Quantitative Estimation Of The Integrated Parameter Of Safety Ability To Live Of Personnel EPS

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Abstract

Opportunity of a quantitative estimation integrated parameters (IP) safety of ability to live (AL) is one of the basic directions of decrease in a traumatism and destruction of personnel EPS. In a basis of the developed method and algorithm of calculation IP AL there are differences of requirements of Rules AL observable in practice from a level of their execution. Quantitative estimations AL open new, earlier inaccessible opportunities regarding the analysis and the control. For example, to compare AL at enterprises EES, to reveal the directions reducing AL, to estimate AL on various categories of maintenance, tests and repair of the various equipment and devices EES

Keywords: *reliability safety of ability to live, integrated parameters*

I. Introduction

As is known [1] AL concerns to number of the basic properties of reliability. However unlike non-failure operation, maintainability, durability and a storage property, methods of quantitative which estimation of parameters, including, methods of calculation of accuracy and reliability, in many respects are developed, methods of a quantitative estimation of parameters AL are in an initial stage of development. It speaks not only variety of conditions of ability to live (many-sided nature and multidimensionality are characteristic features of a problem of reliability), but, first of all that there is a problem of an estimation of safety not the equipment and devices (objects) EPS, and the personnel, the person.

In practice AL, be provided with strict performance and the control of performance of Rules of a labour safety, the safety precautions, fire-prevention technics at maintenance service and repair (MS&R) objects EPS. However, as well as for noted above the basic properties of reliability, qualitative characteristic AL appears insufficient, first of all, owing to imperfection of existing opportunities of its control. Sad acknowledgement to that is the statistics of a traumatism and destruction of personnel EPS.

In [2] it is marked, that according to the theory of academician A.A.Doronisin in development of any science (and AL is a science about safe interaction of the person and a techno sphere) it is necessary to distinguish two periods: descriptive and exact. Descriptive period provided with accumulation of the information, revealing of influencing factors, "mechanical" classification of the information. The exact period characterized by development of methods of the quantitative characteristic of processes, methods of their modeling. Hence and from the point of view of

development of a science, research AL in EPS are in an initial stage of the development, and development of methods and algorithms of quantitative estimation IP AL at operation, tests and repair of objects EPS is one of the basic directions of maintenance AL of personnel EPS.

It is necessary to make a reservation at once, that the official statistics about traumas and destructions of the personnel in EPS, certainly, analyzed and most carefully to exclude similar cases. But, in opinion of authors, it should not and cannot form a basis for calculation of parameters AL. Fortunately, for authentic calculations it is not enough these cases.

II. Method and algorithm of quantitative estimation IP AL

IP AL in a techno sphere average life expectancy of the person [3] is accepted. This parameter is objective enough at an estimation of influence on life expectancy, for example, ecologies of region, but unacceptable for the characteristic of safety at work in EPS.

For quantitative estimation, AL a number of the parameters describing non-failure operation and maintainability of technical objects recommended also. To them concern:
- probability of functioning of objects without undue incident (failures, and accidents) during the set interval of time;
- probability of occurrence even one incident;
- average duration of incident;
- average size of damage.

And though all these incidents, as a rule, occur not on fault of the personnel (but not without its participation), are a source the dangers noted above parameters AL, at presence of corresponding statistical data, can be demanded.

Recommended for practical application IP AL in EPS and a method of its quantitative estimation based on a following axiom: «danger of ability to live arises at infringement of Rules AL. Real AL that above, than above a level of execution of Rules AL». In other words, the reflecting level of execution of Rules AL in EPS recommended IP AL. Generally Rules AL consist of various Rules (in EPS they reflect three directions: a labour safety, the safety precautions, fire-prevention safety), their chapters, sections and positions. We estimate the level of execution of each position of Rules in five-point system. This choice not assignable:
- the five-point system is habitual, since reminds usual system of an estimation of knowledge;
- on the basis of practice of calculations affirms [4], that for the maximal values of the parameters measured in a serial scale, it is expedient to apply estimations within the limits of from 3 up to 6;
- on Strebjes 5 - is an optimum number of intervals when the number of measurements changes in an interval [11÷23] [5] that reflects, as a rule, the maximal number of positions in sections of Rules.

