# Maintenance of Reliability of Methodical Support of the Management of Objects EPS

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**Abstract**

One of the basic problems of development of intellectual control systems of maintenance service and repair of the equipment and devices of electro power systems is increase of reliability of methodical recommendations. The risk of the erroneous decision exists, first of all, because of presence among statistical data of operation of gross blunders, abnormal values. If to that still to add difference not casual samples statistical data of operation from theoretical representative samples random variables from a general data set, to consider multivariate character of statistical data of operation and absence of methods of the analysis small samples multivariate data, difficulty of the decision of this problem becomes obvious. The method which on the basis of fiducially the approach and theories of check of statistical hypotheses is capable to reveal abnormal realizations is developed. And application the express train-methods of calculation of critical fiducially values an interval for the chosen significance value, allows to solve this problem without special tables and the COMPUTER.

**Keywords:** Reliability, faultlessness, statistical data, methods, fiducially approach, abnormal realizations, the importance.

## I. Introduction

*Statement of the problem*

Development of computer technologies, transition from information to intellectual systems, an objective quantitative estimation of individual reliability, profitability and safety of objects of electro power systems are indissolubly connected with the requirement of a safety and a faultlessness of initial data [1].

The problem of safety of data as a whole can be solved by reservation of objects of a database with the closed access [2]. Presence of abnormal data, i.e. infringement of faultlessness, caused mainly human factor and is concrete mistakes of operators. Process of recognition of abnormal data is many-sided and, first of all, depends on type of the equipment and devices that is why demands development of specialized methods of the statistical analysis. The general, thus, multidimensionality and small number of statistical data of operation is. In clause the analysis of the traditional approach is resulted, inadmissibility of neglect marked by conditions of application of existing criteria, the new method offered. The method based on fiducially approach, the theory of check of statistical hypotheses, express train-methods of calculation of critical values of analyzed parameters.

## II. Methods of recognition of abnormal data in small samples.

In [3,4,5] as a result of the analysis for number of realizations of sample $n_S \leq 10$ are allocated as the most effective three methods: N.V.Smirnov, Shovenes and Dickson. We shall take advantage of this recommendation.

First of all, we shall note, that these three methods assume all, that considered small samples concern to representative samples of set of normally distributed random variables. It is known, that characteristic for EPS small samples of statistical data about reliability are received from set of multivariate data, by classification of this set on some versions of an attribute, for example, on a class of a pressure. And, as it is often done, we "shall close eyes" to a degree of their conformity to the normal law. And three criteria are chosen because the last century B.V.Gnedenko recommended to apply at check of hypotheses not less than two criteria [6].

It is established [7], that each of criteria usually reflects the importance of concrete statistical property of sample. We shall result a known example: samples can differ casually on size of average arithmetic value of realizations and essentially to differ on disorder and on the contrary.

We shall consider sample of monthly average values of the charge of the electric power (W) for own needs (o.n.) boiler installations of power units 300 MWt on gas black oil fuel, in %, with number of realizations n=5. It {30,4; 2,38; 2,14; 2,44; 2,48}. We shall estimate with a significance value $\alpha$ =0,1 presence of abnormal realizations. For this purpose:

- range realizations $W_{on}$ in ascending order. Sample gets a kind {2,14; 2,32; 2,44; 2,48; 3,04};
- define average arithmetic value of realizations $M^*(W_{on})$=2,5%
- define average quadratic value of realizations of sample $\sigma^*(W_{on})$=0,318%

N.V Smirnov's criterion provides calculation:

- the greatest deviation $\Delta^* W_{on}$=0,54%
- Statistics $\rho^*(W_{on}) = \Delta^*(W_{on}) / \sigma^*(W_{on}) = 1,7$ (in relative units)
- definition of critical value $\varrho_{0,1}$=1,79

As $\varrho^*(W_{on}) < \varrho_{0,1}$, with a significance value even $\alpha$=0,1, the assumption of presence of abnormal realizations is rejected

Criterion Shovenes also assumes calculation of statistics $\varrho^*(W_{on})$. Further:

- on tabulated values of integrated function of standard normal distribution value of function is defined $F[\varrho^*(W_{on})]$=0.955
- Shovenes statistics is calculated $Sh^*(W_{on})=2 \cdot n\{1- F[\varrho^*(W_{on})]\}$=0.45
- critical value of statistics $Sh_c$ is defined. For $\alpha$=0,1 and n=5 value $Sh_c$=0.40

