EXPOSURE AND RISK ASSESSMENT CONNECTED TO THE HEALTH AND SAFETY OF WORKERS IN THE PRODUCTION OF ELECTRICITY

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INTRODUCTION

In Bulgaria, the EU Directive 2013/35/EC [2] has been transposed into national legislation by Ordinance RD-07-5 for the minimal requirements for providing health and safety at work at risks by exposure to electromagnetic fields [3, 7], in 2016 and entered into force in 2017.
In connection with the introduction of new assessment requirements, such as exposure limit values (ELVs) and action levels (ALs) for electrical, magnetic and electromagnetic (EMF) with frequencies up to 300 GHz, as well as the necessity to assess new physical parameters, a need arose to change approaches regarding the exposure and risk assessment of EMFs in for different professional groups. Some of these parameters are not measurable, and calculations and modelling are very important activities in cases where the values are close to or above the corresponding ALs.
Regarding this, a team from the National Centre of Public Health and Analyses (NCPHA) carried out measurement and exposure and risk assessment of work places in electricity producing sector, according to the requirements of Directive 2013/35/EU.
The expected adverse effects of electrical and magnetic fields with power frequency are: direct effects on the nervous system, analyzers, skin receptors and muscles due to the influence of extremely low frequency range EMF and indirect effects caused by the presence of an object in the electromagnetic field.

AIM OF THE STUDY

Exposure and risk assessment of EMF on workplaces at workshops in electrical power plant according to requirements of Directive 2013/35/EU [2].

MATERIALS AND METHODS

1. Workplaces
The study covers exposure assessment of all jobs related to the work equipment combined into the following groups of work places/occupations depending on the technology:
- Workplaces in electrical distribution systems (internal and external distribution systems);
- Workplaces in electrolysis;
- Workplaces with metalworking machines: lathes, milling machines, electric welding.

2. Measurement method
Measurements are performed by applying a frequency non-selective method, using
“Non-binding guide to good practice for implementing Directive 2013/35/EU, Electromagnetic fields, Volume 1: Practical guide”[4].

3. Measurement parameters
Electric field strength, V/m;
Magnetic flux density, μT;
Static field magnetic flux density, μT.

4. Measurement equipment
For measurement purposes, the following equipment was used:
4.1 Holaday Industries HI 3550, USA
- InAs Hall effect sensor
- measurement range for static magnetic field: 0.1 mT to 0.3 T
Uncertainty: ±0.05 mT (in the range from 0.1 mT to 0.5 mT) ; ±10% (in the range from 0.5 mT to 0.3 T).
4.2 Holaday Industries HI3604, USA
- anisotropic probe,
- frequency range :20 Hz - 2 kHz for electric field; 20 Hz to 1 kHz for magnetic field;
Uncertainty: ± 20%.
The measurement equipment for low-frequency range covers the power frequency (50 Hz) and harmonics, including frequencies up to 1 kHz or 2 kHz, to comprise the emission of spark discharges at high voltages. The dynamic range of the measuring instrument has been selected so that an exposure assessment can be made for both workers protection in the presence of EMFs and the general public protection. The purpose of the latter is to assess the possible risk for workers at "specific risk".
The measured values are root mean square (rms) with averaging over 6-minute periods. The presented measurement data are the maximum rms values obtained for the corresponding occupations/workplaces.
Exposure and risk assessment has been performed by comparison of the measured values with the action levels (ALs) and the exposure limit values (ELVs) as required by Directive 2013/35/EC (Ordinance RD-07-5). [2, 7]

On the risk assessment we took account in account mainly the characteristics of the occupation and work tasks and the specific risk definitions. The limit values adopted by Council Recommendation 1999/519/EC [1] were used as a reference for workers at "specific risk".
This group includes workers carrying active or passive implants, workers carrying medical devices on their bodies, as well as external hormone infusion pumps as well as pregnant workers.

RESULTS AND DISCUSSION

Measurements have been performed at more than 150 points on workplaces, on walkways and observation areas. The survey results are grouped by occupations/ workplaces, technologies and workshops.

Electrical occupations
As it was expected the results from measurements in electric workshop/electrical occupations are of greatest interest in terms of exposure to electric and magnetic fields.
Hereafter results for selected occupations/jobs in electrical distribution systems (indoor and outdoor distribution systems) where the highest exposure to EMFs occurs are presented.
Table No. 1 shows data from the measurement of the electric field strength on selected work places in electrical distribution systems.

