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DIELECTRIC SEALERS AS A SOURCE OF RF OVEREXPOSURE IN WORKING ENVIRONMENT

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Abstract. *Dielectric heaters/sealers are widely used in the industry for different purposes as: welding, sealing, or curing dielectric materials. They are amongst electromagnetic field (EMF) sources in the industry that may cause excessive exposure to radiofrequency (RF) fields. This is due to their high power and possible use of unshielded electrodes. The frequencies used for sealers operation are in the range 10-100 MHz (mainly 13.56, 27.12, 37.00 and 40.68 MHz).*
The paper presents study of the electric and magnetic fields in plastic industry in Bulgaria covering 98 dielectric sealers of different types: frequencies 27.12 MHz, 40.68 MHz, 42 MHz. Most of them emit at frequency 27.12 MHz with powers from 0.6 kW to 50 kW. The article discusses specificity of the dielectric sealers as sources of EMFs in working environment and related approaches for measurements and exposure assessment.
The average values of the electric field strength measured at the working places were from 64.4 V/m to 143.3 V/m; the maximal values were in the range 130 - 170 V/m, as the highest ones were registered around the highest power sealers (50 kW). Higher values were registered in the working premises with several sealers as well.
Maximal electric field strengths reached up to 10 times action levels according to Directive 2013/35/EU [1]. The measured magnetic flux densities were in the range 0.19 – 0.25 μT, exceeding the action levels according to Directive 2013/35/EU. The EMF exposure assessment corresponds to the results of the medical study of workers in plastic industry conducted in our country that has shown adverse health effects observed in 31 % of persons working with dielectric sealers.

Keywords: *radiofrequency (RF), dielectric sealers, overexposure, EU Directive, health hazards*

1. INTRODUCTION

Dielectric heating as an industrial process applied in many industries, as microwave drying of dielectric materials, welding, plastic heating and gluing. Depending on the treated material, different power and frequency are used in dielectric heaters (plastic sealers). This equipment consists of high frequency generator, feeder lines and conductive plates where the treated material should be placed. The emitted EMFs are with high level of electric field strengths and not so high magnetic field strengths. These fields are not sinusoidal, with complex form of the signal, also intermittent. EMF exposure is mainly on the upper part of the body, mainly on torso and hands of the worker. The equipment emits many harmonics besides the main allowed frequencies as 13.56 MHz, 27.12 MHz, 37 MHz, 40.68 MHz, and they are not fixed during the welding. The frequency and the voltage of the devices depend on the processed material and on the technological process.

The heating process lasts from several seconds in welding machines to minutes and hours in heating and drying of food, dielectric materials and wood. Most machines are shielded authomated system, but most sealers are operated manually and workers perform their duties close to the RF electrodes.

It is very difficult to shield the emitting parts of the equipment because of the specificity of the technological process. In most cases the heated material should be placed between the conductive plates manually. Even some shielding is available by the manufacturer of the equipment, it is difficult to be used by the worker because of the need of continuous process monitoring and manual feeding.

Exposure assessment on the work places is very complicated problem because of the complex of the emitted fields, intermittency of the exposure, the availability of several emitting machines in the room, the lack or poor shielding of the machine, the presence of harmonics, and the main reason – the need of performing measurements and exposure assessment in the near-field zone.

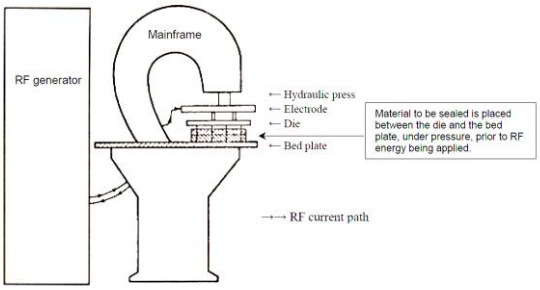

Figure 1. Principal scheme of dielectric heater [2]

When the exposure limits for EMFs are exceeded, this could lead to harmful effect on workers. Adverse health effects considered here could be direct effects (thermal effects as a result of tissue heating, others non-thermal effects, induced limb currents), and indirect effects which result from the presence of objects in the field as interference with medical

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electronic equipment, with active implanted medical devices as pacemakers, insulin pumps; passive implants; electric shocks or burns from contact currents from touching a conductive object in an electromagnetic field) [1, 3].

Health hazards from high level of RF-EMF exposure was reported by the International Labour Organization (ILO) in its Practical Guide, prepared in collaboration with ICNIRP and WHO in 1998 [2]. The results from investigations of this particular work group showed that the exposure to high RF field could lead to reproductive and teratogenic outcomes, eye irritation, RF burns and neurological problems (hand numbness, diminished two-point discrimination and carpal tunnel syndrome).