The participant of «ability to live» can execute estimation of a real level of execution of Rules AL, i.e. the executor of concrete work at operation, tests and repair of objects EPS or the Expert on maintenance AL. As the Expert executions of Rules AL responsible for the control, heads of divisions of the enterprise can participate. Advantage of this way (a direct five-ball estimation of a level of execution of Rules AL) is the knowledge the Expert of a real level of execution of positions of Rules AL.

Serious lack is subjectivity of estimations. Well-known, that estimation in this case depends not only on knowledge and on qualification of the Expert. Maintenance of independence of examination, decrease in subjectivity reached by specification of concept corresponding this or that estimation «a level of execution of positions of Rules AL». It reminds tests for examinations, but only reminds. In our case, each position is set by five possible levels of execution of the positions corresponding estimations in five-point system. If besides the made levels of execution to place in the casual order and to limit time of the answer for conformity of each level of execution real, objectivity of the analysis on this computer technology will be practically deprived subjectivity.

Thus, generally some estimation of a level of real execution $L_{i,j,k,s}$ where $i=1,m_g$ is compared

with each position of Rules AL; j=1,$m_{h,i}$; k=1,$m_{r,i,j}$; s=1,$m_{c,i,j,k}$; m_g – number of Rules; $m_{h,i}$ - number of chapters in i-th Rule; $m_{r,i,j}$ – number of sections in j -th chapter i-th Rules; $m_{c,i,j,k}$ – number of positions k-th section, j-th chapter i-th Rules.

It would seem to receive IP a level of execution of positions enough to combine these estimations and to divide into the general number of positions. However, it would be a serious mistake, same, as well as an estimation of average progress at school, in classes, etc. [6]. The mistake consists in that, the mathematical theory of measurements does not suppose performance of elementary mathematical operations above parameters with a serial scale of measurements (in this case their addition). And levels of performance of positions of Rules AL just are measured in a serial scale.

Naturally there is a question – whether «much it $5m_\Sigma$», where m_Σ - the general number of positions. Probably, one undoubtedly – loading on the Expert will be very big. But this problem is equivalent to a problem of an estimation of reliability and profitability EPS as a whole which as well so, is bulky. Therefore in this bulkiness not anything surprising.

For this reason significant interest estimations IP AL not as a whole, and on each concrete work of personnel EPS (represent analogue: non-failure operation of objects EPS). The Method of calculation IP AL (BJ) generally reduced to following sequence of calculations:

1. For each section of Rules distribution of estimations of a level of execution of positions is calculated. We shall designate number of display L-th estimation, where L=1÷5, through $r_{i,j,k,L}$.

   It is obvious, that $\sum\limits_{i=1}^{5} r_{i,j,k,L} = m_{c,i,j,k}$

2. Frequency of display L-th estimation under the formula is defined

$$f^*_{i,j,k}(L) = r_{i,j,k,L} \Big/ m_{c,i,j,k} \tag{1}$$

where i=1,m_g; j=1,$m_{h,i}$; k=1,$m_{r,i,j}$;

We shall notice, that $r_{i,j,k,L}$ and $f_{i,j,k}(L)$ are measured in a quantitative scale and to them known mathematical operations can be applied. As

$$\left. \begin{array}{l} 0 \le f^*_{i,j,k}(L) \le 1 \\ \sum\limits_{i=1}^{5} f^*_{i,j,k}(L) = 1 \end{array} \right\} \tag{2}$$

That sizes $f_{i,j,k}(L)$ can be considered as normalized the random variables unequivocally describing estimations of execution of positions of sections of Rules AL.

