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WORKING CONDITIONS AS A RISK FACTOR FOR THE HEALTH OF EMPLOYEES OF A METALLURGICAL ENTERPRISE

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The metallurgical industry is one of the most developed industries in Ukraine, where employees' workplaces are exposed to harmful and dangerous factors of the production environment of various natures, which can contribute to the development of occupational and work-related pathology. Based on the results of the study protocols and maps of working conditions for 2011-2021, the study of working conditions of workers in the open-hearth, sintering and blast furnace shops of a metallurgical enterprise as a health risk factor was conducted. It has been determined that the working conditions of the employees of the studied workshops are harmful, belong to class 3 of the 4th degree of harmfulness, and correspond to a very high degree of suspected occupational risk. It is established that the leading occupational risk factors at this enterprise include the production microclimate (class 3.4) and the content of dust and chemicals in the air of the working area (classes 3.1-3.4), which in turn requires the use of effective preventive measures aimed at preventing the adverse effects of production factors on the health of workers.

Key words: *working conditions, occupational risks, metallurgical enterprise, production factors.*

Connection of the publication with planned research works.

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Introduction.

The metallurgical industry is one of the most developed production sectors in Ukraine, with the largest number of enterprises located mainly in four regions: Donetsk, Zaporizhzhia, Luhansk, and Dnipro [1]. Workplaces (WP) of metallurgical industry workers are exposed to harmful occupational factors of various nature that can contribute to the development of occupational and work-related pathology [2, 3]. Every year in Ukraine, about 5-8 thousand occupational diseases are registered, and the total morbidity of workers employed in harmful and hazardous working conditions increases by 32-50% due to occupational diseases. An analysis of occupational morbidity by industry shows that the most significant number of cases is registered in the coal (70-79%), metallurgical (2.2-2.8%) and machine-building (2.7-3.8%) industries [4, 5].

The working conditions (WC) of employees of metallurgical enterprises are actively studied and analysed, but due to the modernisation of production, introduction of mechanisation and automation of various technological processes in production, there are changes in the working conditions of employees in the main and auxiliary workshops, which necessitates additional study of them, research of the impact of harmful and dangerous factors of the production environment on workers. Therefore, the issue of studying occupational health and safety in hazardous industries remains relevant and requires attention to develop and implement effective prevention measures [6].

The aim of the study.

To perform a hygienic assessment of the WC of employees of a metallurgical enterprise as a health risk factor.

Object and research methods.

The study of occupational health and safety of WC at WP of a metallurgical enterprise in the open-hearth shop (155 WP of the steelmaking shop and auxiliary steelmaker of the open-hearth furnace), blast furnace shop (77 WP of the blast furnace) and sinter shop (44 WP of the sinter shop) for 2011-2021 was conducted. To assess the WC, 8287 studies of occupational environmental factors were conducted and analysed, including 2366 indicators of the industrial microclimate in warm and cold seasons, 5761 indicators of work area air pollution (WAA), 220 indicators of industrial noise and vibration, and 130 maps of WC to assess the severity and intensity of the work process.

The results of the research were calculated mathematically on a personal computer using the statistical package of the licensed programme "Statistica, version 13" (Copyright 1984-2018 TIBCOSoftwareInc. All rights reserved. Licence № JPZ8041382130ARCN10-J). The normality of the distribution of quantitative traits was analysed using the Shapiro-Wilk test. The studied parameters had a distribution that differed from the normal one, and therefore, the descriptive statistics were presented in the form of the median with an interquartile range – Me (Q_{25}; Q_{75}).

The assessment and determination of the WC class of employees were carried out following SSS 3.3.6.042-99 "Sanitary standards of the microclimate of industrial premises" and SSSandR "Hygienic classification of work according to the indicators of harmfulness and dangers of the production environment's factors, difficulty and tension of the labour process" (approved by Order of

the Ministry of Health of Ukraine № 284 of 08.04.2014) (after this referred to as HCofW № 248-2014).

Research results and their discussion.

The professional duties of a sinter operator in a sinter shop during sintering include monitoring the serviceability of sintering and roasting machines during their operation, equipment maintenance (cleaning aspiration ducts, placer hoppers of gas suction vacuum chambers, collectors, multicyclones, exhauster bins, prepits, exhaust pipes during sintering or roasting machine shutdowns). During the sintering of the sinter, the employee breaks large pieces of hot sinter on the grates of the hearths, unloads the sinter from the sintering grate bowls, beats the sinter from the grates and hearths, takes samples of the charge, sinter, pellets, sorts the sinter and pellets, and supplies coke. He/she is directly involved in the repair of sinter shop equipment. The sinter operator performs physical work of moderate severity (category II b), which includes work performed while standing, involving walking, moving small (up to 10 kg) loads and is accompanied by moderate physical exertion.

