SECTION: OCCUPATIONAL SAFETY

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DIGITALIZATION AND AUTOMATION IN OCCUPATIONAL SAFETY UNDER MARTIAL LAW IN UKRAINE

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Abstract

The article examines the role of digitalization and automation in occupational safety under martial law in Ukraine. Emphasis is placed on the application of automated control and monitoring systems to enhance worker safety at critical infrastructure facilities, as well as in industry, construction, transport, and energy sectors. Modern technologies such as sensor networks, SCADA systems, robotics, drones, and intelligent video surveillance are analyzed. The significance of these technologies for reducing occupational risks, minimizing the human factor, and ensuring operational continuity amid personnel shortages is substantiated.

Keywords: occupational safety, digitalization, automation, monitoring, martial law, worker safety, civil safety, critical infrastructure protection.

Introduction

In the context of martial law, occupational safety issues have become particularly significant. The military situation in Ukraine imposes additional risks on workers at critical industrial, energy, construction, and transport facilities. Automated control and surveillance systems have become an important component of personnel protection, as they enable hazard detection and rapid response without direct human involvement. The role of digital technologies that provide continuous monitoring and prompt emergency response is increasing [1, 2].

Ensuring uninterrupted operation of strategically important facilities is of paramount importance. Automated control systems capable of autonomous process monitoring and management support facility operability and minimize risks to workers. The introduction of modern digital solutions enhances personnel safety, even under constraints of limited qualified engineering and operator staff [1].

Main body

At the current stage, distributed sensor networks and Internet of Things (IoT) solutions are employed to remotely collect data on equipment status and environmental conditions. Intelligent sensors measure parameters such as temperature, pressure, harmful gas concentration, humidity, radiation background, and vibrations. This enables timely detection of accidents and initiation of automatic warnings or shutdowns when safe limits are exceeded [1, 4].

Programmable logic controllers (PLC) and SCADA systems provide automated technological process control. Modern SCADA systems integrate artificial intelligence analytics to predict potential failures and warn of threats in advance [1].

Since the onset of the full-scale invasion, the need for robotic complexes and unmanned aerial vehicles (UAVs) has increased to enhance occupational safety by performing hazardous operations such as inspection of hard-to-reach or gas-contaminated areas, damage detection, firefighting, or explosive ordnance disposal. Drones are used for aerial photography, monitoring power lines, oil and gas pipelines, and large industrial complexes. Highly sensitive onboard sensors and cameras enable rapid damage detection post-attacks or accidents without risking human lives [2, 6].

Video surveillance systems employing computer vision and AI analyze real-time camera streams to detect signs of danger such as smoke, fire, unauthorized personnel intrusion, equipment malfunctions, or overloads. These video analytics systems automatically alert security services to intrusion attempts or detect workers lacking personal protective equipment, accelerating response [3].

In construction and transportation, automated machinery (excavators, cranes, self-propelled equipment) reduces human presence in hazardous zones during loading, dismantling, or earthworks. Automotive and railway transport employ collision warning systems, automatic braking, and remote technical monitoring. Electronic traffic management and infrastructure monitoring systems ensure safe transport conditions allowing fast emergency responses [4].

Currently, Ukraine implements numerous projects deploying automated occupational safety systems. Examples include intelligent fire protection systems combining smoke sensors, thermal imaging cameras, and flame detectors enabling swift fire localization and automatic extinguishing, significantly reducing response time and fire spread without human intervention [5].

Gas and liquid leak detection sensor networks identify minimal concentrations of vapors or gases. Detected threshold exceedances trigger control center alerts and automated valve shutdowns to prevent explosions or poisoning. Continuous radiation and environmental contamination monitoring systems operate at nuclear power plants and chemical enterprises, especially important during wartime to promptly detect threats [1].

Special physical threat detection systems respond to explosion, decompression, or gunshot signals. Acoustic sensors and shockwave detectors at facility perimeters instantly record loud explosions or shots, activating alarms, evacuation plans, and security alerts. Ground-penetrating radar and laser scanning systems detect

unauthorized equipment or personnel movement in restricted zones such as mines, shelters, or strategic objects from distance, enhancing security response times [2].

Geofencing and personal worker identification enhance occupational safety; for instance, workers carry GPS and accelerometer-enabled bracelets or badges, and approaching hazardous zones triggers alerts for the worker and engineers. Some systems autonomously halt machinery or restrict hazardous zone access to increase protection [6].

During martial law, widespread deployment of unmanned and ground robotic systems occurs. Autonomous robots inspect sites after alarm signals (e.g., post-shelling damage, gas leaks, or fires) without endangering personnel. Patrol drones with thermal and optical cameras detect threats remotely, such as hostile UAVs or hostile activities, enabling timely security and emergency response [2].

A significant advantage of automated systems lies in continuous operation without direct human involvement, crucial amid wartime personnel shortages. Many engineers and operators serve in defense or cannot be physically present due to movement restrictions or attack threats. Automation supports constant monitoring of critical parameters, reducing human factor influence due to fatigue or oversight, and enhancing threat response efficiency [1].

Automated systems enable remote process management; personnel can evacuate promptly during air alarms or direct threats, while control systems maintain autonomous operation. For example, automated substations remotely redistribute loads and disconnect damaged lines without onsite staff presence, minimizing risks and facilitating rapid power restoration [3].

Automation preserves scarce resources by replacing humans in hazardous operations, reducing costly protective gear needs and extensive personnel training. Robotic complexes and smart sensors perform routine or labor-intensive tasks faster and more precisely, increasing overall production reliability. These technologies reduce accidents and improve operational sustainability even under heightened risks [5].

In conclusion, implementation of automated control systems is critical for occupational safety assurance under martial law in Ukraine. Digital solutions based on intelligent sensors, robotics, and IT enable risk reduction and increase occupational safety measure effectiveness. Automated monitoring and control adoption is vital amid limited human resources and elevated accident likelihood.

Therefore, digitalization and automation of occupational safety processes should become a priority. Developing new technologies and investing in adapted monitoring and management systems will enhance the resilience of Ukraine’s critical infrastructure, safeguarding workers’ lives and ensuring continuous production even under extreme wartime conditions.

Conclusion

Thus, the implementation of digital and automated systems in occupational safety represents a strategic step towards enhancing worker protection under martial law conditions. The use of advanced technologies not only minimizes the risk of occupational injuries but also ensures continuity and stability of critical infrastructure

operations. Further research and development of such systems will contribute to improving the effectiveness of occupational safety measures and safeguarding workers' health and lives even amid extreme challenges.

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