

# HEALTH LEVEL OF THE OPERATORS WORKING IN SHIFTS

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## Abstract

We studied working conditions of the workers employed in oil-refining factory. Dynamic monitoring of the functional state of operators throughout the shift showed that an adequate rest after shift can maintain high levels of major systems functioning, and mental and physical performance, as well as reserve capacity of the body throughout the day and night shifts. In the transition from daytime to night shifts, the rest between shifts is 8 hours, which is not enough and has an unfavorable effect on the workers' performance.

## Keywords

oil refining, production factors, shift, mental and physical capacity, health.

## INTRODUCTION

Development of oil production and refining industry of Kazakhstan due to its economic and social attractiveness led to the development of new and alternative forms of organizing production which is rotational method of work which also includes extended (12 hours) day and night shifts. The influence of this form of production (12 hours shifts and 2 weeks shifts) on the health of employees is not studied well enough and is a serious problem of labor hygiene.

Studying the effects of different stressors for 12-hour shift regime work on the functional state of the organism is of interest because the rotational and night work causes changes in the normal course of the biological clock of an organism that effects on maintaining the operating state for a sufficient level of efficiency (Bobko N. A., 2006, Victorov V., Kamensky, Yu.N., Kirpichnikov A.B., 1996).

Shift and especially expedition rotational methods of work produce adverse in the health of workers. These changes are caused by tension and spending of organisms' functional reserves in the process of adaptation to unusual rhythms of work and rest from the strain of social and biological rhythms. (Shustov V. Ya., Korolev V.V., Trubetskov A.D., 1995; Yushkova O.I., Kuzmina L.P., Poroshenko A.S. et al, 2008).

In this connection, nowadays it has become necessary to conduct additional studies of health of the workers employed in manufacturing where labor organized by expeditionary-shift method is a prerequi-



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site for appointment of workmen's compensation and the rationale for the regime of "work and rest".

**OBJECTIVE IS** to investigate functional state of operators in the dynamics of shift in expedition-rotational method of labor.

## MATERIALS AND METHODS

The objects of the research which was a complex of hygienic and physiological studies were jobs and working operators serving the installation of "Tengizchevroil" gas processing plant. Psychophysiological studies covered 30 operators at the average age of  $38.3 \pm 1.0$  and working experience of  $9.8 \pm 0.5$  years. All patients were divided into two groups. Group 1 (82.5%) included operators occupied with processing equipment at the facilities of the plant. Group 2 (17.7%) included operators watching the progress of the technological process from the remote control. Physiological examinations were carried out to all operators 4-fold in the dynamics of shifts: in the beginning and end of day and night shifts for 14 days shift. Analysis of outcomes was performed taking into account the specifics of the operations and organization of the labor process.

Estimation of the functional state of the respiratory system was conducted by spirometry on a portable spirograph (SMP-21/01- "P-D", Russia) which gives the following indicators: vital capacity (VC), expiratory reserve volume RVexp; inspired reserve volume RVinsp; respiration rate (RR); tidal volume (TD); minute volume of respiration (MVR); maximum ventilation of lungs (MVL). Parameters for ventilation index (VI) and breathing reserve (RD) were obtained by calculation.

Status of central hemodynamics was studied using traditional clinical methods. All operators were

measured heart rate reduction states (HR), systolic (SBP) and diastolic (DBP) blood pressure (Korotkov). According to the results of physiological studies adaptive capacity by Berseneva (AC) and functional state index by Pirogov (FSI) were additionally calculated.

Functional state of the operators' central nervous system was studied by the method of reflexometer using a computer program. Hidden time of sensory-motor reactions: simple auditory and visual-motor reactions, complex auditory and visual-motor reactions were recorded.

Psychological status of the operators was studied by Eizenck tests (expressed in whole introversion and emotional stability), Spielberger-Hanin (re-active and trait anxiety). Mental stress was determined by questionnaire of T.A. Nemchinov, violations of the vegetative status were determined by the Wayne questionnaire, state of health by the form of health self-assessment of Afanasiyev.