When studying the parameters of the production microclimate, it was found that the median air temperature at the sinter WP in the warm season was 35.2^{0}C, and the temperature ranged from 20.4 to 43°C (TLL 20-22°C), which exceeded the threshold limit level (TLL) by 0.4-13.2°C. The median relative humidity was 35%, with a maximum recorded value of 71%, which is 11% higher than the permissible level. The median air velocity at the sinter WP was 0.5 m/s, with fluctuations ranging from 0.04 to 2.1 m/s, where the maximum value did not meet hygiene requirements (TLL 0.2-0.5 m/s) and exceeded the TLL by 4.2 times. The median intensity level of heat exposure to the sinter from the heated surfaces of the process equipment was 1054 W/m^2, with a range of 142 to 1852 W/m^2 (TLL 140 W/m^2), which exceeds the permissible level by 2 – 1712 W/m^2. During the cold season, the median air temperature was 13^{0}C, ranging from 1.9 to 16.5^{0}C. The median relative humidity was 56%, with fluctuations ranging from 34% to 72%, with the maximum value exceeding the TLL by 12% (TLL 40-60%). The median air velocity during this period was 0.6 m/s, with fluctuations ranging from 0.4-1.5 m/s, with the maximum value exceeding the TLL by 3.75 times.

Thus, following the HCofW № 248-2014 criteria, sinters WC is classified as Class 3 of the 4th degree (harmful working conditions) in terms of the industrial microclimate **(table 1)**. Employees are exposed to unfavourable microclimatic conditions for 93.5% of their working time and high level of infrared radiation for 87.1%.

The following chemicals were detected in the WAA of sinter: iron sinter, sulphur dioxide, carbon monoxide, ammonia, nitrogen dioxide, manganese oxide, and iron (III) oxide (in terms of iron). Only the content of iron sinter and iron (III) oxide (in terms of iron) in the WAA exceeded the threshold limit value (TLV). Thus, the median maximum one-time concentration of iron sinter was 25.0 mg/m^3 and ranged from 3.0 to 243.1 mg/m^3, where the maximum value exceeded the TLV by 60 times, which classifies the working conditions as Class 3 of the 4th degree of hazard. The median maximum one-time concentration of iron (III) oxide (in terms of iron) was 17.7 mg/m^3, with minimum and maximum values exceeding the TLV by 2.5 and 3.4 times, respectively, corresponding to Class 3 of the 1st degree of hazard.

Table 1 – WC by indicators of the production microclimate at the sinter WP

Indicators of the production microclimate	Min	Max	Median (Q_{25};Q_{75})	TLL	Working conditions class
Warm period of the year					
Air temperature (°C)	20,4	43	35,2 (31,4;38,6)	20–22	**3.1-3.4**
Infrared radiation (W/m^2)	142	1852	1054 (432;1316)	≤140	**3.1-3.2**
Air humidity (%)	19	71	35 (29,9;43,6)	40–60	**3.1**
Air velocity (m/s)	0,04	2,1	0,5 (0,3;0,6)	0,2–0,5	**2-3.2**
Cold period of the year					
Air temperature (^{0}C)	1,9	16,5	13,0 (6,9;14,2)	17-19	**3.2**
Air humidity (%)	34	72	56 (40;60)	40–60	**2-3.1**
Air velocity (m/s)	0,4	1,5	0,6 (0,4;1,1)	0,4	**2-3.2**

Due to the fact that unidirectional substances (nitrogen dioxide, carbon monoxide, sulphur dioxide) were present in the sinter WAA, but the sum of the ratios of the actual concentrations of each of them to their TLV was ≥1 (1.21), the working conditions in this case are classified as Class 3 of the 1st degree of hazard **(table 2)**. It was found that industrial dust and chemicals in the workers' WAA and exceeding the established TLV affected sinter workers during 93.5% of their working time.

The median equivalent noise level at the sinter WP was 85.4 dB, ranging from 60.5 to 96.4 dB, with the maximum value exceeding the TLL (80 dB) by 16.4 dB, which places the WC in hazard class 3.3.