3. Discrete values of statistical function of distribution (s.f.d) estimations L=1÷5 under the formula:

$$\left. \begin{array}{l} F^*_{i,j,k}(L) = \sum\limits_{L1=1}^{L} f^*_{i,j,k}(L1) \\ F^*_{i,j,k}(1) = f^*_{i,j,k}(1) \\ F^*_{i,j,k}(5) = 1 \\ i = 1, m_g; \ j = 1, m_{h,i}; \ k = 1, m_{r,i,j} \end{array} \right\} \tag{3}$$

4. According to order a method [7] estimation IP of a level of execution k-th section j-th chapter i Rules is calculated under the formula;

$$\left. \begin{array}{l} BJ^*_{i,j}(k) = \sqrt[5]{\prod\limits_{L=1}^{5} F^{*\beta_L}_{i,j,k}(L)} \\ \beta_L = \dfrac{L}{2^L - 1} \end{array} \right\} \tag{4}$$

where i=1,m_g; j=1,$m_{h,i}$; k=1,$m_{r,i,j}$

In table 1 numerical values are resulted β_L for of some values L

Table 1. Settlement values β_L.

L	1	2	3	4	5
β_L	1	2	0,75	0,5	0,31

5. For i Rules estimation IP of execution j-th chapter is calculated under the formula:

$$BJ_i^*(J) = \sqrt{\prod_{k=1}^{m_{c,i,j}} BJ_{i,j}^*(k)} \tag{5}$$

where $i=1,m_g$; $j=1,m_{h,i}$; $k=1,m_{r,i,j}$

6. Estimation IP of a level of execution i Rules under the formula is calculated

$$BJ^*(I) = {}^{m_{h,i}}\!\!\sqrt{\prod_{j=1}^{m_{h,i}} BJ_i^*(J)} \tag{6}$$

where $i=1,m_g$; $j=1,m_{h,i}$; $k=1,m_{r,i,j}$

7. Estimation IP of a level of execution of Rules AL or parameter AL is calculated

$$BJ^* = {}^{m_g}\!\!\sqrt{\prod_{i=1}^{m_g} BJ^*(I)} \tag{7}$$

The Estimation of importance IP spent on a scale of the importance, which presented in table 2. Here for comparison the known scale of Harrington desirability [4], which with success is put into practice at analysis IP is resulted. Some distinction of a uniform scale (the length of an interval is constant) from scale Harrington formally. It executed for convenience of an estimation of interrelation of discrete argument and function of Harrington desirability looking like:

$$\left.\begin{array}{l} d_{i,k} = \exp[-\exp(-\overrightarrow{y_{i,k}})] \\[2mm] \overrightarrow{y_{i,k}} = \dfrac{2 \cdot y_{i,k} - (y_{i,max} - y_{i,min})}{y_{i,max} - y_{i,min}} \\[2mm] y_{i,max} = \max\left\{y_{i,j}\right\}_{j=1,m_i} \\[2mm] y_{i,min} = \min\left\{y_{i,j}\right\}_{j=1,m_i} \end{array}\right\} \tag{8}$$

Here $\overline{y_{i,k}}$ - absolute size of argument of Harrington function, having a quantitative scale of measurement

Table 2. A scale of the importance of parameter AL

Categories of the importance	Intervals functions of distribution	Harrington Scale	
		Categories of desirability	Intervals of function of distribution
It is inadmissible	0 – 0,19	Critical (Very badly)	0 – 0,19
Badly	0,0 – 0,39	Dangerous (badly)	0,2 – 0,36
Satisfactory	0,4 – 0,59	Admissible (well)	0,37 – 0,62
Well	0,6 – 0,79	Comprehensible (well)	0,63 – 0,79
It is indicative	0,8 – 1,00	Background (very good))	0,8 – 1,00

Results of calculations under formulas 4÷7 allow:

- to compare with a level of execution of sections, chapters and Rules, to reveal «weak parts » and to plan ways of their elimination;

- to compare with conditions of maintenance AL at different enterprises EES, in shops of power stations, in regional electric networks, etc.

It is necessary to note repeatedly, that as IP reliability and profitability (efficiency) of work of power station it is useless at formation of the basic directions of increase of an overall performance of concrete boiler installation of the same power station as the average estimation of a parameter of reliability of power transformers not in a condition to solve questions on classification of a

technical condition of power transformers, and IP BJ it is useless at analysis AL of the personnel at performance of concrete version MS&R of objects EPS. This statement in any to a measure does not reduce the importance of an integrated estimation of a level of execution of Rules AL, and only testifies to necessity of automated control AL for set of versions of corresponding operation, a kind and type of test and repair of set of objects EPS. And if, for example, non-failure operation of work of power station is defined by non-failure operation of the equipment and devices AL on power station it is defined AL at performance of separate works.