Table No. 1

Workplace	Highest measured value *Emax V/m*	Low ALs (for 50 Hz) *10000 V/m*	High ALs (for 50 Hz) *20000 V/m*	Reference level - CR 1999/519/EC *5000 V/m*	Risk: *low medium high*	Workers at specific risk
Workplace indoor distribution system 6 kV	8.03	-	-	-	low	-
Workplace transformer platform, under rims	11970	✔	-	✔	medium	✔
Workplace measuring instruments	103	-	-	-	low	-
Workplace transformer own needs 28 T – 15.76/6 kV	1280	-	-	-	low	-
Workplace block transformer – 7T, 15.75/400, under rims	5020	-	-	✔	medium	✔
Workplace Block Transformer – 8T, 15.75/400, under rims	5340	-	-	✔	medium	✔

Table No. 2 shows data from the measurement of the magnetic flux density on selected work places in electrical distribution systems.

Table No. 2

Workplace	Highest measured value Bmax	Low ALs (for 50 Hz) 1000 μT	High ALs (for 50 Hz) 6000 μT	Reference level - CR 1999/519/EC 100 μT	Risk: *low medium high*	Workers at specific risk
Workplace – generator 7th block In front of powering exciter system	183	-	-	✔	medium	✔
Rim Lines under generator 7th block	335	-	-	✔	medium	✔
Workplace at generator – 8 block	447	-	-	✔	medium	✔
Workplace at measuring instruments	36.40	-	-	-	low	-
Workplace at cooling system	181	-	-	✔	medium	✔

As it could be seen on the transformer platform the low ALs for the electric field strength for non thermal effects are exceeded. The electric field strengths exceed reference levels according to CR 1999/519/EC [1] on workplaces around block transformers and transformer platform. No values above the ALs for magnetic flux density were registered, but at several points values exceeding of the reference levels according to CR 1999/519/EC [1] were registered.

Electrolysis facility
The main source of a permanent magnetic field is the DC power supply to the electrolysis facility. In this case the electrolyzer is completely shielded.
A conservative estimate of the exposure was made on the basis of averaged field values for two different distances from the facility - 0.1 m and 0.5 m, at two heights to the floor of the room - at the worker's head (1.8 m) and the chest (1.5 m).
The assessment takes into account the fact that there is no permanent workplace in the room. The measured values in electrolysis facility at electrolyzer are in the range of 0.06 to 0.79 mT. Magnetic field density values of static field exceeding 0.5 mT, which is the AL for interference with active implanted devices, e.g. cardiac pacemakers, are recorded in single points adjacent to the supply cables (at 0.1 m) and at the entrance to electrolyzer.

Workshops with metalworking machines: lathes, milling machines, electric welding
The sources of EMF in this workshop are the following: power tools of metalworking machines; power supply to the plasma system; the arc welding power generator; cables with high values of the electrical current at arc welding.
At the considered work places measured EMF values were as follows:
Extremely low frequency (ELF) electric field strength from 1.45 to 2.65 V/m.
Magnetic flux density (magnetic induction) in the ELF range: 0.08 μT to 23.5 μT.

CONCLUSION

The measured values of electric field strengths and magnetic flux density in the ELF range (mainly power frequency 50 Hz) do not exceed the action values for non-thermal effects, except for single points on a transformer platform where the low action values are exceeded for the electric field strength. At the same points, values above the reference, in accordance with CR 1999/519/EC, are also established for both the electric field strengths and magnetic flux density.
Notwithstanding the single values exceeding the low ALs, the results show that the exposure limit values (ELVs) with respect to the health effects are met. A health risk associated with exposure to electromagnetic fields at the described workplaces can not be expected for workers at a specific risk because the exposure limit values are not exceeded.
There is a health risk for workers at specific risk (carrying active and passive implants, medical devices on their body (pumps) and pregnant women working on or in the immediate vicinity of the transformer site, as well as at individual points in the electrolysis facility.
In the light of the results of the study and the established health risk to workers', recommendations have been made to the employer, which are related to working practices for minimizing exposure, safety rules and practices, warning signs, training of workers and health surveillance.
On the workplaces for plasma cutting, arc and oxygen welding workers are expected to be exposed to other part of non-ionizing radiation - optical radiation, which is the subject of a separate assessment in the present study.

REFERENCES

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