Over a 12-hour shift (beginning and end of shifts) and the dynamics of 14 day shifts (at 7.00 a.m., 5.00 p.m., 7.00 p.m., 5.00 a.m.) mental efficiency of operators was registered by the blank method of Anfimov. When conducting three tests the number of symbols, the number of correctly detected symbols and the number of different errors were traced. To identify somatic illness, activity of the nervous system and emotional state a letter-hopping method "SUN" was used.

Subjective opinions of operators on the impact of various factors and conditions on their health, the prevalence of complaints, the methods of organizing work and life were analyzed in the interview questionnaire which included 50 questions. Each of these characteristics has been evaluated by both average indicators and individually for each operator. Statistical data analysis was conducted using the statistical package «Statistica», version 5.5. to determine average and dynamic changes of indicators for the operators of designated groups and Fisher and Student's test for 95% reliability.

## RESULTS

While assessing labor conditions at the sites of gas processing plant it was established that in the normal course of the technological process operators of group 1 served technological equipment at various installations of the plant during the equipment inspection and fill in regime lists.

Conducted physiological studies of operators of group 1 showed that by the end of the shift there was increase in cardio-respiratory system of operators of Group 1 which demonstrated the pressure growth, which was accompanied by increase in peripheral vascular tone by 43.2% ( $p < 0.05$ ) with increasing

sympathicotomy ( $p < 0.05$ ) forming workers' tension. Rising of additional volume (AV) to a 0.70 l to 0.77 l ( $p < 0.001$ ), breath frequency from 16.4 to 18.1 1/min ( $p < 0.001$ ), minute volume of respiration (MVR) from 11.4 liters to 13.9 liters ( $p < 0.001$ ) not exceeding normal range, allowed the body to cope with the imposed loads. However, the reduction of breathing reserve (BR) from 0.92 to 0.899 conditional units ( $P < 0.001$ ), as well as the increase in VI from 3.02 to 4.03 arbitrary units ( $P < 0.001$ ), indicative of wasteful consumption of reserves of breath, which could cause a drop in performance and was regarded by us as fatigue.

A slight increase in DBP from 74.4 to 75.4 mm Hg (to 1.3%) and TPVR from 1398 to 1429 dyn/cm<sup>2</sup> \* from  $10^{-5}$  (to 2.2%) with a significant increase in activity of the respiratory system of MOD (to 17%) determined the decrease in physical performance in employees of group 2 by the end of the shift. Concentrated mental activity with a high psychological stress in the conditions of hypodynamic led to mismatch of synchronous activity of the respiratory and cardiac component and manifested inadequate stimulation of respiration with increasing frequency (8.5%) and depression (to 7.6%). The formation of these processes during the change reduced the reserves of the respiratory system and was associated with low physical activity.

Organization of labor process in the dynamics of the day was reflected in the integral indicators. Gradual transition of the functional state of the organism from the level of "below average" (Index of Functional Status (IFS) = 0.51 arbitrary units (a.u.)) in the morning to the level of "medium" (IFS = 0.57 a.u.) in the evening reflecting the influence of physical tension related to the movement within the working area. In the operators of group 2 IFS remained unchanged throughout the entire shift, corresponding to the "medium" level.

The indicators characterizing the state of the neuromuscular system which are the power of right and left hands remained unchanged in the operators of group 1 throughout the work. In the workers of group 2 the force of both hands during a change did not much diminish: for the right hand it was from 40.2 kg to 37.2 kg, and for the left hand it was from 40.3 kg to 37.2 kg (4.7% and 7.9%). Minor and frequent movements of regional minor groups of muscles when work on a PC, fixed position of the body during the shift without significant physical tension caused the identified changes and were the reflection of the developing working-fatigue in the system

Changing the status of the central nervous system during the change in the operators reflect the particular nature of work and the resulting slight fatigue towards the end of the shift. In individuals of group 1

to the end of the shift we determined the displacement of the balance of nervous processes in the cortical link of the auditory analyzer towards slowdown, which was probably due to the periodic location of the working groups in areas with significant noise emission. Features of work of group 2 operators' who monitoring the progress of the displayed production process, requires exercising constant vigilance and readiness to respond quickly to any changes shown on the display. This is shown in the dynamics of the central nervous system functioning. Audible and visual indexing indicating the course of the technological process in the conditions of sufficient light and no noise interference lead to activation of nerve processes in the cortical areas of the visual and auditory analyzers that determine the quality of performance set by labor problems. By the end of the shift hidden time of both simple and complex sensor-motor reactions of different modalities decreased (Figure 1). Shortness of complex sound-motor reactions decreased to 30% and visual-motor reactions decreased to 13% by the end of the shift that indicated the displacement of the nervous processes balance in the direction of excitation in the analyzer regions of the cortex.