The median equivalent corrected total vibration level at the sinter WP was 89.02 dB, with vibration levels ranging from 69.1 to 103 dB, with the maximum exceeding the TLL by 11 dB (3.1 WC class). It was found that

Table 2 – Hazardous substances content in the WAA and assessment of the sinter WC

Hazardous substances in the WAA	Concentration, mg/m^3			TLV, mg/m^3	Hazard class	Working conditions class
	Min	Max	Median (Q_{25}; Q_{75})			
Iron sinter	3,0	243,1	24,97 (17,3;64,8)	4	3	**2-3.4**
Sulphurous anhydride	0,65	5,7	5,01 (4,9;5,1)	10	3	**3.1**
Carbon monoxide	4,9	19,2	7,2 (6,6;8,0)	20	4	
Nitrogen dioxide	0,2	1,2	0,66 (0,2;0,9)	2	3	
Ammonia	1,0	9,1	5,0 (5,0;5,01)	20	4	**2**
Manganese oxides (disintegration aerosol)	0,08	0,2	0,08 (0,08;0,08)	0,3	2	**2**
Iron (III) oxide (in terms of iron)	15,2	20,6	17,7 (16,9;18,2)	6	4	**2-3.1**

industrial noise and general vibration affect workers throughout their working hours.

When assessing the severity of the sinter labour process, it was found that he has a forced working posture during the work shift of about 30% of the total shift duration – working conditions class (WCC) 3.1, the employee performs an average of 332 forced bends over 300 (WCC 3.2), the static load of the muscles of the body and legs was 263124 kg*s (WCC 3.2). In terms of labour intensity, the sinter has a three-shift work schedule (night shift) (WCC 3.1), a working day of 8 hours (WCC 2), and a duration of concentrated observation of about 70% of the work shift (WCC 3.1). Thus, the WCs of sinter are classified as Class 3 of the 3rd degree of hazard in terms of labour intensity and Class 3 of the 1st degree of hazard in terms of tension.

The responsibilities of the open-hearth furnace steelmaker and their assistants include preparing the steelmaking unit for melting, maintaining the technological process of steelmaking in open-hearth furnaces and controlling technological parameters during melting, regulating the supply of charge, necessary additives, fuel and air to the furnace. The steelmaker prepares the steel outlet chute, drains slag and discharges steel into the ladle, ensures timely sampling and determines the readiness of the melting. He/she monitors the proper functioning of the open-hearth furnace and the automation and mechanisms of various furnace equipment. Performs hot and cold repairs of the furnace. Participates in acceptance of the furnace after repairs.

Among the most difficult operations performed by steelmakers are filling furnace sills, introducing various additives into molten steel during metal melting, and processing and closing the tap. These technological operations are performed manually and require significant physical effort from employees (about 80% of the time is spent working with manual labour). The open-hearth furnace steelworker and steelworker's assistant perform heavy physical work (category III), including constant movement, carrying heavy (over 10 kg) loads requiring great physical effort.

Numerous high-temperature sources (molten metal and slag, heated surfaces of the open-hearth furnace, etc.) contribute to creating unfavourable microclimatic conditions at the WP in the warm and cold seasons. It was found that the median air temperature at the WP of the open-hearth furnace steelmakers and their assistants in the warm season was 35.9°C, the air temperature ranged from 26.0 to 59.6°C (TLL 18-20°C) and exceeded the TLL by 6.0-39.6°C. The median relative humidity in the open-hearth furnace shop was 26%, with the relative humidity ranging from 7 to 55%, with the minimum value being 33% below the TLL. The median air velocity at the open-hearth furnace steelmakers and their assistants was 0.6 m/s, ranging from 0.12 to 2.7 m/s, where the minimum and maximum values did not meet the permissible level (TLL 0.5-0.6 m/s), and the maximum value exceeded the TLL by 4.5 times (3.2 WC class). Steelmakers and their helpers are exposed to thermal radiation, the intensity and duration of which varies and depends on the type of steelmaking equipment and the period of the technological process. Thus, the median level of heat exposure intensity averaged 1590 W/m^2, ranging from 342 to 4240 W/m^2 (TLL 140 W/m^2), exceeding the permissible level by 202 to 4100 W/m^2. In the cold season, the median air temperature was 28°C, ranging from 23 to 36.5°C, which does not meet the TLL (16-18°C). The median relative humidity was 42%, ranging from 22% to 62% (TLL 40-60%). The median air velocity during this period was 0.5 m/s, with fluctuations ranging from 0.2 to 1.2 m/s, with the maximum value exceeding the TLL by 3 times (3.2 WC class). The median level of heat exposure intensity in the cold season was 1260 W/m^2, with both the minimum and maximum values exceeding the TLL and ranging from 522 to 3210 W/m^2 (TLL 140 W/m^2). Employees were exposed to unfavourable microclimatic conditions for 94.2% of their working time, and infrared radiation for 88.5%.

