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CRITERIA THE ESTIMATION EXPEDIENCY OF CLASSIFICATION INFORMATION ON RELIABILITY OF THE EQUIPMENT AND DEVICES EPS

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Abstract

Analysis of statistical data about refusals, maintenance service and repair of objects of electric systems, is an indispensable condition of a quantitative estimation of reliability of their work. The analysis assumes classification of data on a sort of attributes and their versions. Thus, the basic question there is a revealing significant version of attributes. The importance of an attribute established based on statistical criteria of check of hypotheses. The criteria based on boundary fiducially estimation of intervals are offered.

INTRODUCTION

Necessity and methodology of the analysis of reliability of work of the equipment and devices (objects) of electro power systems (EPS) according to about their deterioration, refusals, tests and restoration of a technical condition are regulated by corresponding Normative materials. Prominent feature of these data is dependence on the big number of attributes and their versions. This dependence carries data to a class multivariate. Multivariate character of data not considered at a quantitative estimation of parameters of reliability (PR) objects EPS.

1. Classification parameters of reliability of objects EPS

The variety of properties of reliability and describing these properties PR causes necessity of grouping PR on a way of calculation. As an example in table 1 formulas of calculation of the some PR power units (PU) TPS are resulted. Following designations are accepted: $\mathbf{n}_{б}$ – number of power units; $\mathbf{m}_{от,i}$ – number of switching-off i-th PU; $\mathbf{m}_{от,\Sigma}$ - number of switching-off of all PU; $\tau_{p,i,}$ - j- th realization of duration of the worker (p) conditions i-th PU; $\mathbf{m}_{ав,i}$ – number of emergency switching-off i- th PU; $\mathbf{m}_{ав,\Sigma}$ – number of emergency switching-off of all PU; $\tau_{ав,i,j}$ - j-th duration of emergency switching-off i-th PU; $\mathbf{m}_{н.п.,i}$ – number of unsuccessful start-up i-th PU; $\mathbf{m}_{п\ i}$ – number of start-up i- th PU; $\tau_{нп,\ i,j}$ - duration j- th idle time after unsuccessful start-up i-th PU; $\mathbf{m}_{x.p.,i}$ – number of switching-off in a cold reserve i-th PU; $\mathbf{m}_{x.p.ав,i}$ – number of translations PU from a condition of cold reserve in an emergency condition; $\tau_{п.р.,i}$ – duration of idle time in scheduled repair i-th PU.

Let's distinguish PR, calculated as:

- an average arithmetic random variables. According to tabl.1 is T_{p}^{*} and $T_{ав}^{*}$;

- relative size of total duration of a condition. As an example parameters $P^*_{ав}$, $P^*_{р}$, $P^*_{х.р.}$ serve (see tabl.1.)
- probability of occurrence of event. In tabl.1 it- $Q^*_{ав}$, $Q^*_{п}$, and $Q^*_{х.р.}$
- specific number of events. In table 1 it is specific number of emergency switching-off PU ($h^*_{ав}$) and its versions (automatic switching-off PU, emergency switching-off PU by the personnel, manually, switching-off PU under the emergency application).
- function noted above individual parameters. In table 1 the factor of readiness $K^*_{г}$ and factor of technical use $K^*_{т.и.}$ are resulted.

