THE ROLE OF HUMAN FACTORS IN OCCUPATIONAL HEALTH AND SAFETY

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Abstract: The reliability of occupational health and safety systems depends not only on the technical condition of equipment and the availability of protective devices but also on the characteristics and actions of the people involved in production processes. Employees operate machinery, control technological operations, make decisions under changing conditions, and respond to potential hazards. Consequently, their professional competence, physical condition, attention, experience, and attitude towards safety have a direct influence on workplace risk. This article examines the role of human factors in occupational health and safety, with particular emphasis on the relationship between individual behaviour and the technical and organizational conditions of work. The main factors contributing to human error are analysed, including fatigue, psychological stress, insufficient training, excessive workload, ineffective communication, and deficiencies in workplace organization. The study also considers the application of ergonomic principles, occupational risk assessment, employee training, and safety management measures to reduce the probability of incidents. The analysis indicates that human-related risks cannot be effectively controlled through disciplinary measures or instructions alone. Their reduction requires coordinated improvements in work organization, equipment design, employee competence, and management practices.

Keywords: human factors, occupational health and safety, human error, occupational risk, ergonomics, safety culture, employee competence, workplace accidents, risk management

Introduction. The development of industrial production, the introduction of automated equipment, and the increasing complexity of technological processes have changed the requirements for occupational health and safety. Modern production facilities are characterized by the interaction of personnel, machinery, electrical systems, control devices, and information technologies. Under these conditions, the safety of a production process depends on the technical reliability of equipment as well as on the ability of employees to operate it correctly.

The human factor is an integral element of this interaction. In occupational safety, it refers to the influence of human physical, physiological, psychological, cognitive, and professional characteristics on the performance of work activities. These characteristics determine how an employee perceives a hazard, interprets technical information, follows operating procedures, and responds to an abnormal situation.

In practice, the same equipment and working environment may produce different safety outcomes depending on the competence and condition of the personnel operating them. An experienced worker who understands the operating characteristics of a machine may identify an unusual vibration or sound before equipment failure occurs. Conversely, insufficient experience, reduced concentration, or misunderstanding of operating instructions may prevent timely recognition of a developing hazard.

However, occupational accidents cannot be explained solely by the actions of individual employees. Unsafe behaviour may develop under the influence of inadequate workplace organization, unrealistic production targets, poorly designed equipment, insufficient maintenance, or ineffective safety supervision. Therefore, the investigation of human-related incidents requires consideration of both individual and organizational conditions.

The relevance of this issue is particularly evident in industries where employees perform operations involving moving machinery, electrical installations, high temperatures, hazardous substances, lifting equipment, and work at height. In such environments, even a short interruption of attention or an incorrect operational decision may lead to serious consequences.

The purpose of this study is to examine the influence of human factors on occupational safety, identify the principal conditions that contribute to unsafe actions, and substantiate measures for reducing human-related risks within occupational health and safety management systems.

Materials and Methods. The research is based on a theoretical and analytical study of human factors in occupational health and safety. Scientific literature, international occupational safety recommendations, and established approaches to human reliability and risk management were examined.

The literature analysis was used to identify the main theoretical approaches to human error, employee behaviour, ergonomics, and safety culture. Particular attention was given to the works of J. Reason, E. Hollnagel, and S. Dekker, whose research examines the relationship between human performance, organizational conditions, and the occurrence of accidents.

A systems approach was applied to analyse the interaction between personnel, technological equipment, workplace conditions, and organizational management. This approach makes it possible to examine an incident not as an isolated mistake but as the result of interactions between several elements of a production system.

Comparative analysis was used to distinguish the influence of physical, physiological, psychological, cognitive, professional, and organizational factors on the performance of work activities.

In addition, occupational risk assessment principles were considered to determine how changes in employee condition, workload, competence, and working environment may affect the probability of hazardous events.

The study is theoretical and analytical in nature. Its purpose is to systematize existing scientific approaches and identify practical directions for incorporating human factors into occupational safety management. No experimental measurements or independently collected accident statistics are claimed.

Results. Human Factors as an Element of the Occupational Safety System. In a production environment, an employee does not perform work independently of other system components. The result of an operation is determined by the interaction between the worker, the equipment, the technology being used, and the conditions under which the task is performed.

For this reason, human factors should be considered an essential component of the occupational safety system. Their influence is expressed through several interrelated characteristics.

Physical characteristics determine whether an employee is capable of performing a particular task without exceeding acceptable physical limits. These include strength, endurance, coordination, mobility, and sensory abilities. For example, work involving the manual movement of heavy loads places considerable demands on physical capacity, while the operation of complex machinery requires adequate coordination and visual attention.

Physiological characteristics are associated with the functional condition of the human body. Fatigue, insufficient rest, sleep deprivation, and excessive physical exertion can reduce work capacity and increase the likelihood of operational errors.

Psychological characteristics include attention, emotional stability, motivation, stress resistance, and the ability to make decisions under pressure. Their influence becomes particularly

important when employees perform tasks requiring continuous monitoring or rapid responses to changing conditions.