According to the data obtained on the indicators of the production microclimate, the workplace of the open-hearth furnace steelmakers and their helpers can be classified as Class 3 of the 4th degree of hazard (harmful working conditions) according to the HCofW № 248-2014.

The concentration of industrial dust and other chemicals in the WAA of workers in the open-hearth shop can reach significant levels. In the WAA of steelmakers and their assistants, sulphur dioxide, carbon monoxide, nitrogen dioxide, crystalline silicon dioxide with a dust content of 2 to 10%, iron (III) oxide (in terms of iron), magnesite, chromium anhydride, nickel, nickel oxides, sulphides and mixtures of compounds were present. Exceedance of the TLV was observed for the content of crystalline silicon dioxide, iron (III) oxide (in terms of iron) and magnesite in the WAA. Thus, the median maximum single concentration of crystalline silicon dioxide was 18.4 mg/m^3 with a fluctuation of this indicator in the range from 4.1 to 192.1 mg/m^3, where the maximum value exceeded the TLV by 48 times, which places the WC in Class 3 of the 4th degree of harmfulness. The median maximum one-time concentration of iron (III) oxide was 9.1 mg/m^3, with a minimum and maximum value ranging from 0.6 to 23.0 mg/m^3, where the upper value exceeded the TLV and classified the WC as Class 3 of the 1st hazard level. The median maximum one-time concentration of magnesite in the workers' WAA was 16.1 mg/m3 with a concentration fluctuation from 0.03 to 35.5 mg/m3, exceeding the TLV classifies the WC as Class 3 of the 1st degree of hazard. The WAA of the open-hearth furnace steelmakers and their assistants also contained unidirectional substances (nitrogen dioxide, carbon monoxide, sulfur dioxide) that did not exceed the TLV, but when calculated, the sum of the ratios of the actual concentrations of these substances to their TLV was ≥1 (1.72), the WC, in this case, belongs to Class 3 of the 1st degree of harmfulness **(table 3)**.

Workers are exposed to industrial dust and chemicals almost throughout their working hours (94.2%).

The noise sources in the open-hearth shop are steelmaking units, the operation of the electric bridges and overhead cranes; gas flows in the furnace during melt blowdown, freight and railway transport, etc. The median equivalent noise level of the WC of the open-hearth furnace steelmakers and their assistants was 92.9 dBA, with fluctuations ranging from 67.3 to 98.9 dBA, where the maximum value exceeds the TLL by 18.9 dB and places the WC in hazard class 3.3. Industrial noise affects employees throughout their working hours.

When assessing the severity of the work process of a steelmaker of an open-hearth furnace and their helpers, it was found that the employee lifts and moves up to 24.7 kg during a work shift (WCC 3.1), has a static load per shift when holding a load with one hand 240 kg*s, with two hands 77160 kg*s, with the participation of the muscles of the body and legs 201600 kg*s (WCC 3.2), is in a tilted position for more than 27.3% of the total shift duration (WCC 3.1), performs an average of 224 forced torso bends of more than 300 (WCC 3.1), has horizontal movement in space (transitions due to the technological process during the shift) up to 7 km (WCC 2). In terms of labour intensity, the worker has three-shift work (night shift work), which corresponds to Class 3 of the 1st degree of hazard, has a load on the visual analyser (blinding effect of molten metal), has an intellectual load (solving complex issues with a choice according to a known algorithm), which places the WC in Class 3 of the 1st degree of hazard.