Table 1. Sample of parameters of reliability of power units 300 MWt TES

Condition	Parameters of reliability	Formula of calculation
	Individual parameters	
Finding PU in work	Relative size of total duration of work PU within year, %	$P^*_p = \sum_{i=1}^{n_б} \sum_{j=1}^{m_{от,i}} \tau_{p,i,j} / n_б \cdot 8760$
	Average duration of continuous work, cl	$T^*_p = \sum_{i=1}^{n_б} \sum_{j=1}^{m_{от,i}} \tau_{p.i,j} / \sum_{i=1}^{n_б} m_{от,i}$
Emergency остановв PU	Specific number of emergency switching-off (on 1000 cl. works)	$h^*_{ав} = 10^3 \sum_{i=1}^{n_б} m_{ав,i} / \sum_{i=1}^{n_б} \sum_{j=1}^{m_{OT}} \tau_{p,i,j}$
	Specific number of switching-off under the emergency application;	$h^*_{а.з.} = 10^3 \sum_{i=1}^{n_б} m_{аз,i} / \sum_{i=1}^{n_б} \sum_{j=1}^{m_{OT}} \tau_{p,i,j}$
	Specific number of automatic switching-off at system failures	$h^*_{a.o} = 10^3 \sum_{i=1}^{n_б} m_{a.o.,i} / \sum_{i=1}^{n_б} \sum_{j=1}^{m_{OT}} \tau_{p,i,j}$
	Relative number of emergency switching-off	$Q^*_{ав} = \sum_{i=1}^{n_б} m_{ав.,i} / \sum_{i=1}^{n_б} m_{от,i}$
Finding in emergency repair PU	Average idle time in emergency repair, cl.	$T^*_{ав} = \sum_{i=1}^{n_б} \sum_{j=1}^{m_{ав,i}} \tau_{ав.i,j} / \sum_{i=1}^{n_б} m_{ав,i}$
	Relative size of total duration of idle time in emergency repair, cl.	$P^*_{ав} = \sum_{i=1}^{n_б} \sum_{j=1}^{m_{ав,i}} \tau_{ав.i,j} / n_б \cdot 8760$
Preservation of equipment PU	Probability of refusal PU at start-up	$Q^*_{НП} = \sum_{i=1}^{n_б} m_{н.п.,i} / \sum_{i=1}^{n_б} m_{п,i}$
	Probability of translation in a condition emergency repair from a condition of a cold reserve	$Q^*_{рез,о.р.} = \sum_{i=1}^{n_б} m_{рез,о.р.} / \sum_{i=1}^{n_б} m_{рез,i}$
Cold reserve	Relative size of total duration of a finding in a cold reserve	$P^*_{рез} = \sum_{i=1}^{n_б} \sum_{j=1}^{m_{рез,i}} \tau_{рез.i,j} / n_б \cdot 8760$
Scheduled repair	Average duration of scheduled repair	$T^*_{п.р} = \sum_{i=1}^{n_б} \sum_{j=1}^{m_{п.р,i}} \tau_{п.р.i,j} / \sum_{i=1}^{n_б} m_{п.р.,i}$
Complex parameters		
Factor of readiness		$K^*_Г = P^*_p / (P^*_p + P^*_{ав})$
Factor technical uses		$K^*_{Т.И}. = (P^*_p + P^*_{ав} + P^*_{рез})$

2. Criteria of an estimation of character of a divergence $M^*_{\Sigma,Э}(\tau_{ав})$ and $M^*_{V,Э}(\tau_{ав})$.

Following criteria recommended:

Criterion K1. It is based on comparison of probability of empirical value of absolute size of a relative deviation $M^*_{V,Э}(\tau_{ав})$ from $M^*_{\Sigma,Э}(\tau_{ав})$ with critical (c) value of this probability equal α_k. Calculations spent in following sequence:

- the absolute size of a relative deviation $M^*_{V,Э}(\tau_{ав})$ from $M^*_{\Sigma,Э}(\tau_{ав})$ under the formula defined:

$$\delta M^*_{V,Э}(\tau_{ав}) = \frac{[(M^*_{V,Э}(\tau_{ав}) - M^*_{\Sigma,Э}(\tau_{ав})]}{M^*_{\Sigma.Э}(\tau_{ав})} \tag{1}$$

- tabulated data of [1] discrete values of statistical function fiducially distributions (s.f.f.d.) $F^*[\delta M^{**}_V(\tau_{ав})]$ the required probability is defined α_{v}=1- $F^*[\delta M^{**}_V(\tau_{ав})]$. Here $\delta M^{**}_V(\tau_{ав})$ - counted on the basis of imitating modeling (**) possible values of absolute size of a relative deviation $M^*_{V,Э}(\tau_{ав})$ from $M^*_{\Sigma,Э}(\tau_{ав})$.

Note. *Фидуциальные distributions for the first time have been entered into R.E.Fisherom's consideration in 30th years of the last century. These distributions characterize likelihood distributions of possible values of estimations of parameters of distribution of random variables. It specified that it is necessary to trust only statistical conclusions which basis is empirical data. A.N.Kolmogorov in 1942-year note, that fiducially probabilities and intervals are the most suitable at small number of supervision [2]. Transition from confidential intervals to fiducially is expedient at multivariate character of statistical data. Application to multivariate data of the mathematical device of functions of distribution of random variables of casual sample of general set can lead to erroneous recommendations. As it has noted been above the statistical data describing reliability of objects EPS concern to a class multivariate, and samples of these data on set version of an attribute (VA) – are not casual.*

- if α_v does not exceed α_k classification of set of statistical data on j- th versions i- th an attribute is inexpedient. In engineering calculations α_k is accepted usually equal 0,05 or 0,1.

