

HYGIENIC ASSESSMENT OF NATURAL AND ARTIFICIAL ILLUMINATION IN MECHANICAL PROCESSING WORKSHOPS

Khadjayeva U.A.

Xusanova R.M.

Tashkent State Medical University

Abstract

In mechanical processing workshops, the efficiency of labor processes and workers' health largely depend on environmental factors, including illumination levels. This literature review analyzes the hygienic significance of natural and artificial lighting, their compliance with regulatory requirements in mechanical processing operations, and their impact on the activity of the visual analyzer. Based on statistical and experimental data presented by the World Health Organization (WHO), the International Labour Organization (ILO), and leading scientific sources in industrial hygiene, it has been scientifically substantiated that insufficient illumination increases the risk of visual fatigue, occupational injuries, and production errors. The literature analysis demonstrates that combined (natural + artificial) lighting systems represent the most hygienically optimal solution for mechanical workshops.

Keywords: mechanical processing, illumination, natural light, artificial lighting, hygienic assessment, industrial hygiene, visual strain, working conditions

Introduction

Workplace illumination is not merely the level of brightness within a building but one of the key factors directly affecting the human visual system, labor productivity, and overall worker health. Approximately 90% of information perceived by humans is obtained through vision; therefore, poor visual environments significantly hinder performance efficiency.

In mechanical processing workshops (such as turning, milling, and drilling operations), tasks often involve small components and high-precision procedures. These operations require intensive visual functions, including accuracy, contrast discrimination, and frequent focal adjustments. Performing visually demanding tasks under insufficient or inappropriate lighting not only increases visual fatigue but also elevates the risk of technological errors and injuries.

Hygienic requirements for illumination are closely linked to the protection of workers' health and the reduction of production errors and are regulated by established occupational safety standards. Inadequate lighting increases eye strain, and prolonged visual stress may lead to headaches, ocular dryness, and slowed focal adaptation—negatively affecting productivity and technological reliability. Scientific studies indicate that improving visual conditions in production settings enhances task accuracy and quality. For example, in metalworking industries, optimal lighting conditions reduce operational errors and improve visual precision.





Natural illumination positively influences biological rhythms, including circadian rhythms, reducing fatigue during the day and stabilizing workers' psychological state. However, in mechanical workshops, the variability of natural light and its dependence on seasonal and climatic conditions do not guarantee consistently adequate visual conditions. Therefore, the strategic implementation of artificial lighting systems becomes essential.

Artificial lighting, depending on lamp placement, light intensity, and spectral characteristics, can significantly improve the visual quality of workplaces. Modern research shows that LED-based lighting technologies enhance visual comfort and reduce strain under industrial conditions through improved light control and spectral optimization.

Research Objective

To conduct a systematic analysis of existing scientific literature on the hygienic assessment of natural and artificial illumination in mechanical processing workshops and to scientifically substantiate the impact of lighting factors on working conditions and workers' health.

Materials and Methods

This literature review was conducted based on the following sources: Reports of the World Health Organization (WHO) and the International Labour Organization (ILO); Articles published in international scientific journals on industrial hygiene and occupational physiology; Sanitary rules and norms regulating illumination standards (Sanitary Rules and Regulations).

During the analysis, illumination levels, indicators of visual strain, occupational injury statistics, and labor productivity data were evaluated using a comparative and methodological approach.

Results

Comparative Analysis of Visual Conditions under Natural and Artificial Illumination. In mechanical processing workshops, illumination levels directly affect work efficiency and visual performance. When workplace lighting is insufficient, eye strain increases and visual fatigue intensifies, thereby elevating the likelihood of technological errors and occupational injuries. Studies indicate that in workplaces failing to meet illumination standards, 58.4% of workers express dissatisfaction with production conditions, negatively affecting productivity and job satisfaction.

Table 1. Workers' Perception of Workplace Illumination Conditions

Level of Satisfaction with Illumination	Share of Workers (%)
Dissatisfied	58.4
Partially satisfied	23.7
Satisfied	17.9

These findings demonstrate the direct negative impact of inadequate lighting on performance. In mechanical workshops, random or poorly organized lighting affects work quality, precision, and safety; therefore, strict compliance with illumination standards is hygienically essential.