Table 3 – Content of hazardous substances in the WAA and assessment of the WC of the open-hearth furnace steelmaker and their assistants

Hazardous substances in the WAA	Concentration, mg/m³			TLV, mg/m³	Hazard class	Working conditions class
	Min	Max	Median (Q_{25};Q_{75})			
Crystalline silicon dioxide with a dust content of 2 to 10%	4,1	192,1	18,4 (11,8;33,3)	4	3	**3.1-3.4**
Sulphurous anhydride	2,4	10,3	5,7 (5,0;6,4)	10	4	**3.1**
Carbon monoxide	6,0	23,0	9,0 (8,0;12,0)	20	4	
Nitrogen dioxide	0,05	10,7	1,3 (1,1;1,7)	2	3	
Magnesite	0,03	35,5	16,1 (7,4;24,3)	10	4	**2-3.1**
Chromium anhydride	0,002	0,006	0,002 (0,002;0,002)	0,01	1	**2**
Iron (III) oxide (in terms of iron)	0,6	23,0	9,1 (6,1;13,7)	6	4	**2-3.1**
Nickel, nickel oxides, sulphides and mixtures of compounds	0,03	0,2	0,03 (0,03;0,03)	0,05	2	**2-3.2**

Thus, the WCs of the open-hearth furnace steelworkers and their assistants are classified as 3rd class of the 3rd degree of hazard in terms of hard work and 3rd class of the 2nd degree of hazard in terms of intensity.

The blast furnace operator's functional responsibilities include producing iron and slag, drying the casting trough, and replacing tuyere and cooling devices during the maintenance of blast furnaces. Prepares iron and slag troughs and other equipment for iron and slag production. Prepares slag ladles for receiving slag and fills cast iron ladles with coke fines. Monitors the flow of iron and slag in the troughs during their release. Regulates the filling of ladles. Operates the appropriate equipment during blast furnace operations, casting iron and slag. Participates in the repair of furnace equipment. The blast furnace operator performs heavy physical work (category III), which includes work associated with constant movement, carrying significant (over 10 kg) loads that require great physical effort.

As a result of the assessment of the WC in terms of microclimatic indicators, it was found that the median air temperature in the warm season was 35.80°C with temperature fluctuations ranging from 25.9 to 57.40°C (TLL 18-200°C), with a maximum excess of TLL by 37.40°C. The median relative humidity in the blast furnace shop was 36%, with fluctuations ranging from 15% to 55%. The air velocity at WP of the blast furnace operator ranged from 0.3 to 1.5 m/s with a median of 0.6 m/s, with the maximum value exceeding the TLL (TLL 0.5-0.6 m/s) by 2.5 times. The median level of heat exposure intensity was 2468 W/m², with fluctuations ranging from 2100 to 4320 W/m² (TLL 140 W/m²). During the cold season, the median air temperature was 30.4°C, with temperatures ranging from 11.5 to 35°C. The median relative humidity was 43%, with fluctuations ranging from 4 to 59% (TLL 40-60%). The median air velocity during this period was 0.4 m/s, with fluctuations ranging from 0.3-0.8 m/s and exceeding the maximum value of the TLL by two times. Unfavourable microclimatic conditions affect the blast furnace operator for a long time during the work shift (88.7%). The median intensity level of thermal exposure in the cold season was 846 W/m², with fluctuations ranging from 246 to 1460 W/m² (TLL 140 W/m²). The blast furnace operator is exposed to an increased level of infrared radiation for 69.8% of the working time.

According to HCofW № 248-2014, the blast furnace operator's operating conditions can be classified as Class 3 of the 4th degree of hazard (harmful working conditions).

The WAA of a blast furnace operator contains sulphur dioxide, carbon monoxide, nitrogen dioxide, crystalline silicon dioxide with a dust content of 2 to 10%, iron (III) oxide (in terms of iron), manganese oxide, naphthalene, blast furnace slag dust, phenol, aluminium oxide, and carbon dust. The TLV was exceeded for crystalline silicon dioxide, iron (III) oxide (in terms of iron), blast furnace slag dust, carbon dust, and aluminium oxide. The median maximum one-time concentration of crystalline silicon dioxide was 14.8 mg/m³. It ranged from 1.8 to 201.9 mg/m³, where the maximum value exceeded the TLV by 50.3 times and thus classified the working conditions as Class 3 of the 4th degree of hazard. The median maximum one-time concentration of iron (III) oxide was 7.8 mg/m³ with a minimum and maximum value ranging from 3.0 to 25.2 mg/m³, which exceeded the TLV by 4.2 times at the maximum value and corresponds to Class 3 of the 2nd degree of hazard. The median maximum one-time concentration of blast furnace slag dust in the workers' WAA was 27.9 mg/m³, with dust concentrations ranging from 9.5 to 93.3 mg/m³. These concentrations exceeded the TLV by 1.6 and 15.6 times, which places the WC in Class 3 of the 4th degree of hazard. The median maximum one-time concentration of carbon dust in the employees' WAA was 5.7 mg/m³, with a fluctuation in the range from 1.0 to 61.9 mg/m³, where the maximum value exceeded the TLV by 10 times and thus classified the working conditions as Class 3 of the 3rd degree of hazard. The median maximum one-time concentration of aluminium oxide in the WAA was 51.2 mg/m³ with a concentration fluctuation from 35.7 to 66.3 mg/m³ and exceeding the TLV

