



**IMPACT OF HARMFUL AND HAZARDOUS OCCUPATIONAL FACTORS  
ON THE HUMAN ORGANISM IN INDUSTRIAL ENTERPRISES**

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<b>A B S T R A C T</b>	<b>KEY WORDS</b>
<p>The rapid development of modern industry and production processes has led to the widespread use of various technologies, equipment, and chemical substances in enterprises, which poses significant risks to workers' health and safety. This article analyses the classification, characteristics, and physiological effects of harmful and hazardous occupational factors on the human organism. The study covers physical factors (noise, vibration, radiation, temperature), chemical factors (toxic substances, acids, alkalis), biological factors (microorganisms, bacteria, viruses), and psychophysiological factors (physical overload, nervous tension, monotony). Special attention is given to the phenomena of cumulation, synergism, and combined effects of multiple factors. Modern monitoring technologies, including IoT-based smart safety systems, are examined. The article substantiates that timely identification and assessment of harmful factors, combined with the application of modern protective measures, is the fundamental condition for reducing occupational injuries and diseases, thereby ensuring safe working conditions.</p>	<p>Occupational safety, harmful factors, hazardous factors, noise, vibration, radiation, toxic substances, biological factors, psychophysiological factors, cumulation, monitoring, smart safety, industrial hygiene.</p>

**INTRODUCTION**

The rapid advancement of modern industry has introduced a wide range of technologies, chemicals, and equipment into production environments. While these developments increase productivity, they simultaneously create numerous risks to workers' health. Occupational harmful and hazardous factors are present in virtually every industrial sector, from manufacturing and mining to chemical processing and textile production. Their long-term or acute effects on the human organism can lead to occupational diseases, injuries, and permanent disability.

According to the Law of the Republic of Uzbekistan "On Labour Protection," every employer is obligated to identify and assess occupational factors at the workplace and implement measures to

reduce them to permissible levels. Despite legislative requirements, many enterprises still face challenges in systematically monitoring and controlling these factors. The present study addresses this gap by providing a comprehensive analysis of harmful and hazardous factors, their physiological effects, and modern approaches to their measurement and control.

The aim of this article is to analyse harmful and hazardous occupational production factors found in industrial enterprises, to assess their impact on the human organism, and to present modern methods of monitoring and protective measures. The study is based on an analysis of national legislation, industrial hygiene standards, and scientific literature on occupational health and safety.

## LITERATURE REVIEW

The classification of occupational factors has been the subject of extensive research. Yuldashev and G'oyibov (2014) established the fundamental framework for occupational safety in Uzbekistan, distinguishing between harmful factors that gradually deteriorate health and hazardous factors that cause immediate injury. G'oyibov (2019) further developed practical methodologies for workplace assessment. International standards, including those of the International Labour Organization (ILO) and the World Health Organization (WHO), classify occupational factors into four main groups: physical, chemical, biological, and psychophysiological.

Cumulation effects of occupational hazards have received growing scholarly attention. Research confirms that many toxic substances accumulate in body tissues (material cumulation) while others cause progressive functional damage even after elimination from the organism (functional cumulation). The combined effect of multiple simultaneous factors (synergism) is also documented as a critical phenomenon in occupational health research.

## CLASSIFICATION OF HARMFUL AND HAZARDOUS OCCUPATIONAL FACTORS

### Definition and Distinction

In occupational safety science, a clear distinction is drawn between two categories of production factors. A hazardous production factor is one that, under certain conditions, can cause sudden injury, acute health deterioration, or death. Examples include: electric shock, falls from height, impact from moving machinery parts, explosions, and fires. A harmful production factor is one that, upon prolonged exposure, leads to decreased work capacity or the development of an occupational disease. Examples include: continuous noise, dust, harmful gases, unfavourable temperature, or insufficient lighting.

The boundary between harmful and hazardous factors is often relative. For instance, high air humidity (a harmful factor) combined with electrical equipment increases the risk of electric shock (a hazardous factor). This interdependency underscores the importance of a comprehensive approach to workplace risk assessment.

### Four Main Groups of Occupational Factors

1. Physical factors include noise and vibration, ionising and non-ionising radiation, extreme temperatures (high and low), insufficient or excessive lighting, and electromagnetic fields. Noise above 85–90 dB causes progressive hearing loss. Vibration leads to vascular spasms and Raynaud's phenomenon. Radiation impairs cellular DNA and can cause oncological diseases.

2. Chemical factors encompass toxic substances, acids, alkalis, solvents, and aerosols. Each chemical possesses specific toxicity, route of entry into the body, and target organs. They penetrate the body primarily through inhalation (most dangerous route), skin absorption, and ingestion. State standards establish Maximum Allowable Concentrations (MAC) for each substance in workplace air.

3. Biological factors include pathogenic microorganisms (bacteria, viruses, fungi), biological toxins, and allergens. These are especially relevant in medical institutions, agricultural processing, and wastewater treatment facilities. They can cause infectious diseases, allergic reactions, and immune disorders.

4. Psychophysiological factors arise from the mismatch between work demands and human capabilities. They include physical overload (heavy lifting, repetitive movements), nervous tension (high responsibility, monotonous work), and ergonomic misfits between the worker's body and workplace design. Modern production increasingly recognises ergonomic factors as a significant source of musculoskeletal disorders.