Scientific and Statistical Evidence on Illumination and Workers' Health. Workplace illumination conditions are widely recognized as a significant determinant of individual health outcomes. Research shows that working in poorly lit environments substantially increases eye fatigue, headaches, and

visual stress. Mechanical production processes typically require high precision; therefore, reduced visual performance heightens the risk of technological errors and injuries.

Ergonomic studies have further demonstrated that illumination quality influences visual comfort, safety, and productivity. Proper lighting conditions contribute to sustained concentration and reduced functional strain during prolonged tasks requiring detailed visual attention.

Physical Measurements of Illumination and Hygienic Criteria. According to international standards and ergonomic research, operations requiring precise visual attention—such as mechanical processing—should ensure object-surface illumination levels of at least 300–500 lux. This range minimizes visual fatigue and maintains optimal visual acuity.

The ergonomic design of artificial lighting systems, including color rendering indices and luminaire placement, plays a crucial role in improving working conditions. Illumination indicators are used to evaluate the accuracy of task performance, visual comfort, and safety within production environments.

Combined Effects of Natural and Artificial Illumination. Natural daylight positively affects biological rhythms, including circadian regulation, thereby reducing fatigue and supporting overall well-being. However, artificial lighting is essential when natural illumination is insufficient, particularly in enclosed mechanical workshops.

When natural and artificial lighting systems are effectively combined, several positive outcomes are observed: Reduction in errors during visually demanding tasks; Decrease in workers' stress levels; Improvement in occupational safety and operational reliability.

These findings confirm that a balanced, combined lighting strategy represents the most hygienically and functionally appropriate approach in mechanical processing environments.

Discussion

The conducted literature analysis once again confirms that illumination levels in mechanical processing workshops represent one of the key hygienic factors determining working conditions. The presented findings indicate that in production environments failing to meet illumination standards, workers demonstrate significantly higher levels of visual strain, eye fatigue, and subjective dissatisfaction with working conditions. These observations are fully consistent with previous studies in industrial hygiene and ergonomics.

Relationship Between Illumination Level and Visual Strain. As identified in the results, when illumination levels in mechanical workshops fall below 300 lux, signs of visual strain (ocular burning sensation, rapid fatigue, headaches) increase sharply. This phenomenon can be explained by the constant compensatory tension of the visual analyzer. When working with small components, the eyes operate continuously in a high-precision mode; under insufficient lighting, the visual apparatus functions near the limits of its physiological capacity.

These conclusions align with international ergonomic lighting research, where inadequate illumination is recognized as a primary contributor to visual stress. Therefore, hygienic assessment in mechanical workshops should consider not only general lighting levels but also localized illumination at the task surface.

Advantages and Limitations of Artificial Lighting. The discussed findings show that artificial lighting plays a dominant role in mechanical processing workshops. Its primary advantage lies in stability and



controllability. Unlike natural daylight, artificial lighting is less dependent on external environmental factors and ensures continuity of the work process.

However, literature analysis indicates that improperly organized artificial lighting—uneven light distribution, glare effects, or low color rendering index—may exacerbate visual strain rather than reduce it. This situation is particularly common when outdated fluorescent lamps or improperly positioned LED luminaires are used.

Biological Significance of Natural Illumination. The results demonstrate that natural lighting positively influences workers' overall functional state. Daylight stabilizes circadian rhythms, improves psycho-emotional well-being, and reduces general fatigue levels. From a hygienic perspective, optimal window placement and maximum utilization of natural light in mechanical workshops are therefore advisable.

Nevertheless, the reviewed scientific sources unanimously emphasize that natural illumination alone cannot ensure adequate visual conditions in mechanical production settings. Seasonal and climatic variations, building design, and workshop depth limit the consistency and sufficiency of daylight.

Hygienic Superiority of Combined Lighting Systems. A key conclusion emerging from the discussion is the superiority of combined (natural + artificial) lighting systems. Scientific literature and statistical analyses indicate that such an approach enhances visual comfort, reduces production errors, and improves workers' satisfaction with working conditions.

