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Physical factors affecting the reliability of rail crane operators

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Abstract. *As it is known, load-lifting rail cranes of various models employed as part of Russian Railways repair and recovery trains are high-risk facilities. They normally have large dimensions and powerful engines that generate significant thrust and high energy. The paper examines the effects of harmful occupational factors of physical nature, i.e. industrial noise and vibration on the performance and health of rail crane operators.* **Aim.** *Based on the analysis of the causes of incidents that occurred in the course of operation of rail cranes, generalizing the experimental findings regarding the effects of industrial noise and vibration on crane operators and identifying the correlation between the clinical signs of distress in this category of workers and the levels of the above harmful physical industrial factors.* **Methods.** *Experimental studies and the subsequent evaluation of the effect of industrial noise and vibration generated by the mechanisms of cranes were conducted with the use of an Assistant Total+ noise and vibration analyzer in the course of operation of rail cranes of various models when handling cargo, as well as when crane engines idle. Measurements were conducted at workstations where the operator is to be at during the operation and maintenance of the crane, i.e. the control cabins, operator seat, control handles, near the crane engine.* **Results.** *The paper provides a classification of sources of noise and vibration that affect crane operators, experimental findings regarding the levels of industrial noise, general and local industrial vibration for various models of cranes. Clinical signs of distress are identified, a list is set forth of the most typical occupational health problems for this category of workers.* **Conclusions.** *The paper concludes that the reduction of industrial noise and vibration caused by the mechanisms of rail cranes is a relevant engineering and socioeconomic problem. From the socioeconomic point of view the solution to this problem will allow improving the working conditions of crane operators, while in terms of engineering it will enable higher technical and operational characteristics of crane mechanisms.*

Keywords: *working conditions, harmful occupational factors, rail crane, industrial noise, local industrial vibration, general industrial vibration, sources of industrial noise, sources of industrial vibration.*

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As it is known, load-lifting rail cranes employed as part of repair and recovery trains are high-risk facilities. They normally have large dimensions and powerful engines that generate significant thrust and high energy. These circumstances largely define the high levels of the factors of operating conditions and workflow at the workstations of crane operators.

Rail crane operators' work is not associated with excessive physical activity, however, it requires significant nervous and emotional effort, tension in the visual and auditory analyzers. The causes of accidents associated with the operation of cranes, along with the technical failures and "physical fatigue" of crane structural components, include the "human factor", i.e. errors by crane operators associated with reduced productivity and fatigue in the course of the working shift. That is due to the powerful and lasting vibration and noise affecting the operator and generated by the crane's mechanisms in the course of operation. These effects cause reduced performance during the work shift, while if such effects are lasting and recurring there is a risk of occupational health problems [1-4].

The sources of noise affecting rail crane operators should be divided into several groups:

– noises produced by the crane moving along the track. Despite the fact that the crane does not move fast when handling cargo, the operation is associated with the interaction between the rough surfaces of the wheel and rail, impacts within automatic coupling devices between the crane and flatcars. In this case the noise is nonstationary stochastic pulse processes.

– noises generated by main equipment (diesel generator, traction motor, speed transformer). As it is known, tear and wear of cogged wheels causes a significant increase of vibration in the speed transformer and traction motor frame.

– noises generated by auxiliary equipment (electrical machines and rectifying installation cooler fans, air conditioning system of the cabin). The sound power level of a fan is in complicated dependence with its parameters. For instance, as the blade speed increases the aerodynamic noise grows more rapidly than mechanical one, therefore a well-designed fan predominantly produces aerodynamic noise.

Depending on the design of rail cranes the level of noise they produce may differ. The paper cites the findings of experimental studies of the levels of noise for various models of cranes.

Thus, for the KZh-1572A hydraulic crane intended for recovery, construction and installation, maintenance and loading operations on 1520 mm gauge tracks, the primary sources of noise are the carriage and pivoting frames connected with a 360-degree rotation crown installed on two four-axle bogies fitted with a hydraulic travelling mechanism, as well as the crane's engine. The measurement data of the noise levels at the workstations where the operator is to be at during the operation and maintenance of the crane are given in Table 1.

The measurements were taken using an Assistant Total+ noise and vibration analyzer in the course of operation of rail cranes when handling cargo.

