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Estimation Of Electrical Equipment Service

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Abstract

This article examines the possibility of determining the indicators for the qual-ification of personnel servicing electrical installations based on statistical data based on the frequency and duration of the work carried out by a group of electrical engineers to eliminate the failure. And also the subsequent transition to the time characteristics, showing the productivity of the work of a separate electrician. Key words: operating time to failure, personnel qualifications, trouble-free operation, distribution laws, preventive inspections, electrical equipment.

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1. Introduction

Electric grid organizations, as well as enterprises, consumers of electricity have a large number of electrical equipment that needs regular preventive mainte-nance. Periodic maintenance of the devices is performed by personnel responsible for a certain area in accordance with the completed inspection schedule, which makes it possible to ensure trouble-free operation of the system by means of equip-ment failure warnings [1,2]. Naturally, personnel involved in repair activities must have a high level of skill.

2. Theory of the question

Regardless of the type (brand) of electrical equipment, the location at the ap-propriate level of the electricity supply system for effective operation after a certain time, the equipment must undergo preventive maintenance. In systems, sudden fail-ures are possible, they must also be eliminated. It should be, first of all, to assess the level of those who eliminate failures and conduct maintenance and preventive examinations. Improving the trouble-free operation of electrical equipment, and therefore the system as a whole [3], is the quality of service of the system and a reduction in the time spent on maintenance and preventive inspections.

The time of preventive examinations θ consists of a number of components. These include the detection time of a possible failure tde, organizational time tor, this is the preparation time, carrying out preventive maintenance, the elimination time of violations in the work of equipment tl, the time of testing the equipment tte operation to the point of inclusion in the work that has undergone preventive examination of equipment tex. Then

$$\bar{\theta} = t_{de} + t_{or} + t_1 + t_{te} + t_{ex}.$$

The time of the components of expression (1) depends on the level of organization of work at the enterprise and, first of all, the qualification of the maintenance staff. For electrical equipment of levels 2-6 of power supply systems of an industrial enterprise, approximate durations, referred to the total duration of preventive maintenance of equipment, are given in Table 1.

Table1 Percentage of the components of the duration of repair and maintenance inspections of electrical equipment

t_{de}	t_{or}	t_l	t_{te}	t_{ex}
10-15	25-50	40-65	5-10	1-5

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The time of detection of a possible failure of electrical equipment as a percentage of the total time of the repair and preventive examination is up to 15%. The organizational component consists of the time for preparation and delivery of tools, spare parts, backup electrical equipment, materials for repair. This component reflects the level of the the repair service organization, the backup equipment, provision spare parts and materials. It can be up to half the time from the total duration of the repair and preventive examination. The larger the dimensions, volume, weight (metal consumption) of electrical equipment, the greater the organizational time.

From the total time this component can reach up to 50% of the total time for the prevention of equipment. If the reserve electrical equipment, spare parts are stored in the workshop or their delivery to the service site of electrical equipment is not difficult, this component does not exceed more than 40%. Substitutions that have undergone analysis of parts, assemblies, and equipment depend significantly on the number of personnel involved in the prevention of equipment and their qualifications, and represent up to 50% of the total time for examination. The sampling time does not exceed 10%, and the commissioning of equipment is usually 5%.

3. Experiment Procedure

The components of the inspection time are not constant. They depend on many factors, so they are random. They are characterized by average parameters and laws of distribution of random durations. The laws of distribution of components reflect the law of distribution of the time for carrying out preventive examinations [4,5]. It is defined by expression

$$\beta(\theta)=\frac{\overline{P}_{de}}{\overline{P}}\beta(t_{de})+\frac{\overline{P}_{or}}{\overline{P}}\beta(t_{or})+\frac{\overline{P}_{1}}{\overline{P}}\beta(t_{1})+\frac{\overline{P}_{te}}{\overline{P}}\beta(t_{te})+\frac{\overline{P}_{ex}}{\overline{P}}\beta(t_{ex}).$$

If we take into account that the probability of the duration of the preventive examinations is

$$\overline{P}=\frac{\overline{\theta}}{\overline{\tau}+\overline{\theta}},$$

and the probability of a component of preventive examinations, for example, elimination of violations

$$\overline{P}_1=\frac{\overline{\theta}_1}{\overline{\tau}+\overline{\theta}},$$

then the density, probability distribution of the duration of preventive inspections of electrical equipment, will be

$$\beta(\theta)=\frac{\overline{\theta}_{de}}{\overline{\theta}}\beta(t_{de})+\frac{\overline{\theta}_{or}}{\overline{\theta}}\beta(t_{or})+\frac{\overline{\theta}_{1}}{\overline{\theta}}\beta(t_{1})+\frac{\overline{\theta}_{te}}{\overline{\theta}}\beta(t_{te})+\frac{\overline{\theta}_{ex}}{\overline{\theta}}\beta(t_{ex}),$$

where β (θ) – is the probability density of the distribution of the durations of preventive inspections of electrical equipment; P – probability of duration of preventive examination; P_{de}, P_{or}, P_1, P_{te}, P_{ex} – respectively, the probabilities of the time of detection of damage to equipment, organizational time, the time to repair the damage, the time of testing the health of the equipment and the time of switching on the equipment; θ_{de}, θ_{or}, θ_1, θ_{te}, θ_{ex}, – average time of detection of equipment damage, organizational time, the time of elimination of damage to equipment, the time of sampling and the time of switching on the equipment; $\beta(t_{de}),\beta(t_{or}),\beta(t_1),\beta(t_{te}),\beta(t_{ex})$ – according to the probability density of the distribution of the detection time of violations, the organizational time, the time for elimination of violations, the time of sampling and the inclusion in the operation of electrical equipment.

