**MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE**

**NATIONAL TECHNICAL UNIVERSITY**
**«KHARKIV POLYTECHNIC INSTITUTE»**

# Basics of psychophysiological assurance of the reliability of professional activity and efficiency of a human operator

**METHODOLOGICAL INSTRUCTIONS**
**before performing practical work from the course**
"Basics of labor protection"
for full-and part-time students of the Educational and Scientific Institute of Economics, Management and International Business (NNIEM)

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## Introduction

Technical progress on the modern stage of society development is accompanied by the continuous increase of human role in the achievement of high efficiency and quality of work. Complex mechanization of production processes, control systems automation, the usage of computer engineering, and information models of individual and collective usage radically change labor characteristics. A man performs operator functions, his activities continuously become more complicated despite permanent progress of technique and automation of production processes.

Modern control system imposes responsibility both on a man, using technique and on that who ensures efficiency and reliability of this usage. Role of human factor in occupational safety is very great. Psychophysiological features of labor process participants are especially important. Psychophysiological basis of safety is based on psychology and physiology of a man. Psychophysiology of occupational safety is based on such sciences as physiology of labor, engineering psychology, ergonomics, etc.

Safety psychology considers the application of psychological knowledge for occupational health safety ensurance and is a key point in the structure of actions aimed at human safe activity.

Both, internal and external factors influence on the occurrence of such adverse state as stress, fatigue, and decrease in working capacity. The following external factors may be present at production enterprises: microclimat parameters, light, noise, vibration, the other labor environment, social-psychological climate, management style, etc. The following factors may be considered as internal reasons of adverse functional conditions: nervous system type, temperament, professional skills, etc.

The aspect of internal factors which have an impact on the appearance of adverse functional conditions is not well studied nowadays. When hiring an employee and during his adaptation it is necessary to take into consideration his psychological features, as they directly impact success and work speed, his condition. It is necessary to take into account an employee's functional conditions during his work performance.

The objective of the metodological instructions "Basis of psychophysiological assurance of professional activity reliability and human operator efficiency" is the formation of theoretical knowledge and practical skills which include holistically interconnected physiological and psychological patterns of employee's professional activity, causing efficiency, reliability and occupational health safety, professional health and longevity increase.

## 1. Functional condition of operator

Functional conditions largely determine professional reliability of the labor subject. It is the level of faultlessness, infallibility and timeliness of work operations while interacting with technical system or the other employees. Reliability is formed during professional preparation, experience, the level of person's plunge into work activities, the level of skills, etc.

**Functional condition** is a complex of physical characteristics, psychological and behavioral functions and qualities which cause performance of activities. The list of functional conditions is formed directly during the performance of work.

**Functional reliability** of the labor subject is a characteristic of a human's functional systems which ensure his dynamic stability during professional task performance within a defined period of time and target quality.

This characteristic appears under the following conditions: adequate work requirements, corresponding development levels of professionally significant mental and physiological functions, and means of their regulation under normal and extreme conditions.

Optimal functional labor condition is efficiency. Work efficiency decrease occurs naturally in the course of activity. As a rule, work efficiency decrease occurs due to relatively long work performance.

There are the following functional conditions of operator (efficiency phases):

*Pre-work state* (mobilization phase). Pre-work (or start / pre-start) state is a transition phase between physical dormant state and working state of a human; pre-work state has connection with thoughts about upcoming activity and mobilization readiness to work performance.

*Optimal working state* (stable performance, compensation phase). Creation of optimal conditions for human work performance or any other functional system brings this functional system to proper work condition. Indicators of the functional state of the body become stable and slightly exceed the initial level or are equal to it.

*Trained state and "good shape"* is stable optimal functioning state. Long and systematic performance of any activity leads to permanent optimal work condition. The more a man is trained, the better results he brings, which proves progressive achievement of the function maximum.

Main negative functional conditions are as following: the feeling of discomfort, mental fatigue, mental tension, lack of motivation, emotional stress, monotony, anxiety, indifferent state, readiness for activity, etc.

**Fatigue** is a temporary deterioration of the human body functional state resulting from work, which is expressed in working capacity decrease, in physiological functions changes and in the number of subjective feelings, united by a feeling of fatigue.

Modern fatigue classification is built on the basis of three major indicator groups: fatigue nature; fatigue symptoms; means and duration of recovery.

The following activity factors which may cause fatigue are: unsatisfactory microclimate and lighting use of technology, violation of the regime of work and rest, integral intensity of activity.

The state of fatigue can be expressed by: 1. The feeling of weakness; 2. Attention disorder; 3. Sensory disorder; 4. Dysmotility; 5. Memory and thinking defects; 6. Weakening of will; 7. Drowsiness.

Fatigue includes three phases:

1. Subcompensation phase. A high level of physiological reactions begins to decrease; indicators of the functional state are worsening. At the first stage, labor productivity is practically not reduced; the feeling of fatigue is slightly expressed.

2. Decompensation phase. At this phase, there is a steady deterioration of the body functional state; the most important functions for this work are also changed. This phase is characterized by both visible vegetative disorders - tachycardia, increased respiration and movement's coordination accuracy disorder, appearance of a large number of errors in work, etc.

3. Breakdown phase. At this phase, there is a significant disorder of regulating mechanisms, visible inadequacy of body reaction to environmental signals, sharp performance decrease, up to the inability work performance.

**Monotony** is another common unfavorable functional state at work.

This is a specific functional state, characterized by vital activity level decrease caused by monotonous stimuli, i.e. decrease of external stimulation.

The symptoms of working monotony are as following: attention sharpness decrease, weakening of ability to switch attention, decrease of vigilance, cleverness decrease, weakening of the will, drowsiness.

The state of monotony may reveal due to a professional situation with special working conditions.

It may appear as a result of the prevailing circumstances of life, including insaturation with events, boredom.