Since $Sh^*(W_{on}) > Sh_c$, that is accepted the assumption of presence of abnormal realization $W_{on,5}$=3,04%

The criterion of Dickson provides:

- calculation of statistics $r(W_{on})=\max\{r_1(W_{on}); r_2(W_{on})\}$

where:
$$r_1(W_{on}) = \frac{W_{on,2}-W_{on,1}}{W_{on,5}-W_{on,1}} = \frac{2,32-2,14}{3,04-2,14} = 0,2$$
$$r_2(W_{on}) = \frac{W_{on,5}-W_{on,4}}{W_{on,5}-W_{on,1}} = \frac{3,04-2,48}{3,04-2,14} = 0,62$$

- definition of critical value $r_k$. For $\alpha$=0,1 and n=5 value $r_c$=0.40
- comparison $r(W_{on})$ and $r_c$. As $r(W_{on})$ is more $r_c$, that is accepted the assumption of presence of abnormal supervision $W_{on,5}$.

Thus, from three criteria two confirm presence of abnormal supervision.

## III. The recommended method.

The recommended method based on criterion of recognition of the importance of distinction of parameters of reliability calculated on set of multivariate data and not casual sample of this set [5]. For example, there is some data set about reliability of switches 110-500 kV. After it possible to estimate average duration idle time in emergency repair (as average temperature on hospital). We shall assume, that us switches 110 kV interest. In the first this sample not random, and in the second, on former, includes multivariate data (as average temperature of patients in surgical branch). These comments in brackets we, first of all, wish to pay attention to that fact, that both to a data set, and to sample it is impossible to apply methods of recognition of the mistakes, stipulated for one-dimensional data representative samples.

The enlarged block diagram of algorithm of the control of a faultlessness of sample is present on fig.1.

