

reliability, professionally significant qualities, technology

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## **THE FORMATION OF PROFESSIONAL RELIABILITY OF LOCOMOTIVE DRIVERS**

**Summary.** Any activity accustoms on the base of the general abilities which develop in this activity, and "special" abilities are the general abilities which have got lines of efficiency under the influence of requirements of activity. And the more technical is the activity, the bigger role in its realization is played by "special" abilities [8, 9]. Hence, definition of effective receptions of psychophysiological and psychological diagnostics should be combined with a finding of optimum ways of vocational training.

## **ФОРМИРОВАНИЕ ПРОФЕССИОНАЛЬНОЙ НАДЕЖНОСТИ МАШИНИСТОВ**

**Аннотация.** Любая деятельность осваивается на фундаменте общих способностей, которые развиваются в этой деятельности, а «специальные» способности – это общие способности, приобретшие черты оперативности под влиянием требований деятельности. И чем «техничнее» деятельность, тем большую роль в ее реализации играют «специальные» способности [8, 9]. Следовательно, определение эффективных приемов психофизиологической и психологической диагностики должно сочетаться с нахождением оптимальных способов профессионального обучения.

### **1. INTRODUCTION**

Specificity of concrete kinds of work makes certain demands to the general and more private psychophysiological and psychological properties and qualities of the person which presence defines professional suitability to this or that trade. Therefore experimental activity should be directed on studying of those professionally significant qualities (PSQ) and their integration which are required in professional work, and regulation of this activity to be carried out in the conditions comparable to real conditions. The activity modelling specific features of psychological structure of professional work should act as the testing [9]. Thereby the «internal conditions» of this activity will be modelled.

Exterior and internal factors not directly call behaviour and, therefore, appropriate mental processes, and through installation; in the beginning there is an installation as modification, the adjustment of the integrated subject expressed up of his psychophysiological functions to execution of particular activity then on its warp the concrete behaviour is realized. During adjustment to laying ahead activity for locomotive driver those services models which one are coupled to laying ahead activity are statistical and become dominant [1, 7].

Specific feature of labour activity of the locomotive driver of the main movement is work in the conditions of long influence of monotonous factors. Hence, maintenance of high level of readiness for

emergency action (REA) in conditions of monotony has huge value in activity of the locomotive driver of the main movement [4], and the condition of the lowered vigilance is considered as the internal, psychophysiological precondition for occurrence of failures, emergencies and debacles [5].

Essential necessity of professional work of the locomotive driver is the requirement for long concentration of attention with simultaneous ability to its emergency switchings, and the exit for frameworks of optimum values can even interfere at achievement of high level of professional skill [5]. Besides «in difficult kinds of activity there can be intense situations – the circumstances generating considerable difficulties and at the same time demanding from the person fast, exact and faultless actions» [2, p. 3]. In this connection emotional stability to any of intense factors of professional work is considered as professionally significant quality.

The level of uneasiness raises and mental function of self-checking is overloaded because of insufficiently developed PSQ. On the one hand, it partially helps to compensate insufficiently developed PSQ, but on the another – the level of pressure raises up to intensity. It is expressed in infringements of logic structure of operating actions, and also in increase in time of their performance. There is also because in normal conditions repeatedly and regularly fulfilled actions lead to formation of skills which it is not enough in extreme conditions of activity. Developing any system of self-control, the locomotive drivers get quality of actions, skills and the abilities similar professional that helps to cope with adverse conditions with smaller expenses, keeping power resources [3, 4].

On possibility of diagnostics, formation, perfection, correction professional reliability (as integrated professionally significant quality) the locomotive driver specified by following positions:

- PSQ is a cash level of possibility of display of function (mental and psychomotor processes), necessary for efficiency of professional work;
- PSQ – merge of congenital and acquired;
- PSQ are a part of structure of the person and the general macrostructure of the person;
- Abilities in development and specialisation in activity are realised in PSQ;
- Neurodynamic basis of PSQ are typological qualities of nervous system [8, p. 58-59].