Subjectively, the state of monotony is accompanied by an unpleasant emotional feeling of the need to get out of the situation, to change the environment.

These feeling and other monotony symptoms disappear when person gets back to a standard informationally deep environment.

These are the characteristics of a monotonous activity: repeatability of operations; excessive fragmentation of operations; simplicity of action; low or medium difficulty of the work performed; insufficient number of irritants; lack of muscle efforts; rhythmic actions; narrowed attention. The monotony may potentially result in glut.

Mental state with productivity and performance decrease due to uninteresting, boring, monotonous work is called **mental satiety (psychological saturation)**. Most often, due to willpower a person manages to maintain productivity in monotonous work for some time, but then satiety inevitably sets in.

**Occupational stress** is the one that develops in the course of a person's work activity. The development of occupational stress is expressed in the form of accumulated stress.

The symptoms of accumulated professional stress: labor productivity decrease; constant feeling of internal discomfort; loss of work value motives (change of activity motivation); disappointment in the results of their own activities and in themselves; psychosomatic diseases, stable depressive states.

Production or occupational stress is a multidimensional phenomenon expressed in physiological and psychological reactions to a difficult work situation.

Occupational stress can be caused by both physical and psychological factors, by existing and predicted ones.

Adverse external labor activity impacts can result in the following physical stressors: increased physical activity, poor development of ergonomic components, etc.

Psychological stressors include: increased responsibility, lack or excess of information, uncertainty of situation, increased motivation, time shortage, frequent or fast behavior strategies change in the course of the formed situation, dissatisfaction with career growth, increased conflict in the team, etc.

**Professional burnout** is a protective mechanism developed by a person in response to adverse effects on his psyche in professional activity area. The process of professional burnout develops in stages, in accordance with the mechanism of stress development. Stress stages: anxiety; resistance; exhaustion. Professional burn out may result in a person's decision to leave the profession.

**Neuropsychic stress (NPS)** is considered as a general body reaction during activity stereotype change and is significantly revealed during an imaginary or real life or health threat.

The state of neuropsychic tension can be revealed in the deviation of two types:

excitation increase or development of inhibitory reactions; extreme response forms depend on personality individual qualities or caused by very acute mental factors.

NPS is dangerous for an individual and team as it reveals in behavior disorganization, slowdown of previously acquired skills, inadequate reactions to external stimuli, difficulties in distributing attention, narrowing the amount of attention and memory, and impulsive actions. Such changes in the mental sphere negatively impact efficiency level and specialists' work safety.

Human behavior in a state of neuropsychic stress is characterized by its inflexibility, lack of lability and plasticity.

At the same time, stereotyped actions pass more quickly and with automatism tendency. Therefore the violation of a complex professional activity structure is also considered to be a general characteristic of the state of NPS.

- During complex task performance associated with high responsibility.
- When obstacles are present.
- When strong sudden irritants emerge against the backdrop of harmful factors influence on vital functions.
- While working under lack of time and information conditions which are necessary to take a decision and organize activities.
- When mastering new activities, lack or excess of information.

## 2. Operator's efficiency and working modes

Efficiency is optimal labor functional state. Efficiency decrease occurs naturally in the course of activity. As a rule, efficiency decreases due to the relatively long performance of activities.

**Efficiency** is the value of body functional capabilities, characterized by the quantity and quality of work performed within certain period of time under the most intense stress.
Efficiency is evaluated by two groups of indicators:

- labor productivity (quantity of goods produced, reject rate, work failures, work speed decrease, etc.)
- psychophysiological systems and the human psyche indicators.

There are seasonal efficiency deviations. Within annual cycle, as a rule, the highest efficiency is observed in the middle of winter, and it decreases during hot season.

Efficiency changes throughout life. Physical efficiency at the age of 20 to 30 years is at maximum level, within next 10 years it decreases by 30%, and in the next 10 years it is only

about 60% of youth.

There is current and post-work recovery. Current recovery takes place during all periods of functional activity, ensuring the deployment of functions during working in period, maintaining efficiency at proper level during work performance. Post-work recovery ensures human body or its organs physical indicators return to its original state after a workload. Untrained workers demonstrate visible post-work excitation which depends on the hardness of work performed. Super recovery. Appearance of increased efficiency is noted upon some time after work when a human body has certain preparedness. The processes of human body energy reserves consumption and recovery are as following: I - work, II - rest: 1 - consumption; 2 - recovery; 3 - super recovery; 4 - initial level; 5 - return to the initial level.

## 3. Work and rest regime

Person's work and rest regime during production process is necessary condition, which allows saving not only human health, but also his high efficiency.

During work process, a person must keep increased attention, quickly process received information, perform different operations at defined speed, possess precise movement coordination, etc.

During the day, all this can lead to body overstain and overwork, work safety reduction, which contributes to accidents.

Rational work and rest regime is developed taking into account fluctuations in human efficiency. The main task of such schedule is to increase the period of employee's high production results, as well as to reduce the fatigue phase.

Work and rest regime is defined by:

1) work shift duration (weeks, months);

2) duration and intensity of continuous work process;

3) duration, periodicity of work breaks and the means of rest organization;

4) duration of recreation period after work;

5) daily work time (day or night shift, stable or rolling work schedule, etc.).

Intra-shift work and rest regime is the order of work and rest time rotation during the work shift.

Daily work and rest regime is organized taking into account the regularity of human physiological processes daily rhythm.

It covers the organization of work in shifts, start and end time of work shift and shift duration.

Flexible working time is a form of working time organization where individual employees or teams have one common time of mandatory presence at their workplaces and working time intervals defined by the employees themselves.

## 4. Prevention of negative functional states of operator activity

Efficiency maintenance is possible with:

- operator functional condition control;
- establishment of reasonable work and rest regime;
- rest and recreation actions provision when overwork signs are observed.

Monitoring and evaluation of operator's functional state is an important measure to ensure his activities high efficiency. It is aimed at solving the problem of operator's health preserving and strengthening.

