Research of Influence of Noise Pollution on the Value of the Threshold Current Tangible

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Abstract. Stable safety while working on electrical installations can be achieved by following the rules of the electrical safety. Today maximum permissible levels of touch voltage and electric current flow through any part of a person's body are established by Russian Federation GOST system 12.1.038-82. Unfortunately, recommended by International Electrotechnical Commission (IEC) maximum allowable amount of electric current and voltage level do not take into account interaction between said electric current and other physical factors; noise, in particular. The influence of sound frequency and its pressure level on body resistance has been proven earlier in thesis by V.V. Katz. Studies of the noise effects on the value of the threshold current tangible have been renewed in laboratories of Life Safety Department in South Ural State University. To obtain reliable results, testing facility that includes anechoic chamber, sources of simulated voltages and noise and a set of recording instruments was designed and built. As a rule, noise influence on electrotechnical personnel varies depending on noise level or/and the duration of its impact. According to modern theories, indirect noise influence on various organs and systems through central nervous system has to be considered. Differential evaluation of noise pollution and its correlation with emerged effects can be obtained with the usage of the dose approach. First of all, there were conducted studies, in which frequency of the applied voltage (f) was 50 Hz. Voltages and currents that caused sensations before and during 97 dB noise affections were measured. Obtained dependence led to questioning previous researches results of the necessity of reducing the amperage of tripping protection devices. At the same time electrical resistance changes of human body were being studied. According to those researches, no functional dependence between fluctuations in the magnitude of the resistance of human body to electric current flow and constant noise affection were found. Taking into account that contradiction, additional studies of primary electrical safety criteria for cases when exposed to high frequency noise pollution were conducted.

1. Introduction
Preventing injuries from electricity is a priority in the organizations of energy profile. According to the frequency of deaths cases of electrocution are much greater than other types of injuries. Sustaining the safety when working in electrical installations is achieved by compliance with electrical requirements. Currently in force in the Russian Federation GOST 12.1.038-82 establishes the maximum permitted levels of touch voltages and currents flowing through the human body, taking into account the duration of exposure [1]. Studies conducted in the South Ural enterprise of backbone electrical grids, show that in most cases the working conditions of the personnel engaged in the power industry...
enterprises, are harmful to varying degrees. At the same time one of the factors determining the conditions of work, is the noise.

2. Methodical bases

For increased noise sources in the main electric networks include power transformers, autotransformers, air circuit breakers, the phenomenon of the corona, compressors and other equipment.

Unfortunately, the currently recommended International Electrotechnical Commission (IEC), the maximum allowable current and voltage levels do not account touch joint action of the electric current, and other physical factors, such as noise.

Factors for the most part of the electric nature, devoted to research works of V.I. Shchutsky, V.E. Manoilov, B.G. Menchov, P.A. Dolin, A.I. Sidorov. On the influence of the factors of non-electrical nature of science has a lack of knowledge. More research is needed, in particular, studies on the effects of industrial noise.

Earlier thesis V.V. Katz has been proven to influence the sound pressure level and frequency of the resistance of the human body \[2\]. As a result of studies it found that intermittent noise has a more significant effect than constant throughout a work shift. However, further research in this direction was not followed.

At the Department of life safety of the South Ural State University have been renewed in the laboratory studies the effects of noise on the value of the threshold current tangible. To obtain reliable results, was designed and built testing facility including anechoic chambers, sources simulated stress and noise, block recording devices \[3\]. The features of the source of the simulated strains are opportunities for influencing the signals of any shape and frequency, as well as provide a constant rate of rise of the signals.

Noise impact on the electrical staff, as a rule, is unstable in terms of noise and (or) time of its action. This is due to the presence of diverse technological equipment and the different duration of technological operations. To assess the effect of the noise factor is used the concept of the equivalent sound level, which reflects the value of the level within a certain time, averaged over the rule of the same energy \[4\]. With this approach, an essential criterion valuations are functional changes in the audio analyzer (preservation of auditory perception).

According to modern concepts must be considered indirectly through the central nervous system effects of noise on the various organs and systems. Differentiated evaluation of noise pollution and the subsequent correlation with it causes the effect can be obtained in the case of the dose approach. According to \[4\], as the characteristics of this production factor is allowed to use the noise dose, as an integral value that takes into account the acoustic energy, acting on a person for a certain period of time (accumulation of noise exposure)

\[
D = \int_0^T p_A^2(t)dt \quad D = \int_0^T p_A^2(t)dt
\]

But practical interest is not the absolute value of the energy, and with respect to its assessment of a percentage of the allowable value

\[
D_{rel} = \frac{D}{D_{per}} \cdot 100
\]

From a physical point of view, equivalent sound level and noise dose are analogues and mathematically interrelated \[5-9\].

