

## THE NEW EUROPEAN DIRECTIVE REGARDING THE EXPOSURE OF WORKERS TO THE RISKS ARISING FROM PHYSICAL AGENTS

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**ABSTRACT** *Following the entry into force of Directive 2004/40/EC of the European Parliament and of the Council of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields), serious concerns were expressed by stakeholders, in particular those from the medical community, as to the potential impact of the implementation of that Directive on the use of medical procedures based on medical imaging. This paper aims to present the new requirements of this new Directive and to analyse the compliance with these requirements of an overhead power line when the worker has to work with the line energised.*

**KEYWORDS** *exposure, physical agents, risk, assessment, European Directive*

### 1. INTRODUCTION

In 2013, the European Union (EU) produced a directive 013/35/EU concerned with the minimum health and safety requirements for risks arising from exposure to electromagnetic fields [1]. It is a requirement for all EU member states to implement the Directive by July 2016. The new directive is to replace a 2004 directive which has never entered into force because of problems with its implementation. The agreed text reviews exposure limitations on the basis of new scientific evidence and provides for derogations, in particular for medical applications using magnetic resonance imaging.

The new directive takes account of new scientific studies in order to review exposure limitations, in particular in the low frequency range, so as to avoid the difficulties encountered with the implementation of the 2004 directive, while ensuring a high level of worker protection. The text also addresses the problems encountered by introducing derogations from the exposure limitations for medical applications using magnetic resonance imaging and, in duly justified circumstances, upon authorization by the member state and provided that limits are only temporarily exceeded, for specific industry sectors or activities. In both cases, however, protection against adverse health effects and safety risks must be ensured. The directive also enables the member states to authorize, on their territory, an equivalent or a more specific protection system for the armed forces. As the directive only defines minimum requirements,

member states are free to maintain or establish stricter requirements.

The directive 2013/35/EU includes exposure limit values (ELVs) and action levels (ALs) to protect workers against adverse health effects. The ELVs are limits on exposure to electromagnetic fields based directly on established biological effects and biological considerations. The ALs are levels provided for measurement or calculation purposes to determine whether the ELVs are likely to be exceeded. For a particular exposure scenario, measured or calculated field strengths can be compared to the appropriate ALs.

Compliance with the AL will ensure compliance with the relevant ELV. Non-compliance with the AL does not necessarily mean non-compliance with the corresponding ELV. However, in this situation it is necessary to test compliance with the relevant ELV to determine whether additional protection measures are required [4].

Different adverse health effects are produced from exposure to electromagnetic fields at different frequencies. Because of this, ELVs are provided for non-thermal effects (0-10 MHz) in Annex II of the Directive and thermal effects (100 kHz-300 GHz) in Annex III of the Directive. In the intermediate frequency range (100 kHz-10 MHz) both thermal and non-thermal ELVs need to be considered. The ELVs are defined in terms of the internal dose quantities SAR and induced electric fields. These internal quantities are very difficult to measure within the body. They can only be assessed accurately using the numerical calculations. Annex II and III of the

directive provide the ALs in terms of external field quantities as a means to allow measurements and analytical calculations to be used in compliance assessments

## 2. THE EMF DIRECTIVE CONTENTS

The directive has the following structure:

### Chapter I General Provisions

- Scope, definitions, exposure limit values and action levels compliance

### Chapter II Obligations of Employers

- Risk assessment process

### Chapter III Miscellaneous Provisions

- Health surveillance, penalties, derogations

### Chapter IV Final Provisions

- Practical guides, transposition date

### ANNEX I Physical quantities regarding the exposure to electromagnetic fields

- Electric and magnetic field strength, magnetic flux density, power density, limb current, contact current, specific energy absorption and rate

### ANNEX II Non-thermal effects, Exposure limit values and action levels in the frequency range from 0Hz to 10MHz

- Static and low frequency limits

### ANNEX III Thermal effects, Exposure limit values and action levels in the frequency range from 100 kHz to 300 GHz

- High frequency limits

## 2.1 General Provisions

In the introductory part is indicated the subject and the scope of the directive. This directive covers all known direct biophysical effects and indirect effects caused by electromagnetic fields, the exposure limit values (ELVs) cover only scientifically well-established links between short-term direct biophysical effects and exposure to electromagnetic fields and the directive does not cover suggested long-term effects and the Directive does not cover the risks resulting from contact with live conductors.