On fig.1 the integrated block diagram of algorithm of quantitative estimation IP AL is resulted. As initial data of algorithm (fig.1, the block 1) results of an estimation of a level of execution of positions of Rules AL serve.
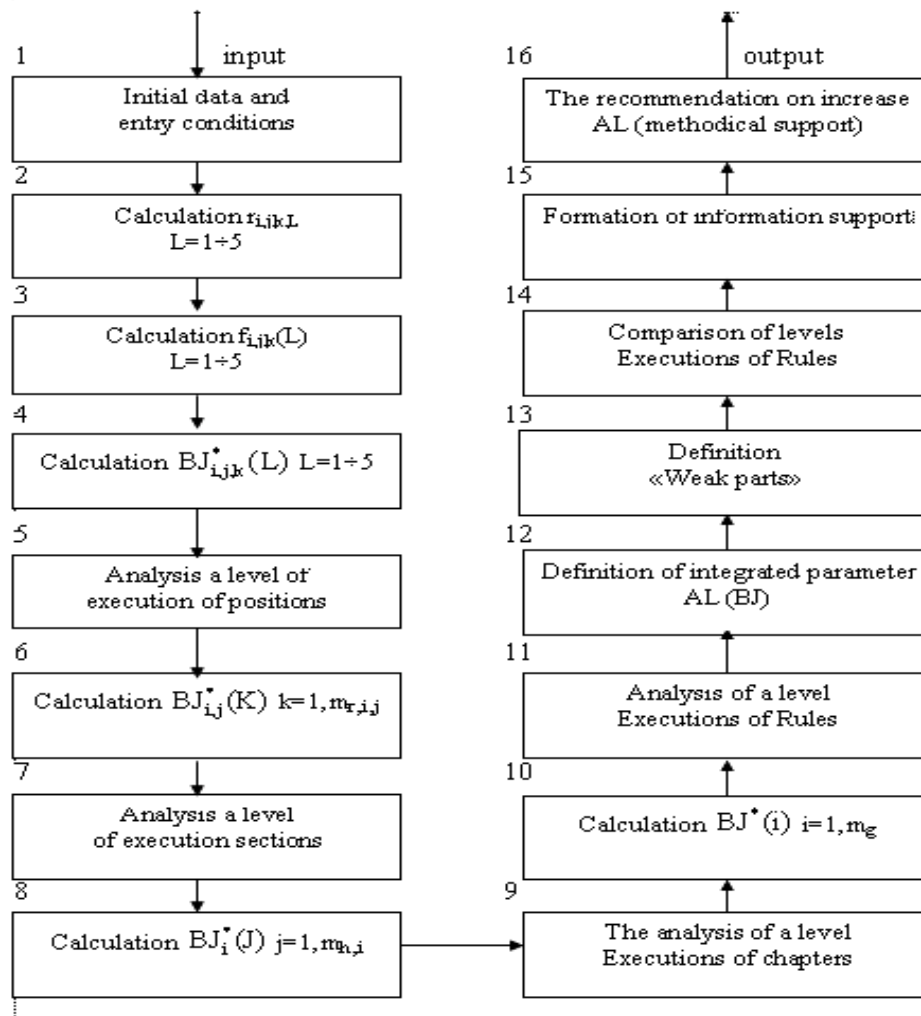

Figure 1 Integrated block diagram of algorithm of estimation IP AL.

The integrated block diagram of the automated system of formation of estimations of a level of execution of positions of Rules AL in dialogue with the Expert is resulted on fig.2. An essence of dialogue – acknowledgement (1) or denying (0) statements about a level of execution of position.