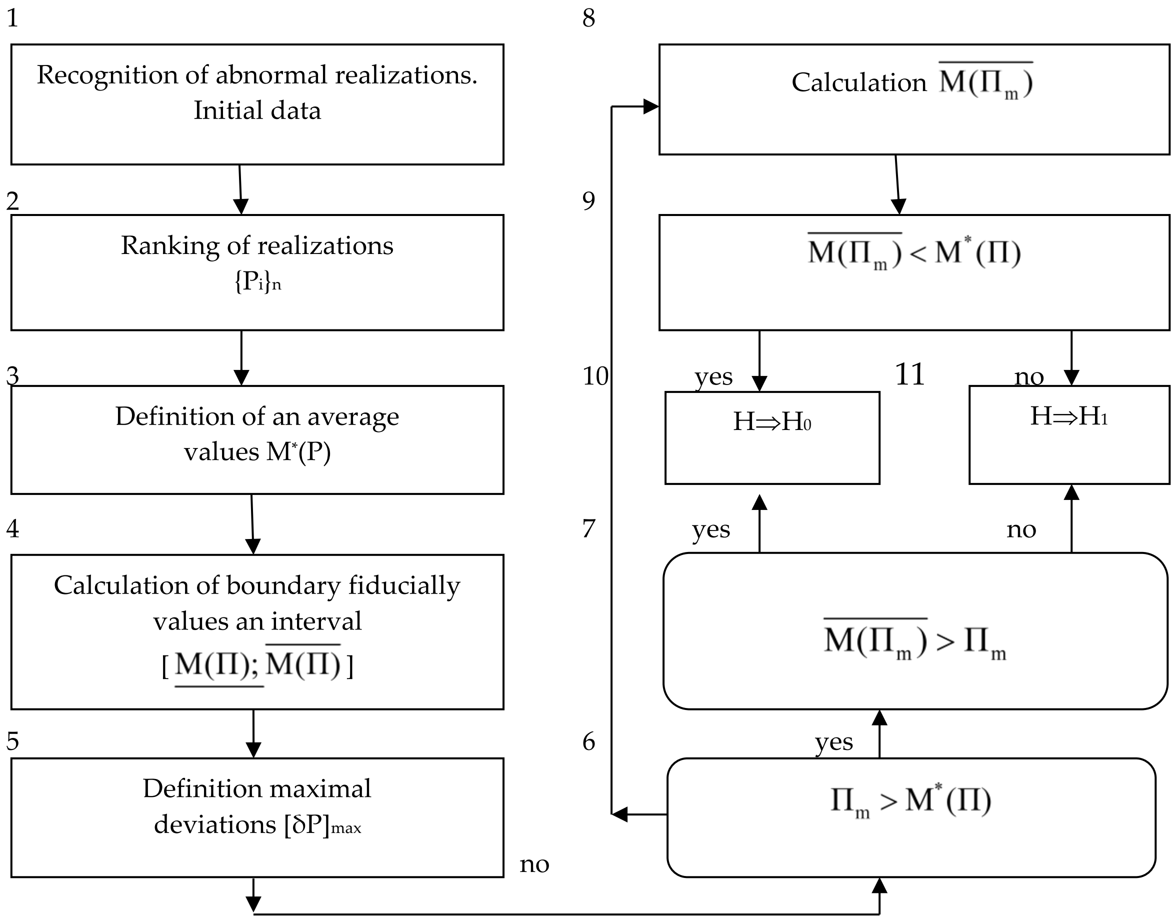



Fig.1. The integrated block diagram of algorithm of recognition of abnormal realizations

The algorithm (sequence of calculations) provides:

*The block 1.* As initial data sample of random variables (parameters) in volume n serves. Such sizes can be time of a finding in emergency repair, monthly average relative value of the charge of the electric power for own needs of boiler installation of the power unit, size of the fifth harmonic on trunks of substation, etc. It is necessary to evaluate the accuracy of these data;

*The block 2.* First of all, it is necessary to arrange these data in ascending order (to range);
*The block 3.* Average arithmetic value of realizations is calculated. We shall designate it as M*(P);
*The block 4.* Boundary values of fiducially an interval are defined $[\underline{M(\Pi)}; \overline{M(\Pi)}]$.They can be calculated a method of imitating modelling on the COMPUTER for any significance value [7]. But, is much easier for of some the parameters calculated as an average arithmetic random variables, or the probability of occurrence of event, or relative duration of a condition, boundary values fiducially an interval to define the express train-method under the formula approximating interrelation of critical values, a significance value and number of realizations [8]. For example, for M*(P) the top boundary value fiducially interval is defined under the formula $\overline{M(P)} = M^*(P)(1 + A/\sqrt{n})$, and the bottom boundary value - under the formula

$\underline{M(P)} = M^*(P)(1 - A/\sqrt{n})$. If n=5, that for $\alpha$=0,1; 0,05 and 0,01 relative deviation $A/\sqrt{n}$ be accordingly equal 42,4%; 50,4 and 63,5%;

*The block 5.* The maximal relative deviation 1-th and n-th realizations of random variables of sample from average value under the formula pays off: $[\delta P]_{max}$=max{$\delta(P_1)$;$\delta(P_2)$}, where $\delta P_1$=|$[P_1$-$M^*(P)]$|; $\delta P_n$=|$[P_n$-$M^*(P)]$|;

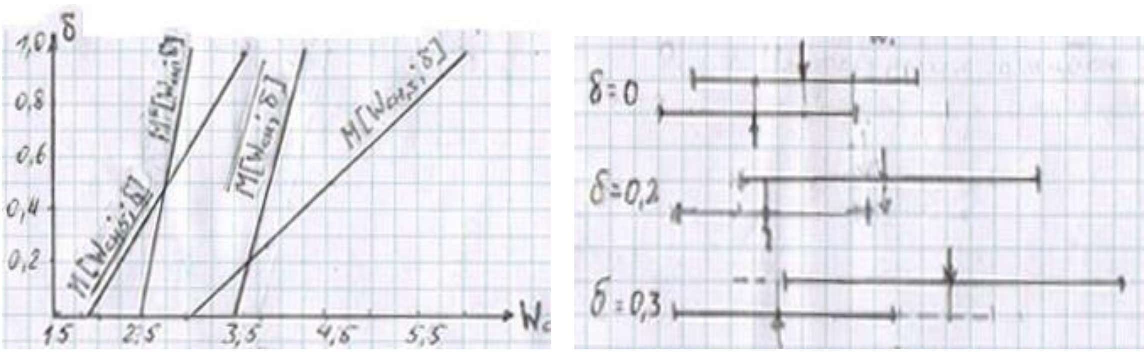
*The block 6.* The parity of realization $P_m$ and M*(P) is checked Here $P_m$ realization on which the size $[\delta P]_{max}$ defined. If $P_m$>$M^*(P)$ in the block 7 check of an accessory of realization $P_m$ to set of possible values {M(P)} is spent, casually differing M*(P) and being an interval $[M^*(P)\,; \overline{M(P)}]$. If $P_m$ belongs to this set, our assumption (H) about it abnormal ($H_1$) is erroneous and H⇒$H_0$ (*see the block 10*). Otherwise - $P_m$ it is possible to consider abnormal, and assumption $H_0$ - erroneous (*see the block 11*) with risk of the erroneous decision $\alpha$. If $P_m < M^*(P)$, management is transferred the block 8 where the size $\overline{M(P_m)}$pays off;