Cognitive characteristics determine how employees receive, process, retain, and interpret information. The ability to understand warning signals, remember operating procedures, recognize deviations, and select appropriate actions is directly related to safe work performance.

Professional characteristics include theoretical knowledge, practical experience, technical competence, and familiarity with occupational hazards. An employee may know general safety requirements but still be unable to apply them correctly if practical training is insufficient.

These characteristics do not operate separately. Their combined influence determines the reliability of human performance under specific working conditions. Consequently, the assessment of occupational risks should take account of the actual demands placed on employees, rather than relying exclusively on formal qualification documents or the completion of safety briefings.

Human Error and Its Contribution to Occupational Accidents. Human error is generally understood as an action or omission that differs from the action required to achieve a safe and intended operational result. In production activities, it may occur during equipment operation, maintenance, inspection, transportation, or the execution of routine technological procedures.

One important category is the unintentional error. Such errors occur when an employee performs an action incorrectly despite intending to complete the task properly. Examples include selecting an incorrect control, overlooking a warning indicator, or incorrectly identifying the position of a machine component.

Another category is associated with insufficient attention. Long periods of repetitive work, external distractions, interruptions, and fatigue may reduce an employee's ability to monitor the production process continuously. This is particularly relevant to operations in which the development of a hazardous situation is gradual and must be identified through observation.

Knowledge-related errors arise when employees do not possess sufficient information or practical competence to recognize the consequences of their actions. An employee who is unfamiliar with the operating limits of equipment may unintentionally create an unsafe condition.

Decision-making errors occur when the selected method of action is inappropriate for the actual circumstances. Such errors may become more likely during equipment malfunctions, emergency situations, or unexpected changes in production conditions.

A separate issue is the deliberate violation of safety procedures. Employees may bypass protective devices, remove machine guards, ignore established isolation procedures, or use equipment for purposes for which it was not designed. Such actions may be associated with time pressure, inadequate supervision, established unsafe habits, or the perception that safety procedures interfere with production targets.

It is important to distinguish between an employee's immediate action and the underlying causes of that action. For example, if a worker removes a machine guard to complete an operation more quickly, the investigation should also establish why the production process allows or encourages such behaviour. The absence of suitable equipment, poor workplace design, inadequate planning, and weak management control may all contribute to the incident.

Therefore, the analysis of human error should be based on the conditions in which the work was performed. This approach provides a more reliable basis for preventing similar incidents than simply identifying the employee responsible for the final unsafe action.

Influence of Fatigue, Stress, and Working Conditions. The functional condition of employees is an important determinant of safe work performance. Even a highly qualified specialist may

experience a reduction in performance when working under conditions of prolonged fatigue or excessive psychological pressure.

Fatigue develops as a result of sustained physical or mental activity without adequate recovery. Its effects may include slower reactions, reduced concentration, impaired coordination, and difficulties in maintaining attention. In operations involving moving machinery, transportation, electrical equipment, and work at height, these changes may increase the probability of an accident.

Psychological stress also affects the quality of decision-making. Employees who experience continuous pressure may have difficulty concentrating on complex tasks or evaluating several possible courses of action. Stress can become particularly significant when workers are expected to meet unrealistic deadlines or operate under conditions of uncertainty.

The working environment may intensify these effects. High temperatures, excessive noise, vibration, inadequate lighting, poor ventilation, and uncomfortable working postures can increase physical and mental workload.

The relationship between these factors is important. For instance, high ambient temperatures may increase physiological strain, while prolonged work without adequate breaks may further reduce concentration. Similarly, excessive noise may interfere with communication between employees and make it more difficult to recognize warning signals.

From an occupational safety perspective, these conditions should be assessed as elements of workplace risk. The prevention of human-related incidents therefore requires appropriate work-rest schedules, reasonable workload distribution, suitable environmental conditions, and consideration of employees' functional capabilities.

The Role of Professional Competence and Safety Awareness. Professional competence is one of the principal conditions for the safe performance of work. It includes knowledge of technological processes, understanding of equipment operating principles, practical skills, and the ability to recognize and control occupational hazards.

The effectiveness of safety training should not be evaluated only by the number of briefings conducted or the availability of signed training records. A more important criterion is whether employees can apply the acquired knowledge in actual working conditions.

For example, an employee working with electrical equipment must understand the hazards of electric shock, the purpose of protective devices, and the established procedures for safe isolation and verification. Similarly, personnel operating lifting equipment must understand load limits, stability requirements, signalling procedures, and the potential consequences of incorrect operation.

Training should therefore combine theoretical explanations with practical exercises and assessment of competence. It should also be repeated when equipment, technological processes, working conditions, or occupational responsibilities change.

Safety awareness is closely connected with professional competence. An employee may possess the necessary technical knowledge but fail to apply it if occupational safety is regarded as a secondary requirement. Developing an appropriate attitude towards safety requires consistent management attention, clear responsibilities, and the participation of employees in identifying workplace hazards.