## **2. THE ANALYSIS OF RESULTS OF ASCERTAINING EXPERIMENT WITH LOCOMOTIVE DRIVERS**

The estimation of the articulation of PSQ was defined by means of the techniques applied in engineering psychology for carrying out psychophysiological inspections on a railway transportation that has allowed to reveal interrelation of reliability of activity with a level of development of these qualities.

### **Technique of an estimation of level of vigilance (Readiness for emergency action) in the conditions of monotonously operating factors (REA)**

#### *The inspection maintenance.*

The examinee takes seat in an armchair in front of the panel of the examinee (PE) and the monitor, which established on the level of his eyes to a distance of 100-150 centimeters.

The examinee should watch for light «spot» which is consecutive, with an interval 1 second in a clockwise direction moves in a circle on an obverse part of the panel of the examinee (PE). Each step is accompanied by a sound signal. As a signal to action infringement of sequence of flashes of light, that is moving light «spot» through one circle in the direction of travel serves. Thus the examinee should react fast pressing the button therefore light «spot» comes back in a starting position and continues a consecutive movement in a circle.

Such signals move with the prevention and without the prevention. At giving of a signal with the prevention in the circle centre the yellow indicator which flash warns the examinee that soon the skip will follow on which he should react quickly lighted. The interval of time from a warning signal to the skip varies from 5 to 25 seconds. At giving of a signal without the prevention moving occurs suddenly

for the examinee. The general duration of inspection - 1 hour. 12 signals, 6 of which with the prevention and 6 emergency in this time move. Signals follow under the standard program.

*Processing and estimation of results of inspection.*

In the course of task performance reaction time (RT) on each signal is registered. If  $RT > 4$  seconds the signal admission is registered. On termination of inspection are automatically counted up:

1. Arithmetic-mean RT on signals with the prevention;
2. Arithmetic-mean RT on signals without the prevention;
3. Root-mean-square deviation RT on signals with the prevention;
4. Root-mean-square deviation RT on signals without the prevention;
5. Quantity of admissions of signals (Nrea);
6. Readiness for emergency action ( $Prea = 2 - 1$ ).

**Technique of definition of speed of switching of attention (SA)**

*The inspection maintenance.*

The square divided into certain number of small squares in which in a casual order the Arabian numbers from 1 to 25 black and from 1 to 24 red colours are placed, is shown to the examinee. The examinee should carry out search of numbers consistently: at first only black colour (A), then only red (B). Thus search of black numbers is carried out in an ascending order, and red in the descending. Then the mixed search of black and red numbers is carried out, in which course the examinee appears before necessity to switch attention from one sequence to another (SA<sub>t</sub>). On time spent for performance of each of tasks, it is possible to judge speed of switching of attention.

*Processing and estimation of results of inspection*

Time of switching of attention (T<sub>sa</sub>) is counted up under the formula of  $T_{sa} = SA_t - (A + B)$ , where SA<sub>t</sub> - time spent for performance of the third task, A - time spent for performance of the first task, B - time spent for performance of the second task.

Error (SA<sub>er</sub>) change of a direction of one of the numbers (both numbers decrease or both numbers increase), both numbers (the black decrease, red increase), change of colour of a number (instead of black number it is shown red or instead of red - black), and also the admission of the next number is considered (if some numbers are passed successively the quantity of errors corresponds to quantity of the passed numbers), repeated display, return to the previous numbers, non-observance of an order of alternation of colour.

**Technique of definition of emotional stability (ES)**

*The inspection maintenance.*

Inspection is spent at just after an estimation of speed of switching of attention. The examinee is offered to execute the mixed account of black and red numbers (as in the task 3), and it is warned that in the middle of work active hindrances will be shown to it. As an active hindrance the voice saying numbers in the same combination and an order in which they should name the examinee, since 9 black - 16 red serves. Each pair of numbers repeats by the voice 2 times that serves as a hindrance for the correct account. Giving of hindrances to the examinee joins after a finding it of pair of numbers: 8 black - 17 red. On a difference in time of performance of the task with hindrances (ES<sub>t</sub>) and without (SA<sub>t</sub>), taking into account features of performance of 4th task, the estimation of individual indicators is taken out.

*Processing and estimation of results of inspection.*

The indicator of emotional stability of Tes pays off as a difference in time spent for performance of the task with hindrances and without hindrances:  $T_{es} = ES_t - SA_t$ .

