Experimental research on electromagnetic disturbance level in a thermoelectric power station

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Abstract: - The paper is structured in four parts. In the first part there is presented the specific issues of risk level evaluation. Part two consists of a bibliographical summary regarding the electromagnetic field (EMF), emphasizing EMF with industrial frequency. In the third part the measurements results of the induction electromagnetic field in a thermoelectric plant are given, and noise level measurements on the same points in which the magnetic field induction was measured. Also we present the results obtained by processing experimental data, referring to the two values (magnetic induction and noise level) using the statistical model of experimental data processing and assessing the risk level. The last part of the paper contains the research conclusions that focus primarily on: comments and comparisons on the level of risk and comments on the relationship between the magnetic induction and electrical noise level.

Key-Words: - electromagnetic field, experimental research, risk, thermoelectric power station.

1 Introduction

According to [1] the risk means "the possibility of reaching a danger, of having to face a trouble or suffered a loss, potential danger" (derived from the French “risque”). The notion of risk is used in many fields [2] (9-10), [3] (245-251), [4] (pp.215-216), with different connotations, sometimes improperly. According to the defined notion [1] (pp. 223-224), the risk is related to a random event (uncertainty) and to a specific hazard.

Risk analysis involves: identifying risk factors, assessing the level of risk and risk management. Risk factors are practically the causes that lead to the initiation and propagation of an undesirable event. The establishment and the spread of risk has generally two sequences (Fig. 1): inherent risk (initial or initiator) and associated risk (concourse risk).

The assessment of the level of risk involves determining the values of following:
• probability of occurrence (p) of the unwanted event, in the analysis period;
• frequency of occurrence (f) of the undesirable event in the analysis period;
• size (gravity) of the effect (k).

The size of the consequences is assessed, in instance, depending on: the impact over life and/or health of people (social consequences), the environmental impact (ecological consequences), the economic impact (losses).

Risk management involves anticipating the possibilities of occurrence, the coordination of actions to minimize the consequences. A key direction in power systems risk management is the protection against accidents and illness caused by the interference of some disturbance agents in the working environment.

The paper is devoted to analysis, based on experimental data, of the risk of exceeding the allowable values, in the most vulnerable areas of a thermoelectric power station (TPS), of the following sizes:

• Electromagnetic field induction (B_m)
• Level of noise (Z_m)

We also seek a possible influence on the level of electromagnetic disturbance over the noise level.

To assess the level of risk will proceed according to those proposed in [5] assessing the probability (p) that the measured values of magnetic induction (B_m) and the noise level (Z_m) to exceed the allowable (B_a, Z_a) of these sizes.

Assessment will be made in two situations:
HP. 1: Allowable values are fixed, given in a normative; HP. 2: Allowable values are, in fact, medium values of some random variable sizes.

Hypothesis 2, is justified on the grounds that, the body reaction to the presence of disturbances is differentiated according to the inherent characteristics and of the extrinsic influence factors. It's natural to assume a dispersion of the allowable limits, due to differential characteristics of human been, and by the factor variations.

The measured values \((B_{m}, Z_{m})\) have the character of stochastic variable sizes that fall naturally in the normal distribution with parameters: medium values \((m)\) and dispersion \((\sigma)\) [2, 3, 4]. For this reason, for assessing the risk level, we work with normal distribution, using appropriate models for the two hypotheses.

In the first hypothesis the representation of figure 1 is valid, and for the second hypothesis the representation of figure 2. In the second hypothesis we assume the two values acceptable \((B_{a}, Z_{a})\) random variables with normal distribution. Following equivalences are made

\[ X \equiv \{B, Z\}, \quad X_{a} \equiv \{B_{a}, Z_{a}\}, \quad X_{m} \equiv \{B_{m}, Z_{m}\}. \]

\[ f(X) = \frac{1}{\sqrt{2\pi}\cdot\sigma} e^{-\frac{(X-m)^2}{2\sigma^2}} \]

\[ f(X_{a}) = \frac{1}{\sqrt{2\pi}\cdot\sigma} e^{-\frac{(X_{a-}-m)^2}{2\sigma_{a}^2}} \]

\[ f(X_{m}) = \frac{1}{\sqrt{2\pi}\cdot\sigma_{m}} e^{-\frac{(X_{m}-m)^2}{2\sigma_{m}^2}} \]

\[ X_{a} \quad X_{m} \quad X \]

\[ p_{1} \]

\[ p_{2} \]