Essential decrease in time of dialogue at acknowledgement of conformity of a level of execution to real execution of positions is reached by automatic deleting from the list of the remained variants of execution of position. The general number of positions of Rules AL is less; the application of a method is more effective. Therefore, the method also recommended for control AL of concrete operative works, test and restoration of deterioration of object EPS.
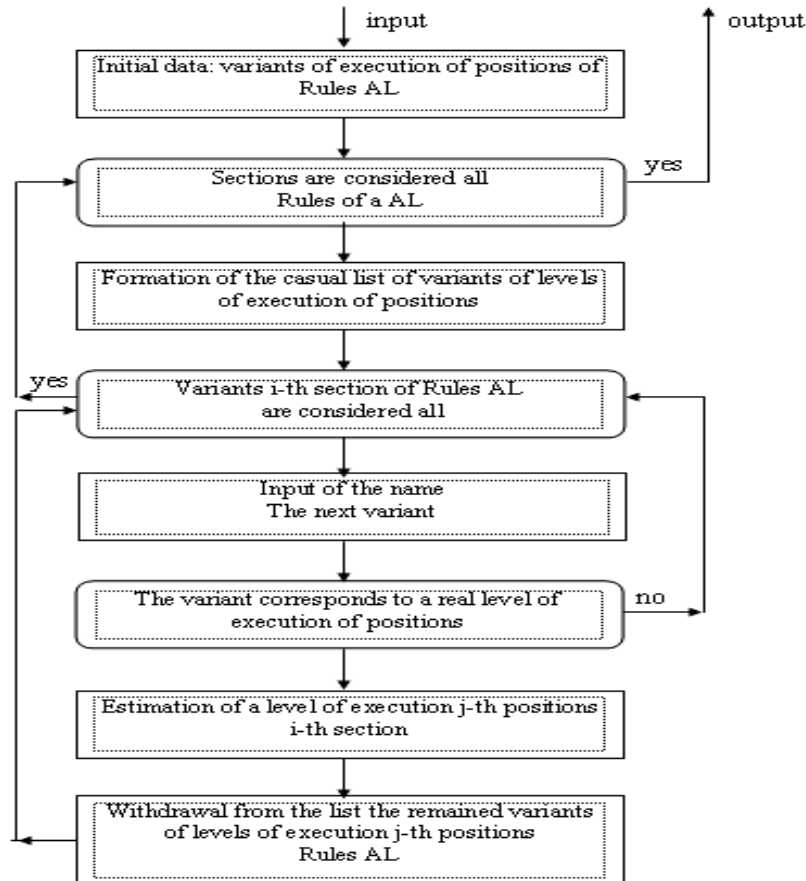
Figure.2. Integrated block diagram of algorithm formation levels execution positions of Rules AL

Conclusion

1. One of the basic directions of decrease in a traumatism and destruction of the personnel on objects EPS, is transition from qualitative to quantitative characteristic AL;

2. For such properties of reliability as non-failure operation, maintainability, durability and storage property questions of a quantitative estimation in many respects solved. Calculation corresponding reliability parameters based mainly on statistical data about refusals and reconstruction deterioration. For AL these questions are in an initial stage of the decision. In many respects it speaks distinction of solved problems;

3. The statistics of a traumatism and destruction of the personnel demands increase of efficiency of the analysis of each case. At the same time it should not form the basis for a quantitative estimation of parameters AL. Parameter AL – average "life expectancy" for characteristic AL of personnel EPS is unacceptable;

4. AL, certainly, depends on damageability of objects EPS. For example, the more service life of objects, their reliability below, and danger of maintenance service above. The likelihood parameters AL describing occurrence of failures and ethnogeny accidents as sources of danger at presence of the corresponding information can be useful.

5. The method and algorithm of a quantitative estimation recommended IP AL developed. In a basis of a method of calculation of this parameter there is an information on levels of execution of positions of Rules AL.;

6. Results of quantitative estimation IP AL allow:
   - to compare AL at various enterprises EES, their divisions;
   - to reveal «weak parts», being a principal cause of discrepancy real AL to shown

requirements;

- to operate AL by liquidation of «weak parts»;

- to calculate objective IP AL on various categories of maintenance, tests and repair of a various kind of objects EPS

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