*The block 9.* Here the accessory of M*(P) to set of possible realizations {$M(P)_m$}, casually differing from $P_m$ and being in an interval $[P_m; \overline{M(P_m)}]$ is checked. Therefore, if $M^*(P)$ does not enter into this interval H⇒$H_1$. Otherwise, H⇒$H_0$, i.e. it is possible to consider the assumption of abnormal character $P_m$ erroneous. In conformity with the block diagram of algorithm, the criterion of check of assumption H⇒$H_1$ looks like:

$$\left.\begin{array}{l} \text{if } P_m>M^*(P), \text{ and } \overline{M(P)} < P_m, \text{ then } H\Rightarrow H_1 \\ \quad \text{and if } P_m<M^*(P) \text{ и } \overline{M(P_m)} < M^*(P), \text{ then } H\Rightarrow H_1 \\ \text{otherwise } H\Rightarrow H_0 \end{array}\right\} \qquad (1)$$

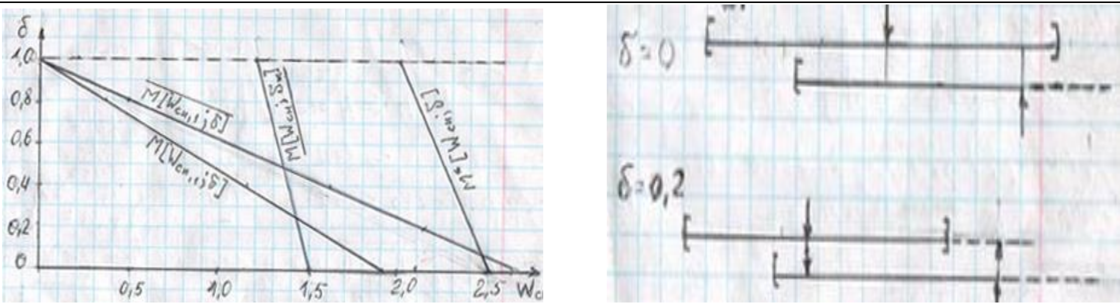
But, naturally, the expert has a question: why conditions of the control differ at $P_m$>$M^*(P)$ and $\Pi_m$<$M^*(P)$? The answer to this question is given in the graphic form on fig. 2 and 3. As an example is used the same sample of realizations of the charge of the electric power for own needs of boiler installation $W_{in}$ in volume n=5 a kind {2,14; 2,38; 2,44; 2,48; 3,04}.

On fig. 2 the illustration of the decision of a question on a faultlessness of value $W_{on}$ of the power unit with $W_{on}$=3,04% and with artificial increase $W_{on}$ at value δ, which changes in an interval [0,1] is resulted.




a) b)

Fig. 2. An illustration of parities fiducially intervals at $M^*(W_{on},\delta)$<$W_{on,5}(\delta)$.
a) - dependence of boundary values fiducially intervals from δ;
b) - parities of boundary values fiducially intervals




a) b)

Fig. 3. An illustration of parities fiducially intervals at $M^*(W_{on};\delta)>W_{on,1}(\delta)$;
a) - dependence of boundary values fiducially intervals from δ;
b) - parities of boundary values fiducially intervals

First of all, these figures evidently testify what even at $\alpha$=0,1 $W_{on}$=3,04% does not concern to gross blunders. Erroneous decisions at use of criteria Shovenes and Dickson are natural, since we "have closed eyes" and have broken conditions of their application. Therefore important not only to apply in calculations not less than two criteria but also in any a measure not break a condition of application of the chosen criteria.

