

## **A STUDY ON THE CAUSES AND CONSEQUENCES OF ACCIDENTS WITH CRANES FOR LIFTING AND MOVING LOADS IN INDUSTRIAL PLANTS AND CONSTRUCTION SITES OF THE RUSSIAN FEDERATION**

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*The article is devoted to the investigation of the causes and consequences of crane lift crashes at industrial facilities and construction sites in the Russian Federation. The distribution of accidents by types of lifting cranes and accidents by occupations of deceased workers is shown. Accidents are categorized for their reasons. The causes of most accidents are the "human factor": low technological discipline, inadequate staff qualifications, poor-quality installation and untimely equipment repair. Also, the level of industrial safety is affected by technical, organizational and financial problems at enterprises. The main reason for the decline in the level of industrial safety is a significant amount of equipment that has fulfilled its calculated resource.*

*Key words: Hoisting crane, Safety, Accident, Industrial injuries*

### **INTRODUCTION**

Industrial production, construction of buildings and structures is inextricably linked with the lifting and transportation of various cargoes. The main link in the chain of transport technologies – lift facilities, the technical condition and reliability of which depends on performance of transport-technological systems. As a rule, lifting constructions are objects with significant mass and large geometric parameters in the work area are always people. Such structures include cranes, elevators, cable cars, funiculars, lifts (towers), etc., as well as facilities that ensure their operation (gantry rails, overpasses, etc.). Operation of lifting equipment has always been a threat due to a certain risk resulting from their specific destination. The risk exists both for facility personnel and for other persons, the so-called "third parties".

Lift facilities are hazardous production facilities, which must comply with the rules of industrial safety.

Industrial safety of hazardous production facilities - the state of protection of vital interests of the individual and society from accidents on these objects and their consequences (Federal law of 21.07.1997 N 116-FZ). The main objective of industrial safety – preventing or minimizing the consequences of accidents at hazardous production facilities.

The aim of this work is to analyze the state of industrial safety at operation of load-lifting cranes and systematize the causes of accidents with a fatal outcome.

### **THE SOURCE DATA FOR THE STUDY**

Cranes occupy an important place in the process of Russian industry and the construction and refer to production facilities of increased danger. State control and

supervision of observance of requirements of industrial safety at these facilities is performed by the Federal service for ecological, technological and nuclear supervision (Rostehnadzor). Therefore, the most reliable information about the number, nature, and circumstances is materials of investigation of accidents are available in the annual reports on the activities of Rostehnadzor. These materials form the basis of the analysis.

### **GENERAL CHARACTERISTICS OF INDUSTRIAL SAFETY OF LIFTING STRUCTURES**

In 2016 the monitoring was carried out in 76832 of supervised enterprises and organizations. These objects include more than 725 thousand units of elevating equipment of different types. Of this number were operated 200113 lifting 24086 cranes and lifts (towers).

In line with global integration and changes in the rate of production of domestic manufacturers of lifting equipment park the PS in Russia, intensively filled with foreign equipment [08]. On the territory of the Russian Federation operates almost 131 thousand units of equipment imported, which is 18 % of the total number registered in Rostehnadzor lifting equipment. The import component of the market is represented mainly by technology, the capacity of which is over 40 tons. It is also worth noting that the place of truck-mounted cranes with carrying capacity up to 10 tons filled with cranes-manipulators of foreign production, which are more convenient and compact when working with light weights.

During operation of lifting structures of all types in 2016 year, there have been 62 technical accidents killed 38 people, in 2015 there were 59 technical accidents killed 58 people. The numbers of received grievous bodily harm were, respectively, 16 and 21.

In the operation of cranes in 2016 year, there have been 42 accidents; one accident in the operation of lifts (towers) 2 accident – when operating construction lifts and one accident – when operating the cableway. In particular, the operation of tower cranes was 13 accidents, crawler cranes - 11 accidents, and the use of mobile cranes - 4.

Financial losses from accidents in 2015 amounted to 90.5 million rubles, and in 2016 – 25.9 million.

During the period of statistical observation from 1993 to 2016 year, there were 957 crashes on load-lifting cranes, of which [05]:

- on automotive cranes - 272;
- tower cranes - 252;
- overhead travelling cranes - 125;
- on cranes with crawler movement - 94;
- on cranes of the gantry type -77;
- cranes on a special wheeled self-propelled chassis - 80;
- cranes-portals - 43;
- railway cranes - 14.

The rate of fatal injuries (number of deaths per 1000 registered cranes) were observed from 0,372 to 0.103 [05].

It is established that the largest share of accidents falls on truck cranes and tower cranes used on construction sites.

### **CAUSES OF ACCIDENTS**

Accidents occur for reasons of technical, operational, organizational and other nature.

#### Technical considerations:

- the use of elements that do not meet the specified technical requirements;
- lack of quality control in the manufacture and installation of equipment;
- malfunction of protective devices;
- adoption of the draft insufficient functionality and (or) their subsystems;
- error when carrying out repair and rehabilitation works and trials;
- other defects and design limitations;
- the absence or failure of fencing of sites;
- low quality steel used in the fabrication of the crane;
- lack of project development and wrong constructive solution of the bearing element crane.