## 2.2 Exposure limit values and action levels

The directive 2013/35/EU includes exposure limit values (ELVs) and action levels (ALs) to protect workers against adverse health effects. The ELVs are limits on exposure to electromagnetic fields based directly on established biological effects and biological considerations. The ALs are levels provided for measurement or calculation purposes to determine whether the ELVs are likely to be exceeded. For a particular exposure scenario, measured or calculated field strengths can be compared to the appropriate ALs. Compliance with the AL will ensure compliance with the relevant ELV. Non-compliance with the AL does not necessarily mean non-compliance with the corresponding ELV. However, in this situation it is

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Annex II and III of the Directive provide the ALs in terms of external field quantities as a means to allow measurements and analytical calculations to be used in compliance assessments.

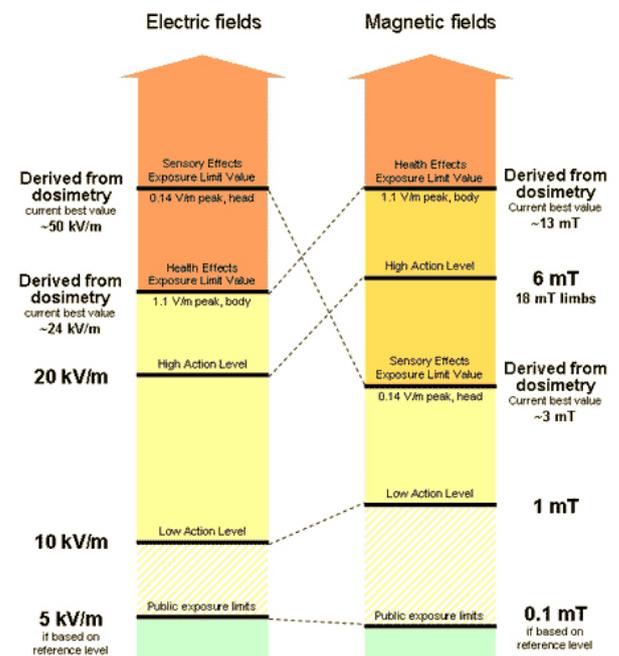


Fig 1. Converted ELVs to equivalent external fields for frequency of 50 Hz [10]

Because the Directive allows member states a three years gap for transposition, until to 1<sup>st</sup> of July 2016, there is still a variety of regulation in place.

The exposure limit values and action values of the 2004 Directive are still in force for many of European Countries.

In some member states, national legislation is still in force with stricter or more lenient limits than those in the Directive. In Luxembourg and Bulgaria, the limit for electrical field strength for brief exposures (several minutes) is respectively 2.1 and 2.5 times the action value in the Directive. For longer exposures the limit is half of the action value in the Directive. In

Poland, the magnetic field limit is one half of the action value in the Directive and there are also time-integrated exposure limits.

In table 1 is drawn the exposure limits for some of European countries and some of non-European countries, for frequency of 50 Hz.

Country	Electric field Strength [kV/m]	Magnetic flux density [mT]
Directive 2013/35/EU	10	1
Austria	10	0.5
Bulgaria	5	-
France	10	0.5
Hungary	10	0.5
Luxemburg	5	0.1
Romania	10	0.5
Australia	10	0.5
Russia	-	0.1
Switzerland	10	0.5
USA	25	1

**Table 1.** – The exposure limits for electric and magnetic field, for 50 Hz.

### 2.3 Obligations of employers

Employers must ensure that the ELVs for employees are not exceeded. To do this, they must assess the risks and determine the exposure [1]:

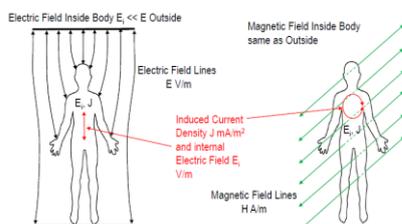
- Based on emission specifications given by the device manufacturers;
- By measurement;
- By calculation where necessary;

The assessment is to be made by competent services or persons at suitable intervals and the data preserved in a suitable traceable form.

The directive further obligates employers to take measures to avoid or reduce the risks and to inform employees and / or their representatives of such measures and to provide employees with information about the possible risks and their effects [3].