Depending on the objectives set, the control and assessment of the operator's state can be: research, statement, prediction. Depending on the methods used, state control can be carried out by changing: physiological indicators, psychological indicators, biochemical indicators.

## 5. Operator functional condition evaluation

## Functional condition is evaluated with the help of physiological and psychological methods

1. In order to get a complete picture of human body functional state, it is necessary to investigate a number of indicators characterizing various aspects of his life.

Determination of heart rate (HR), respiratory rate (RR), and measurement of blood pressure (BP), lung capacity (VC) can provide a lot of information for individualization, assessment of classes structure correctness, body functional condition determination.

To assess functional readiness of those involved in primary or repeated physical work, as well as to determine its exposure, a number of simple functional methods and tasks (tests) are used.

When start to study the functions of human systems and organs, first of all, it is necessary to determine a number of indicators in dormant state. These are the initial data on which it is necessary to rely in the research process.

Pulse is one of available indicators which provide important information.
There are several methods to determine pulse rate.

The most simple one is palpation (on the carotid, temporal and other arteries accessible for pulsation).

Please note that during pulse measurement the cardiovascular system is very sensitive to various influences (emotional, physical stress, etc.). It is recommended to count the pulse in dormant state with 10 second interval, 2-3 times in a row in order to obtain reliable values and notice a deviation of the heart rhythm (arrhythmia).

In order to determine reliable HR result it is recommended to make measurement within one minute.

HR is measured in dormant state after 5-7 minutes rest lying on back or sitting.

Initial position for HR measurement in standing position is to lean back against the wall so that the legs are at a foot distance from the wall, to stand during 1-2 minutes before measurement.

After physical activity, it is more reliable to count HR by hand placement on the heart area (area of the 4th intercostal space under the pectoral muscle); in temporal, carotid artery areas.

The dynamics of heart rate depends on the age, gender and intensity of the upcoming work. Stable physical condition sets in upon 3-4 minutes of continuous work and HR fluctuations are significantly reduced. When monitoring pulse, determine its frequency and rhythm.

Respiratory rate is one of the most important indicators and depends on age, health, fitness level, and during physical activity - on intensity.

Respiratory rate is calculated during 1 minute in a dormant state while sitting. In this case, breathing should be natural, normal, without delays and acceleration. To calculate the respiratory rate, you need to place your palm so that it covers the lower part of chest and the upper of abdomen. Breathe evenly.

Normal Respiratory rate for 5 year old children is 19 inhales and exhales per minute, for an adult person it deviates within 14-18 per minute. When doing physical exercises respiratory rate in dormant state decreases up to 10-15 per minute. Physical activity should be regulated so that the respiratory rate after this activity does not exceed 30 for adults and 40 for children; respiratory rate restoration to the initial value should come within 7-9 minutes.

To assess human body functional state, blood pressure is measured along with measuring the pulse rate. Blood pressure is measured with a tonometer according to the method of N.S. Korotkov on the right hand in a sitting position after a 5-10-minute rest.

The cuff is applied to the middle of the bare shoulder 1-2 cm above the elbow. Person's

hand should be comfortably placed on the table and turned palm up. The moment of tones appearance corresponds to systolic pressure, and their disappearing corresponds to diastolic pressure. The use of modern electronic tonometers is more effective.

The spirometry method allows determining lungs vital capacity (VC). The measurement is carried out with a dry or air spirometer. The most convenient for research is dry spirometer, which is a small box with a scale with divisions, an arrow and an exhalation tube, on which a mouthpiece is put on. The study is carried out three times, the best result to be recorded. According to spirometry results, it is possible to evaluate cardiovascular system function. With age, lungs vital capacity changes.

Various methods are used to determine the functional capabilities of people who make physical exercises: spirometry, dynamometry, tests with a dosed load.

The dynamometry method determines the muscle strength of the arms and the strength of the muscles of the body. The backbone strength of the trunk muscles is checked with a special spring backbone dynamometer. The result is recorded in the protocol.

The most important when conducting functional tests are: well-being after the test, demonstrating how the worker got over the load; heart rate changes, blood pressure, etc.

The degree of change in hemodynamic parameters depends largely on their initial values in dormant state. Pulse rate and blood pressure are examined first out of all hemodynamic parameters. Normally, unidirectional changes in blood pressure and pulse occur during physical load.

Blood pressure reacts to the load by increasing the maximum pressure, which indicates an increase of heart contractions strength, and decrease in the minimum pressure. Accordingly, the pulse pressure rises, which indirectly points to heart stroke volume increase, the pulse quickens.

All these changes return to the initial data within 3-5 minutes, and the faster this happens; the better is the function of the cardiovascular system. Such a reaction is called normotonic; it is favorable. Consequently the more intense the load, the greater the change in heart rate and blood pressure.

Different values of heart rate shifts, blood pressure and the duration of recovery to the initial level depend not only on the intensity of the applied functional test, but also on physical shape.

With a normotonic response to functional test with 30 squats, the pulse rate increases within 60-80% from the baseline; an increase above this rate indicates at heart functional ability deterioration. Blood Pressure $_{max.}$ should not increase by more than 15-30%, and Blood Pressure $_{min.}$ decrease by more than 10-35%.

Pulse pressure during this test should not increase by more than 60-80% compared to the initial values. The percentage increase in pulse pressure should not significantly stand behind heart rate increase percentage.

Psychological methods include methods for evaluating the effectiveness of various psychometric tests performance and the subjective signs analysis of functional states specific types.

## 6. Human-operator functional states assessment

### 6.1 Differentiated assessment of work efficiency and safety

To study the dynamics of working capacity among the representatives of different professions, a questionnaire "Differentiated assessment of working capacity" (abbreviated as DAWC) was prepared. It is a modified version of the well-known Western BMSII test used to assess the severity of labor in various types of professional activities.