At the beginning of group 1 operators' change there was a very low value of health and mood (2.7 and 2.9 points), while the indicators of activity were within the optimal values ( $5.0 \pm 0.1$  points). The mismatch of these three indicators showed some pre-launch tension of the organism at the beginning of a shift. The increase of the values of well-being and mood ( $p < 0.01 - 0.001$ ) (to 19.4% and 9.4%) during the shift reflected adaptation of the workers' organisms to the conditions and nature of work. Declining of activity to 4.5 points ( $p < 0.001$ ) by the end of the working shift indicated the development of the beginning of fatigue.

Higher baseline values of health and mood making 3.1 and 3.4 points at low values of activity ( $4.49 \pm 0.15$  points) were identified at the beginning of the change in group 2. The mismatch of these parameters at the beginning of the change also reflected the pre-launch tension of the body, but not so clearly expressed as in the operators of group 1. Further improvement of health, mood and decrease in activity towards the end of the change is observed as a sign of adaptation of the organism to the nature of work.

Dynamics of mental work capacity of the operators of the allocated groups during the extended work shift reflects the features of the organization of work and nature of the entry requirements to higher nervous activity of the operators. So, in the operators of group 1 with a decrease of the quantitative characteristics of the tests towards the end of shift the quality of their performance did not change, and on the contrary, the number of errors decreased, especially when perform-

ing simple tests (25–27%). Features of stereotypical working operations under hypodynamic conditions and in the mode of sensory expectations of the workers of group 2 identified the dynamics of changes in mental capacity, which was shown in both reducing the quantitative characteristics of the tests (7–18%), and in increasing the number of erroneous actions (in 17–37%). The biggest change was achieved when a complex test with differentiation and switch of attention was conducted. These functions were central in occupational safety in group 2 operators.

Among patients of group 1 there were 68% of introverts, 32% of extraverts, while among the operators of group 2 there were no extraverts at all (Figure 2).

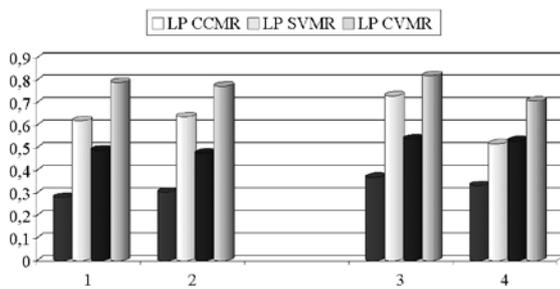
There were emotionally unstable persons in both groups of operators, but if in Group 2 their number did not exceed 10%, in group 1 they were almost half of the surveyed persons (40%).

Thus, group 2 of the operators was dominated by the number of phlegmatic persons who did not experience psychological discomfort in both standby regime for a signal, and who had sufficient qualities for adoption and implementation of fast decisions and actions.

When comparing the functioning of the central nervous system in the morning time during the watch the balance of nervous processes in hearing and visual cortex in the organization of work during a day shift was standard, but there was also a shift of balance towards excitation before working in the night shift. This is a proof of the rest sufficiency to recover the balance of nervous processes. Sharp strengthening of inhibitory processes (40–60%) in the transition to the night shift reflected not only adapting to the conditions of work, but also violations of the chronobiological rhythms. Gradual accumulation of fatigue in the dynamics of the day shift in the cortical link of the hearing analyzer (in 4–26.3%) during the night shift increased (up to 25.4–34.6%). Joining the aforementioned processes of fatigue in the visual cortex (in 34.4–42.5%) determined retention of inhibition in the dynamics of the night shift. Transition of work to the night shift was the most tedious and stressful for the operators' CNS which was kept in the operators till the end of the watch for the next 7 days.

A similar pattern was found with regard to mental capacity, which was improving during 7 days in one shift in a "before work" state qualitatively (to 13.2–18.4%) and quantitatively (to 27.9–38.5%).