Lack of this criterion is necessity of the reference to the tables setting discrete values fiducially distribution $F^*[\delta M_V(\tau_{ав})]$ allowing for set n_v and $\delta M^*_{V,Э}(\tau)$ roughly to define probability $F^*[\delta M^*_{V.Э}(\tau_{ав})]$.

Example 1. Let some data set is known about $\tau_{ав}$ PU TPS capacity 300 MWt $M^*_{V,Э}(\tau_{ав}) = 72{,}4$c.. Sample of realizations is received $\tau_{ав}$ for one of PU and settlement size $M^*_{V,Э}(\tau_{ав}) = 51$c. at n_v=2. It is required to establish character of a divergence $M^*_{\Sigma,Э}(\tau_{ав})$ and $M^*_{V,Э}(\tau_{ав})$. For the decision of this problem:

- it is calculated $\delta M^*_{V,Э}(\tau_{ав}) = \frac{[|51 - 72{,}4|]}{72{,}4} = 0{,}296$

- on tabl.1 [1] for n_v=2 we find probability $F^*[\delta M^{**}_V(\tau_{ав})] \cong 0{,}5$

- as α_v=0,5. and $\alpha_к$=0,05<<α_v, classification of a data set about $\tau_{ав}$ it is inexpedient.

Criterion K2. It is based on comparison $\delta M^*_{V,Э}(\tau_{ав})$ and $\delta M^*_{V,K}(\tau_{ав})$. According to the [1] size $\delta M^{**}_{V,K}(\tau_{ав})$ corresponding $\alpha_к$=1- $F^*[\delta M^{**}_{V,K}(\tau_{ав})]$, it is calculated under the formula

$$\delta M^{**}_{V,K}(\tau_{ав}) = A/\sqrt{n_V} \tag{2}$$

0,994 critical values $\delta M^{**}_{V,K}(\tau_{ав})$ approximating with accuracy for set α_k and n_v.

Here $\delta M^{**}_{V}(\tau_{ав})$ - realization of possible absolute values of a relative deviation $M^{**}_{V}(\tau_{ав})$ and $M^{*}_{\Sigma,Э}(\tau_{ав})$; $M^{**}_{V}(\tau_{ав})$ - realizations of the possible values $M^{*}_{V}(\tau_{ав})$ modeled on s.f.d. $F^{*}_{\Sigma}(\tau_{ав})$ for a preset value n_v; A – constant factor.

The size defined α_k. For $\alpha_к$=0,05 factor A=1,13, and for $\alpha_к$=0,1 – it is equal 0,95. Thus, classification of a data set $\tau_{ав}$ it is expedient, if $\delta M^{*}_{V,Э}(\tau_{ав})$ exceed $\delta M^{**}_{V,K}(\tau_{ав})$.

Example 2. We shall take advantage of data of an example 1. $M^{*}_{\Sigma,Э}(\tau_{ав}) = 72{,}4c.$ and $M^{*}_{V,Э}(\tau_{ав}) = 51c.$; n_v=2. Define critical value $\delta M^{**}_{V,K}(\tau_{ав}) = 1{,}13/\sqrt{2} = 0{,}80$. Thus, as $\delta M^{*}_{V,Э}(\tau_{ав}) \ll \delta M^{**}_{V,K}(\tau_{ав})$ classification of a data set with a significance value 0,05 is inexpedient.

The considered example shows, that criterion K2 is simple enough. It is necessary to execute only two elementary calculations.

Criterion K3. It is based on comparison of experimental estimations $M^{*}_{V,Э}(\tau_{ав})$ and $M^{*}_{\Sigma,Э}(\tau_{ав})$ with boundary values fiducially intervals

$$\left[\underline{M^{**}_{V,(1-\alpha_L)}}(\tau_{ав});\quad \overline{M^{**}_{V,\alpha_L}(\tau_{ав})}\right],$$

Calculated on s.f.f.d. $F^{*}[\delta M^{**}_{V,K}(\tau_{ав})]$.

