Exposure to electromagnetic fields produced by industrial processes

Koen VAN REUSEL
Laborelec
Belgium
koen.vanreusel@engie.com

***Abstract*— The penetration in industrial practice of electrothermal processes is dependent on compliance with the legislation on the exposure of workers to electromagnetic fields. The purpose of this paper is to provide some typical values of the electromagnetic field around installations of industrial processing. To illustrate the typical values relevant for workers, three case studies with measurement results at industrial sites will be given going from 0 Hz (electrolysis), over kHz (induction heating installation), to MHz (dielectric drying line). A fourth case study with a three-phase cable at power frequency will illustrate how a modelling tool can be helpful to define a safety distance for workers and for the general public respectively.**

Keywords—electromagnetic field, exposure limits, safety distance, exposure of workers, exposure of general public

I. INTRODUCTION

On 29th June 2013, Directive 2013/35/EU of the European Parliament and of the Council concerning the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) entered into force [1]. The limits of exposure as listed in the Directive are based on the guidelines established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [2]. The Directive makes a distinction between non-thermal effects (frequency between 0 Hz and 10 MHz) and thermal effects (frequency between 100 kHz and 300 GHz) of electromagnetic fields on the human body. The thermal effects are the most straightforward and the safety limits can be based on the maximum absorption of power that can be safely absorbed per unit mass of body tissue generated from exposure to electric and magnetic fields. From this maximum acceptable power, limits for the electric and magnetic field can be derived. For the non-thermal effects, it is the force of the fields that has an effect on the nerve system. As to the general public, the limits of exposure can be found in the European Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), published on 12th of July 1999 [3].

II. MEASURED VALUES AROUND INDUSTRIAL INSTALLATIONS TO ASSESS THE SAFETY FOR WORKERS

A. Electrolysis

Table I gives for 8 points of measurement the values for the static magnetic field (0 Hz) in mT for an electrolysis installation.

TABLE I - STATIC MAGNETIC FIELD AROUND ELECTROLYSIS INSTALLATION

Point	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
[mT]	18	22	25	56	63	73	84	87

The measurements are taken in the electrolysis hall at 1.5 m above the floor. The copper bars are at the ceiling (~ 5 m height). (For the sake of confidentiality, no pictures of the points of measurement can be shown.) At the instance of measurement, the direct current in the electrolysis system was 182 kA.

For the measurement of the static magnetic field (0 Hz), an isotropic Hall effect sensor with detection in the 3 axes is used (Holaday Industries, Model HI-3550). The device detects the peak of the static magnetic field and it is this value that is noted at each measurement point.

For the static magnetic field (0 Hz), there is a strong overshoot of the limit of 3 mT, which entails a risk of interference with active implanted devices such as cardiac pacemakers (risk already present from 500 µT). These values also entail a significant risk of attraction and projection (risk present already from 3 mT). On the other hand, there is no exceeding of the exposure limit (2T).

B. Induction heating

The limit set out in the Directive (see Annex 2 of the Directive) decreases from 564 µT to 526 µT for frequencies between 532 Hz and 570 Hz and from 375 µT to 300 µT for the frequencies between 800 Hz and 1000 Hz, see Annex 2 of the just mentioned directive.

An isotropic probe (MASCHEK ESM-100) is used for the measurement.

For an induction heating installation of 240 kW and a frequency range between 800 Hz and 1 kHz, a maximum value of the magnetic field of 93 µT has been measured at the the operator's position at the filling of the crucible. This value is below the limit of 300 µT. For an induction heating installation of 1250 kW and a frequency range between 530 Hz and 570 Hz, at the point where the electrical busbars enter the operation room (measurement taken at 1.5 m above the floor), a maximum value of the magnetic field of 110 µT has been measured at 532 Hz. This value is below the limit of 564 µT. (For the sake of confidentiality, no pictures of the points of measurement can be shown.)

C. Radiofrequency installation

A radiofrequency drying installation at 27,12 MHz is measured at nominal power (for reasons of confidentiality no further details can be given).

The measurements of the electric field are carried out using a Holaday isotropic electric probe, type HI-4422.

Magnetic field measurements are performed using a Schwarzbeck type FSH3D antenna installed on a Rohde and Schwarz type FSH8 spectrum analyzer.

