

## HYGIENIC ASSESSMENT OF WORKING CONDITIONS AND HEALTH CONDITION OF THE OIL REFINERY PLANT WORKERS

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### Abstract.

This work aimed to identify harmful factors in the production environment, identify risk factors, and assess their impact on the health of workers of the Fergana Oil Refinery Plant. The research was conducted in 2010-2014 at the Fergana Oil Refinery. Sanitary and hygienic, laboratory, calculation and statistical methods of research were used to achieve the goal. The research results showed that the activity of professional groups of the main production shops of the refinery is accompanied by an unfavourable impact of a complex of factors of the production environment and labour process. The workplaces of these categories of specialists correspond to the general class of working conditions according to the hygienic classification - 3 class 1, 2, 3 and 4 degrees (3.1, 3.2, 3.3, and 3.4), where the high level of gas pollution, industrial noise and vibration, the severity of the labour process is observed. The technological cycle of production, consisting of sequential production operations, based on a multistage chain of chemical reactions, allowed identifying one of the leading harmful production factors - chemical. The composition of chemical pollutants of the working zone included a wide range of gases and chemical substances: carbon monoxide, sulphur dioxide, hydrogen sulfide, chlorine, toluene, benzene, acetone, hydrocarbons, kerosene, mineral oils, phenol, sulphur oil, gasoline, methylethyl ketone, diesel fuel. Thus, based on the obtained research results, the nature and intensity of unfavorable production factors have been revealed, the level of professional risk for the employees' health has been assessed, the risk factors determining the employees' professional health have been identified, the priorities in implementation of preventive measures at the enterprise have been determined.

**Keywords:** professional health; working conditions; professional risk; oil refinery.

Development and liberalization of Uzbekistan's economy, ensuring freedom of economic activity, created favorable conditions for the formation of new modern industries and contributed to the reconstruction and modernization of existing promising industrial enterprises. Changes in technologies, complete or partial replacement of equipment are often accompanied by the impact on the body of workers by newly formed or changed complexes of harmful industrial and professional factors, and the previously existing preventive measures to improve working conditions no longer ensure the preservation of working capacity and health of workers for a long time. Thus, one of the most harmful and hazardous production facilities, where a large contingent of the labour force has been formed, has different qualifications and performs from simple to highly complicated labour operations, is oil refining [1, 2, 3].

The analysis of the studied material on morbidity collected based on the conclusions of medical examinations, separate research works, reports on morbidity in the context of enterprises and forms of pathologies among the workers of oil refining also indicate the formation of professional

risks, which include the whole complex of physical and chemical factors of the production environment [4, 5, 6].

In this regard, the comprehensive assessment of working conditions, study of employee morbidity, and establishment of occupational risks in particular at oil refineries are timely and relevant.

**The work aimed** to identify harmful factors of the production environment, identify risk factors, assess their impact on the health condition of the Ferghana Oil Refinery workers' health condition, and develop a comprehensive risk management program.

**Material and methods.** The research was carried out in 2010-2014 at one of the leading enterprises of the Republic of Ferghana Oil Refinery (hereinafter referred to as "FORP"), focused on processing oil into gasoline, aviation kerosene, fuel oil, diesel fuel, lubricating oils, greases, bitumen, petroleum coke, raw materials for petrochemistry, as well as for production of consumer goods. The plant processes more than 70% of the total volume of crude oil raw materials in the country.

Hygienic researches of working conditions and their estimation were carried out according to current normative and methodical documents: methodical instructions "Identification of dangerous and harmful industrial factors at labouratory researches on working conditions estimation"; SanPiNRUZ №0294-11 "Hygienic norms. Maximum permissible concentrations (hereinafter - MPC) of harmful substances in the air of the working zone"; SanPiNRUZ №0325-16 "Sanitary norms of permissible noise levels at work places"; SanPiN RU №0326-16 "Sanitary norms of general and local vibration at work places". A general assessment of working conditions by classes and degree of harmfulness was assessed in accordance with SanPiNRUZ No. 0141-03 "Hygienic classification of working conditions by indicators of harmfulness and danger of factors of production environment, severity and intensity of working process" [7, 8, 9, 10, 11].