In many cases, methodology is original diagnostic tool because it is designed to explore a subject's condition on an individual basis rather than to assess the workload data indirectly on a group level.

For the answers of test participants, four-point scale which highlights four degrees of severity of each symptom is used: low (or almost absent), moderate, strong, or severe.

This type of scoring scale is convenient because it sets the expanded range of quantitative gradations without centering the mean. In addition, numerical scores from 1 to 4 points naturally correlate with simple verbal characteristics of the experience in terms of strength or frequency:

- “no, it’s not like that at all” (1 point);
- “probably so” (2 points);
- "correct" (3 points);
- “absolutely true” (4 points);
- “almost never” (1 point);
- "sometimes" (2 points);
- "often" (3 points);
- “almost always” (4 points).

The questionnaire is used to assess persistent and typical display of the condition in accordance with how often certain symptoms occur during the working day.

Objective: to determine the level of severity of states of reduced efficiency.
Instruction: You are offered a series of statements that characterize feelings and sensations that you may experience in the process of work. Please look and read each one carefully and rate how it fits your usual experiences during the working day.

| № | Statement | Almost never | Sometimes | Often | Almost always |
|---|---|---|---|---|---|
| 1 | Work gives me pleasure | 1 | 2 | 3 | 4 |
| 2 | I can easily concentrate on my work | 1 | 2 | 3 | 4 |
| 3 | The work does not seem “dull” or too monotonous to me | 1 | 2 | 3 | 4 |
| 4 | I work almost in disgust | 1 | 2 | 3 | 4 |
| 5 | I feel clumsy and sleepy | 1 | 2 | 3 | 4 |
| 6 | I wish there is more variety in my work | 1 | 2 | 3 | 4 |
| 7 | I have a feeling of uncertainty when I do my work | 1 | 2 | 3 | 4 |
| 8 | I have calm and self-collected reaction to emerged interference and malfunctions in my work. | 1 | 2 | 3 | 4 |
| 9 | I have to expend much more effort than I used to in order to cope with the performance of work tasks | 1 | 2 | 3 | 4 |
| 10 | I can control without any effort everything that happens at my workplace | 1 | 2 | 3 | 4 |
| 11 | I lose overall control of the work situation | 1 | 2 | 3 | 4 |
| 12 | I feel exhausted | 1 | 2 | 3 | 4 |
| 13 | I continue to work further though I do not have much interest | 1 | 2 | 3 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| 14 | I can control without any tension everything that happens at my workplace | 1 | 2 | 3 | 4 |
| 15 | I work reluctantly | 1 | 2 | 3 | 4 |
| 16 | I am trying to change activities or to look aside to overcome the feeling of tiredness | 1 | 2 | 3 | 4 |
| 17 | I consider my work relatively pleasant and interesting | 1 | 2 | 3 | 4 |
| 18 | I happens that in some work situations I feel fear | 1 | 2 | 3 | 4 |
| 19 | I'm listless and joyless at work | 1 | 2 | 3 | 4 |
| 20 | Work doesn't bother me very much | 1 | 2 | 3 | 4 |
| 21 | I have to make myself to work | 1 | 2 | 3 | 4 |
| 22 | There are situations when I have to get together instantly and make decisions in order to prevent possible failures and malfunctions | 1 | 2 | 3 | 4 |
| 23 | I want to get up, stretch a little and move around вuring work | 1 | 2 | 3 | 4 |
| 24 | I'm about to fall asleep right at work | 1 | 2 | 3 | 4 |
| 25 | My work is filled with different tasks | 1 | 2 | 3 | 4 |
| 26 | I do my work with a great pleasure | 1 | 2 | 3 | 4 |
| 27 | It seems to me that I can easily cope with any work task given | 1 | 2 | 3 | 4 |
| 28 | I am self-collected and fully involved in the execution of any task set to me | 1 | 2 | 3 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| 29 | I can easily take all the necessary measures to overcome difficult situations | 1 | 2 | 3 | 4 |
| 30 | Time at work flies by | 1 | 2 | 3 | 4 |
| 31 | I'm used to the fact that something unexpected can happen all the time at my work | 1 | 2 | 3 | 4 |
| 32 | I don't react fast enough | 1 | 2 | 3 | 4 |
| 33 | I find myself feeling like time has stopped | 1 | 2 | 3 | 4 |
| 34 | I feel uncomfortable with any, even minor, failure or interference at work | 1 | 2 | 3 | 4 |
| 35 | My work is too monotonous and I would be happy with any change during the workflow | 1 | 2 | 3 | 4 |
| 36 | I'm fed up with this job | 1 | 2 | 3 | 4 |
| 37 | I feel exhausted and completely beaten | 1 | 2 | 3 | 4 |
| 38 | It is easy for me to make any decisions regarding the performance of my work | 1 | 2 | 3 | 4 |
| 39 | Work doesn't bring me even half of the usual pleasure lately | 1 | 2 | 3 | 4 |
| 40 | I feel nervous and irritation | 1 | 2 | 3 | 4 |

**Psychometric testing of the DAWC questionnaire**

It is proposed to use indices of various types of states of reduced working capacity as the main indicators of the test, which are calculated as the sum of points scored by the tested person on the items included to the corresponding scales.

Since the dimension of all scales is the same (10 points per scale, min=10 points and

max=40 points), the procedure of these indices calculation is simple and does not require conversion into comparable units of measurement. It is only important to take into account the type of formulations as "direct" and "reverse" condition symptoms. For the convenience of results processing, the following formulas for calculating each index have been prepared:

- fatigue index (FI) = ∑ (points 9, 11, 12.21, 32) ∑ (points 10, 14, 27, 28) + 25;
- monotony index (MI) = ∑ (points 5, 6, 16, 23, 24, 33, 35) ∑ (points 3, 25, 30) + 15;
- satiety index (PI) = ∑ (points 4, 13, 15. 19, 36, 39) ∑ (points 1.17, 20, 26) + 20;
- stress index (SI) = ∑ (points 7, 18, 22, 31, 34, 37, 49) ∑ (points 8, 29, 38) + 15.

