Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-115 Original scientific paper

EFFECTIVE NOISE MANAGEMENT – THE ROLE OF REGULAR CRANE MAINTENANCE

Željana Kužet[1] *[0009-0004-0958-517X]*, *Vladimir Mučenski*[2] *[0000-0001-9830-4747]*, *Selena Samardžić*[3] *[0000-0003-2578-7412]*

Abstract

Noise is defined as any sound that has the potential to disturb humans. As one of the significant occupational health hazards on construction sites, different levels of noise are produced by different construction equipment. The noise level among crane operators varies between 74 – 97 dB (A), and at some points, it reaches the maximum level of 101 dB (A). Different research indicated that the crane operator's noise exposure depends on the task, crane model, and quality of the crane cab insulation. This research highlights the importance of conducting regular crane maintenance, as it can positively affect the decrease of noise exposure of crane operators. The aim of this study is to represent key elements of cranes that produce high noise and how they should be maintained by defining methods, time frames, and instruments that will be incorporated into the management of workplace noise. Reduction in noise level is accomplished with regular lubrication of moving parts, replacing wear and tear components, and ensuring proper alignment and balance. Through effective noise management that includes consistent inspection and monitoring, noise damping measures, and a set of preventive measures, the noise levels are kept within safe limits, lowering health risks to workers, such as hearing loss and other health issues. Implementing different preventive measures, such as predictive maintenance, scheduled servicing, and training for crane operators and maintenance staff, results in a quieter and safer operational environment.

Key words*: noise, cranes, maintenance, inspection*

[1] Faculty of Technical Sciences, University of Novi Sad, Serbia, zeljana.kuzet.12@outlook.com
[2] Faculty of Technical Sciences, University of Novi Sad, Serbia, mucenskiv@uns.ac.rs
[3] Faculty of Technical Sciences, University of Novi Sad, Serbia, selena@uns.ac.rs

1. Introduction

Noise represents one of the significant occupational health hazard in the construction industry, which among other construction machinery, is also produced by cranes. Crane operators are exposed to average daily noise between 74 and 97 dB (A), at some points, it even reaches the maximum level of 101 dB (A) and the exposure to noise of crane operator depends on the task and crane model (Legris & Poulin, 1998). Proper operation and maintenance of cranes represents one of the least expensive and most rewarding noise control practices. Through regularly lubrication of elements, replacing worn bearings and other parts as needed, but also keeping the doors and windows closed, it can be accomplished the reduce of noise when working with cranes (Suter, 2002). The aim of this study is to represent key elements of cranes that produce high noise and how they should be maintained by defining methods, time frames, and instruments that will be incorporated into the management of workplace noise.

2. Identifying key noise – producing elements in cranes

There are different sources (Finochenko et al., 2019) of noise that are separated into several groups:

- Noise produced by crane moving along the track – because there is an interaction between the rough surfaces of the wheel and rail, impacts within automatic coupling devices between the crane and flatcars;
- Noise generated by main equipment (diesel generator, traction motor, speed transformer) – tear and wear of cogged wheels causes a significant increase of vibration in the speed transformer and traction motor frame;
- Noise generated by auxiliary equipment (electrical machines and rectifying installation cooler fans, air conditioning system of the cabin).

Noise from cranes can also come from lack of lubrication oil of reducer of the crane, or due to adjustment of the tilting of the braking mechanism on both sides of the running mechanism of the cart, during the braking process, the braking torque on both sides is deviated, causing the side torsion to cause vibration. Crane noise can also be from operator violating the rules or incorrectly operating the crane. The quality of crane and its own characteristics is important to control and improve, because it can largely maintain a state that is not excessively loud.

As they are producing different forms of sounds, it is recommended to better understand the causes of these noises, in order to enhance better performance of machine which will improve the operator's safety on work. A first step in understanding the causes of these noises is to identify key noise-producing elements in cranes (Table 1)

Table 1: Key noise-producing elements in cranes

Element of crane		Element of crane	
Supporting structure	Turntable	**Crane drive mechanism**	Gearbox, shaft, belt pulleys, bearings, gears, reducer, electric motor, couplings
Gripping devices	Sheaves, hoist drums and sprockets	**Braking mechanism**	Brakes, brake pads, brake discs, brake drums, pistons, wedges, springs, welded parts, electromagnetic brake device, clutches
Movement mechanism	Wheel, rails, limit switch, couplings, rolling surfaces	**Electrical components**	Electric motor
Hydraulics components	Pumps, valves, hoses, pipelines, cylinders, hydraulic motor	**Cabin of operator**	Radio-devices, heating, ventilation and air conditioning (HVAC) system