Influence of unfavorable factors of the working environment on the state of health of workers was estimated by the indicators of morbidity with temporary disability (hereinafter - TD) and the results of periodic medical examinations. The systematization of the revealed pathology was carried out in accordance with the "International statistical classification of diseases and health problems" of the 10th revision [12].

Occupational risk was determined according to the methodological recommendations "Method of hygienic assessment of occupational risk" [13].

Statistical processing of the obtained results was performed using Microsoft Excel, Statistika 6.0 software packages. For normally distributed features the average value and average error ( $M \pm m$ ) were calculated, reliability of differences was estimated using the parametric Student t-criterion, relative values (frequency, %), statistical significance of the obtained measurements when comparing the average values was determined by the Student's criterion (t) with the calculation of error probability (P), non-parametric Mann-Whitney T-criterion. The level of reliability  $P < 0,05$  was taken as statistically significant changes. Statistical significance for quality values was calculated using the  $\chi^2$  criterion (chi-square).

**Results.** The study of hygienic working conditions included all stages of the FORP technological process. Researches have established that working conditions in the main and auxiliary shops are considerably different. It was found out that more than 50% of professional and qualification groups have non-permanent workplaces and in the comparative aspect do not sharply differ in the composition of production factors. We have identified 20 groups of professions in the main production (3564 people). ), whose activity is associated with the action of an unfavorable production environment, this: an electrician for repair and maintenance of electrical equipment, a master for repair and maintenance of electrical equipment, a turner, a mechanic and electrician, a mechanic for repair and installation of submersible pumps, a mechanic for repair of technological installations, an electric

welder of manual welding, electric and gas welder, equipment engineer, candle manufacturer, commodity operator, drain-filler, loader, process plant operator, commodity operator, gas separator, plant mechanic, compressor plant operator, tool locksmith, electrician.

Basic technological cycle of FORP production consists of sequential production operations based on multistage chain of chemical reactions, which allows distinguishing one of the leading harmful production factors - chemical. Primary processing processes include purification of produced oil from oil gas (removal of dissolved hydrocarbons), water (dehydration on electric desalting plants) and mechanical impurities. Secondary oil product processing processes consist of increasing the number of produced motor fuels associated with chemical modification of hydrocarbon molecules that are part of the oil. Thus, it was found that the composition of chemical pollutants in the working zone of the refinery included a wide range of gases and chemical substances: carbon oxide, sulfur dioxide, hydrogen sulfide, chlorine, toluene, benzene, acetone, hydrocarbons, kerosene, mineral oils, phenol, sulfur oil, gasoline, methylethyl ketone, diesel fuel.

The study of quantitative indicators of the chemical factor in the workplaces of the main professions has established that the excess of normative values is observed only in professional groups whose work activities are directly related to technological plants and electrical equipment, where chemical reactions take place. Thus, among the complex chemical compounds, the actual content of hydrocarbons, nitrogen oxides and sulfuric anhydride in the air of work places exceeded the normative values. Nitrogen oxides content exceeded MPC by 2.0 - 3.1 mg/m<sup>3</sup> at the workstations of locksmiths on the repair of technological installations, electrician and submersible pump locksmiths and electrician's workstations exceeded MPC by 4.6 mg/m<sup>3</sup> at MPC of 5 mg/m<sup>3</sup>. At these workplaces, the hydrocarbons content exceeded the standard values by 200 mg/m<sup>3</sup>. The actual content of sulfur dioxide at the locksmith's workplace for repair and maintenance of technological installations showed an excess of 3.3 mg/m<sup>3</sup> at MPC 10 mg/m<sup>3</sup>.

The vapor content of carbon oxide, hydrogen sulfide, toluene, benzene, acetone, hydrocarbons, kerosene, mineral oil, phenol, sulfur oil, gasoline, methylethyl ketone, diesel fuel did not exceed regulatory values or had minor excesses (2 class and 3 class 1 working conditions).

When studying the reasons behind the high degree of gas contamination of workplaces, it was determined that emissions come from organized and unorganized sources: in the process of evaporation during chemical reactions, from tanks and reservoirs for oil and petroleum products storage (open-type with a hipped roof), at spills in tanks and during commercial operations (open-type overpasses), passes through valves and aircrafts on devices not connected to the flare line, inefficiency of the exhaust system, etc.).