#### Operational aspects:

- open access to the cable the electrical load;
- the destruction of metal;
- the failure of the crane tracks and buffer stops;
- malfunction of electrical equipment;

- failure of the cargo ropes, stationary lifting devices and removable lifting devices;
- lifting a load in an inclined position.;
- improper execution of slinging loads, the overload or overflow containers;
- insufficient supply of warehouse space;
- work in an unintended mode
- the presence of shock loads of stress;
- fatigue (aging) structures;
- corrosion of metals;
- invalid temperature, high humidity, excessive vibration;
- the effect of chemically active reagents, etc.

#### Organizational causes:

- late or incomplete examination (diagnostics) of elements;
- failure to comply with security measures specified in the permit, while performing work on crane ways and walk-through the galleries;
- contents of a technical device in a faulty condition;
- allowed no trained and not certified personnel to manage the crane;
- lack of control over the work equipment;
- other violations of requirements of safety rules.

#### Other:

- wind load;
- the presence of snow loads.

### **THE TYPES OF ACCIDENTS THAT CAUSED THE DEATH**

The following is data on accidents with a fatal outcome for load-lifting cranes for nine years (between 2003 and 2011) for reasons caused them.

Drop shipping as a result of:

- use damaged or not of appropriate weight and type of cargo handling accessories, violation of the schema slinging – 143;
- improper storage violations warehousing – 22.

The falling of the crane as a result of:

- improper installation – 31;
- reloading, malfunction of safety devices – 63.

Injury:

- spontaneously by a load due to lifting it in a tilted position of the cargo ropes (lifting of entrapped cargo) – 1;
- electric shock due to violations of safety requirements when working near power lines – 56;
- mechanisms of cranes working at the exit of the people on the crane track – 27;
- freight, tools, technical devices while people are in the danger zone of operation of the valves 161.

Failure and destruction:

- mechanisms because of the content of technical devices in a failed state – 68;
- cranes (machinery) due to poor manufacture them in the factory – 1.

Other factors – 98.

As a result of these reasons for a specified period of time, killed 671 people.

The data show that most injuries occur because of damage to the goods, tools, technical devices while people are in the danger zone of operation of cranes (161). High mortality occurs still due to the fall in the goods arising out of the use of faulty or do not conform to the weight and nature of cargo handling accessories, because of the violation of the rules of the slinging of cargo (143). The number of accidents caused by destruction of structures of the crane or mechanisms because of the content of technical malfunctions in the device (68), is quite high, indicating that the failure to observe the rules of safety at hazardous production facilities.

### CATEGORIES OF FALLEN WORKERS

In accidents are killed mostly workers, not directly associated with the operation of cranes and repair personnel, concrete workers, carpenters, masons, welders, etc. category of workers (Table 1).

### MEASURES TO ENSURE SAFE OPERATION OF CRANES

Improving the safe operation of lifting equipment can be achieved through organizational, technical and performance discipline in the enterprises and organizations. In this regard, by the order of Rostehnadzor from 12.04.2016 No. 146 amendments to the Federal rules and regulations in the field of industrial safety "safety Rules for hazardous production facilities which are used elevating constructions", previously approved by order of Rostehnadzor dated November 12, 2013, No. 533.

This document establishes the new security rules, taking full account of the provisions of the technical regulations of the Customs Union. The document specifies requirements for activities in the field of industrial safety at the facilities, where applicable, the fixed load-lifting mechanisms. List of lifting equipment, the use of which is necessary to fulfill these requirements. Established the General principles of industrial safety; requirements on organizations and personnel engaged in the installation, commissioning, repair, reconstruction, modernization, operation of lifting equipment. Govern the procedure of the conformity assessment and examination of industrial safety.

An important step of examination of industrial safety expert examination of technical condition of lifting equipment directly at the place of its installation and operation.

### CONCLUSION

Common problems and risk factors affecting the state of industrial safety at operation of load-lifting cranes remain. These include:

- high level of wear of load-lifting cranes;
- low level of industrial and technological discipline;
- the lack of qualified specialists, low level of training and retraining of specialists, insufficient knowledge of industrial safety requirements and practical skills;
- the precarious financial situation of many organizations, inadequate amounts allocated to the owners of the means of implementation of measures aimed at improving of industrial safety, for training and retraining of qualified specialists and employees and creation of favorable conditions for work.

Improving safety at the enterprises and in organizations can be achieved by adopting appropriate measures on the part of the heads of organizations do not ensure security, but also to the experts, the direct executors that do not meet the requirements of the rules and safety standards established technologies and rules [07].

Table 1: Categories of workers who died in operation of cranes

Category of the dead	Years							
	2009	2010	2011	2012	2013	2014	2015	2016
- maintenance personnel	9	14	15	22	4	4	-	-
- slingers	7	7	6	8	8	13	4	5
- crane driver	14	12	7	15	11	4	12	6
- concrete workers, masons, carpenters, welders and other employees	19	21	26	33	26	22	31	16
- other people (third party)	3	0	0	1	1	3	9	1
The total number	52	54	54	79	50	46	56	28

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