Fig. 1 Risk level evaluation in hypothesis HP 1

Fig. 2 Risk level evaluation in hypothesis HP 2

Relations for calculating the risk level \(p_{1}\), \(p_{2}\) for hypothesis HP1, respectively HP 2 are:

\[ p_{1} = \frac{1}{\sqrt{2\pi}\cdot\sigma_{m}} \int_{X_{m}}^{\infty} e^{-\frac{(X_{m}-m)^2}{2\sigma_{m}^2}} dX_{m} \quad (1) \]

\[ p_{2} = \frac{1}{\sqrt{2\pi}\cdot\sigma_{m}} \int_{X_{m}}^{\infty} e^{-\frac{(X_{m}-m)^2}{2\sigma_{m}^2}} dX_{m} + \frac{1}{\sqrt{2\pi}\cdot\sigma_{a}} \int_{X_{a}}^{\infty} e^{-\frac{(X_{a}-m)^2}{2\sigma_{a}^2}} dX_{a} \quad (2) \]

2 Layout of the effects of the EMF

The problem of the biological effects of electromagnetic fields is discussed for over four decades; the international scientific community is still seeking a definitive answer. In general, it's analyses, separately, the effects of low frequency fields 50 Hz or 60 Hz and the effects of high frequency electric fields (0.9 - 1.9) GHz [6, 7, 8]. The effects of electric and magnetic fields (EMF) on living organisms it's due to the conversion of their energy into other forms of energy (thermal, mechanical, electrical, chemical, etc...) inappropriate for the organism. Serious consequences certainly occur [9, 10] during the long-term exposure to EMF of a certain intensity, but in case of dynamic tension to the organism (changes caused by short circuits or atmospheric discharges, changes caused by a oscillating system in relation to EMF). The risk of serious consequences may be magnified if, in addition to the initial risk factor (EMF), there are additional factors (eg. psychological stress, some degradation of general health, etc.). Thermal effect of EMF on biological systems is well known currently, more difficult to quantify are the others effects of EMF (mechanical, chemical, electrical) which can influence the exchange of information with the outside over plasma membranes or may have the opposite effect of heating [9].

Parameters characterizing the biological effects of the exposure of the human body in electric field are: electric field \((B)\) and induced current density \((J)\). The link between the two parameters is based on the law of electromagnetic induction and electric conduction law, having as an influence factor equivalent conductivity of the human body [11, 12].

Currently, it operates primarily with the accepted limits of electromagnetic induction \((B_{a})\) easily measurable limits based on thermal effect of EMF on the human body.

There are several organizations, internationally recognized [13, 14, 15], which sets acceptable limits for (B) starting from the fact that the “specific power absorption rate” (SPAR) [10] indicator can not be measured directly for professional and public area. International Commission on Non-ionizing Radiation Protection (ICNIRP) is a nongovernmental organization whose acts, based on a broad consensus on the scientific results of the protection against the effects of EMF are recommended by the EC and are the basis of national standards.

This paper refers to the EMF of industrial frequency (50 Hz) of professional domain, in which case, the permissible values are shown in [13, 14, 15, 16].
Noise caused by any source, has obviously, negative effect on living organisms, including humans. Noise is generated within the TPS, mainly mechanical and electromagnetic processes. Noise is also limited by specific standards [17]. EMF noise interference can worsen with cumulative effects, which justifies conducting of combined research.

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3 Results obtained

Methodology for assessing the risk level was applied with reference to the four areas investigated in TPS Oradea

- Electric connection station (ECS);
- Electric generators (EG);
- Electric power transformers (EPT);
- Electrical control room (ECR).

The instruments used for making measurements were teslamerter CA 40 GAUSSMETER for measuring the magnetic field induction, and a sound level meter 2800 QUEST for noise measuring.

Referring to how to perform measurements were done, required some clarification:

a) Induction of EMF was measured at 1.8 m height, in points located at a distance of 1m from the equipment investigated, as follows:

- In 30 points from ECS near each medium voltage cells, in 3 different points;
- In 20 points around the two EG in operation when measurements were perform;
- In 12 points around the four EPT under load during the measurement period;
- In 23 points of the ECR, marked in Fig. 3.

![Fig. 3. Example given regarding the points](image)

Noise level was measured in the same points as the EMF induction. Values for $Z_m$ are more homogeneous than those obtained for $B_m$, they are not suitable for statistical processing, and they are presented in Table 1.