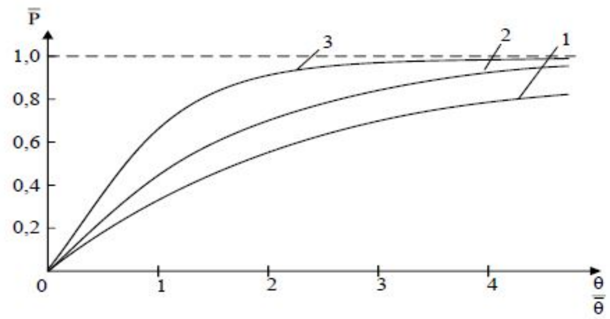

Figure 1. Dependence of probability of duration of examinations for exponential – 1, log-normal – 2 and truncated-normal – 3 distributions

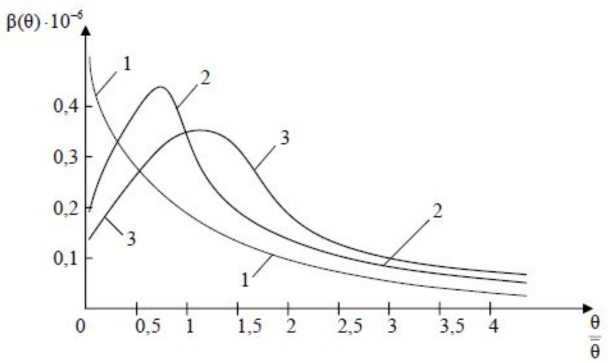

Figure 2. Dependences of the distribution functions of the duration of preventive examinations for exponential – 1, log-normal – 2 and truncated-normal – 3 distributions

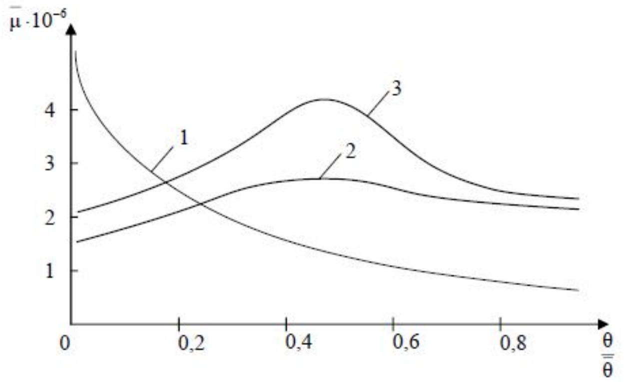

Figure 3. Dependences of the frequency of preventive examinations for exponential – 1, log-normal – 2 and truncated-normal – 3 distributions

Based on the experimental data, the dependencies of the probability of the duration of the examinations, the probability density and the frequency of the examinations were constructed depending on the current value of the duration of the examinations to its mathematical value (Fig. 1 - Fig. 3). It should be noted that while the standard deviation for the log-normal distribution was σ = 0.3, and the truncatednormal deviation σ = 0.3, the normalizing factor γ = 0.4.

4. Discussion of the result

Analysis of the graphs in Fig. 1 - Fig. 3, constructed on the basis of production data obtained from electrical equipment cards, in which all its dependencies on functioning are indicated, shows that the exponential distribution of inspection durations is the most advantageous. This distribution type demonstrates the optimal ratio of probability indicators, the shortest recovery time of equipment β(θ), with a low probability of failure of devices P , as well as the lowest frequency of works. The exponential impulse distribution flows is 30% more efficient than the rest, as discussed in previous papers [5]. It corresponds to the highest qualification of the maintenance staff, as the achievement of high quality indicators of ongoing work and a reduction in maintenance time is possible only in this case. The worst preventive parameters examinations are observed with a truncated-normal distribution of durations.

With a more detailed functions examination, it is possible to identify the following features regarding their forms. The exponential law is displayed by a curve line, while the logarithmically normal law is represented by a figure. To bring it to the form of an exponential, it is required to take the root-mean-square value equal to zero.

The truncated-normal distribution appears to be a more complex form figures. In this case, for simplification, it is necessary to operate both the mean-square value and the normalizing factor, even such a simple analysis indicates a decrease in the values of the mathematical expectation of the failure duration under the exponential law in comparison with the remaining distributions. It should also be emphasized that the root-mean-square deviation increases the duration failures, especially when combined with an increase in the normalizing index, this also complicates the calculation process.

If in the information cards the operating time for the failure of electrical equipment [6,7] are given in the machine-hours, then the transition to the calendar clock is necessary. The transition to the calendar clock is made by using the operating time of the electrical equipment per day, then

$$\bar{\tau}_{ch} = 24\bar{\tau}_{m} t_{d}^{-1},$$

where ch – the operating time for failure of electrical equipment in calendar hours; 24 – the number of hours per day; m – time between failures in a machine clock; d t – duration of the equipment operation per day, h.

In production reports, and often in literary sources, the time spent on conducting preventive inspections and the time per one electrician are indicated. In order to compare the results of published sources with the calculated analysis data, it is proposed to apply the dependence

$$\bar{\theta} = K_{pr} t_{r},$$

where Kpr – is a coefficient that reflects the number of electricians performing repair and preventive inspections; tr – is the time for inspections by one electrician.

5. Conclusion

The considered dependencies can be used in the transition from the time between failures in the machine-hours to the calendar hours, from the average time of preventive inspections of electrical equipment by a group of electricians to the time duration of inspections by one electrician, to evaluate the laboriousness of preventive examinations, to compare the results reflecting the characteristics reliability in different sources.

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