A level before work at night change for 7 consecutive days of the shift was declining gradually not only in the volume of watched signs (to 5–16%) and deleted signs (to 7–11.8%), but also by reducing the error (in 22.4–67.5%). This process demonstrated strategy for maintaining quality by reducing the quan-



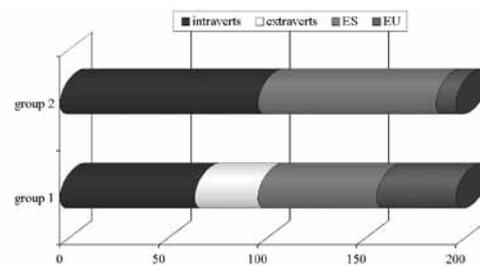
**Figure 1.** Indicators of the central nervous system in operators of professional groups 1 and 2 in the dynamics of the working shift

**Note:** LP SHMR – latent period of simple hearing motor reaction, LP CHMR – latent period of complex hearing motor reaction, LP SVMR – latent period of simple visual-motor reaction, LP CVMR – latent period of complex visual-motor reaction; Abscissa axis: 1, 2 – Group 1, 3, 4 – Group 2; 1, 3 – beginning of the shift, 2, 4 – end of the shift

titative characteristics of the. In the transition from day shift to work at night shift the background values of mental capacity decreased due to quantitative (to 13.4%) and qualitative characteristics, especially when performing tests with switching attention (213%). Comparing the mental abilities at the end of the day during the first week of the shift it should be noted that the quantitative and qualitative characteristics of simple tests reduced gradually (to 10.3–13.7% and 47.8%), but quality and quantity of complicated tests with differentiation of attention remained unchanged. The transition from day shift to work at night revealed only a slight decrease of mood. Dynamics of “before work” levels of health and mood of the night shift operators gradually increased to the end of the shift ( $p < 0.01$ ), whereas their activity decreased ( $p < 0.01$ ). Decrease of such indicators as health and mood corresponded to fluctuations of daily biorhythms. In spite of insignificant decrease in activity towards the end of the shift, its value remained at a sufficiently high level, indicating the restoration of the reduced capacity of the organism to the beginning of the next shift. This allows the operators to maintain a sufficiently high level efficiency during the entire 14 days shift.

Neuro-psychic tension (NPT) recorded in the beginning of the shift ( $38.7 \pm 1.5$  points) was regarded by the operators as “weak detensive”. In the dynamics of the first week its severity did not change, remaining at the level of  $34.5 \pm 1.5$  points, and remained “weak detensive” till the end of the shift. Transition of work to the night shift made an effect on the operators’ organisms manifested by formation of neuro-psychological stress of “intensive” level (up to  $61.0 \pm 1.6$  points,  $p < 0.01$ ).

Dynamics of changes of reactive anxiety (RA) over the shift reflected slight reduction of PT to the end of the first week (up to 32.4 points) and keeping it at the average level (35–36 points) before the end of work.



**Figure 2.** Prevalence of persons with different typological profile among operators of groups 1 and 2

**Note:** ES-emotionally stable, EU-emotionally unstable.

This allows us to say about quick involvement of operators into the work and preserving their confidence in their own capacity to implement it. However, an analysis of vegetative feeling obtained by the Wayne test testified to the emergence of a number of autonomic dysfunctions ( $17.0 \pm 1.6$  points) to the end of 14 days shift. Working in the day shift was characterized in the operators by preservation of heart blowout and peripheral vascular resistance, weakening of sympathetic influences till the end of the shift, accompanied by increasing vascular resistance and decreased heart rate. Reconfiguring functioning of the cardiovascular system during shifts’ change was accompanied by increase in all circulatory dynamics parameters except for stroke volume of blood that was regarded as a system tension, manifested as a less favorable response of the system on the workload due to amplification of heartbeat and reduction of peripheral vascular resistance. Tension of circulatory dynamics formed in the second part of the shift was maintained until the end and determined reduction in work from the “average” to a lower level “below average” (Figure 3).

56% of group 1 operators and 80% of group 2 operators assessed their health status as “good”. 40% of employees of group 1 estimated their health status as “satisfactory”, and 4% of the respondents could not answer this question. In the second group 10% of the interviewed operators considered state of their health as “satisfactory”.