<table>
<thead>
<tr>
<th>Investigated area</th>
<th>EGS</th>
<th>EG</th>
<th>EPT</th>
<th>ECR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement points</td>
<td>1.</td>
<td>52</td>
<td>93</td>
<td>67</td>
</tr>
<tr>
<td>2.</td>
<td>50</td>
<td>98</td>
<td>68</td>
<td>64</td>
</tr>
<tr>
<td>3.</td>
<td>51</td>
<td>92</td>
<td>63</td>
<td>61</td>
</tr>
<tr>
<td>4.</td>
<td>49</td>
<td>91</td>
<td>64</td>
<td>65</td>
</tr>
<tr>
<td>5.</td>
<td>50</td>
<td>-</td>
<td>65</td>
<td>59</td>
</tr>
<tr>
<td>6.</td>
<td>54</td>
<td>-</td>
<td>67</td>
<td>58</td>
</tr>
<tr>
<td>7.</td>
<td>53</td>
<td>-</td>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td>Average Value</td>
<td>51</td>
<td>93</td>
<td>67</td>
<td>62</td>
</tr>
<tr>
<td>Allowable values ($Z_a$ [17])</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Referring to the induction of EMF ($B_m$), the work has been summarized in graphical form and tabular results referring to the 4 areas of the TPS. A peculiarity of the four case studies is to allow an equal dispersion of allowable values measured ($\sigma_{Em} = \sigma_{Ea}, \sigma_{Bm} = \sigma_{Ba}$), at the second hypothesis. Another feature is that if in EGS and EG case, the measured values ($B_m$) are significantly higher than allowed ($B_a = 5\mu T$). For this reason, for these two areas, a random calculation variable was defined:

$$B_c = B_m - B_a$$  \hspace{0.5cm} (3)

For this random variable the average value and dispersion are calculated [2, 3, 4]

$$m_{Bc} = m_{Bm} - m_{Ba}$$  \hspace{1cm} (4)

$$\sigma^2_{Bc} = \sigma^2_{Bm} + \sigma^2_{Ba}$$

In these circumstances, the level of risk, if one accepts the hypothesis of calculation. 2 (HP 2), is calculated as follows:

$$p_2 = \text{Prob.} (B_m > B_a) = \text{Prob.} (B_c > 0) = \int_{0}^{\infty} f(B_c)dB_c$$  \hspace{0.5cm} (5)

The results obtained referring to the induction of EMF is presented in Fig. (4 ÷ 7) where probability density functions are shown (PDF) and are presented in Table 2 where the characteristic values of random variable "B".

![Fig. 4. PDF for magnetic induction (B) at EGS level](image)
4 Conclusion

Matters concerning occupational health risks to staff operating at TPS, by considerations of exposure to electromagnetic interference and noise, have not yet received categorical responses, and require deep studies, with the participation of some specialists in the fields concerned: engineers, doctors, biologists, psychologists. Disturbance level was assessed based on magnetic field induction values (B) and noise values (Z).

Measurements taken in the four areas of TPS Oradea, presumable of being electromagnetic noise disturbed terms reflect the following results:

- Noise level is:
  - in permissible limits, according to [17] in EGS and ECR;
  - over the admitted limits according to [17] in EPT and EG.
- The induction of the EMF is differentiated in the four areas, namely:
  - in EGS and around EG the measured values exceed the amounts allowable, risk of exposure over the allowable values being 70% - in EGS, and respectively 84% - in the EG;
  - in the EPT zone and the ECR zone, the measured values are below the acceptable risk, exposure of workers to values exceeding the permissible limit is practically zero;
- Comparative analysis of the values of induction noise and EMC shows that these phenomena do not influence each other, although both have adverse effects on human environment.

References:


[4] I. Felea, “Ingineria fiabilității în electroenergetică” (Reliability engineering of the power systems), (EDPRA București, 1996);


[8] D. Cristescu., M.Ungureanu, “Relaţia instalaţii electroenergetice – mediu şi fundamentarea elementelor de impact” (Relation between power electric installations-environment and base of the impact elements), ( Rev. Energetica, 46, 6, pp. 285-293, 1998);

[9] M. Ianoz, “Efecte biologice ale câmpurilor electromagnetice” (Biologically effects of the electromagnetic fields), (Rev. Producerea, transportul şi distribuţia energiei electrice şi termice, 10, (2000);


[14] *** European Committee For Electro Tehnical Standardisation (CENELEC), SC111A: Human exposure to Electromagnetic Fields, April 1993;


[16] *** Hotărârea 1136 din 30/08/2006 privind cerințele minime de securitate și sănătate referitoare la expunerea lucrătorilor la riscuri generate de câmpuri electromagnetice (Decision 1136 from 30/08/2006 regarding the minimal security and health requirements referring on the workers expose to risk generated by electromagnetic fields), (Monitorul Oficial, Partea I, nr. 769 din 11/09/2006);