Test norms for the DAWC questionnaire

| Severity of the condition | Test results in scores | | | |
|---|---|---|---|---|
| | Fatigue index | Monotony index | Satiety index | Stress index |
| Low | up to 15 | up to 15 | up to 16 | up to 16 |
| Moderate | from 16 to 25 | from 16 to 25 | from 17 to 24 | from 17 to 24 |
| Strong | from 26 to 31 | from 26 o 30 | from 25 to 30 | from 25 to 30 |
| Severe | from 32 and more | from 31 and more | from 31 and more | from 31 and more |

Visible fatigue level is a state of exhaustion and discoordination in the course of the main activity processes, which develops as a result of prolonged and intense exposure to workloads, with the dominant motivation to complete work. and rest.

Moderate level of monotony is a state of reduced conscious control over the performance of activities that occurs in situations of monotonous work with frequent repetition of stereotypical actions and a depleted external environment, accompanied by the state of boredom, drowsiness and a dominant motivation to change activities.

High level of mental satiety is a state of rejection of too simple and subjectively uninteresting or meaningless activity, which displays in visible desire to stop work (rejection of activity) or to diversify a given performance stereotype.

Perceptible level of tension/stress is a state of increased mobilization of

psychological and energy resources that develops in response to falsity increase or subjective significance of an activity, with the dominance of motivation to overcome difficulties, implemented both in a productive and destructive form (the predominance of procedural motives - motives of self-preservation or psychological protection).

### 6.2 Acute mental fatigue questionnaire

This technique is designed to assess the degree of mental fatigue that develops during one working day for people whose work is related to the processing of information flows. These include representatives of various kinds of operator professions, dispatching services employees, computer users of a general profile, students and many others. In connection with the data from the questionnaire for acute physical fatigue, this technique helps more deeply characterize the syndrome of acute fatigue that develops among the representatives of wide professions.

This technique is similar to the questionnaire for acute physical fatigue in terms of test material presentation, data collection and processing method. It also contains 18 statements that characterize various symptoms of mental fatigue in terms of signs of overall efficiency decrease, specific deviations in sensations and perception, cognitive discomfort, changes in the emotional-volitional regulation of activity and social contacts.

The wording of symptoms of fatigue is presented both in direct (points 1, 2, 5-16) and reverse form (points 3, 17, 18). The questionnaire, offered to to the tested person to fill out, is given below.

The scheme of the tested person work with the questionnaire is similar to that given above. In relation to each statement, he can give one of three answers: agree (answer "yes"), disagree (answer "no"), not sure (answer "yes - no"). The answers received for each item of the questionnaire are translated into a three-point rating scale, taking into account the type of statement formulation:

- direct statements (points 1, 2, 5-16):
- "yes" = 2 points; "yes - no" = 1 point; "no" = 0 points;
- reverse statements (points 3,17,18):
- "yes" = 0 points; "yes - no" = 1 point; “no” = 2 points.

Mental fatigue index (MFI) - general indicator of the methodology is calculated on the basis of the received partial assessments and is equal to the sum of the scores for all items of the questionnaire. The higher the MFI value, the greater the degree of mental fatigue. MFI values can vary in the range from 0 to 36 points.

- MFI < 10 points: no signs of mental fatigue;
- 10 < MFI < 16 points: mild degree of mental fatigue;
- 16 < MFI < 28 points: moderate degree of mental fatigue;
- MFI> 28 points: severe degree of mental fatigue.

### 6.3 Questionnaire for acute mental fatigue assessment

**Instruction**. “Read each of the following statements carefully and match them with your feelings at the moment. Cross out the answer "yes" if it corresponds to your current feelings, or the answer "no" if not. If you find it difficult to choose an answer, underline both options "yes - no". Consistently answer all the statements of the questionnaire; do not think for a long time about the answer - as a rule, the first feeling is the most accurate!

- I feel overall weakness "yes - no"
- I have to force myself to respond as quickly as possible on upcoming information “yes-no”
- I am calm and self-collected "yes - no"
- I'm stuffy "yes - no"
- I want to take a little distraction from work “yes - no”
- I have a heavy head "yes-no"
- It became difficult for me to think “yes - no”
- I feel annoyed "yes - no"
- I don't feel like talking "yes - no"
- I don't pay attention to how my colleagues work "yes - no"
- I began to have pauses during work "yes - no"
- Time flows slowly "yes - no"
- I want to get up and stretch "yes - no"
- My eyes are tired "yes - no"
- I have to strain my hearing "yes - no"
- I constantly have doubts about the correctness of the work "yes - no"
- I have fun "yes - no"
- I want to work "yes - no"

### Mental fatigue index. Results processing

More detailed qualitative interpretation of obtained results may include the analysis of

symptoms frequency of decreased efficiency and cognitive discomfort (points 1, 2, 4, 6, 7, 9, 11, 14, 15, 16) compared to regulatory processes discrepancies that support activity (points 3 , 5, 8, 10, 12, 13, 17, 18).

### 6.4 Acute physical fatigue questionnaire

This technique is aimed at acute physical fatigue degree determination that develops during one working day. It is valid when the work is performed with intense dynamic and static loads, the need to maintain a fixed working position for a long time, frequent change of various types of activity and travel (for example, work in the offices, educational activities, operator work, etc.).

The questionnaire consists of 18 short statements, including both direct symptoms of physical discomfort (points 1-10, a group of fatigue symptoms), and accompanying changes from a group of symptoms of mental instability and exhaustion (points 11-14), as well as emotional and motivational assessments (points 15-18, group of symptoms of motivational involvement).

The formulations of the symptoms of the first and second groups are given in direct form, i.e. they indicate signs of fatigue, and the third group is given in reverse form, i.e. they fix possible positive symptoms of the condition. The questionnaire offered to the tested person to fill out, is given below.