Error (ES<sub>er</sub>) change of a direction of one of the numbers (both numbers decrease or both numbers increase), both numbers (the black decrease, red increase), change of colour of a number (instead of black number it is shown red or instead of red - black), and also the admission of the next number is considered (if some numbers are passed successively the quantity of errors corresponds to quantity of the passed numbers), repeated display, return to the previous numbers, non-observance of an order of alternation of colour.

**Technique of an estimation of time sense (TS)**

Estimates a parity of processes of excitation and braking.

*The inspection maintenance.*

In the panel centre a yellow signal will light up three times and through one and two time to die away. Then the signal will light up for uncertain time. The problem - to remember and reproduce a short interval of time (a reference interval) pressing the button.

*Estimation of results.*

Average value TS and root-mean-square deviation is counted up.

The increase in premature reactions (underestimation of time intervals), specifies in prevalence of exciting process, and at increase in overdue reactions (reevaluation of time intervals) - prevalence of brake process.

**Technique of an estimation of reaction to moving object (RMO)**

Estimates a parity of processes of excitation and braking.

*The inspection maintenance.*

From any part of a circle to constantly burning bulb will promptly move light «spot». The problem - pressing the button to stop «spot» while it will be combined with constantly burning bulb.

*Estimation of results.*

At prevalence of force of exciting process the increase in number of premature reactions is observed, at prevalence of brake process - increase in late reactions.

**Technique of an estimation of time of simple visually - impellent reaction (SIR)**

*The inspection maintenance.*

On the device panel yellow and red signals will consistently light up. The yellow signal is equivalent to a command "Attention". The problem - in reply to the red signal as soon as possible to press the button, on the yellow signal - it is not necessary to press the button.

*Estimation of results.*

Average value of speed of simple visually-impellent reaction and its root-mean-square deviation is counted up.

**Technique of an estimation difficult visually - impellent reaction (DIR)**

*The inspection maintenance.*

In the panel centre yellow, green or red signals can light up. The yellow signal is equivalent to a command "Attention". After a yellow signal the green or red signal will be given. The problem - as soon as possible to press the button the left hand at occurrence of the red signal and the button the right hand - at occurrence of the green signal. On the yellow signal it is not necessary to press the buttons. Not pressing not on that button in reply to any signal will be considered as an error.

*Estimation of results.*

Average value of speed of difficult impellent reaction ( $T_{dir}$ ) and its root-mean-square deviation, quantity of errors ( $N_{dir}$ ) is counted up.

**Technique of an estimation of volume of attention (Va)**

*The inspection maintenance.*

For studying of volume of attention it is offered to use cards: on a checkered background, the size four on four cages, are definitely located points.

For a short time (by a tachistoscope principle, about 1 second) the first card (with two points) is shown to the examinee. After a pause (about 3 seconds) and the card is shown the second time. After the second presentation the examinee should for limited time (from 15 to 25 seconds) on the available form to reproduce on memory the seen card. Each card is shown twice consistently on accruing complexity (from 2 to 9 points).

*Estimation of results.*

On reproduction of 2-5 figures on 15 seconds, 6-7 figures on 20 seconds, 8-9 figures on 25 seconds.

Criteria of performance: not less correctly reproduced 10 signs on any two cards containing the maximum result of the surveyed.

### Technique of definition of individual psychomotor rate – tapping-test (TEPP)

*The inspection maintenance.*

The problem - to hold the probe strictly vertically in the right hand (the lefthander in left) and as it is possible to knock more often on a metal plate to a command «Stop!».

*Estimation of results.*

The number of blows for six consecutive equal intervals of time is registered.

As a whole the technique is applied to definition of force of nervous system on E.P. Ilin or mobility of nervous processes on V.P. Zagradsky.