In the complex of harmful factors of the enterprise's working environment, the priority is production noise. Equivalent noise levels at the workplaces of the main professions of RORP depend on the type of apparatus serviced, operating electrical installations, technical equipment. So, at workplaces: locksmiths on the repair of technological installations excess was on 8 dBA, locksmiths - electricians and locksmiths on repair and installation of submersible pumps on 5 dBA above the remote control; electricians on repair and maintenance of electric equipment on 11 dBA; the driver of compressor installations on 10 dBA (3 class "harmful" 1 and 2 degrees).

Hygienic analysis of working conditions showed that FORP workers are exposed to vibration. As for the vibration speed level, the excess of indicators was noted at the work places of locksmiths on the repair of technological installations up to 100 dB (at the norm 92 dB) (3 class 2 and 3 degrees). At the floor level near the compressor units, the machinist is exposed to medium and high-frequency vibration, parameters of which exceed the remote control (category 3a) by 2-6 dB in the medium geometric octave bands 16-31.5 Gz (3 class 2 degree). Physical loads during repair and installation work (partially mechanized work) exceed the recommended standards (3 class 2 degrees).

According to regulatory documents, the working conditions of the main professional qualification groups are assessed as 3 class "harmful" 3 and 4 degrees (3.3. - 3.4) due to the severity of the labour process and the excess of nitrogen oxide vapour content on average exceeded the MPC by 0.5 - 4.6 mg/m<sup>3</sup> at non-permanent workstations of locksmiths for the repair of technological installations, electric fitters and fitters for repair and installation of submersible pumps, and by 4.6 mg/m<sup>3</sup> (maximum one-time norm 5 mg/m<sup>3</sup>) at electric fitters for repair and maintenance of electrical equipment as well as due to the excess of hydrocarbons in the air (by 200 mg/m<sup>3</sup>) and sulfur dioxide content by 3.3 mg/m<sup>3</sup>.

The study and analysis of working conditions of FORP employees allowed identifying the leading production factors, namely, chemical factors, industrial noise and vibration, which are potential professional risks for several leading professional groups. The specifics of the working auxiliary shops' labor activity are also characterized by the influence of harmful factors of the production environment and labour process. However, the labour of these categories of specialists mainly belongs to classes 2 and 3.1.

Table .1.

**Potential (a priori) occupational health risk to employees of the FORP**

Profession	Noise	Vibration	Heavy work process	Pollutination			Risk category
				NO <sub>2</sub>	SO <sub>2</sub>	C <sub>6</sub> H <sub>5</sub> OH	
Electric installer for repair and maintenance of electrical equipment	3.2	2	3.2	3.2	2	3.2	High
Electrical locksmith	3.1	2	3.1	3.1	2	3.2	Medium
Submersible pumps repair and installation locksmith	3.1	2	3.3	3.1	3.1	3.2	High
Locksmith on repair of technological installations	3.2	3.3	3.1	3.2	3.2	3.2	Very High
Compressor Unit Machine Manager	3.2	3.2	3.1	3.1	2	3.2	High

Based on the obtained results, the potential (a priori) occupational risk of health violations for workers of leading professions is estimated as high and average (Table 1).

The system of ensuring chemical safety consists of obligatory hygienic rationing of chemicals in their use conditions at work. The traditional criterion for evaluating the safety of the production environment's chemical factor is its comparison with hygienic standards. Hazard assessment of chemical factor exposure is based on assessing the degree of an excess of actual levels of harmful substances in the working zone's air relative to MPC. One of the objective indicators of excess concerning MPC is determining the potential hazard factor (K), expressed as a ratio of actual

concentration to maximum permissible concentration (C / MPC). The calculated potential hazard coefficients of the main chemical substances of the industrial zone of the FORP are presented in Table 2.

Table 2

**The potential hazard coefficient of the main chemical substances in the air of the industrial zone of the FORP**

Indicators	C <sub>6</sub> H <sub>6</sub> (II)	H <sub>2</sub> S (II)	SO <sub>2</sub> (IV)	C <sub>6</sub> H <sub>5</sub> OH (II)	CO (IV)	NO <sub>2</sub> * (III)
C <sub>факт</sub> (mg/m <sup>3</sup> )	3,1	5,2	5,5	0,5	3,6	7,2
MPC ((mg/m <sup>3</sup> )	5	10	10	0,3	20	5
K	0,62	0,52	0,55	1,7	0,18	1,44

In the presence in the air of several chemicals of unidirectional action, their values are summed up; however, the potential danger of the complex of substances should not exceed one ( $\leq 1$ ). Estimating harmful working conditions is determined by the multiplicity of the excess of one unit, which corresponds to the characteristic features of biological action on the body of substances constituting the combination. In our case, the sum of values, hydrogen sulfide, carbon monoxide, nitrogen oxide, having an acute effect, exceeds one unit. Thus, the working conditions on the working zone's chemical factor, where there are substances with an acutely directed mechanism of action, taking into account their summation, corresponds to class 3 of 2nd degree.