The DGKu railcar is one of the models of rail crane. Its design includs a load-lifting crane. It is intended for loading, unloading and transportation of loads, including 25-meter rails on its own platform or coupled flatcar, transportation of workers to work sites, conducting shunting operations in station tracks. The measurement data for the DGKu railcar in cargo handling mode are given in Table 2.

It should also be noted that when the operator is in the control cabin even if the engine idles, the noise can be as high as 52 to 63 dBA, or 61 to 78 dBA if the operator is communicating with the dispatcher via the radio. Thus, among the harmful physical factors affecting crane operator workstations noise stands out as a persistent high-intensity factor whose prolonged effect causes easy fatiguability, hearing loss, reduced performance.

The effects of noise on the human body are not limited to the auditory organ. Through the fibers of auditory nerves the stimulation is transmitted to the central and autonomic nervous systems and thus affects the internal organs and causes significant changes in the functional

Table 1. Levels of noise at the workstations of track machine operators, KZh-1572A rail crane

Measurement point	Center frequency band, Hz									dBA
	31.5	63	125	250	500	1000	2000	4000	8000	
RC	95	95	87	81	78	75	73	71	69	80
control cabin	104	105	88	86	83	78	76	82	76	83
engine platform	107	110	110	104	105	101	95	95	90	84

Table 2. Levels of noise at the workstations of track machine operators, DGKu rail crane

Measurement point	Center frequency band, Hz									dBA
	31.5	63	125	250	500	1000	2000	4000	8000	
RC	95	95	87	81	78	75	73	71	69	80
transport mode	96	96	88	85	82	82	76	74	68	86
operating mode	95	92	90	88	83	80	74	71	61	84

state of the body and the mental condition of the person creating the feeling of anxiety and irritation. The effect of noise on the central nervous system causes the increase of the latent period of visual motor reaction, leads to reduced mobility of nervous processes, changes in the electroencephalographic indicators, disrupts the bioelectric activity of the brain accompanied by overall functional changes in the body (starting with noise of 50 to 60 dBA), substantially changes the brain potentials, their dynamics, causes biochemical changes in the brain structures. Changes in the functional state of the central and autonomic nervous systems occur much earlier and at lower levels of noise than those causing reduced auditory sensitivity [5 – 7]. The above negative effects of noise cause crane operators to make errors and develop occupational health problems.

Crane operators are also affected by general and local vibration. The general vibration is felt under the feet and on the seat of the operator, local vibration affects the control handles. Vibration is generated by the running engine that sends it to the operator's cabin via the rigid frame. During a crane's operation vibrations occur both in the vertical and horizontal planes. The bouncing of the crane's mechanisms has the frequency range of 1.5 to 8.0 Hz. The cross shake that is imparted to the control cabin as the load swings has the frequency range of 0.2 to 1.0 Hz.

Given that the resonance frequency of human organs is within the range of 1 to 15 Hz, the operator is exposed to vertical oscillations of the most unfavorable range.

Vibration is also a physical factor of high biological activity. In case of lasting exposure it causes chronic occupational health problems, the hand-arm vibration syndrome disease that is the second on the list of railway personnel occupational health problems. General vibration primarily affects the supporting-motor apparatus and causes pains in the lower back, extremities, joints, muscles, tendons and around the stomach. The hand-arm vibration syndrome is manifested as systemic abnormalities with vascular tone disorder, absence of appetite, insomnia, irritability, easy fatiguability and pain sensitivity. Workers affected by vibration experience vertigoes, decomposition of movement, symptoms of motion sickness. Shock vibration is especially hazardous as it causes microtraumatization of various tissues with subsequent changesin them. Changes in metabolic processes, blood chemistry values are observed. General vibration with frequencies lower than 0.7 Hz (rocking) causes sea sickness as the result of disrupted vestibular system activity [5]. Vibration measurements made in the cabins of KZh-1572A and DGKu cranes showed that the levels of vibration (on the floor) are between 100 and 116 dB which exceeds the maximum permissible values by up to 9 dB (per vibration velocity levels) [8 – 11].

Thus, reducing the noise and vibration is a relevant technical and economic task whose solution will allow improving the technical and operational characteristics, as well as the working conditions of crane operators [12].

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