In fig. 2 and 3 average value of realizations for set δ was calculated under the formula

$$M^*[W_{on},\delta] = M^*(W_{on})[1+\frac{\delta}{n}) \qquad (2)$$

at δ=0, $M^*(W_{on})$=2,5%

As the greatest deviation $W_{on}$ with i=1,5 from $M^*(W_{on})$ took place for $W_{on}$=3,04%, i.e. $M^*(W_{on})<W_{on,5}$ (as it was required to establish), dependence of this size from δ analogy to $M^*(W_{on};)$ it is linear and pays off under the formula:

$$W_{on,5}(\delta)= W_{on,5}(1+\delta) \qquad (3)$$

The top boundary values fiducially interval for $M^*(W_{on})$ at δ=0 and $\alpha$=0,1 equaled

$$\overline{M^*(W_{on})} = (1+\delta_c)\cdot M^*(W_{on}).$$

And at δ>0 - under the formula:

$$\overline{M^*(W_{on},\delta)_c} = (1+\delta_c)\cdot M^*(W_{on},\delta) \qquad (4)$$

The bottom boundary value фидуциального an interval for $M^*(W_{on};\delta)=W_{on,5}(\delta)$ it is calculated under the formula:

$$\underline{M^*(W_{on,5};\delta)} = (1-\delta_c)\cdot M^*(W_{on,5},\delta) \qquad (5)$$

The analysis of a parity fiducially intervals of possible realizations of $M^*(W_{on};)$ and $M^*(W_{on,5};\delta)$ shows, that at performance of conditions $W_{on,5}>M^*(W_{on})$ (see the block 6) and $\overline{M^*(W_{on},\delta)} > W_{on,5}(\delta)$ (see the block 7) is necessarily carried out also a condition $\underline{M^*(W_{on,5};\delta)} < M^*(W_{on},\delta)$, but not on the contrary. It is distinctly presented on fig. 2b. Here top fiducially the interval is an interval $\left\{\underline{M[W_{on,5};\delta]};\overline{M[W_{on,5};\delta]}\right\}$, and bottom is an interval $\left\{\underline{M[W_{on};\delta]};\overline{M[W_{on};\delta]}\right\}$. For δ=0,25 condition $\overline{M(W_{on},\delta)} > W_{on,5}(\delta)$ it is not carried out, and the condition $\underline{M^*(W_{on,5};\delta)} < M^*(W_{on},\delta)$ is carried out.

Therefore, to check this condition there is no necessity. We shall pass now to a case, when $P_m<M^*(P)$. Calculations we shall lead for sample {3,04; 2,42; 1,90; 2,64; 2,47} Here too the $M^*(W_{on})$=2,5, and abnormal is supposed size $W_{on,1}$=1,9%. Formulas for calculation of boundary values fiducially interval in functions from it will a little transform and looks like:

$$M^*[W_{on,\delta}]= M^*(W_{on})\cdot(1 - \delta/n)$$

$$W_{on,1}(\delta)= W_{on,1}\cdot(1-\delta)$$

$$\underline{M[W_{on},\delta]} = M^*[W_{on},\delta]\cdot(1-\delta_c)$$

$$\overline{M[W_{on,1};\delta]} = M^*[W_{on,1};\delta]\cdot(1+\delta_c)$$

According to data fig. 3a and 3b, if a condition of $M^*[W_{on};\delta]$ it is less, than the top boundary value fiducially interval $\overline{M[W_{on,1};\delta]}$ that corresponds to assumption H⇒$H_0$ conformity to this assumption it is observed and for a parity $\underline{M^*[W_{on};\delta]}$ and $W_{on,1}(\delta)$. Therefore, to check it there is no necessity. On fig. 3b δ=0 both conditions are satisfied, and already δ=0,2 condition of $M^*[W_{on};\delta]<\overline{M[W_{on,1};\delta]}$ it is not carried out, and condition $W_{on}(\delta)>\underline{M^*[W_{on};\delta]}$ is carried out, that confirms sufficiency of the control of the first condition.

The algorithm of transition to correct sample is simple:

- if presence of abnormal supervision is established, it is replaced in sample by an average arithmetic estimation of M*(P);
- considering probability of presence more than one abnormal realization, in sample control check (n-1) realizations spent also. Calculation comes to the end at performance of a condition of criterion 1, at which H⇒$H_0$

The automated system so simplifies the decision of a question on presence of abnormal supervision in small sample of multivariate data that allows to hope for development of one more step of a problem of a faultlessness of methodical recommendations.

## Conclusion

The urgency of a problem of maintenance of a faultlessness of a database of intellectual systems and their methodical recommendations in due course increases:
1. The quality monitoring of presence in small samples of the multivariate given abnormal realizations is developed. The method based on fiducially approach and the theory of check of statistical hypotheses;
2. Basis of a method there is a recommended criterion of check of uniformity of sample;
3. Application the express train-methods of calculation of critical values fiducially interval allows to translate the decision of a problem on absence of abnormal supervision group of problems successfully solved on calculators.

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