The scheme of the tested person work with this technique is simple: he expresses his agreement (with the answer "yes") or disagreement (the answer is "no") for each of the statements. If there are doubts about the choice of the answer (“it seems to be yes, and it seems to be no ...”), he is given the opportunity to give an intermediate assessment, emphasizing both answer options (the answer is “yes - no”). For quantitative processing of the results, the answers of the subject are easily transformed into a three-point rating scale.

**Instruction**. “Below is a list of statements that characterize certain symptoms that you may experience in the process of work. Select the appropriate answer depending on how you feel at this moment. Cross out "yes" if you have the experience or "no if you don't. If you hesitate choosing an answer, underline both "yes-no" answers. Try not to leave gaps when filling out the questionnaire and do not think for a long time about choosing an answer.

Feeling tired "yes - no"

- Muscle pain "yes - no"
- Rapid breathing "yes - no"

- Weakness in the legs "yes - no"
- Shortness of breath "yes - no"
- Heart palpitations "yes - no"
- Dry mouth "yes - no"
- Trembling in the hands “yes - no”
- Difficulty breathing "yes - no
- Feeling exhausted "yes - no"
- Increased tension "yes - no"
- Desire to change the nature of work "yes - no"
- Excitement "yes - no"
- General feeling of discomfort "yes - no"
- Accuracy and purposefulness of actions "yes - no"
- Interest "yes - no"
- Feeling of freshness "yes - no"
- Energy "yes - no"

**Physical fatigue index. Results processing**

Direct statements (points 1-14):

- “yes” = 2 points, “yes-no” = 1 point, “no” = 0 points.
- Reverse statements (points 15-18):
- “yes” = 0 points, “yes-no” = 1 point, “no” = 2 points.

The main indicator of this technique is physical fatigue index (PFI), which is calculated as a total score for 18 statements. PFI scores can take values ranging from 0 to 36 points. The following PFI gradations are used to interpret the obtained estimates:

- PFI < 11 points: no signs of physical fatigue;
- 11 < PFI < 18 points: slight degree of physical fatigue;
- 18 < PFI < 25 points: moderate degree of physical fatigue;
- PFI > 25 points: a strong degree of physical fatigue.

For better data interpretation it is possible to determine the severity of fatigue symptoms for different groups of symptoms (“fatigue”, “mental exhaustion” and “motivational inclusion”), and then evaluate the contribution of each of these groups to the total value of PFI.

## 6.5 Methodology "Assessment of neuropsychic stress" (T.A. Nemchin)

The given questionnaire is a list of signs of neuropsychic stress, compiled according to

the data of clinical and psychological observation; it contains 30 main characteristics of this condition, divided into three severity degrees. The study is carried out individually in a separate, well-lit and isolated from extraneous sounds and noises room.

Instruction: "Depending on the answer you have chosen, the content of which corresponds to the characteristics of your condition at the present time, put the letter A, B or C next to the number of each item of the questionnaire."

**Questionnaire:**

• Presence of physical discomfort:
a) the complete absence of any unpleasant physical sensations;
b) there is minor discomfort that do not interfere my work,
c) a large number of unpleasant physical sensations that seriously interfere with the work.
• Presence of pain:
a) complete absence of any pain;
b) pain sensations periodically appear, but quickly disappear and do not interfere with work;
c) there are constant pain sensations that significantly interfere with the work.
• Temperature sensations:
a) the absence of any changes in body temperature;
b) a feeling of warmth, body temperature increase;
c) a feeling of body coldness, limbs, a feeling of "chills",
• State of muscle tone:
a) normal muscle tone;
b) moderate increase in muscle tone, a feeling of some muscle tension;
c) significant muscle tension, twitching of individual muscles of the face, neck, arm (tics, tremor);
• Coordination of movements:
a) normal coordination of movements;
b) accuracy increase, ease, coordination of movements during writing, other work;
c) decrease in the accuracy of movements, impaired coordination, deterioration of handwriting, difficulty in performing small movements that require high accuracy.
• The state of physical activity in general:
a) normal physical activity;
b) motor activity increase, speed and energy movements increase;
c) motor activity sharp increase, the inability to sit in one place, fussiness, desire to walk, change the position of the body.
• Cardiovascular system feelings:
a) absence of any unpleasant sensations from the heart;
b) feeling of increased cardiac activity that does not interfere with work,
c) presence of unpleasant sensations from the heart - increased heart rate, a feeling of constriction in heart area, tingling, heart pain.

• Gastrointestinal symptoms:
a) absence of any discomfort in the abdomen;
b) single, quickly passing sensations in the abdomen that not interfere with work - suction in the epigastric area, feeling of slight hunger, periodic "rumbling";
c) severe discomfort in the abdomen - pain, loss of appetite, nausea, thirst.
• Respiratory symptoms:
a) absence of any sensations;
b) increase in depth, breathing quickening not interfering with work;
c) significant changes in breathing - shortness of breath, feeling of insufficiency of inspiration, "lump in the throat".
• Excretory system symptoms:
a) absence of any changes;
b) moderate activation of the excretory function - more frequent desire to use the toilet while fully maintaining the ability to abstain (endure);
c) sharp increase of the desire to use the toilet, difficulty or even impossibility to endure.
• Sweating condition:
a) normal sweating without any changes;
b) moderate increase of sweating;
c) appearance of profuse "cold" sweat.
• Condition of the oral mucosa:
a) normal state without any changes;
b) moderate increase in salivation;
c) feeling of dryness in the mouth.
• Skin coloration:
a) usual color of the skin of the face, neck, hands;
b) face, neck, hands skin redness;
c) blanching of face, neck skin, appearance of a "marble" (spotted) shade on hands skin.
• Susceptibility, sensitivity to external stimuli:
a) absence of any changes, normal sensitivity;
b) moderate increase of susceptibility to external stimuli that does not interfere with work;
c) sharp exacerbation of sensitivity, distractibility, fixation on extraneous stimuli.
• Feeling of self-confidence, in your abilities:
a) usual feeling of confidence in one's strengths, in one's abilities;
b) increasing the feeling of self-confidence, belief in success;
c) feeling of self-doubt, the expectation of failure.
• Mood:
a) normal mood;
b) elated, elevated mood, a feeling of elation, pleasant satisfaction with work or other activities;
c) decreased mood, depression.

