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METHOD OF MEASUREMENT THE HUMAN OPERATOR PROFESSIONAL FITNESS TO THE EXTREME ACTIVITY

New method of the assessing suitability of the human operator extreme activities is proposed. It is based on a three-component statistical criterion. In evaluating the suitability of an operator the stability of a generalized estimate of ratio of energy of the biological signal can be used. As a "benchmark" standards the indicators of the psycho-physiological state of a group of operators having a positive long experience are accepted. If number of samples obtained in the experimental study is limited, then to improve the reliability the robust procedure of estimation is proposed to use.

Introduction. Effectiveness of the human operator activities primarily depends on its suitability to carry out responsibilities for particular type of work. Activity, associated with the permanent change of physical and psychological pressures and with needs to take the adequate operational decision, is called as the extreme activity. Successful implementation of operators to such type activity depends primarily on the psycho-physiological state of operator [1]. For the extreme activity of operators their mental state and reaction on the transition from the "quiet" state to "excited" state is important. Research should be carried out in these both (calm and excited) states. As the initial information the EEG measurements are provided, which give α- rhythms of the brain. With this information, you can only judge a qualitative change in the psycho-physiological condition of the operator. The ability of the operator to mobilize his resources should be numerically characterized [2].

Basic material. As an integral assessment of the psycho-physiological state of operator, which characterizes his professional competence, the area under the curve of the spectral density of α- rhythm as an estimate of the "total energy" of operator is proposed to use. Under the operator total energy we mean an opportunity to mobilize its energy resources in emergency situations [3]. To quantify the operator total energy the relative measure – the coefficient of energy sustainability θ is introduced. It is the ratio of the total energy (TE) of α-rhythms in a quiet (TE_{calm}) and excited (TE_{excit}) states of the operator:

$$\theta = \frac{TE_{calm}}{TE_{excit}} \tag{1}$$

When θ = 1, then in an emergency situation the energy TE of operator doesn't change, and he won't be able to react on stress factors.

The professional selection procedure can be regarded as a kind of test, in which the properties of the operator may be evaluated qualitatively and as well determine (measure) quantitatively. It is not at variance with conceptual foundations of psychological measurements [4].

These properties can be measured by specialized system of technical equipment. Calibration by traceability to standard units of measured physical variables are

not required. It is enough to "bind" the measurement result to a reference value. There is a new approach to definition the reference value for such measurements, proposed in VIM-3, as a process of experimentally obtaining one or more quantity values that can reasonably be attributed to a given value [5].

For the formation of such reference value a group of operators was involved. They are members of winter expedition to the Antarctic station "Akademik Vernadsky"), having a positive (long and successful) experience in extreme conditions. The operators of this tested group have different qualifications. Individual biorhythms of operators vary throughout the day time as well depend on changes of atmospheric and climatic parameters. Consequently, the set of operators is a physical model of professional competence of operators of this type activity.

Changes to individual properties of the operators appear as variation (dispersion) of the coefficient energy sustainability in relation to its reference value, defined in the study of the group of operators:

$$\overline{\theta} = \frac{1}{N_3} \sum_{i=1}^{N_3} \overline{\theta}_i \qquad (2)$$

where $\overline{\theta}_i = \frac{1}{N_2} \sum_{j=1}^{N_2} \overline{\theta}_{ij}$ – the average value of energy sustainability of the *i*-th operator, N_2 – number of days of the experiment; N_3 – number of operators.

Mean value $\overline{\theta}_i$ takes into account the effect of the variability of the *i*-th operator biorhythms and their sensitivity to fluctuations of atmospheric and climatic conditions.

Thus, the variation σ_R^2 of coefficients of individual personal energy sustainability θ_i from a reference value $\overline{\theta}$, corresponding to the energy stability of the hypothetical ideal operator of the particular type activity, characterize the possible scattering. Within the range of this scattering the individual stability coefficients of operators are distributed. This coefficients confirmed suitability of operators for this kind of activity. This dispersion will be called as dispersion reproducibility σ_R^2 of the operator professional level.

In general σ_R^2 depends on three components:

σ_{op}^2 – variation of a scattering of integral properties of operators of the study group, which reflects their personality,

σ_d^2 – variation of scattering properties of the operators due to individual sensitivity to changes in operating conditions within specified limits,

σ_{ck}^2 – cyclical impact of variability of biorhythms during the day.

To find these variations the experiment was carried out. It allows to allocate the appropriate component. As a result of the experiment, the variation of the operator energy sustainability coefficients θ_i with respect to the reference value $\overline{\theta}$ is determined. It reflects the reproducibility of the suitability of the operators

$$\tilde{\sigma}_R^2 = Var\left(\bar{\theta}_i\right) = \frac{\sum_{i=1}^{N_3}\left(\bar{\theta}_i - \bar{\theta}\right)^2}{\left(N_3 - 1\right)}. \quad (3)$$

Components of this variation can be used as admissible standard (norm) in the professional selection of operators for extreme activities.

Decision of professional competence is based on the statistical analysis of results of a number of study of psycho-physiological properties of the operator – applicant and comparison of their results with norms established in the experiment. Variation *var* (θ) of population of the considered component is evaluated on the basis of the variation $s^2(\theta)$ of the sample of limited number of observations.

In the experiment, usually is not possible to provide enough large number of observations for each statistical sample. In this case, the distribution will be characterized by asymmetry coefficient (central moment of the third order), which may lead to a false decision of a existence of outliers. In accordance with the classical approach, that pseudo- outlier should be excluded from the available data as further processing will lead to a reduction in the statistical reliability of the results. Therefore, to improve the accuracy of results and their reliability a robust procedure for assessing the results is proposed for use [5]. Such procedure is resistant to outliers and takes into account all available, even the "bad" data. Wherein the median absolute deviation criterion (*MAD*) is used

$$MAD = med\left\{\left|x_i - M_n\right|\right\}, \quad (4)$$

where $M_n = med\{x_i\}$ – the median of the elements in the sample x_i, n – number of elements in the sample.

For more accurate estimation of the standard deviation *s*, the correction factor *k*(*n*), depending on the sample size *n,* is used. The values of *k*(*n*) are given in [7]. Then

$$s = k(n)MAD. \quad (5)$$

Estimated value of standard deviation *s* takes into account all elements of a sample of small volume, which takes place during the selection process of candidate operators.

If the variance of ratio energy sustainability of the tested operator is estimated, then may be find the estimation of the statistical difference of variance $s^2(\theta_{ck})$ obtained for process of testing the operator-applicant, and the scattering rate obtained from joint physical modeling experiment. A statistical procedure for testing hypotheses from χ^2 chi-square [8] is used. Calculated is value

$$\frac{s^2(\theta_{ck})\cdot \nu_{ck}}{\sigma_{ck}^2} = \chi_{ck}^2, \quad (6)$$

where $\nu_{ck} = N_3 N_2 (N_1 - 1)$ – is the number of degrees of freedom.

The resulting value χ_{ck}^2 – is compared with the tabulated value of this statistic. By comparison the decision about the suitability of the prospective operator to extreme activity is being made.

Conclusion. Thus, the statistical model estimating the suitability of operators is proposed. It is based on establishing the reproducibility level of professional operators. This assessment allows to define some of the boundaries within which variation of the professional suitability is allowed. The two-step procedure is proposed. Objective statistical estimation for the integral indicator with a given statistical reliability to produce a decision on suitability of the operator as extreme and other activities is allowed.

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