10th IMEKO TC10 Conference on
Technical Diagnostics
Budapest, HUNGARY, 2005, June 09-10

THE EXPERIMENTAL METHOD OF REDUCING MAGNETIC FIELD INTENSITY IN INDUSTRIAL BUILDINGS

Beata Palczynska[1)], Ludwik Spiralski[1)], Stanislaw Galla[2)]

[1)]Gdynia Maritime University, Faculty of Marine Electrical Engineering, Gdynia, Poland
[2)]Technical University of Gdansk, Department of Metrology and Measurement Systems, Gdansk, Poland

Abstract – The paper presents the experimental method of reducing the level of disturbances intensity in the buildings of an operating industrial plant. The necessity to examine the electromagnetic field resulted, among others, from the observed susceptibility of the workers of one department of the plant to various discomforts and diseases. Due to the measurements, sources of strong magnetic field within low frequencies have been located. On the basis of the analysis of the measurement results some conclusions and recommendations have been formulated. They concern the ways of reducing the level of magnetic intensity in some selected places.

Keyword: magnetic field

1. INTRODUCTION

Each effective analysis of the problem of disturbances requires the following: identifying a source (sources) of disturbances, indicating an object (sensors, elements, sets, subsets, systems) susceptible to disturbances, giving and acquiring the mechanisms of disturbances transmission (the way to couple a source of disturbances with an object susceptible to this disturbances). Bearing in mind the above, it is possible to distinguish three basic methods of behaviour while reducing the influence of disturbances. It is possible to suppress it in the place of its origin, to design and to make sets (instrumentation) of higher noise immunity; and finally, to make it difficult for disturbances to be transmitted through coupling canals [1, 2].

When the problem of disturbances occurs in the enviroment of an operating industrial plant, the possibility to make use of various methods and solutions reducing disturbances intensity is considerably limited.

In order to lower magnetic field intensity in laboratories in the main industrial building, the following procedure has been suggested:

- locating the main sources of disturbances on the basis of the carried out measurements of the electromagnetic field in some selected places of the building,
- formulating some conclusions and recommendations, which aim at reducing their intensity on the basis of the analysis of the obtained results,
- confirming the effectiveness of the applied methods of minimising the disturbances level with the use of repeated measurements.

2. EXPERIMENTS

The examinations of the electromagnetic field were undertaken because the personnel of the Development Department of the plant complained of discomforts they suffered and because greater susceptibility to various diseases was observed. Simultaneously, laboratories of the industrial building of this department were adapted to the installation of the measurement-control instrumentation. These rooms are situated on the ground floor of the building – under electric hardening furnaces. In the place near the hardening furnaces there are complex wiring systems of great power emitting the intensive electromagnetic field. The purpose of the examinations was to make measurements of the electromagnetic fields within low frequencies occurring in some selected places.

The measurements were carried out during the production shift with the use of ESM-100 H/E fieldmeter of Maschek [3]. This isotropic meter of the electromagnetic field enables measurements of both the electric field component and the magnetic component within the range from 5 [Hz] to 400 [kHz] in four successive measurement subranges: from 5 [Hz] to 400 [kHz] (-3dB limit), at frequency 50 [Hz] (for 12 [dB] of the band-pass filter), in the band from 5 [Hz] to 2 [kHz] and from 2 [kHz] to 400 [kHz]. In each measurement subrange the meter enables the measurements of the field intensity in the range: from 1 [nT] to 20 [mT] for the magnetic field and from 0,1 [V/m] to 100 [kV/m] for the electric field. H (magnetic) and E (electric) fields displayed simultaneously in 3 dimensional values:

$$H = \sqrt{H_x^2 + H_y^2 + H_z^2}\ . \tag{1}$$

$$E = \sqrt{E_x^2 + E_y^2 + E_z^2}\ . \tag{2}$$

All measurements were carried out on the height 0,8 ±0.1 [m] from the surface floor.

3. CONCLUSIONS AND RECOMMENDATIONS

During the measurements great dynamics of changes in magnetic intensity was observed and it depended both on the place and the time of the measurements. These changes occurred especially in the areas, where the magnetic field of very high intensity (directly above the hardening furnaces) appeared (Fig. 1).