Studies of workers in plastic industry conducted in Bulgaria [4] have shown that adverse health effects have been observed in 31 % of persons working with dielectric sealers. It is important to mention that more that 90% of the workers are women. The main findings were in autonomous nervous system and cardiovascular system. The changes in autonomous nervous system are asthenic and vegetative-asthenic syndrome with vegetative and vascular dysfunctions and mainly sympathetic and less often parasympathetic attitude of the vegetative functions; EEG abnormalities connected to the dominance of theta rhythm. The latter finding correlates with the established neurovegetative changes. Changes in the ECG, which mainly affect the atrial and ventricular conduction and they are of extra cardiac origin.

Irritative eye symptoms and a high prevalence of numbness in hands were found in a study of Kolmodin-Hedman et.al. in Sweden [5]. Significantly lower heart rate and more episodes of bradycardia were registered in J. Wilén, et al. [6].

In women, conditions connected to ovarian dysfunction have been observed: menstrual disorders (shortened or prolonged), frequent metrorrhagia, amenorrhea, oligomenorrhea. There are also data on the pathological course of pregnancy. The study has found suppression of immunological reactivity as well.

Biochemical studies have showed changes in the protein profile in the blood serum; anaemic conditions in the peripheral blood, changes in the morphology of erythrocytes.

The main operation frequency used by the dielectric sealers – 27.12 MHz has been studied over 10 years as it is the one used for ultrahigh frequency (UHF) therapy in physiotherapy. UHF therapy has wide application for treatment of various acute and chronic inflammatory processes of internal organs; degenerative processes; diseases of the musculoskeletal system, peripheral nervous system; female reproductive organs, etc. This is a proof for the biological efficiency of electromagnetic fields with such frequency.

Study of the medical staff in physiotherapy [7] suggests that medical staff exposed to EMR is at higher risk for dyslipidemia. Another study of medical staff in physiotherapy exposed to EMF has found higher excretion rates of stress hormones: cortisol, adrenaline and nor-adrenaline among the medical staff in physiotherapy [8].

2. Materials and methods

2.1. Objects

Here we present results of a study of the electric and magnetic fields in plastic industry in Bulgaria conducted in the 80s [4]. The investigation covers 98 dielectric sealers of different types: frequencies 27.12 MHz (68.06 %), 40.68 MHz (30.92 %) and single with frequency 42 MHz (1.02 %). The powers vary from 0.6 kW to 50 kW. Most common power of the equipment was 2.5 kW - 54,88% followed by those with power 6 kW. There are single-unit devices with power 0,8 kW, 1 kW, 3.2 kW, 40 kW, 50 kW.

Generally, devices should be equipped with shielding of all emitting elements but in most cases this is impossible because of the specificity of the technological process. More often, the shields are available for the generator and for the feeders, not for the plates (the capacitor). This is due to the fact that use of shields complicates and slows down the technological process when loading the machines is manually.

2.2. Method

Frequency-non-selective method corresponding to the frequency range of the devices was used for measurements. Since the measurements are performed in the near field zone of the devices, separately the electric field and magnetic field values were measured.

Electric fields predominate then the magnetic fields in the workplaces around the machines. Nevertheless, both electric and magnetic fields were measured and evaluated.

The measurements were performed at working places in the absence of the worker at the operator's normal location (typically 30 – 60 cm from the electrodes) on three levels above the ground corresponding to the levels of head, torso and pelvis of the worker. Limitations connected to the instrument, technological process and measurement procedure could prevent closer measurements to the machine. Additionally, when possible, measurements on the level of workers' hands were performed. In premises with several emitting devices, EMF levels in surrounding area were scanned to receive information about the EMF interaction. All measurements are spot measurement with searching the maximum value for the place of interest, during the whole cycle of welding.

In such technological processes there is a need of measurements of the contact and induced currents, as well. Unfortunately, at this time (the 80s) such measurements were very difficult to be realized.

It should be mentioned that there were not any personal protective measures for the workers. Only shielding exist on every machine but there were not in use.

2.3. Measurement equipment

Measurements were performed using the following equipment for RF electric and magnetic field NFM - 1 (Pracitronik, Germany), calibrated for the frequencies and range of measurement.

2.4. Measured parameters:

- electric field strength E, V/m;

- magnetic field strength H, A/m / calculated magnetic flux density B, T.

- frequency range: 60 kHz-350 MHz

- dynamic ranges: E = 2 V/m – 1500 V/m; H = 0. 1 – 80 A/m

The received results were compared with the action levels according to Directive 2013/35/EU [1] and reference levels in Council Recommendation 1999/519/EC [9] for workers at particular risk.

Table 1. Action Levels for thermal effects according to Directive 2013/35/EU [1] and reference levels for the general public according to Council Recommendation 1999/519/EC [9]

	Frequency range	Electric field strength, (V/m)	Magnetic flux density, (μT)
Directive 2013/35/EU	10 ≤ f < 400 MHz	61	0.2
Council Recommend-ation 1999/519/EC*	10 ≤ f < 400 MHz	28	0.092

*applied for workers at particular risk and at work places accessible to the general public (persons which are not directly related with the technological process).