• Sleep features:
a) normal, ordinary sleep;
b) good, strong, refreshing sleep the day before;
c) restless sleep with frequent awakenings and dreams during the previous several nights, including the day before.
• Features of the emotional state in general:
a) absence of any changes in emotions and feelings;
b) sense of concern, responsibility for the work performed, "excitement", active desire to act;
c) feeling of fear, panic, despair.
• Noise immunity:
a) normal state without any changes;
b) increase of noise immunity during work performance, ability to work in the conditions of noise and other irritants;
c) significant decrease of noise immunity, inability to work with distracting stimuli.
• Speech features:
a) ordinary speech;
b) speech activity increase, voice volume increase, speech speed up without deteriorating its quality (logicality, literacy, etc.);
c) speech disorders - the appearance of long pauses, hesitations, an increase of the number of unnecessary words, stuttering, too quiet voice.
• General assessment of mental state:
a) usual state;
b) state of composure, increased readiness for work, mobilization, high mental tone;
c) feeling of fatigue, lack of concentration, absent-mindedness, apathy, decreased mental tone.
• Memory features:
a) regular memory
b) improving memory - it is easy to remember what you need;
c) memory impairment.
• Attention Features:
a) normal attention without any changes;
b) concentration ability improvement, distraction from extraneous matters;
c) deterioration of attention, inability to concentrate on business, distractibility.
• Wits:
a) ordinary intelligence;
b) increased intelligence, good resourcefulness;
c) decreased intelligence, confusion.
• Mental performance:
a) normal mental performance;
b) mental performance increase ;

c) significant decrease of mental performance, rapid mental fatigue.

• Phenomena of mental discomfort:

a) absence of any unpleasant sensations and experiences from the psyche as a whole;

b) feeling of mental comfort, mental activity increase, or single, mild, quickly passing phenomena that do not interfere with work;

c) pronounced, diverse and numerous mental disorders that seriously interfere with work.

• The degree of prevalence (generalization) of signs of stress:

a) single, weakly expressed signs that are not paid attention to;

b) clearly expressed signs of tension, not interfering with activity, but on the contrary, contributing to its efficiency;

c) large number of various unpleasant signs of tension that interfere with work and are observed from various organs and systems of the body.

• Tension state occurrence frequency:

a) feeling of tension almost never develops;

b) some signs of tension develop only during difficult situations;

c) signs of tension develop very often and often without sufficient reasons.

• Tension state duration:

a) very short, no more than a few minutes, quickly disappears even before the difficult situation has passed;

b) continues almost entire time of being in a difficult situation and performing the necessary work, stops shortly after its completion;

c) very significant duration of tension state that does not stop for a long time after a difficult situation.

• Overall severity of tension:

a) complete absence or very weak severity;

b) slightly visible, distinct signs of tension;

c) visible, excessive stress.

### Methodology processing and result interpretation

After filling out the form, the points are calculated by summing them up. For the "+" mark put against point "a" 1 point is calculated, against point "b" 2 points, against point "c" - 3 points. The minimum number of points which can be calculated is 30, and the maximum is 90.

## 7. Regulation of negative functional states

In general functional states characterize the entire range of variations of mental activity (sensations, perceptions, ideas, imagination, memory, thinking, speech, motivation, and emotions) of a person during sleep and wakefulness.

Negative functional states (NFS) can be independently regulated only at the early

stages of their formation. At severe stages, professional help from psychologist is required.

The range of methods for functional state regulation is quite wide. They include a number of general recommendations and methods of psychological regulation.

General recommendations for the regulation and prevention of negative functional conditions are as following:

- change of environment and activities. For example, during break, it is recommended to ventilate the work area and go outside to fresh air. It is proved that the influx of fresh air improves mental activity;
- Compliance with the regime of work and rest. Even a short break of 3–5 minutes can briefly distract from work and thereby switch attention;
- regular medical check. Physical health is the basis of mental well-being;
- Proper nutrition and proper sleep. Meals should be regular, meals should be different and rich in fiber, portions should be moderate;
- various types of specialized gymnastics, breathing exercises, self-massage, etc., indirectly contributing to the normalization of the course of mental processes.

Central place among psychoprophylactic means of actively influempacting the internal state of a person is taken by the group of methods combined by the name psychological (mental) self-regulation (PSR), which refers to the impact of a person on himself with the help of words and corresponding mental images.

Typical task of applied work aimed at the prevention of unfavorable functional states is stressful conditions symptoms removal and emotional tension degree decrease, as well as the prevention of their undesirable consequences.

In addition, against the background of human condition normalization (mainly due to calming down, relaxation), it often becomes necessary to activate the course of recovery processes in order to achieve high efficiency as soon as possible, as well as to strengthen the mobilization of the body's internal resources.

There are different methods and modifications of PSR techniques that in general are adequate for these tasks. First of all, they should include the methods given in Table 1.

Among the methods used by psychologists in working with the NFS, there are the ways to regulate stressful conditions, as well as states of satiety, monotony and fatigue (Table 2).

For such an NFS as stress, the following methods of self-regulation are applicable:

Breathing exercises for quick stress relief. Breathe in for a count of 1 to 10, hold your breath, and then exhale for a count of 10 to 1.

Exercise "Arithmetic" for concentration. It is necessary to calculate how many days are left till significant dates of the current year (for example, before a birthday, before a wedding day, vacation). Thus, the attention is concentrated on mathematical operations and, as a result, the level of anxiety is reduced.