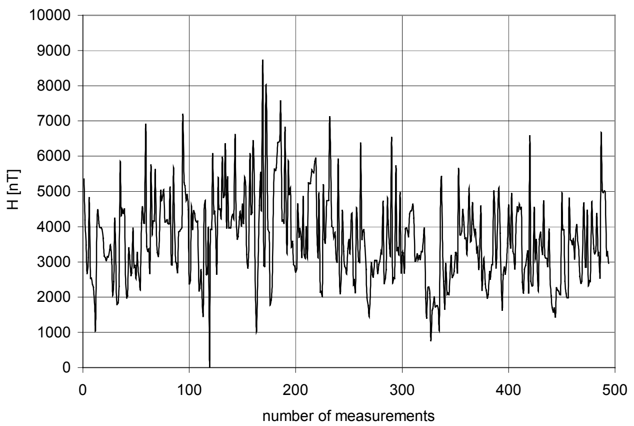

Fig. 1. The graph of magnetic field intensity changes in time in room no 4, for the measurements registered every 0.5 [s] and the number of 493-sample registration

From the carried out measurements of the magnetic field it results that the measured values of magnetic intensity assume very high values and change in time; their spectrum depends strongly on frequency (Fig. 2). The greatest magnetic field intensity occurs in the rooms situated below the high power supply production facilities – hardening furnaces (room no 3, 4 and 5) (Fig.3, Fig. 4). The magnetic field spectrum spreads out mainly in low frequency range below 2 kHz (Table 1, 2, 3).

It results from the observations made that the original sources of excessive electromagnetic intensity appearing in the examined rooms are transient states (impulse overvoltage and currents – surges), in the electric wiring of the hardening furnaces (Fig. 5).

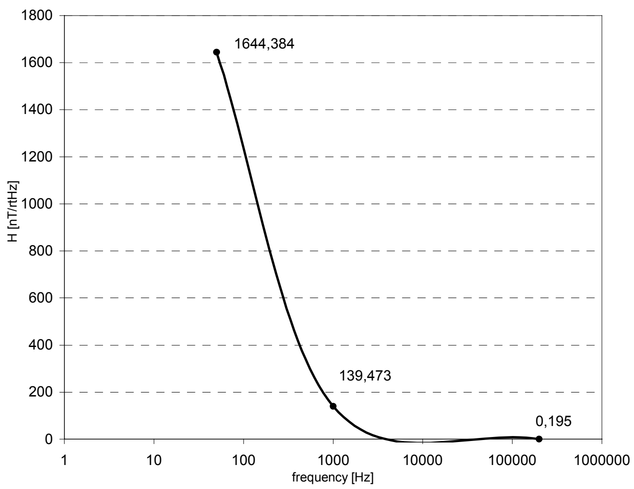

Fig. 2. Magnetic field spectrum – an assessment on the basis of maximal values of magnetic field intensities for the results obtained in all measurement bands

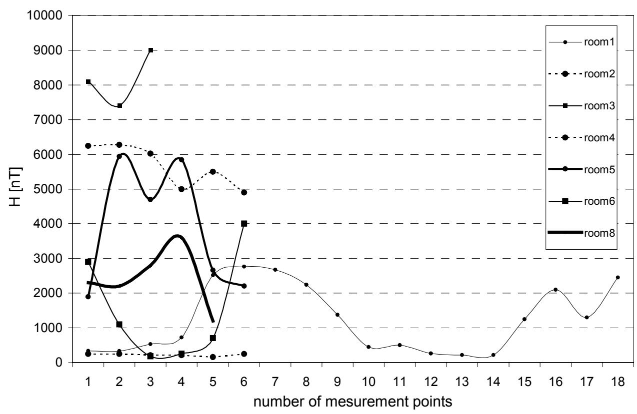

Fig. 3. Magnetic field intensity in the band from 5 Hz to 400 kHz in the selected rooms

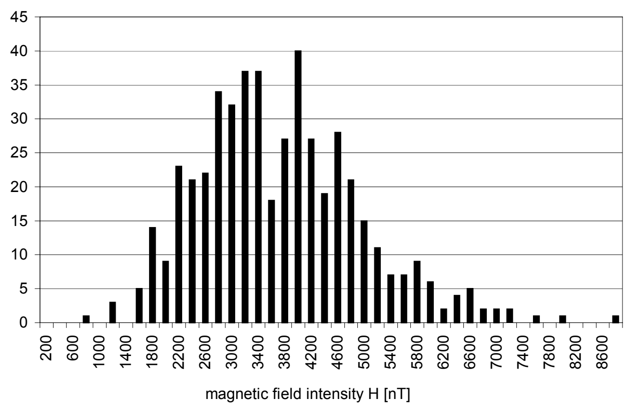

Fig. 4. The histogram of magnetic field intensity changes in time in room no 4, for the measurements registered every 0.5 [s] and the number of 493-sample registration