Comparison carried out in following sequence:

If $$M^{*}_{V,Э}(\tau_{ав}) < M^{*}_{\Sigma,Э}(\tau_{ав}) \tag{3}$$

and $$M^{*}_{V,Э}(\tau_{ав}) < \underline{M^{**}_{V,(1-\alpha_k)}(\tau_{ав})} \tag{4}$$

where $$\underline{M^{**}_{V,(1-\alpha_k)}(\tau_{ав})} = M^{*}_{\Sigma,Э}(\tau)\cdot\left(1 - A\Big/\sqrt{n_v}\right) \tag{5}$$

That classification is expedient

If $$M^{*}_{V,Э}(\tau_{ав}) > M^{*}_{\Sigma,Э}(\tau_{ав}) \tag{6}$$

and $$M^{*}_{V,Э}(\tau_{ав}) > \overline{M^{**}_{V,\alpha_k}(\tau_{ав})} \tag{7}$$

where $$\overline{M^{**}_{V,\alpha_k}(\tau_{ав})} = M^{*}_{\Sigma,Э}(\tau)\cdot\left(1 + A\Big/\sqrt{n_v}\right) \tag{8}$$

That classification is expedient.

If the condition (3) is carried out,

and $$\underline{M^{**}_{V,(1-\alpha_k)}(\tau_{ав})} < M^{*}_{V,Э}(\tau_{ав}) \tag{9}$$

and $$M^{*}_{\Sigma,Э}(\tau_{ав}) > \overline{M^{**}_{V,\beta_k}(\tau_{ав})} \tag{10}$$

where $$\overline{M^{**}_{V,\beta_k}(\tau_{ав})} = M^{*}_{V,Э}(\tau)\cdot\left(1 + A\Big/\sqrt{n_v}\right) \tag{11}$$

That classification is expedient

If the condition (6) is carried out,

and $$\overline{M^{**}_{V,\alpha_l}(\tau_{ав})} > M^{*}_{V,Э}(\tau_{ав}) \tag{12}$$

and $$M^{*}_{\Sigma,Э}(\tau_{ав}) < \underline{M^{**}_{V,(1-\beta_k)}(\tau_{ав})} \tag{13}$$

where $$\underline{M^{**}_{V,(1-\beta_k)}(\tau_{ав})} = M^{*}_{V,Э}(\tau)\cdot\left(1 - A\Big/\sqrt{n_v}\right) \tag{14}$$

That classification is expedient

In all other cases, classification is inexpedient.

Example 3. We shall address again to initial data of an example 1. As $M^{*}_{\Sigma,Э}(\tau_{ав}) > M^{*}_{V,Э}(\tau_{ав})$, we shall checkup conformity (4). For what it is calculated $\underline{M^{**}_{V,(1-\alpha_k)}(\tau_{ав})}$.

$$\underline{M^{**}_{V,0,95}(\tau_{ав})} = 72,4 \cdot \left(1 - 1,13/\sqrt{2}\right) = 14,4\,c.$$

It is necessary to note, that for any $\alpha_k = \beta_k$ the size of constant factor A can be calculated under the formula [1]

$$A = 18,5a2 - 7,33a + 1,48 \qquad (15)$$

As $M^{*}_{V,Э}(\tau_{ав}) > \underline{M^{**}_{V,0,95}(\tau_{ав})}$, we shall check up a condition (10). For what we shall calculate $\overline{M^{**}_{V,\beta_k}(\tau_{ав})}$. At $\alpha_k = \beta_k = 0,5$

$$\overline{M^{**}_{V,\beta_k}(\tau_{ав})} = 51 \cdot \left(1 + 1,13/\sqrt{2}\right) = 91,9\,c.$$

But as $\overline{M^{**}_{V,0б5}(\tau_{ав})} > M^{*}_{\Sigma,Э}(\tau_{ав})$ classification is inexpedient.

Resulted calculations show, that, despite of a seeming bulkiness of criterion, calculation are small and simple. The opportunity concerns to advantages of this criterion to consider a mistake of the second sort. In the illustrative purposes in figure 1 the scheme of algorithm of application of criterion K3 is resulted the block.