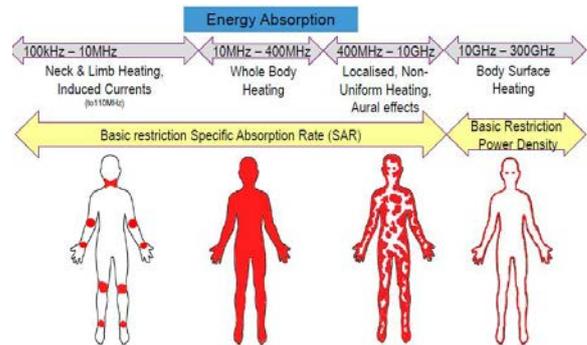
### 2.4 Provisions aimed at avoiding or reducing risks

The employer shall take the necessary actions to ensure that risks arising from electromagnetic fields at the workplace are eliminated or reduced to a minimum.



**Fig. 2.** Below 100kHz, **E** and **H** effects are considered separately

In Figure 2 is shown the Electric and magnetic field, both outside and inside the body, for frequencies below 100 kHz.



**Fig. 3.** Thermal effects above 100 kHz

In Figure 3 is shown the thermal effects of the EMF, for frequency above 100 kHz.

The employer shall devise and implement an action plan that shall include technical and/or organisational measures to prevent exposure exceeding the health effects ELVs and sensory effects ELVs. If the health effects ELVs and sensory effects ELVs are exceeded, the employer shall take immediate action to reduce exposure below these ELVs. This action can include the following measures [1]:

- other working methods that entail less exposure to electromagnetic fields;
- the choice of equipment emitting less intense electromagnetic fields, taking account of the work to be done;
- technical measures to reduce the emission of electromagnetic fields, including, where necessary, the use of interlocks, shielding or similar health protection mechanisms;
- appropriate delimitation and access measures, such as signals, labels, floor markings, barriers, in order to limit or control access;
- in the case of exposure to electric fields, measures and procedures to manage spark discharges and contact currents through technical means and through the training of workers;
- appropriate maintenance programmes for work equipment, workplaces and workstation systems;
- the design and layout of workplaces and workstations;
- limitations of the duration and intensity of the exposure;
- the availability of adequate personal protection equipment.

In case of excessive spark discharges and contact currents, specific protection measures shall be taken, such as the training of workers and the use of technical means and personal protection, for example the grounding of work objects, the bonding of workers with work objects (equipotential bonding) and, where appropriate the use of insulating shoes, gloves and protective clothing. In case of static magnetic field, specific protection measures, such as controlling movements, shall be taken.

Employers shall ensure that the workers shall not be exposed above the health effects ELVs and sensory effects ELVs, unless specific measures has been taken. If, despite the measures taken by the employer, the health effects ELVs and sensory effects ELVs are exceeded, the employer shall take immediate action to reduce exposure below these ELVs. The employer shall identify and record the reasons why the health effects ELVs and sensory effects ELVs have been exceeded, and shall amend the protection and prevention measures accordingly in order to prevent them being exceeded again. The amended protection and prevention measures shall be preserved in a suitable traceable form. If the worker reports transient symptoms, the employer shall, if necessary, update the risk assessment and the prevention measures.

## 2.5 Worker information and training

The employer shall ensure that workers who are likely to be exposed to risks from electromagnetic fields at work and/or their representatives receive any necessary information and training relating to the outcome of the risk assessment, in particular [1]:

- measures taken in application of the directive;
- the values and concepts of the ELVs and ALs, the associated possible risks and the preventive measures taken;
- the possible indirect effects of exposure;
- the results of the assessment, measurement or calculations of the levels of exposure to electromagnetic fields;
- how to detect adverse health effects of exposure and how to report them;
- the possibility of transient symptoms and sensations related to effects in the central or peripheral nervous system;
- the circumstances in which workers are entitled to health surveillance;
- safe working practices to minimise risks resulting from exposure;
- workers at particular risk.

## 2.6 Health surveillance

Health surveillance is a public health methodology, which aims to detect undesired health effects in a given population; with the primary aim to eliminate the source of the problem. Its tools range

from medical screening tests to follow-up and register analysis. Individuals benefit from screening tests (i.e., early discovery of a disorder that leads to better health outcome), or from the identification of adverse effects caused by the (working) environment. According to the definition of the International Labour Office (ILO) [8] at page 22, “Occupational health surveillance is the ongoing systematic collection, analysis, interpretation and dissemination of data for the purpose of prevention”. In contrast to surveillance of the working environment, which examines factors in the working environment, workers’ health surveillance gathers health-related data of and from workers in order to identify and tackle harmful exposures at work. The combination of the two approaches provides the best result to obtain a more accurate picture of the given occupational safety and health situation. Health surveillance observations may include taking personal medical histories, questionnaires and bio monitoring to detect early occupational diseases. This is the reason that health surveillance may feature both primary and secondary prevention characteristics in occupational health and safety [3].