Organizational Conditions and Safety Culture. The behaviour of employees is significantly influenced by the organizational environment. Management decisions determine the availability of protective equipment, the quality of maintenance, the organization of working time, the clarity of instructions, and the level of supervision.

Where production targets consistently take priority over safety requirements, employees may develop practices that deviate from established procedures. Over time, these practices can become accepted as normal workplace behaviour, even when they involve considerable risk.

An effective safety culture requires a different organizational approach. Safety requirements must be incorporated into production planning, equipment maintenance, personnel management, and the evaluation of operational performance.

The participation of employees is particularly important. Workers are often the first to identify unusual equipment behaviour, deteriorating working conditions, or practical difficulties in following safety procedures. Their observations can provide valuable information for improving workplace safety.

Organizations should establish clear procedures for reporting hazardous conditions and near misses. The information obtained should be analysed to identify recurring problems and determine whether corrective measures are necessary.

A constructive approach to incident investigation should distinguish between intentional violations and errors arising from inadequate system design or working conditions. This does not eliminate individual responsibility; rather, it ensures that corrective measures address both employee actions and the circumstances that contributed to them.

Application of Ergonomics and Modern Technologies. Ergonomics provides a scientific basis for adapting work processes, equipment, and workplaces to human capabilities and limitations. Its application is important because many operational errors arise from unsuitable interfaces, inconvenient working positions, excessive physical demands, and poorly organized information.

The design of control panels, for example, should ensure that indicators are clearly visible, control elements are logically arranged, and warning signals can be distinguished under actual working conditions. In manual operations, workplace dimensions and equipment arrangement should reduce unnecessary movements and excessive physical strain.

Modern digital technologies create additional opportunities for managing human-related risks. Electronic training systems can provide employees with access to updated safety instructions. Digital checklists can support the consistent execution of inspection procedures, while monitoring systems can identify deviations in equipment operation.

Wearable monitoring devices may provide information about certain workplace exposures and physiological conditions, provided that their use is appropriate and complies with privacy and data-protection requirements. Thermal imaging, vibration monitoring, and predictive maintenance systems can also reduce the likelihood of equipment failures that place additional demands on employees.

Artificial intelligence can support the analysis of operational data, identification of recurring unsafe conditions, and prioritization of preventive measures. Nevertheless, automated systems should be treated as supporting instruments rather than substitutes for professional judgement and effective safety management.

The practical value of these technologies depends on their correct selection, technical reliability, data quality, and integration into existing occupational safety procedures.

Discussion. The results of the analysis confirm that human factors should be considered within the overall structure of occupational risk management. The occurrence of an accident is often preceded by a combination of technical, organizational, environmental, and individual conditions. An employee's action may represent the final event in this sequence without necessarily being its primary cause.

This distinction is important for the development of effective preventive measures. If an investigation identifies only the employee's failure to follow an instruction, the organization may

introduce additional briefings or disciplinary measures while leaving the original problem unresolved. If the underlying cause is an unsuitable machine design, excessive workload, or insufficient maintenance, such measures will have limited preventive value.

The approach developed in human reliability research emphasizes the need to examine the relationship between human performance and the conditions in which work is carried out. J. Reason's analysis of organizational accidents demonstrates the importance of considering failures at different levels of a system. E. Hollnagel's research further contributes to understanding how variations in human performance occur during normal operational activities.

These approaches are particularly relevant to modern industrial enterprises, where production processes increasingly depend on interaction between personnel and automated systems. As automation develops, the nature of human responsibility changes: employees may perform fewer direct manual operations but become more involved in monitoring, interpreting information, and responding to abnormal conditions. Consequently, the requirements for attention, technical understanding, and decision-making remain significant.

The integration of human factors into occupational health and safety management also requires continuous assessment. Employee training, workplace inspections, incident investigations, and risk assessments should be treated as interconnected processes. Their purpose is not merely to demonstrate formal compliance but to identify and eliminate the conditions that may lead to occupational injuries.

Thus, a human-centred approach to occupational safety should combine technical reliability, ergonomic design, professional competence, effective management, and employee participation.

Conclusion. Human factors have a direct influence on the effectiveness of occupational health and safety measures. The physical and psychological condition of employees, their professional competence, attention, experience, and attitude towards safety affect the way production tasks are performed and occupational hazards are controlled.

The analysis establishes that human error should not be interpreted exclusively as an individual failure. Its occurrence may be associated with fatigue, inadequate training, excessive workload, unsuitable workplace design, ineffective communication, or deficiencies in organizational management.

The prevention of human-related occupational risks therefore requires a comprehensive system of measures. These include improving professional training, adapting working conditions to human capabilities, controlling workload and fatigue, strengthening safety culture, improving communication, and applying appropriate digital technologies.

Particular attention should be given to the investigation of near misses and unsafe working conditions. Such information makes it possible to identify weaknesses before they develop into serious occupational accidents.

The practical effectiveness of occupational safety management depends on the ability of an organization to consider human capabilities and limitations when designing work processes and establishing safety procedures. Accordingly, the human factor should be incorporated into all stages of occupational risk assessment, prevention, monitoring, and continuous improvement.

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