The developed experimental setup allows you to simulate the noise pollution with any parameters on the selection of the researcher and provide the necessary relative noise dose (Drel) on the selected time interval. According to the method of \[10\], the simulated load must comply with the noise load per shift, that is Drel = 100%. It is assumed that the workplace provided for permissible noise factor working conditions, that is 80 dB \[4\]. Taking the duration of each experiment of 30 minutes, we obtain the dependence of the equivalent sound level of noise relative dose, guided by GOST 12.1.003-83.
Table 1. Correlation between equivalent sound level and the relative noise dose (for 30-minute acoustic impact)

| Relative noise dose, % | Equivalent sound level, dB |
|------------------------|---------------------------|
| 3.2                    | 82                        |
| 6.3                    | 85                        |
| 12.5                   | 88                        |
| 25                     | 91                        |
| 50                     | 94                        |
| 100                    | 97                        |

Noise limit value has been recalculated in accordance with this duration [4]. Reducing the exposure time from 8 hours to 30 minutes, in our opinion, it is possible to obtain a linear dependence of the effects of noise on the threshold current is significant.

The graphic interpretation of the dependence of the equivalent sound level of noise relative dose will be as follows (Figure 1).

![Figure 1. The dependence of the equivalent sound level of noise relative dose](image)

The monotony of rescheduling shows good correlation. From a functional point of view, we obtain a logarithmic dependence of the equivalent sound level of noise relative dose (for the 30-minute exposure) with the squared value of 1

\[
L_{eq} = 4.3536 \ln(D_{rel}) + 76.972
\]  

3. **Depending on the experimental**

First of all, studies have been conducted, in which the frequency of the applied voltage (f) is equal to 50 Hz. This is due to the fact that at a given frequency operates a significant part of the machinery and electrical equipment in any manufacturing industry. The studies were conducted on the way "hand - hand", measured voltages and currents, causing sensations to exposure to noise, and when exposed to noise levels of 97 dB.

The resulting dependence (3) allows you to make a return payment of the equivalent sound level in relation to the conditions of the experiment (Table 2).
### Table 2. Experimental data \((f_{\text{current}} = 50 \text{ Hz})\)

| Relative noise dose, % | Equivalent sound level, dB | The threshold current tangible, mA |
|------------------------|----------------------------|----------------------------------|
| 0                      | 77                         | 1.38                             |
| 17                     | 89                         | 1.43                             |
| 33                     | 92                         | 1.49                             |
| 50                     | 94                         | 1.58                             |
| 67                     | 95                         | 1.57                             |
| 83                     | 96                         | 1.59                             |
| 100                    | 97                         | 1.62                             |

Thus, it must be defined the maximum permissible sound levels at successive stages of the research, and now we can correlate these values with the measured values of tangible threshold currents (Figure 2).

Mathematically, the dependence of the threshold current of the tangible equivalent sound level can be expressed as a polynomial of order 2 with squared value equal to 0.9618:

\[
I_{TTC} = 0.001L_{eq}^2 - 0.1626L_{eq} + 7.9387
\]  

(4)

At the same time carried out the study changes the electrical resistance of the human body. According to the results of fluctuations in the value of the human body resistance to electric current when exposed to constant noise during the working shift does not have a clearly defined functional dependence. The difference between the maximum and the minimum value is 1 kΩ.

The analysis presented depending casts doubt on previously obtained in [2] the result of the need to decrease the setting trigger tripping devices. Given this contradiction, further studies were carried out of the primary criteria for electrical high frequency when exposed to noise pollution. The frequency of 5000 Hz is used in combination Electronic Equipment rail mine transport with inductive transmission of energy moving objects [11].

Experimental conditions are the same as in the previous study. The obtained values of the sound level measured and appreciable current threshold values are summarized in Table 3.
Table 3. Experimental data ($f_{\text{current}} = 5000$ Hz)

| Relative noise dose, % | Equivalent sound level, dB | The threshold current tangible, mA |
|------------------------|-----------------------------|----------------------------------|
| 0                      | 77                          | 8.02                             |
| 17                     | 89                          | 8.29                             |
| 33                     | 92                          | 8.62                             |
| 50                     | 94                          | 8.60                             |
| 67                     | 95                          | 8.77                             |
| 83                     | 96                          | 8.83                             |
| 100                    | 97                          | 8.86                             |

Graphic dependence of the threshold current of the tangible equivalent sound level during the high-frequency voltage is shown in Figure 3.

![Figure 3. The dependence of the threshold current of the tangible equivalent sound level ($f_{\text{current}} = 5000$ Hz)](image)

From a mathematical point of view, this relationship takes on the character of a polynomial of order 2:

$$I_{\text{TTC}} = 0.002L_{eq}^2 - 0.3052L_{eq} + 19.617$$

(5)

In this case, the squared value was 0.9666. The measured values of the human body resistance to electric current are independent. This oscillation interval of the order of 0.03 Ω.

4. Conclusion

Thus, the experiments carried out by us suggest about the impact of noise on the value of the threshold current tangible. According to those researches, no functional dependence between fluctuations in the magnitude of the resistance of human body to electric current flow and constant noise affection were found. Taking into account that contradiction, additional studies of primary electrical safety criteria for cases when exposed to high frequency noise pollution were conducted.

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