In accordance with national law and practice, the results of health surveillance shall be preserved in a suitable form that allows them to be consulted at a later date, subject to compliance with confidentiality requirements. Individual workers shall, at their request, have access to their own personal health records.

If any undesired or unexpected health effect is reported by a worker, or in any event where exposure above the ELVs is detected, the employer shall ensure that appropriate medical examinations or individual health surveillance is provided to the worker(s) concerned [9].

## 2.7 Derogations

Directive 2013/35/EU retains the exemption (or derogation) from EMF exposure limits that was such an important feature of the 2011 proposal, but in the course of negotiation, some conditions have been added. Article 10 of the directive sets out the scope of the derogation, stating that the exposure limits may be exceeded during “the installation, testing, use, development, maintenance of or research related to magnetic resonance imaging (MRI) equipment for patients in the health sector”, provided that certain conditions are met. These conditions are that (i) a risk assessment has been carried out and has shown that the exposure limits are exceeded; (ii) “given the state of the art, all technical and/or organisational measures have been applied”; (iii) “the circumstances duly justify exceeding the exposure limit values; (iv) “the characteristics of the workplace, work equipment or work practices have been taken into account”; and (v) the manufacturer’s instructions for use, issued in accordance with the CE marking of the scanner, are followed [13].

## 2.6 Technical amendments of the Annexes

The European Commission is empowered to amend the Annexes of the EMF directive, only purely technical manner. The Commission can take account of the technical harmonisation and standardisation with regard to the design, building, manufacture or construction of work equipment or workplaces, take into account technical progress, changes in the most relevant standards or specifications, and new scientific findings concerning electromagnetic fields,

make adjustments to the ALs where there is new scientific evidence, provided that employers continue to be bound by the existing ELVs set out in Annexes II and III [9, 10, 11].

The table B4 form Annex 2 (AL for static magnetic field) has to be already amended due to ICNIRP new guidelines for limiting exposure to electric fields induced by movement of the human body in a static magnetic field and by time-varying magnetic fields below 1 Hz [5].