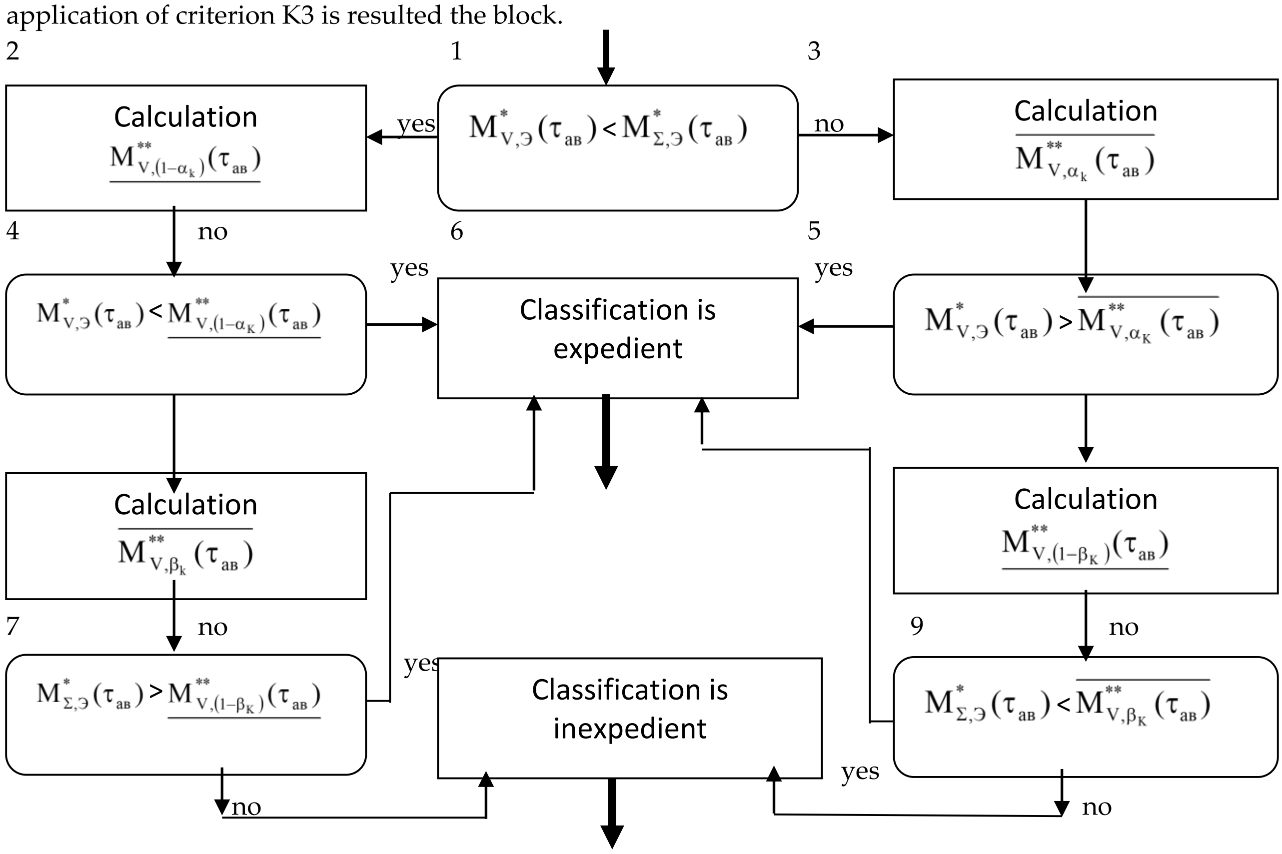

Fig.1. The block the scheme of algorithm of application of criterion K3.

The analysis of the considered criteria allows establishing, that at the manual account VA it is necessary to consider as the basic criterion of check of expediency of classification of statistical data of some criterion K3. Criteria K2 and K1 should be considered as auxiliary mistakes for exception of the manual account.

Conclusion

1. It is necessary to distinguish five versions of ways of calculation of parameters of reliability of objects EPS on multivariate statistical data. These are the parameters calculated as average arithmetic random variables, parameters of relative duration of idle time, the parameters describing probability т frequency of occurrence of casual event, complex parameters.

2. Criteria check of hypotheses about the importance of versions of attributes for the parameters of reliability calculated as average arithmetic random variables recommended. As random variables modeled realizations of parameters of reliability considered, and as critical values boundary values fiducially intervals with the established factor of the importance entered.

References

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