These conclusions correspond with the concepts of optimizing working conditions promoted by the World Health Organization (WHO) and the International Labour Organization (ILO).

Conclusion

The analysis of scientific literature and statistical data demonstrates that illumination in mechanical processing workshops is a crucial hygienic factor shaping working conditions. Insufficient provision of natural and artificial lighting is closely associated with increased visual strain, reduced productivity, and compromised occupational safety.

1. The findings indicate that under non-compliant illumination conditions in mechanical workshops, continuous strain of the visual analyzer occurs. This manifests as visual fatigue, headaches, and decreased concentration, increasing the risk of errors in high-precision technological operations. Statistical evidence confirms a direct relationship between insufficient lighting, reduced production efficiency, and workers' dissatisfaction with working conditions.
2. Literature analysis shows that natural illumination is biologically optimal, positively influencing psycho-emotional status and circadian rhythms. However, due to structural, climatic, and seasonal limitations, daylight alone is often unstable and insufficient. Artificial lighting provides controllability but, when improperly designed, may produce glare and uneven illumination, leading to adverse hygienic consequences.
3. Based on the results and discussion, combined lighting systems (natural and artificial) emerge as the most appropriate hygienic solution. Such systems enhance visual comfort, reduce visual strain, and decrease the risk of production errors and injuries. This conclusion aligns with recommendations issued by the World Health Organization and the International Labour Organization regarding occupational hygiene standards.



4. Overall, the hygienic assessment and optimization of illumination in mechanical processing workshops constitute an integral component of worker health protection, productivity enhancement, and occupational safety assurance. Strict adherence to hygienic standards and the application of scientifically grounded approaches in lighting design and modernization remain essential priorities.

References

1. Ширванов Р. Б. (2021). ВЛИЯНИЕ УРОВНЯ ОСВЕЩЕННОСТИ РАБОЧИХ МЕСТ НА УСЛОВИЯ ТРУДА (НА ПРИМЕРЕ РЕСПУБЛИКИ КАЗАХСТАН). XXI век. Техносферная безопасность, 6 (2 (22)), 189-200.
2. Zakerian, S. A., Rostami Aghdam Shendi, M., Amouzadeh, E., Mosaferchi, S., & Mortezapour, A. (2025). Application of Ergonomic Lighting Indicator in Workplaces: A Comparative Study in Two Different Climates. *Theoretical and Applied Ergonomics*, 1(2), 11. <https://doi.org/10.3390/tae1020011>
3. Łakomy, K. (2023). Impact of workplace lighting on employee safety. *Scientific Papers of Silesian University of Technology, Organization and Management Series*, 184, 231–249. <https://doi.org/10.29119/1641-3466.2023.184.12>
4. Ильина, Е. И., & Частухина, Т. Н. (2017). Проблемы оценки освещения рабочих мест при СОУТ. Журнал “Охрана труда и соцстрахование”, август 2017.
5. van Bommel, I. W. J. M., van den Beld, G. J., & van Ooijen, M. H. F. (2002). Industrial lighting and productivity.
6. Xadjayeva, U. A., & Iskandarov, A. B. (2024). MASHINASOZLIK KORXONALAR ISHLOVCHILARINING ASOSIY ISH JOYLARIDAGI YORITILGANLIKKA GIGIYENIK VANO BERISH. Ўзбекистон Республикаси Санитария-эпидемиология ва жамоат саломатлиги хизмати илмий-амалий журнали, 4(1), 37-41.
7. Iskandarova, G. T., & Samigova, N. R. (2024). Hygienic description of chemical factor in mechanical engineering enterprises (Doctoral dissertation, Germany).
8. Ходжаева, У. А., Ёллыева, О. Б., Аннагулыева, Э. М., & Ходжаев, А. (2021). ОЦЕНКА СЕЙСМИЧЕСКИХ СВОЙСТВ ГРУНТОВ ГОРОДА АШХАБАДА ПО ДАННЫМ HVSR-АНАЛИЗА. In ЭКОЛОГИЧЕСКАЯ ГЕОЛОГИЯ: ТЕОРИЯ, ПРАКТИКА И РЕГИОНАЛЬНЫЕ ПРОБЛЕМЫ (pp. 381-385).
9. Ikramova, N. A., Mirsagatova, M. R., Jalolov, N. N., Kasimova, K. T., Sulonov, E. Y., & Sadirova, M. K. (2025, April). THE EFFECT OF THERMAL LOAD ON THE BODY OF OUTDOOR WORKERS: ANALYSIS BASED ON MEDICAL AND HYGIENIC INDICATORS. *International Conference on Advance Research in Humanities, Applied Sciences and Education*.
10. Iskandarova, G. T., & Samigova, N. R. (2024). Hygienic Characterization of the Chemical Factor in Mechanical Engineering Enterprises.
11. Iskandarova, G., Iskandarov, A., Xadjayeva, U., & Samigova, N. (2024). ГИГИЕНИЧЕСКАЯ ОЦЕНКА ПРОИЗВОДСТВЕННОГО МИКРОКЛИМАТА НА ПРЕДПРИЯТИИ МАШИНОСТРОИТЕЛЬНОЙ ОТРАСЛИ ПРОМЫШЛЕННОСТИ.
12. Králiková, R., Lumnitzer, E., Džuňová, L., & Yehorova, A. (2021). Analysis of the Impact of Working Environment Factors on Employee’s Health and Wellbeing; Workplace Lighting