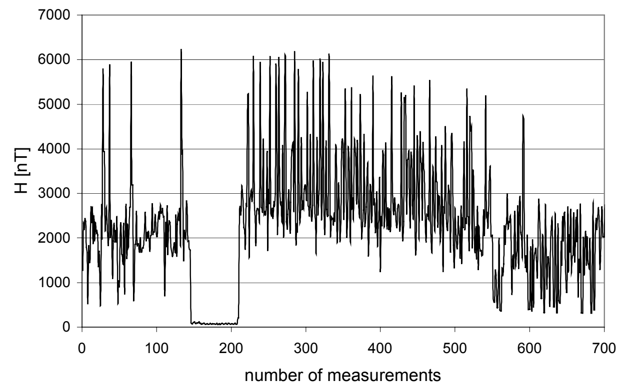

Fig. 5. The graph showing the changes in magnetic field intensity in time together with the registered change of the field to the value of the background (production break)

TABLE 1. The measurements results of magnetic field intensity for four measurement subranges of the meter in room no 3 in different measurements points

No of point	H[nT]			
	Measurement ranges			
	50Hz	5 Hz – 400kHz	5 Hz – 2kHz	2kHz – 400kHz
1	5200	8100	8000	123
2	7200	7400	7860	130
3	6800	9000	5190	147

TABLE 2. The measurements results of magnetic field intensity for four measurement subranges of the meter in room no 4 in different measurements points

No of point	H[nT]			
	Measurement ranges			
	50Hz	5 Hz – 400kHz	5 Hz – 2kHz	2kHz – 400kHz
1	5590	6240	4120	192
2	583	6270	7880	110
3	6280	6020	5100	112
4	6000	5000	4800	120
5	5600	5500	4700	85
6	5000	4900	5300	90

TABLE 3. The measurements results of magnetic field intensity for four measurement subranges of the meter in room no 5 in different measurements points

No of point	H[nT]			
	Measurement ranges			
	50Hz	5 Hz – 400kHz	5 Hz – 2kHz	2kHz – 400kHz
1	2400	1900	2400	70
2	5780	5940	6000	97
3	6800	4700	5500	118
4	5170	5840	5500	100
5	2990	2660	2900	80
6	2270	2200	2500	73

Additionally, the measurements of magnetic field intensity were carried out near the operating hardening furnaces within a full measurement range of the meter (Fig. 6), (Table 4).

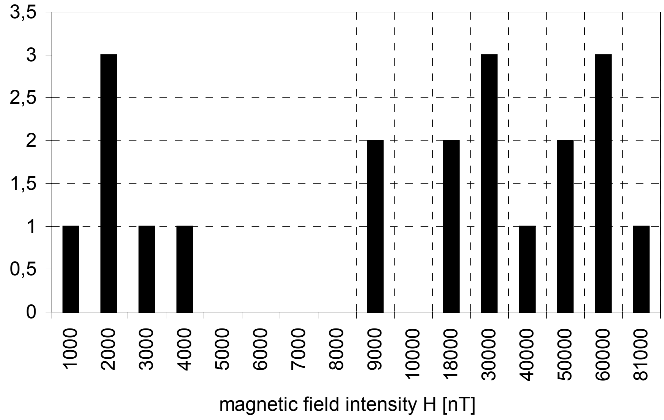

Fig. 6. The histogram of magnetic field intensity changes in time in the neighbourhood of hardening furnaces, for the measurements registered every 0.5 [s] and the number of 493-sample registration

TABLE 4. The measurements results of magnetic field intensity in the neighbourhood of hardening furnaces in different measurement points

No of point	H [nT]	
	Measurement range 5 Hz – 400 kHz	
	H_{min} [nT]	H_{max} [nT]
1	1600	3200
2	2000	43000
3	53000	81000
4	18000	23000
5	40000	60000
6	1000	9000
7	1100	9000
8	2200	44000
9	18000	27000
10	30000	51000

On the basis of the analysis of the obtained measurement results some recommendations have been formulated. They aim at reducing the level of magnetic intensity in some selected places. The level of the magnetic field can be most effectively reduced by limiting the possibility of emitting undesired voltage and current courses in the electric wiring of the hardening furnaces. This procedure requires the analysis of the leads length (circuits, cables, etc. – signal lines, supply lines, masses, groundings), which behave as „emitting antennas" when their length increases. These undesired phenomena can be limited by the use of appropriate filters and the modification of cables systems, where the transient states appear in the electric wiring of the hardening furnaces.