During ascertaining experiment were estimated: level of development PSQ – *readiness for emergency action in the conditions of monotonously operating factors (REA)*: difference between reactions to signals with the prevention and without the prevention (Prea), number of admissions of signals (Nrea); *speed of switching the attention (SA)*: time of performance of the mixed search of black and red numbers (SA<sub>t</sub>), time of switching attention (T<sub>sa</sub>), quantity of errors during performance of the mixed search of black and red numbers (SA<sub>er</sub>); *emotional stability (ES)*: time of performance of the mixed search of black and red numbers at active hindrances (ES<sub>t</sub>), a difference in time of performance of the mixed search of black and red numbers with hindrances and without hindrances (T<sub>es</sub>), quantity of errors during performance of the mixed search of black and red numbers with active hindrances (ES<sub>er</sub>); *difficult visually-impellent reaction (DIR)*: Time of performance of difficult impellent reaction (T<sub>dir</sub>), quantity of incorrect pressing (N<sub>dir</sub>); *time of performance of simple impellent reaction (SIR)*; *time sense (TS)*; *time of reaction for moving object (RMO)*; *attention volume (Va)*; the *tapping-test (TEPP)*; an *expert estimation (EE)*.

For revealing of interrelations of expert estimations and professional reliability with indicators PSQ the received results have been subjected to inter correlation analysis on which basis a number of correlating galaxies has been constructed. The indicator of professional reliability of activity of the locomotive drivers (n=100) (by an expert estimation) significantly correlated with indicators of readiness for emergency action in the conditions of monotonously operating factors (REA – r = -0 287,-0 350); and emotional stability (ES – r = -0 196) (fig. 1) which, in turn, are closely interconnected with indicators SA (r=0,229-0,664), DIR (r=0,196; 0,316), SIR (r=0,560).

The presented results testify the importance of revealed PSQ for success of professional work of the locomotive drivers and possibility of their formation with the help of psychological and pedagogical training.

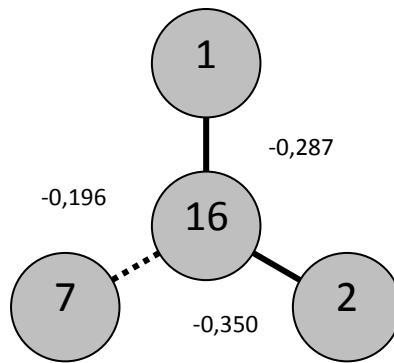
By the level of professional reliability the locomotive drivers were distributed in the groups "the high level", "the average level", "the low level" (fig. 2).

Among the locomotive drivers of the main movement, carried to groups of "the high level" and "the low level", authentic distinctions by results of testing of such professionally significant qualities as REA and ES (tab. 1) were found out.

Table 1

Indicators of testing of some PSQ locomotive drivers  
with various level of professional reliability

Indicators		Groups of the locomotive drivers by results of expert estimations				
		The high level (n=14)	The average level (n=81)	The low level (n=5)	U (best - worst)	p (best – worst)
REA	Prea	0,133±0,02	0,145±0,02	0,194±0,03	17	>0,05
	Nrea	0,714±0,31	1,37±0,14	2,17±0,55	11	<0,05
ES	ES <sub>t</sub>	245,00±10,68	239,40±6,44	292,00±56,07	25	>0,05
	T <sub>es</sub>	26,43±7,16	38,63±3,17	85,40±23,79	11	<0,05
	ES <sub>er</sub>	8,86±3,61	11,51±1,33	21,20±5,79	16	<0,05



1 – The difference between average arithmetic time of reaction for emergency signals and average arithmetic time of reaction for signals with the prevention (Prea);  
 2 – Quantity of admissions of signals (Nrea); 7 – The difference in time of performance of the mixed search of black and red numbers with hindrances and without hindrances (Tes); 16 – The expert estimation of professional reliability (EE);  $p < 0,05$  at  $r = 0,196$ ;  $p < 0,01$  at  $r = 0,258$

Fig. 1. The basis of a correlation galaxy round an indicator of an expert estimation of professional reliability of locomotive drivers

Рис. 1. Основа корреляционной галактики вокруг показателя экспертной оценки профессиональной надежности машинистов локомотивов

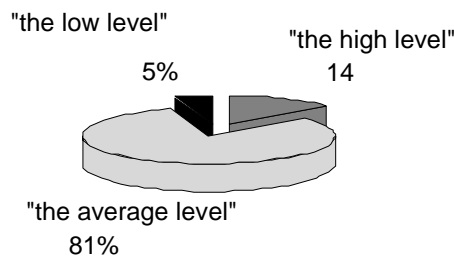


Fig. 2. Distribution of the locomotive drivers on groups with a miscellaneous level of professional reliability