According to the TD and periodic medical examinations results, the morbidity structure, its dynamics, and peculiarities of their manifestation in the age groups in the dynamics for five years have been studied.

Two groups were selected for the TD analysis. The first group included workers whose labour was associated with adverse industrial and professional factors, which in some cases exceeded the permissible values. The control group was made up of administrative and management personnel with safe working conditions, including accountants, personnel departments and office workers.

The structure of occupational and professionally conditioned diseases was analyzed based on temporary disability records for FORP employees (2010-2014) in various age groups and service lengths. It was found that the overall morbidity rate in the dynamics of the first group of workers is increasing significantly (P0.001).

In the study of morbidity from TD according to the international classification of diseases of X- reconsideration among employees of FORP, it was found that the leading place is occupied by diseases of the respiratory organs (42.0%), 2nd place by diseases of the circulatory organs (15.6%), then injuries, poisoning and some other effects of external causes (12.4%), then digestive organs (12.2%) and diseases of the skin and mucous membranes (9.0%) and other nosologies (8.8%).

The analysis of morbidity among employees of FORP showed that during 5 years, the morbidity rate didn't decrease. When studying the groups, they are more often ill at the age of more than 35 years and consider the length of service workers with the length of service from 11 to 20 years. The study of morbidity among professional groups showed that the operators of specialized units, compressor unit operators and locksmiths on the repair of technological units were sicker than other professional groups of FORP.

Dynamic observation of morbidity in the context of age groups (up to 25 years old, 25-35 years old and over 35 years old) showed that employees in the age group over 35 years old (43.7-54.4%) are more susceptible to painful processes, followed by the age group 25-35 years old (32.7-36.2%) and the group under 25 years old (12.9-20.1%). A similar pattern can be seen depending on the length of service (over 21 years, 11 to 20 years and 6 to 10 years).

The morbidity analysis indicates the formation of unfavourable working conditions for workers over 35 years of age, who have more than 21 years of experience.

Among the nosological groups of the enterprise employees, according to the data of periodic medical examinations during the research, there were stably high morbidity rates in three nosological groups: respiratory diseases, circulatory system diseases and digestive organ diseases. It was found that the number of individuals with these pathologies increases with age and length of service.

Correlation analysis between the prevalence of diseases and harmful factors, age of workers and their length of service (respectively  $r = 0.54-0.59$ ;  $r = 0.39-0.45$ ;  $r = 0.32-0.37$ ) showed the presence of a direct force relationship of varying degrees.

When determining the contingent of often sick persons from the professional qualification groups of FORP, it was found that the most often sick persons are such professions as operators of technological plants, compressor plant operators and locksmiths for the repair of technological plants. It was found out that the highest morbidity rate was registered among process plant operators. Low indices were observed among turners, equipment engineers, commercial operators, plant mechanics, electrician locksmiths; however, the number of cases per 100 working years has increased significantly ( $P < 0.001$ ).

During the study of professional morbidity for five years, the results of medical examinations revealed isolated cases of bronchial asthma in locksmiths and electricians to repair and toxic hepatitis in electric equipment repair workers. From 2010 to 2012, 3 groups of workers (electricians, mechanics and electric and gas welders) belonging to the D2 group were registered, i.e. with suspicion of occupational disease related to the influence of chemical factors. The occupational disease development was prevented after preventive measures: medical and health-improving measures, transfer to work with harmless working conditions.

Considering the high prevalence of complaints from the digestive system, FORP workers aged 35 to 50 years with 8-20 years of work experience were examined. The study of objective signs among workers indicated the development of disorders of the digestive system, liver. Thus, the pain in the right foothills and the feeling of gravity were found in 17% of the examined workers, in 19% of them a certain increase of the liver was found (by 1.5-2 sm). Blood analysis showed a tendency to hyperglobulinemia and hypoalbuminemia, which indicate liver functional condition disorders.