Another procedure consists in applying electro-optical and optic-electrical converters as well as fibre optic lines (fibre optic installations) in order to move the susceptible measurement instrumentations to the places where there is low magnetic field intensity.

4. FINAL REMARKS

The works to implement the proposed solutions are nowadays well under way. They aim at lowering the level of magnetic field intensity in selected points of the examined production building.

Because of very high intensity of the magnetic field in laboratories, which exceeds the admissible levels that are nowadays: within frequency 5 Hz – 2kHz (ELF) 250 [nT], and within the range 5 Hz – 400kHz (VLF) 25 [nT], it has been decided that a part of laboratories should be moved to the rooms where a low magnetic field appears (e.g. to the room 2) (Table 5), (Fig. 7). Additional measurements of magnetic field intensity in selected points of this room (Table 6) confirmed great dynamics of long-term changes in magnetic field intensity. The magnetic field intensity values registered in II measurements series (made after about one year after I series) exceeded considerably the admissible levels determined in the normalising standards [4].

TABLE 5. The measurements results of magnetic field intensity for four measurement subranges of the meter in room no 2 in different measurements points (I measurements series)

No of point	H[nT]			
	Measurement ranges			
	50Hz	5 Hz – 400kHz	5 Hz – 2kHz	2kHz – 400kHz
1	212	248	261	11
2	315	250	335	10
3	167	212	204	12
4	174	208	162	11
5	123	156	121	10
6	180	243	202	10

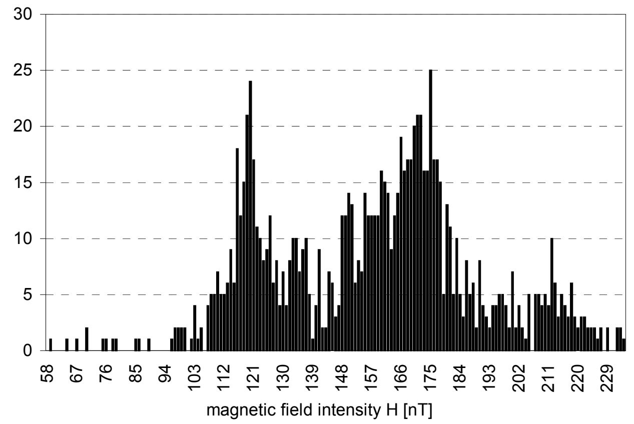

Fig. 6. The histogram of magnetic field intensity changes in time in room no 2, for the measurements registered every 0.5 [s] and the number of 493-sample registration (I measurements series)

TABLE 6. The measurements results of magnetic field intensity for four measurement subranges of the meter in room no 2 in different measurements points (II measurements series)

No of point	H[nT]			
	Measurement ranges			
	50Hz	5 Hz – 400kHz	5 Hz – 2kHz	2kHz – 400kHz
1	1720	1650	1670	34
2	1157	1032	1110	23
3	691	521	701	15

REFERENCES

[1] L. Hasse, J.K. Kołodziejski, A. Konczakowska, L. Spiralski, "Interference in electronic instrumentations", in Polish, *Radioelektronik*, Warszawa 1995.
[2] H. W. Ott, "Noise reduction techniques in electronic systems", *J. Wiley & Sons*, New York 1988.
[3] 3D H/E fieldmeter ESM-100, *Maschek Technical Publication*, Maschek Elektronik Germany, 2001.
[4] PN-T-065080-1, -2, -3, Work protection in electromagnetic radiation fields of frequency 0 Hz to 300 GHz.

AUTHOR(S): Beata Pałczyńska, Ludwik Spiralski, Gdynia Maritime University, Department of Marine Radioelectronics, ul. Morska 83, 81-225 Gdynia, Poland, phone: +48 58 6901552, fax: +48 58 6219938, e-mail: palbeata@am.gdynia.pl, kapsz@pg.gda.pl Stanisław Galla, Technical University of Gdańsk, Department of Metrology and Measurement Systems, ul. Narutowicza 11/12, 80-952 Gdańsk, Poland, phone: +48 58 3471504, e-mail: kapsz@pg.gda.pl,