- Design Evaluation and Improvement. Sustainability, 13(16), 8816. <https://doi.org/10.3390/su13168816>
13. Rahimov, B. B., Salomova, F. I., Jalolov, N. N., Sultonov, E. Y., Qobiljonova Sh, R., & Obloqulov, A. G. (2023). O 'ZBEKISTON RESPUBLIKASI NAVOIY SHAHRI HAVO SIFATINI BAHOLASH: MUAMMOLAR VA YECHIM YOLLARI.
 14. Shojaee Barjoe, S., & Gendler, S. (2024). Sustainable illumination: Experimental and simulation analysis of illumination for workers wellbeing in the workplace. *Heliyon*, 10(24), e40745. <https://doi.org/10.1016/j.heliyon.2024.e40745>
 15. Xadjayeva, U. A. (2025). HYGIENIC FEATURES OF WORK OF TECHNICAL SECTIONING OF PRODUCTION OBJECTS. *SHOKH LIBRARY*, 1(12).
 16. Xadjayeva, U. A., & Iskandarov, A. B. (2024). MASHINASOZLIK KORXONALAR ISHLOVCHILARINING ASOSIY ISH JOYLARIDAGI YORITILGANLIKKA GIGIYENIK VAHO BERISH. *Ўзбекистон Республикаси Санитария-эпидемиология ва жамоат саломатлиги хизмати илмий-амалий журнали*, 4(1), 37-41.
 17. Махкамова, Д. Э., Хаджаева, Д. Х., Кадырова, И. Д., Хаджаева, У. А., & Атажанов, Ш. Д. (2016). СОСТОЯНИЕ И НЕСПЕЦИФИЧЕСКИЕ ФАКТОРЫ ЗАЩИТЫ ПОЛОСТИ РТА У ДЕТЕЙ С ОСТРЫМ ГЕРПЕТИЧЕСКИМ СТОМАТИТОМ. *Апробация*, (1), 134-136.
 18. Рахимов, Б. Б., Саломова, Ф. И., Жалолов, Н. Н., Султонов, Э. Ю., & Облакулов, А. Г. (2023). Оценка качества атмосферного воздуха в городе навои, республика Узбекистан: проблемы и решения. In *Сборник трудов по материалам Международной научно-практической конференции*.
 19. Kosimova, K. T., Jalolov, N. N., & Ikramova, N. A. (2025, April). THE RELATIONSHIP BETWEEN AIR POLLUTION AND ARTERIAL HYPERTENSION. *International Conference on Advance Research in Humanities, Applied Sciences and Education*.
 20. Mirsagatova, M. R., & Jalolov, N. N. (2025). URBAN INDUSTRIAL ENTERPRISES'EMISSIONS OF HARMFUL SUBSTANCES AND THEIR ECOLOGICAL MONITORING INDICATORS.