Рис. 2. Распределение машинистов локомотивов на группы с разным уровнем профессиональной надежности

On the basis of comparison of results of testing of "the high level" and "the low level" locomotive drivers by U-criterion the Mann-Whitney statistically authentic distinctions of indicators of readiness for emergency actions in the conditions of monotonously operating factors (REA) and emotional stability (ES) ( $p < 0,05$ ) are revealed. It allows to draw a conclusion on higher level of the articulation of these PSQ and, hence, higher level of self-checking and self-control in group of "the high level". The received results will be coordinated with correlation is communications of indicators of readiness for emergency actions in the conditions of monotonously operating factors, emotional stability with expert estimations of professional reliability (fig. 1 see).

### 3. TECHNOLOGY OF FORMATION OF PROFESSIONAL RELIABILITY OF THE LOCOMOTIVE DRIVERS

In the course of activity PSQ act in a role of those internal conditions through which external influences and requirements of activity [6] refract, hence, the formation of PSQ is a focal point of formation of professional reliability of the locomotive drivers.

On the basis of the spent theoretical and bibliographic analysis of the literature and results of ascertaining experiment, for increasing the professional reliability the technology of formation of professional reliability where professional reliability acts as the integrated, complex quality allowing to the locomotive drivers effectively to carry out target problems in extreme conditions during demanded time has been developed, approved and introduced.

The technology of formation of professional reliability of the locomotive drivers is understood as purposeful formation PSQ, individual receptions, ways and their sequence, the set parameters of activity providing preservation in difficult conditions. Following components are included in structure of the developed technology of formation of professional reliability of the locomotive drivers: target, substantial, organizational, operational, diagnostic.

**Target component** - formation of professional reliability of machinists on the basis of actualisation generated PSQ, allocated during ascertaining experiment.

**Substantial component** - methods and the means of the psychological and pedagogical training which have been selected on the basis of principles of training, individual approach requirements: modelling of extreme conditions of professional work for formation of representation of structure of algorithms of actions in critical situations adequate to activity, exercises for formation of speed of processing of the information and stability of gnosis functions, a self-estimation of a current condition, ways of self-control with which help formation PSQ of the locomotive drivers was optimised.

Among the reasons causing infringements of structure of actions, it is possible to allocate the loss of elements of algorithm of actions in long-term memory the affective disorganisation or braking of behaviour as consequence of emotional reaction to a situation and insufficient knowledge of ways of overcoming of this or that situation. All these reasons can be appreciably eliminated in the course of training by modelling the critical situations and training self-control receptions in the given situations. It will promote storing and fastening of ways of actions in this or that emergency situation, removal the emotional intensity and, thus, liquidating the reasons causing infringements of spatial structure of actions.

**Organizational component** - realisation of a substantial component in all parts of training: preparatory - actualisation of the generated representations of structure of a complex of actions in critical situations; the basic - formation of skills and schemes of activity with use of various influences and the hindrances corresponding to professional work and demanding display PSQ; final - use of ways of self-control in a complex with elements on a relaxation training for an emotional discharge and minimisation of mental pressure (fig. 3).