3. Effective noise management – inspections and maintenance

3.1 Crane inspections: Types of inspections and essential instruments

Crane inspections represent second step in resolving the problem of noise produced by cranes. Regular inspections of cranes are important in detecting potential risks that can lead to accident during the work and it can represent the potential deficiency of elements that increase noise levels and indicate the possibility of serious accidents during the work with cranes.

Since the elements of cranes must go through detailed inspections, according to Labour Department UK (2001) and Goodwin & McClave (1993) there are different types of crane inspections and essential instruments used to achieve those inspections, such as:

- **Visual inspection (VI)** – includes checking and examining the condition of individual parts of lifting equipment to identify any problems that could impact on integrity of crane with use of adequacy lightning, hammer, loupe, binoculars, endoscopes, borescopes or 3D video – systems, with additional hammer testing;
- **Dimensional inspection (DI)** – includes check of dimensional tolerances of deformations of certain key components and configurations that matter affect the stability, performance and function of the lifting equipment with use of rulers, protractors and callipers;
- **Functional testing (FT)** – consists of the unloaded test and the load performance test in order to check the functionality of various operational and safety systems of the crane, and it includes using the load testing such as concrete or metal blocks/panels;
- **Equipment opening (EO)** – includes check of any covered, closed, hidden or wrapped components to verify whether they are within the limits

recommended by the manufacturer's specification, and it includes using the tools specified by manufacturer;

- **Electrical testing (ET)** – consist electrical tests by authorized electricity operators;
- **Non – destructive testing (NDT)** – includes different methods such as liquid penetrant testing (use of penetrant solution and developer, visible or UV light), magnetic particle testing (use of alternating current (AC) magnetic yoke or a permanent magnet set), electrical testing methods (use of ACPD or ACFM catheter) , ultrasonic testing (use of ultrasonic kit), X-ray testing (via X-ray device), acoustic emission (AE) technique (via AE instrument), microscopic level testing, thermography (using thermal cameras), optical laser – based techniques or monitoring vibrations and creating their footprint using a vibrometer.

3.2 Crane inspections: Systematization of recommended inspection methods for key noise – producing elements of cranes

After defining types of inspections and essential instruments used to achieve those inspections, for the every key noise-producing element of the crane, systematization of recommended inspection methods is done and showed in Table 2 based on Labour Department UK (2001), ACT (2022) and Dickie, D. E. D. (1975).

Table 2: Systematization of recommended inspection methods for key noise – producing elements of cranes

Element of crane		TYPES OF CRANE INSPECTIONS					
		VI	DI	FT	EO	ET	NDT
Supporting structure	Turntable	•	/	•	/	/	liquid penetrant testing, magnetic particle testing, X-ray testing, AE technique, thermography, NDT test for cracks
Gripping devices	Sheaves, Hoist drums, Sprockets	•	•	•	/	/	magnetic particle testing, NDT test for cracks
Movement mechanism	Wheel	•	/	unloaded test	/	/	/
	Rails	•	/	unloaded test, ground voltage measuremen t	/	/	magnetic particle testing, ultrasonic testing, X-ray testing, optical laser –based techniques
	Limit switch	•	/	•	/	/	/
	Couplings	•	•	unloaded test	/	/	/
	Rolling surfaces	•	/	unloaded test	/	/	/
Crane drive mechanism	Gearbox	•	/	/	•	/	/
	Shaft	•	/	/	•	/	
	Belt pulleys	•	/	/	•	/	/

