene when operating units emitting 1 MHz to 3000 MHz electromagnetic fields. Dz.U. 8, 1977 (in Polish).
5. Aniołczyk H, Koperski A. Assessment of the feasibility of implementing national MAI values for 0.1–10 MHz electromagnetic fields according to Draft Standard COMECON-01-873, 08, 84. Med Pr 5: 392–400, 1987 (in Polish).
6. Polish Standard PN-77/T-06582. Methods of assessing field intensities at workplaces (in Polish).

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