Biochemical studies have found that those working in the main production shops, whose history lacked somatic diseases (almost healthy individuals), compared to a homogeneous control group from the administration of the plant, in the blood serum increased activity of organ-specific organ enzymes of the liver. There was found a reliable increase in the activity of transaminases, alaninaminotransaminases (hereinafter - ALT), asparginaminotransaminases (hereinafter - AST) and lactate dehydrogenase (hereinafter - LDH) compared to the control group. The average values of their activity were: ALT- 0.47 mmol/hl, AST- 0.39 mmol/hl, LDG-3.8 mmol/hl.

It has been proved that immunological disorders develop in the organism of workers under unfavorable risk factors. Thus, immunological examination, carried out among the workers of the refinery under the influence of harmful factors of the industrial environment (general class of hazard 3.2-3.3) and more than 15 years of work experience, showed the suppression of the immune system cellular link with a decrease in T-lymphocytes, T-suppressors and an increase in T-helpers ( $P < 0.05$ ), as well as an imbalance in the humoral link of the immune system of all classes of immunoglobulins

and suppression of the phagocytic activity of neutrophils. With the increasing exposition of chemical substances' combination of workers, the frequency of revealed immune shifts naturally increases ( $P < 0,05$ ) and is proportional to the prevalence of immunopathological disorders symptom complexes. High frequency of immune disorders revealed at workers at low work experience (up to 5 years) and intensity of exposure to harmful substances of hazard class (2-3.1) testifies to insufficiency of adaptive-compensatory possibilities of the immune system of an organism that causes the formation of immune insufficiency and development of production conditioned immunopathological conditions.

**Discussion.** The activity of professional groups of the main production shops of FORP is accompanied by the unfavorable influence of a complex factor of the production environment and labour process. Workplaces of these categories of specialists correspond to the general class of working conditions according to hygienic classification - 3 class 1, 2, 3 and 4 degrees (3.1, 3.2, 3.3, and 3.4), where high pollution, industrial noise and vibration, the severity of labour-process are observed. Previously, similar specific factors of the working environment were identified at the refineries, but their magnitude has undergone a significant reduction due to timely and targeted sanitary, security and hygiene measures to improve workers' work.

The presence of harmful factors was also identified at the workplaces of the workers of the auxiliary shops of the object under study, but their general class of working conditions mainly belongs to class 2 and 3 of the 1st degree.

Agreeing with the opinion of the authors who point out the current general trend of strengthening the role of moderate multifactorial effects, causing polyethyological disorders of workers' health and the growth of professionally conditioned diseases, we note that, in general, the nosology of diseases we have identified is professionally conditioned. High rates of respiratory diseases are mainly due to ENT organs (39%). It was shown that the presence of hydrogen sulfide working zone in the air causes an irritating toxic effect on mucous membranes of the upper respiratory tract [14, 15].

The connection between the prevalence of diseases and harmful factors, the age of workers and their length of service established among the main professional groups of the FORP is also professionally contingent.

Harmful production factors at oil refineries contribute to the development of disorders in workers' metabolic metabolism, causing diseases of the cardiovascular system and atherosclerosis [15, 17].

Moreover, the tests' results revealed changes in the functional state of the liver at the refinery workers. For early detection of such changes, it was recommended during medical examination to include studies to determine the serum of organ-specific enzymes ALT, AST and LDH.

Besides, during the study and identification of harmful and dangerous factors, it was found that in addition to the work place pollution, which affects all body systems, the negative impact of heating microclimate in combination with high humidity, due to both technological process and climatic characteristics of the region.

**Conclusion:** Based on the performed work, a comprehensive plan of measures for labour improvement and health improvement was developed in cooperation with the enterprise's labour protection service. The plan includes the technical renovation of equipment and reduction of time for preventive work on outdated equipment; provision of "time protection" for professional groups where the most harmful and dangerous working conditions (3 class 3 and 4 degrees) are established (reduction of working time to 5 hours, organization of periodic breaks); timely certification of working months; and the organization of some measures to improve the labour protection system. will allow to improve working conditions and preserve health and professional longevity of FORP employees.

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