3. Results and discussion

The summary of measurement results is presented on the Figure No 2. Data are grouped according to the devices' power by the following groups: up to 1 kW; > 1 kW -3 kW; > 3 kW -6 kW; > 6 kW. Results from measurements of shielded equipment (13 devices/13.27 %) are within the range 5.5 V/m up to 28 V/m and are not included in the Figure No.2.

The average values of the electric field strength measured at the working places were from 64.4 V/m to 143.3 V/m; the maximal values were in the range 130 - 170 V/m, as the highest ones were registered around the highest power sealers (50 kW). The higher values for powers below 1 kW can be explained by different shielding of the machines (or lack of shielding), also different constructions.

Most often the maximum measured values at the work place are at the level of the head and chest/torso of the worker. Values from 600 up to 1000 V/m were registered in the proximity of electrodes where exposure of the workers' hands may occur.

These results correspond in principle to the data of J. Wilén, et al. [6] where spatially averaged values of electric and magnetic field strengths are 107 V/m and 0.24 A/m, respectively. The maximum reported field strengths there are 2 kV/m and 1.5 A/m.

Electric field strengths in operators of the sealers location ranging typically from 1 to 300 V/m, and magnetic fields ranging from 0.1 to 20 A/m are reported, also, in SCENIHR, Opinion on Potential health effects of exposure to electromagnetic fields [10].

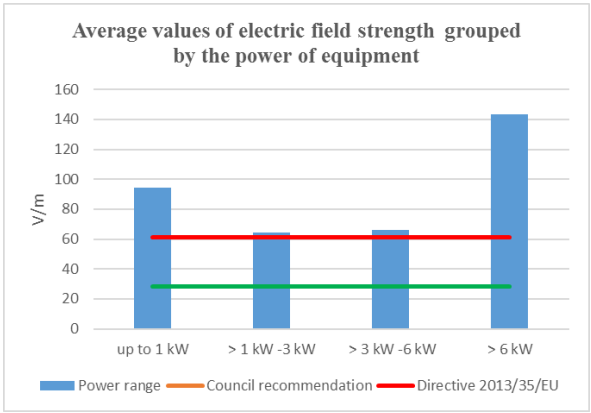

Figure 2. The measurements results grouped by power of the equipment

Another typical observation is that higher values of electric and magnetic field were registered at work places where several sealers were present in single working premise. In such cases electric field strengths from 20 V/m up to 80 V/m were registered. This means that besides workers directly involved in process of dielectric heating/sealing other persons in the area such as other workers, visitors, cleaners, etc. could be exposed to high EMF levels. Considering that for workers at particular risk and those not directly included in the process general public limits are applied, it can be concluded that in premises with more than one device reference levels are exceeded.

Systemizing the data according to the power of devices shows no significant difference in measurement results for the considered intervals. Rather, the results depend on the design of the emitters and the organization of the technological process and working place (mainly, the distance to the electrodes and shielding).

Maximal electric field strengths measured at workplaces with dielectric sealers reach about 10 times action levels according to Directive 2013/35/EU [1]. A review on Occupational exposure to radiofrequency electromagnetic fields Stam R. [11] shows that the majority of highest exposure values are above the action levels in the EU Directive both for the electric and magnetic field.

The average values only in the cases with available and used shielding the EMF values correspond to action levels of the Directive. In all cases of devices without shielding reference levels for workers at particular risk are exceeded. For workers at particular risk reference levels according to the Council recommendation are exceeded even for a part of shielded equipment.

The measured magnetic field strengths (calculated flux densities) were in the range 0.15 A/m to 0.20 A/m (0.19 – 0.25 μT), i.e. magnetic field levels also exceed action levels for thermal effect according to Directive 2013/35/EU [1].

4. Conclusion

Dielectric heating/sealing devices are with high power; work is performed in close proximity to them and often without shielding. The exposure of the workers (mainly women) is in the near field area of the emitters and it is intermittent, inhomogeneous and local. Main exposed parts of the body of the workers are hands, torso, head, and sometimes knees. The results from the study show that operators of dielectric sealers/heaters in most of the cases are exposed to high EMF levels exceeding action levels according to EU Directive. Only in cases where shielding is available and used by the workers, the EMF levels do not exceed the limits. The data from the scientific literature and the studies carried out in the past in our country of workers in this industry show harmful effects on health after prolonged/chronic exposure to EMFs, as it was mentioned above. This is a specific group of workers that should be given serious attention in terms of risk from EMF exposure, taking into account the characteristics of the work process, sources of EMF and proximity of EMF sources. It is necessary to develop a particular method of measurement and exposure assessment for such sources. Measurements, exposure assessment of EMFs should be done on a regular basis, depending on the risk assessment results, perhaps once per year in order to ensure health and safety in the working environment. Also, there is a need of additional studies (epidemiological and experimental) for health consequences of these high RF EMF levels exposed group. There is a need of special prevention program for such workers, and specific medical surveillance. We propose, also, specific rules or legislation for protection of workers in EMF overexposure.

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