Self-order method. Saying, preferably many times, in an undertone or aloud a phrase that expresses the ability to overcome difficulty in order to increase self-control. For

example, “I can do…”, “I have to overcome…”

Neuromuscular relaxation. There are some contraindications for this exercise: epilepsy, spinal cord and brain injuries. It is necessary to consistently strain (for 10 seconds) and relax each sector of the body (3 times each) in the following order: legs, buttocks, abdominals, chest, arms, shoulders, face. Exercise helps to completely relax all muscle groups and overcome anxiety or stress.

Listening to relaxing music also helps to reduce anxiety and stress levels.

For the purpose of self-regulation of fatigue, monotony and satiety states the following exercises are used:

Exercise "I see, I hear, I feel." In order to be distracted, note with increased attention what you see - which objects fall into the field of vision, hear - which sounds, rustles, voices surround you, and feel - the touch of clothes, the unevenness of the coating under your feet, the beating of the heart.

Gymnastics to relax the eyes: tightly close and wide open the eyes 4-6 times in a row with an interval of 15 seconds (for 2 minutes); close your eyes tightly for 3-5 seconds, then open your eyes for 3-5 seconds (repeat 6-8 times); blink rapidly for 1-2 minutes.

Exercise to relax the muscles of the head and neck. Pressing your fingers on the back of the head for 10 seconds, make rotational movements in a circle to the right and left.

Hand relaxation exercise. Spread your fingers wide and strain your hands for 5–7 seconds, then strongly clench your fingers into fists for 5–7 seconds, then open your fists and shake your relaxed hands.

Considered methods of self-regulation and measures for the prevention of negative functional states will allow employees to bring their condition back to normal state, both in non-standard and under normal working conditions. Attentive attitude to your body and timely correction of deviations in its activity will help to prevent a decrease in working capacity, prevent the deterioration of psychological well-being and physical health.

*Table 1*

**Methods of psychological self-regulation**

| № | Method name | Method application | Exercise content |
|---|---|---|---|
| 1. | Neuromuscular relaxation | To reduce the degree of tension and subsequent relaxation of the main muscle groups of the body, and, as a result, a decrease in emotional | Each exercise consists of alternating periods of maximum contraction followed by rapid relaxation of a particular area ofthe body. There is a complete release of tension in the involved muscle group and increased blood supply to the vessels. There is a feeling of warmth and heaviness, softening, a feeling of peace and relaxation. These feelings are a consequence of the elimination of residual, usually unnoticed muscle tension, increased blood supply to the vessels of the |

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|---|---|---|---|
| | | strain. | desired area of the body and, accordingly, increased metabolic and recovery processes. |
| 2. | Autogenic training | Promotes further relaxation, rest, transition to sleep; or has an activating effect. | The exercises consist of repeated verbal formulations in an undertone or aloud and the formation of stable links between "self-orders" and the occurrence of certain states. For example, "I can do…", "I have to overcome…" |
| 3. | Ideomotor training | Stimulation of cognitive processes, increased concentration. | The exercise consists of the mental living of the situation with the reproduction in the imagination of all the muscular and spatial sensations associated with the actions of the body. |
| 4. | Sensory reproduction of images | Relaxation and the possibility of subsequent activation of one's state. | The exercise consists in operating with figurative representations of objects and whole situations that are usually associated with relaxation. For example, it is necessary to imagine in detail a forest clearing, how the Sun warms the body, how birds sing and how easy it is to breathe in the forest. |

*Table 2*

**Ways of self-regulation and prevention of negative functional states (NFS)**

| NFS | Typical situation | Symptoms (psychological and behavioral) | Ways of self-regulation and prevention |
|---|---|---|---|
| **Stress** | It is normal to experience this state in situations of joy and fear | Strong excitement, impulsivity, constant thoughts about the problem, irritability. | Breathing exercises. Exercise "Arithmetic" for concentration. Self-order method. Neuromuscular relaxation. Listening to relaxing music. |
| | | Headaches, insomnia, indigestion, rapid pulse, trembling in the voice, accelerated or slow speech. | |
| **Monotony** | During performance of the same type of tasks (for example, monitoring instrument readings) | The state of boredom, indifference, drowsiness. | •Exercise "I see, I hear, I feel." • Gymnastics to relax the eyes. • Exercise to relax the muscles of the head and neck. • Exercise to relax the |

| | | | |
|---|---|---|---|
| | | | hands.<br>• Listening to dynamic music. |
| | | Too much relaxation in the body, distractibility, inability to concentrate. | |
| **Fatigue** | During increased workload, the presence of a large number of urgent matters, a long absence of rest | Feeling of insecurity, irritability, decreased attention. | |
| | | Skin blanching, increased sweating, slow movements, headaches, frequent colds, and sleep disorders. | |
| **Satiation** | During the performance of a monotonous, low-content activity. | Loss of interest in work, active desire to change it, as well as a feeling of irritation and disgust to the activity performed. | |
| | | Decreased heart rate. | |

## Questions for self-control

1. Psychophysiological analysis of professional activity and professional suitability.
2. Psychophysiological components of working capacity.
3. Functional operating states and efficiency.
4. Psychophysiology of functional states.
5. The concept of psychophysiological functional state.
6. Typical conditions for the professional activity of a human operator.
7. The value of the regime of work and rest.
8. Psychophysiological analysis of the professional activity of a human operator.
9. Assessment of the functional states of the human operator.
10. Prevention of negative functional states of the human operator.
11. Individual quantitative methods for assessing functional states, efficiency and psychophysiological characteristics of a person.
12. Methods of psychophysiological research.
13. General psychophysiology of functional states.
14. Psychophysiology of fatigue.
15. Psychophysiology of monotony.
16. Psychophysiology of stress.
17. Characteristics of NPN.
18. Self-regulation of the NSF.

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Content

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