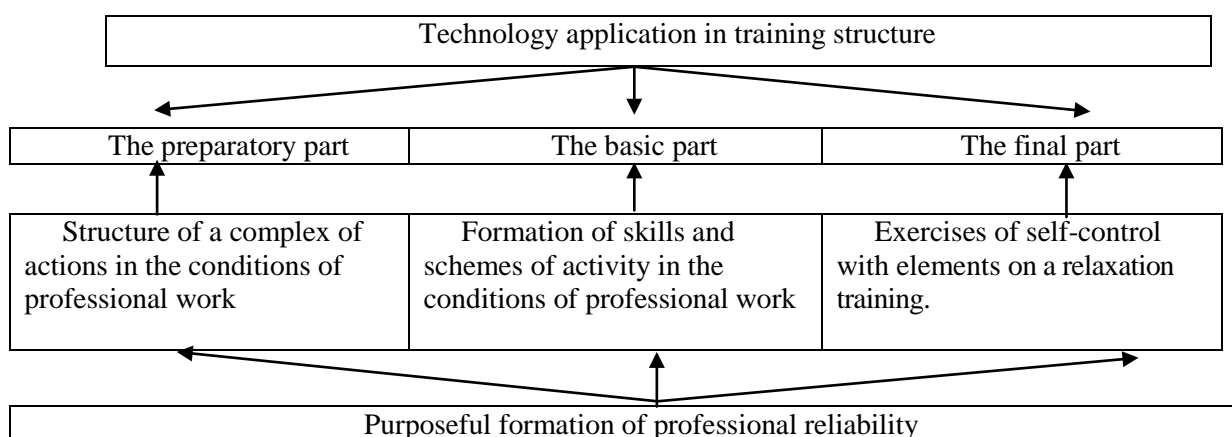


Fig. 3. Structure of training with technology use

Рис. 3. Структура обучения с использованием технологий

Use in educational-training employment of various influences and hindrances corresponding to professional work, methods and means of psychological and pedagogical training to increase readiness for emergency actions in the conditions of monotonously operating factors, emotional stability, concentration

of attention, self-control, removal of mental pressure. The formation of professional reliability of each locomotive drivers was realised in the individual form, depending on modelled conditions, characteristics of nervous activity, personal qualities and algorithms of the organisation of the actions.

**Operational component** - stage-by-stage development of skills and abilities of performance of activity in extreme conditions: acquisition flexible sense of motor schemes of actions, existential structures of a complex of operating actions in critical situations; formation of abilities of self-control of a current condition; the articulation of PSQ, shown in professional work.

During training it is necessary to define level at which the organism practices. Practice shows that at high level of motivation it is difficult to come to the generalised mastering of decisions, and at low one it is possible. It is possible to fix, accelerate, automate only qualitatively irreproachable skill, therefore employment become complicated gradually. But completely to use the skills received at high levels of motivation, the organism should have stronger motives in an activity situation, than in situation business is in a case with the skills received at smaller levels of motivation.

**Diagnostic component** – realization of operative feedback: the included supervision, conversations with locomotive drivers-instructors, locomotive drivers, initial and total control of degree the articulation of PSQ on indicators of hardware psycho diagnostics and productivity of professional work.

The diagnostic purposes applied to feedback, included: revealing the level of expressiveness and display of professionally significant qualities of locomotive drivers in an educational and training process and professional work. In the beginning and at the end of forming experiment psychophysiological testing was held.

Revealed statistically authentic communications of a professional assessment of works of locomotive drivers (n=25) with indicators REA, SA, ES, SIR, DIR ( $p < 0,05-0,01$ ) after forming pedagogical experiment testify that the selected indicators for locomotive drivers have appeared rather objective and informative.

On the basis of results of the spent pedagogical experiment it is possible to take for granted that the technology of formation of professional reliability of locomotive drivers is effective enough. Positive changes after the end of pedagogical forming experiment at locomotive drivers of experimental group (n=25) are observed on indicators of performance of techniques: readiness for emergency action in the conditions of monotonously operating factors (REA), attention switching (SA), emotional stability (ES), simple impellent reaction (SIR), difficult impellent reaction (DIR), attention volume (Va) ( $p < 0,05-0,01$ ). In control group (n=25) the quantity of errors has significantly decreased ( $p < 0,01$ ) during performance of test DIR, on other indicators of significant distinctions is not revealed.

#### 4. CONCLUSIONS

1. At the locomotive drivers, within the limits of the surveyed contingent, force of nervous system does not play crucial importance in formation of high indicators PSQ.

2. Purposeful development of PSQ promotes additional growth of professional reliability of the locomotive drivers. PSQ naturally are developed during professional work, however in preparation of the locomotive drivers it is necessary to use the various conditions modelling activity, receptions and the tasks promoting more effective display of these qualities.

3. Approbation of technology of forming the professional reliability of the locomotive drivers has confirmed its high efficiency that has allowed to raise reliability of professional work.

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