Continuation of the Table

Element of crane		TYPES OF CRANE INSPECTIONS					
		VI	DI	FT	EO	ET	NDT
	Bearings	•	/	/	•	/	/
	Gears	•	•	/	•	/	magnetic particle testing
	Reducer	•	/	•	•	/	/
	Electric motor	•	/	•	•	•	/
	Couplings	•	•	/	•	/	/
Braking mechanism	Brakes	•	•	unloaded test	•	/	/
	Brake pads	•	•	unloaded test	•	/	/
	Brake discs	•	/	unloaded test	•	/	/
	Brake drums	•	/	unloaded test	•	/	/
	Pistons	•	/	unloaded test	•	/	/
	Wedges	•	/	unloaded test	•	/	/
	Springs	•	/	unloaded test	•	/	/
	Welded parts	•	/	unloaded test	/	/	magnetic particle testing, AE technique
	Electromagnetic brake device	•	/	unloaded test	•	/	/
	Clutches	•	/	unloaded test	•	/	/
Electrical components	Electric motor	•	/	/	•	•	/
Hydraulics components	Pumps	•	/	•	/	/	/
	Valves	•	/	•	/	/	/
	Hoses	•	/	•	/	/	electrical testing methods
	Pipelines	•	/	•	/	/	electrical testing methods
	Cylinders	•	/	•	/	/	NDT test for cracks, magnetic particle testing, AE technique
	Hydraulic motor	•	/	•	•	/	/
Cabin of operator	Radio-devices	•	/	/	/	/	/
	HVAC system	•	/	•	•	/	/

3.3 Crane inspections: Timeframe for Execution of Inspection and Testing of Cranes

Inspection and appropriate testing of cranes must be implemented in sufficiently frequent intervals to ensure crane parts that are subject to deterioration due to corrosion, damage, wear, abrasion, be replaced before become unusable with production of strange sound and noise. Table 3 outlines the timeframes for inspecting key noise-producing elements of cranes, based on various authors and their proposed inspection intervals.

Table 2: Timeframes for inspecting key noise-producing elements of cranes

ACT (2022)				
Inspection and testing before installation	**Inspection and testing during commissioning**	**Routine inspection and maintenance**	**Annual inspection (12 months or longer)**	**Major inspection**
All the elements				
Operator inspection (before working-shift)	Turntable, Sheaves, Hoist drums, Sprockets, Wheel, Rails, Limit switch, Couplings, Rolling surfaces, Brakes, Brake pads, Brake discs, Brake drums, Pistons, Wedges, Springs, Welded parts, Electromagnetic brake device, Clutches, Electric motor			
Labour Department of United Kingdom (2001)				
Daily		**Weekly**		**Monthly/ Quarterly**
All the elements – visual inspection		Sheaves, hoist drums, sprockets, braking mechanism, movement mechanism, electric motor, hydraulic components		Depends on manufacturer's manual conditions
Dickie, D. E. D. (1975)				
Frequent (1-5 days)		**Monthly**		**Annual**
Supporting structure (VI,FT) Gripping devices (VI, FT) Crane drive mechanism (VI) Movement mechanism (VI, FT) Braking mechanism (VI, FT) Hydraulics components (VI, FT)		Gripping devices (check for cracks, DI) Crane drive mechanism (DI,EO) Movement mechanism (DI) Braking mechanism (DI, EO) Electrical components (VI, EO) Hydraulics components (EO) Cabin of operator (FT, VI, EO)		NDT for all elements Electrical components (EI, every 6 months)

Additionally, apart from the mentioned inspections, it is necessary for every crane that spends a year or more at the same construction site to undergo a detailed visual inspection of each welded part. NDT testing must be performed before the crane is moved to another location or construction site (Dickie, D. E. D., 1975).

Within the framework of the time definition of tests by NDT methods, a significant difference can be observed in inconsistencies in inspection intervals – according to ACT (2022) NDT tests are carried out earlier installation and during the exploitation of the equipment every 5 or 10 years, depending on the component being used subject to examination. On the other hand, the Dickie, D. E. D. (1975) suggest that NDT tests are carried out as part of annual inspections in order to maintain the means and equipment for lifting loads in the best and safest condition. Significant problem represents the non-uniform system of inspection and verification where there the time intervals of inspection are inadequately determined.

When comparing Rulebook on the procedure of inspection and checking of work equipment and testing of working environment conditions (2023) with ACT (2022) it is observed a significance difference in time interval for preventive inspections, since Rulebook proposes that inspection and testing must occur as specified by technical regulations or manufacturer's instructions, within three years

of the last inspection, with exception for electrical installations (inspection every six months).