Half of the respondents, both in the first (56%), and in the second (50%) groups believed that adverse working conditions affect their health and life duration, 30–60% named environmental factors, and 33–40% of the employees chose the answer “life conditions”.

Analysis of the diseases nature identified by the poll showed that chronic diseases in group 1 made up the bulk (20%), and chronic and acute diseases made 12% (Table 1). People of group 2 indicated acute (30%) or chronic diseases (20%), and also occupation injuries (10%).

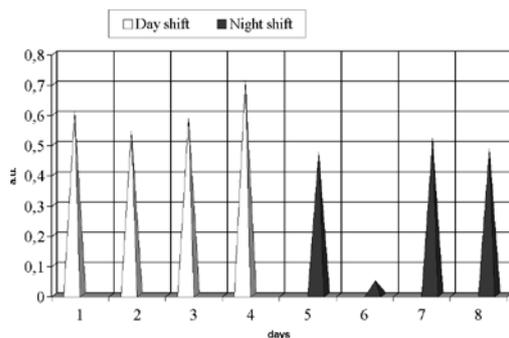


Figure 3. Change in CPI in operators in the dynamics of the shift

Note: horizontal axis: 1, 2 – beginning of the day shift, 3, 4 – end of the day shift, 5, 6 – beginning of the night shift, 7, 8 – end of the night shift;

Table 1. Nature of diseases among workers according to the poll

Questions	Answers	Distribution, %	
		Group 1	Group 2
Nature of diseases	Acute diseases	8	30
	Chronic diseases	20	20
	Chronic and acute diseases	12	-
	Occupational diseases	8	-
	Occupational injures	-	10
	Household injury	8	-
	Nursing process after smb	4	-

As the operators of group 1 were undergone to industrial noise during the work process, 56% of the respondents identified it as a factor disturbing the implementation of work.

In addition, employees of the same group noted such factors of production, as dust and fumes in the workplace (44% each), vibration and low temperature (28%), presence of drafts (16%) and low luminosity (12%) as interfering.

The operators of the central control panels often complained about non-optimal microclimatic conditions: drafts (50%), low temperature (30%), high humidity (20%) and weak illumination (20%). The overall level of gas contamination at the industrial site produced negative reactions in 40% of the operators.

The nature of work performed by the operators of group 1 requires strain of attention (92%), and sensor systems (60%), and in group 2 strain of attention was required by 10% and sensor systems – 60% of the respondents.

More than a half (60%) of group 1 and almost all (90%) operators of group 2 noted that the main production processes are performed by them in a rapid and very rapid rate. High length of work places in 50% of group 1 determined significant movement in the working area in both horizontal and vertical planes.

Peculiarities of organization of the production process and duration of the working shifts (12 hours)

were the cause of the high prevalence of complaints for reduction of efficiency during the work in 60% of workers in the first and 64% in the second professional groups. In this case the bulk of the operators (up to 60% in group 1 and 50% in group 2) noted moderate fatigue both at work at night and at work in the day shift. 4% of group 1 and 10% in the second group were very much tired. 16% of group 1 and 40% of group 2 did not experience fatigue during the day shift, and at night their number was higher: 24% of group 1 and 40% in the second group.

Reduced performance capacity during the change in workers of groups 1 and 2 was accompanied by the formation of a number of autonomic disorders. Among the most common were headache (16% and 20%), heaviness in the legs (30% and 60%), drowsiness and sudorrhea (10% and 12%), irritability (in 4% and 10%). Working in the night shift caused more expressed manifestations of fatigue in the form of drowsiness (30% and 36%) among both groups.

## CONCLUSIONS

1. Impact of adverse factors of production in patients of group 1 caused increase of peripheral vascular tone on the background of sympathicotony and increase of respiratory, resulting in formation of inhibitory processes in the cortical link of the auditory analyzer.
2. Under the influence of unfavorable factors of production in patients of group 2 we found shift of the balance of nervous processes towards excitation, reduction of quantitative characteristics of efficiency, activation of neural processes, without going beyond the limits of physiological norm and reflecting development of work tension.
3. In the transition from daytime to night shifts the rest between changes lasting for 8 hours is insufficient and may cause the development of fatigue, and reduction of functional reserves.

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