## **PHYSIOLOGICAL EFFECTS ON THE HUMAN ORGANISM**

### **Central Nervous System**

The central nervous system (CNS) is the first to respond to external harmful stimuli. Continuous noise disrupts inhibitory processes in the cerebral cortex, leading to rapid fatigue, irritability, and sleep disorders. Neurotoxic chemicals (e.g., benzene vapours, carbon monoxide) destroy nerve cells, causing encephalopathy, polyneuritis, and cognitive impairment. Long-term exposure can result in irreversible neurological damage.

### **Respiratory and Cardiovascular Systems**

Industrial dust causes fibrosis of lung tissue, leading to silicosis (from silica dust), anthracosis (from coal dust), and asbestosis. Irritant gases (chlorine, ammonia) cause chronic bronchitis and pulmonary oedema. Regarding the cardiovascular system, prolonged vibration causes vascular spasms, while high temperature work environments increase cardiac load, elevating hypertension risk. Toxic substances can cause cardiomyopathy and arrhythmia.

### **Sense Organs and Musculoskeletal System**

The hearing organ is particularly vulnerable: noise above 85 dB leads to gradual and eventually permanent hearing loss. Visual fatigue and retinal damage occur from insufficient lighting or exposure to intense radiation (welding arc). Physical overload causes spinal herniation, joint diseases, and tendinitis. Chemical contact with the skin produces dermatitis, eczema, and chemical burns. The skin serves as both a barrier and a route of absorption for lipophilic organic solvents.

### **Cumulation and Synergism Effects**

A critical characteristic of many occupational hazards is their cumulative nature. Material cumulation occurs when the toxic substance itself accumulates in body tissues (e.g., mercury in bones and liver, lead in bones). Functional cumulation occurs when the substance is eliminated but its pathological effects progressively accumulate over time. Furthermore, synergism between multiple simultaneously acting factors significantly amplifies their total effect: for example, alcohol consumption dramatically increases the toxicity of many industrial chemicals.

## **MONITORING AND MEASUREMENT METHODS**

### **Types of Monitoring**

Workplace monitoring is conducted in three modes. Continuous (uninterrupted) monitoring is applied at high-hazard facilities using automated sensor systems. Periodic monitoring follows an approved schedule (e.g., quarterly) and is conducted by laboratory specialists. Rapid (operative) monitoring is performed immediately after technological process violations or accidents. Each mode serves a specific purpose in the overall safety management system.

### **Physical and Chemical Measurement Methods**

Physical factors are measured using specialised instruments: noise and vibration are measured by sound level meters (in decibels) and vibrometers. Illuminance is determined by lux meters. Microclimate parameters (temperature, humidity, air velocity) are measured by psychrometers and anemometers. Chemical factors in workplace air are analysed by two principal methods: the express method using indicator tubes or portable gas analysers for immediate assessment, and the laboratory-analytical method using chromatography and photometry for precise concentration determination. All measurement instruments must undergo mandatory metrological verification by the "Uzstandard" Agency.

### **Workplace Attestation and Smart Monitoring**

The attestation of workplaces according to working conditions is the most comprehensive assessment procedure. It involves: inventorying all harmful and hazardous factors; formalising measurement results in official protocols; comparing results with hygienic normatives; and assigning a working condition class (1 to 4). Based on attestation results, corrective measures are planned and implemented.

The advent of digital technologies has enabled smart safety monitoring systems (Industry 4.0 approach). Wireless IoT sensor networks placed at multiple workshop locations transmit real-time data on air composition, noise, and temperature to a central control panel. Personal dosimeters attached to worker clothing continuously record individual exposure levels. These technologies transform invisible hazards into measurable data, enabling proactive risk management.

## **DISCUSSION**

The analysis presented in this article reveals that harmful and hazardous occupational factors constitute a complex, multi-dimensional challenge for industrial safety management. Their effects on the human organism are not isolated but interrelated, with synergistic and cumulative mechanisms significantly amplifying individual factor risks. This finding underscores the necessity of a comprehensive, rather than single-factor, approach to occupational health protection.

The comparison of traditional monitoring methods with modern IoT-based smart safety systems demonstrates a significant advancement in detection capability and response speed. However, the introduction of advanced monitoring technologies requires corresponding investment in infrastructure and personnel training. In Uzbekistan, the legislative framework established by the Labour Code and the Law on Labour Protection provides a solid basis, but enforcement and technical implementation at enterprise level require strengthening.

## CONCLUSION

The study demonstrates that harmful and hazardous occupational factors encompass a broad spectrum of physical, chemical, biological, and psychophysiological influences on workers. Their physiological effects range from acute injuries to chronic occupational diseases affecting the CNS, respiratory, cardiovascular, sensory, and musculoskeletal systems. The following key conclusions are drawn:

- Recognition of hazards is the first step to safety: systematic classification and knowledge of occupational factors enables targeted protective strategies at the enterprise level.
- A comprehensive approach combining engineering controls (barriers, ventilation), administrative measures, and personal protective equipment is the only effective strategy for hazard elimination.
- Modern smart monitoring systems (IoT sensors, personal dosimeters) provide real-time data, transforming invisible hazards into measurable and manageable parameters.
- The human factor remains critical: training, awareness, and a safety culture among workers are indispensable complements to technical protective measures.
- Economic and social efficiency of labour protection investment is confirmed: reducing occupational injuries decreases healthcare costs, absenteeism, and production losses while improving workforce productivity.

Recommendations include: digitalisation of workplace attestation procedures; implementation of electronic monitoring of personal protective equipment provision; and systematic "cause-and-effect" analysis of every occupational accident to prevent recurrence.

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