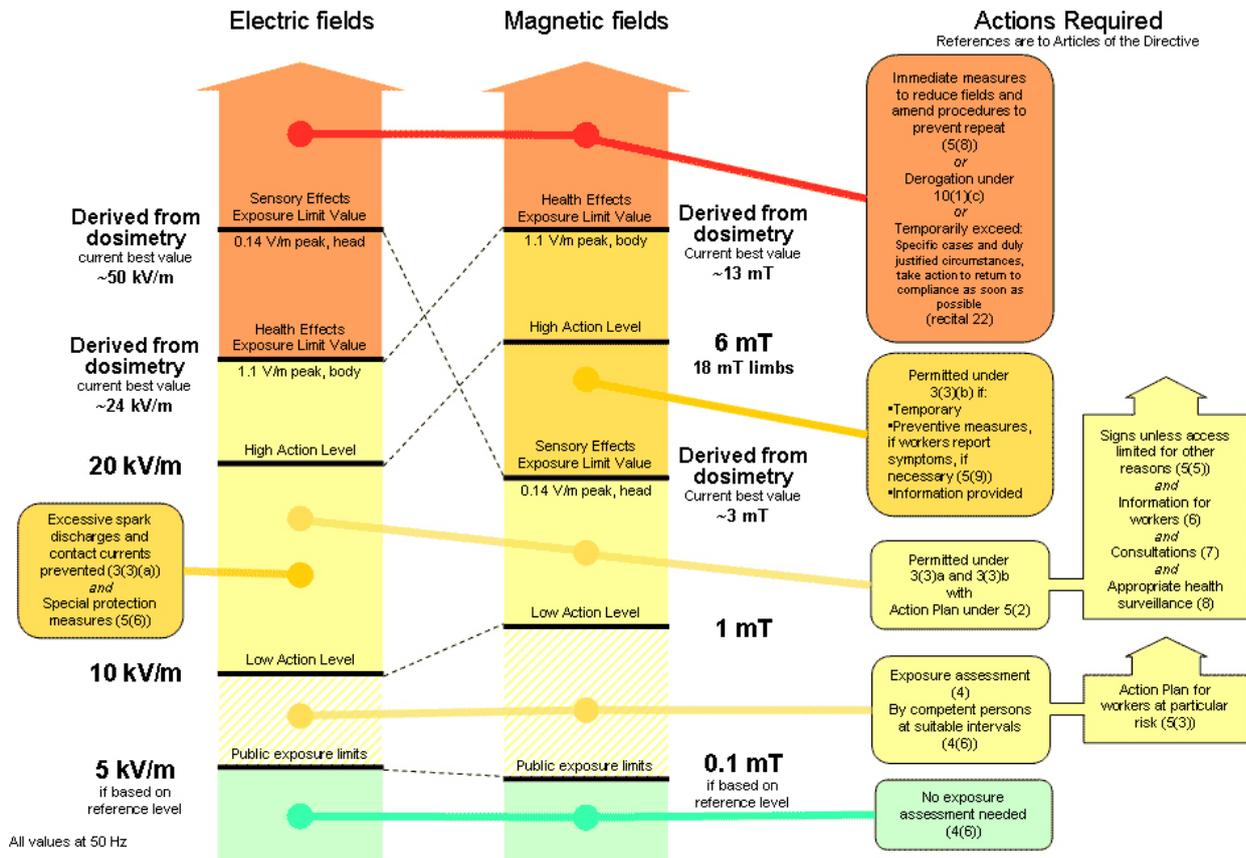


Fig. 4. Relation between ELV, AL and the action required to comply with the directive [14]

## 2.10 Case study

To verify the compliance with the requirements of the Directive, we calculated the electric and magnetic field for a HV overhead line with double circuit, 110 kV. The geometry of the system is shown in figures 6 and 7.

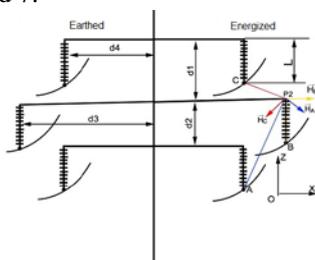


Fig. 5.- The configuration for calculating the magnetic field strength

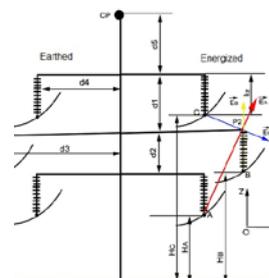


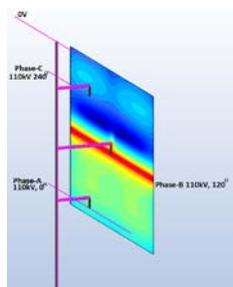
Fig. 6.- Configuration for calculation of the electric field strength

Considering one circuit grounded and one circuit energized and symmetric load on all 3 phases of

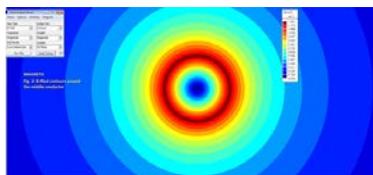
600 A, and the geometric characteristics of the column  $d_1 = 5.3$  m,  $d_2 = 4.60$  m,  $d_3 = 3.05$  m,  $d_4 = 5$  m and  $L = 0.920$  m [1, 12] (see figure 6), on the conductor surface, the total magnetic induction  $B$  is 0.116 mT.

For the calculation of the electric field strength generated by a 50 Hz transmission line it is considered the voltage to ground to be a direct sequence symmetrical system. Phase A is the reference phase (the phase angles are measured relative to this phase) (see figure 7). To calculate the electric field generated by each phase of the network, it is necessary to determine the density of the load line at each of the three phases. To calculate the load line densities it is used the Maxwell relations for the coefficients of potential. In this case, the total electric field strength at the point P2, without worker, is 9.6 kV/m.

To validate the results, we used two software specialised to calculate electric and magnetic fields [7] using finite element method. The results are shown in figures 8 and 9.



**Fig. 7.-** The electric field strength using the Coulomb software



**Fig. 8.-** The magnetic field strength using the Magneto software

The values for electric and magnetic field, computed by the software are 9.3 kV/m and 0.109 mT, respectively. The values are close enough to the calculated values.

### 3. CONCLUSION

The new EMF directive is a mandatory tool to provide assessment of the electromagnetic field exposure for workers. It provides both technical and organizational measures, to assess the exposure of workers for frequencies up to 300 GHz. For exposure limits and action levels it is taking into account all known direct biophysical effects and indirect effects caused by electromagnetic fields.

In the case study analysed in this paper shows the compliance with the requirements of the Directive.

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