3.4 Crane management: Regular maintenance

Maintenance represents the combination of technical, administrative and management measures which are undertaken around the entire life of the equipment with the aim of re-use establishing the condition of the equipment so that it can perform its intended functions. During equipment maintenance, a variety of activities are carried out, such as monitoring, inspection, testing, repair, replacement, cleaning, lubrication, tidying up, but also implementation of preventive activities (KTF standard 2015). Maintenance should be carried out in accordance with the manufacturer's instructions, aimed at preventing possible malfunctions lead to dangerous situations and documented.

Important step when maintaining the cranes is that the control book must be filled out regularly and contain basic information about the crane (ex. location, crane operators, data on periodic inspections and tests etc.). To conduct the maintenance, the crane is located on the place of the easiest access in the least disruptive location. The space under the crane must be fenced off and secured from access of unemployed persons. All drives must be switched off, and in special cases when maintenance work is being carried out must be performed during the operation of one of the crane drives (and there is no risk of injury) is ensured continuous audio or visual communication between the crane operator and the maintenance person.

According to KTF Standard (2015) maintenance of crane can be organized like three lines of maintenance:

- First line of maintenance – dialy, periodic and preventive maintenance performed by the crane operator in accordance with the descriptions in the user manual;
- Second line of maintenance – minor repairs and services that do not require approval or execution by the manufacturer;
- Third line of maintenance – major maintenance, significant services, and repairs/reconstructions that require approval or execution by the manufacturer.

On the other hand, CCOHS (2024) simplifies the maintenance of crane, by dividing the activities of maintenance in two groups, first group is breakdown maintenance, which is conducted after a reported failure, including the reparation of crane as soon as possible, and second group is preventive maintenance which is conducted twice a year, includes inspection of all the elements and theirs purity.

In order to better organize the maintenance process, it is necessary to form maintenance lists which will include the key noise – producing elements in cranes of importance for the safe operation of the crane which are specified by the manufacturer, engineer or company requirements.

4. Conclusion

The steps in this research (identification of key noise-producing elements of cranes, systematization of recommended inspection methods for key noise–producing elements of cranes, and defining time-frames for their inspection and testing) show that they contribute to reducing the noise level. By conducting regular maintenance of key elements of the crane, sources of noise can be detected and eliminated before major damage or downtime occurs. Through effective noise management that includes consistent inspection and monitoring, noise damping measures, and a set of preventive measures, the noise levels are kept within safe limits, lowering health risks to workers, such as hearing loss and other health issues.

REFERENCES

[1] Australian Capital Territory. Work Health and Safety (Tower Crane Code of Practice) Approval 2022, Chapter 10, pp. 56–68. https://www.legislation.act.gov.au/ni/2022-432

[2] CCOHS - Government of Canada, Canadian Centre for Occupational Health and Safety. (2024). *Materials handling - Crane maintenance.* https://www.ccohs.ca/oshanswers/safety_haz/materials_handling/crane_ma.html

[3] Dickie, D. E. D. (1975). Crane Handbook, *Construction safety association of Ontario*, Part 2, Chapter 5–8, 179–301.

[4] Finochenko, T. A., Pereverzev, I. G., & Balanova, M. V. (2019). Physical factors affecting the reliability of rail crane operators. *Dependability*, 19(1), 36–39. https://doi.org/10.21683/1729-2646-2019-19-1-36-39

[5] Goodwin, M. J., & McClave, E. F. (1993). *Innovative Inspection Techniques* (Vol. 1). US Coast Guard Research and Development Center. https://apps.dtic.mil/sti/tr/pdf/ADA265418.pdf

[6] K. T. F. Standard (2015). SAFE USE OF LIFTING EQUIPMENT. https://ktf.no/wp-content/uploads/2022/10/KTF-standard_ENG.pdf

[7] Labour Department UK (2001). Guidance Notes on Inspection, Thorough Examination and Testing of Lifting Appliances and Lifting Gear, https://www.labour.gov.hk/eng/public/os/C/gear.pdf

[8] Legris, M., & Poulin, P. (1998). Noise exposure profile among heavy equipment operators, associated laborers, and crane operators. *American Industrial Hygiene Association Journal*, *59*(11), 774–778.

[9] Rulebook on the procedure of inspection and checking of work equipment and testing of working environment conditions ("Official Gazette of RS", No. 15/2023).

[10] Suter, A. H. (2002). Construction noise: exposure, effects, and the potential for remediation; a review and analysis. *AIHA journal*, *63*(6), 768–789. https://doi.org/10.1080/15428110208984768