TABLE II – ELECTROMAGNETIC FIELD AROUND HIGH FREQUENCY DRYER

Point of measurement	B (µT)	E (V/m)
1	0,02	2,3
2	0,00	0,3
3	0,01	0,4
4	0,00	0,2
5	0,00	0,3
6	0,00	0,2
7	0,00	2,8
8	0,00	0,7
9	0,00	0,3
10	0,00	0,3
11	0,01	0,8
12	0,00	0,3
13	0,00	0,3
14	0,01	1,0
15	0,00	2,4

The measurements are taken along the installation - in the immediate vicinity - that is to say 30 cm - from the outer casing. (For the sake of confidentiality, no pictures of the points of measurement can be shown.)

In the frequency band between 10 MHz and 400 MHz, the electric field cannot exceed 61 V/m. The magnetic field cannot exceed 0.2 µT. Table II gives the measured values for the magnetic and electric field at 15 different points of measurement around the installation at 30 cm from the casing.

The conclusion here is that at a distance of 30 cm from the outer casing, the limit of 61 V/m for the electric field and 0.2 µT for the magnetic induction is nowhere exceeded.

III. MODELISATION OF A CABLE AT POWER FREQUENCY TO DEFINE A SAFETY DISTANCE FOR WORKERS AND FOR THE GENERAL PUBLIC

New cables (type EXeCVB 1 x 240 RM / 25, 15kV) will be placed on the façade of a factory. The cables are cable ladders in galvanized steel (type HD KL 110). The cables are in trefoil position.

Each conductor traversed by a current emits a magnetic field. Each energized conductor emits an electric field. The magnetic field is evaluated by simulation and the results are compared with the limits prescribed in the standard for workers and in the European Recommendation for the general public. The evaluation of the electric field does not require calculation because the cables are fitted with a screen. It is enough to put at least one of the two ends of this screen to ground to suppress the electric field. The evaluation of the magnetic field requires a calculation by finite elements in 2 dimensions. The modeling is done in COMSOL Multiphysics® Modeling. The result of the modelisation is given in Fig. 1.

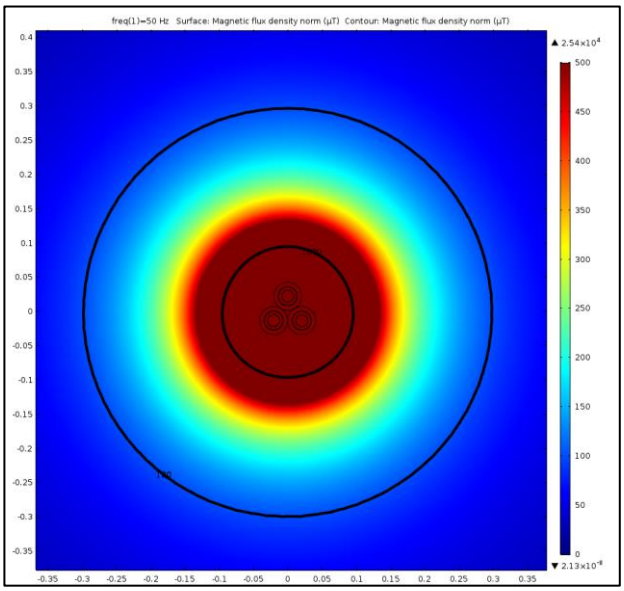

Fig. 1 - The magnetic field [µT] around a cable (distance in [m])

The model does not take into account the galvanized steel ladders. Galvanized steel is a low-magnetic steel, its shielding capacity extends only to high frequency and not to 50 Hz frequency.

The current is 630 A.

The value of the magnetic field decreases with the distance of the cable and the two circles in black give the distance at which the field decreased down to 1000 µT (limit for workers) and 100 µT (limit for the general public). The value of 1000 µT is located 10 cm from the cable; the value of 100 µT is reached at 30 cm from the cable. Consequently, a safety distance of 10 cm for workers, and 30 cm for the general public can be respectively defined.

IV. CONCLUSION

The values for the electromagnetic field around installations of industrial processing can be easily obtained by measurement and/or by numerical modelling. The European Directive 2013 /35/EU and the European Council Recommendation 1999/519/EC provide limits for safety assessments for workers and the general public. The assessment is not only a legal obligation, but it offers also a possibility to define safety distances where necessary.

REFERENCES

[1] DIRECTIVE 2013/35/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields).

[2] https://www.icnirp.org/

[3] COUNCIL RECOMMENDATION of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC).

[4] Cigré Technical Brochure 795 – Extrapolation of measured values of power-frequency magnetic fields in the vicinity of power links (2020), Cigré WG C4.28, www.e-cigre.org.