Table 4 – Generalised assessment of the factors of the working environment of employees of a metallurgical enterprise

Production factor / Occupation	Microclimate	Dust	Chemical factor	Noise	Vibration	Labour intensity	Difficulty of work	General assessment of working conditions	Risk level
Sinter workshop									
Sinter	3.4	3.4	3.1	3.3	3.1	3.1	3.3	**3.4**	Very high
Blast furnace workshop									
Blast furnace operator	3.4	3.4	3.4	3.3	-	3.2	3.3	**3.4**	Very high
Open-hearth furnace workshop									
Steelmaker / steelmaker's assistant of the open-hearth furnace	3.4	3.4	3.2	3.3	-	3.2	3.3	**3.4**	Very high

by 17.9 and 33.2 times, which places the WC in Class 3 of the 4th degree of hazard.

The WAA of a blast furnace operator also contained chemicals that did not exceed the TLVs but had a unidirectional effect (nitrogen dioxide, carbon monoxide, sulphur dioxide). In the calculation, the sum of the ratios of the actual concentrations of each of them to their TLVs was ≥1 (1.6); thus, the pollutants, in this case, belong to Class 3 of the 1st degree of harmfulness. Industrial dust and chemicals are exposed to the blast furnace operator during 83.7% of the work shift.

At the WP, industrial noise affects the employee during the entire work shift. The median equivalent noise level at the WP of a blast furnace operator was 81.9 dBA with a minimum and maximum value ranging from 72 to 101.1 dBA, where the maximum value significantly exceeds the TLL (80 dBA) and places the WC in hazard class 3.3.

When assessing the severity of the work process of a blast furnace operator, it was found that he lifts and moves up to 15 kg during a work shift (WCC 2), has a static load per shift when holding a load with one hand 180 kg*s, with two hands 2040 kg*s, with the participation of body and leg muscles 141230 kg*s (WCC 3.1), is in a tilted position for more than 27% of the total shift duration (WCC 3.1), performs an average of 379 forced bends over 300 (WCC 3.2), has horizontal movement in space (transitions due to the technological process during the shift) up to 5 km (WCC 2). In terms of labour intensity, sinter operators work in three shifts (night shift), which corresponds to Class 3 of the 1st degree of hazard, has a load on the visual analyser (blinding effect of molten metal), has an intellectual load (solving complex issues with a choice according to a known algorithm), and the time spent passively observing the technological process is 12% of the work shift, which places the working conditions in Class 3 of the 1st degree of hazard.

Thus, a blast furnace operator's WC, in terms of labour intensity, belongs to Class 3 of the 3rd degree of hazard and, in terms of intensity, to Class 3 of the 2nd degree of hazard.

The analysis of the factors of the production environment on the WP of workers in the sintering, open-hearth and blast furnace shops of a metallurgical enterprise allows us to conclude that the overall assessment of the WC for all occupations at this enterprise belongs to class 3 of the 4th degree of hazard, which corresponds to a very high level of occupational risk **(table 4)**.

Conclusions.

1. The obtained results of the general assessment of the WC of employees of a metallurgical enterprise following the "Hygienic classification of work according to the indicators of harmfulness and dangers of the production environment's factors, difficulty and tension of the labour process" № 248 indicate that the WCs are harmful and belong to the 3rd class of the 4th degree of harmfulness and correspond to a very high degree of suspected occupational risk.

2. The leading unfavourable factors of the production environment among workers in the sintering, open-hearth and blast furnace shops include the production microclimate (class 3.4), the content of dust and chemicals in the WAA (class 3.1-3.4), high levels of industrial noise (class 3.3), hard work and intensity (class 3.1-3.3), which form a high risk of occupational and work-related pathology, and an increase in the incidence of morbidity with temporary disability. The data obtained confirm the need for further in-depth study of the factors of the production environment and the application of effective preventive measures to prevent the adverse effects of production factors on the health of workers in this industry.

Prospects for further research.

Industrial dust is one of the leading risk factors for workers at a metallurgical enterprise, where significant exceedances of the TLV have been established. Therefore, it is planned to study further industrial aerosols for the content of ultrafine suspended particles of various sizes and their chemical composition in various technological processes.