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Risk-based approach in "personnel-machinery-production environment" system at the facilities running tower cranes*

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Риск-ориентированный подход в системе «персонал-механизмы-производственная среда» на объектах, эксплуатирующих башенные краны***

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Introduction. The paper discusses the applicability of a risk-based approach in the "personnel-machinery-production environment" system at the facilities running tower cranes through the introduction of IT-technologies that provide open communication of the staff, management team of the operating organizations, and the National Supervisory Authority, to reduce the accident rate.

Materials and Methods. An example of a hazardous production facility running tower cranes is given. Materials on the analysis of operational status of tower cranes within the framework of the current legislation in the field of industrial safety are used. The necessity for innovations and transformations, one of whose methods is the risk-based approach allowing for the implementation of all required levels of control, is identified.

Research Results. The stages of introduction of the risk-oriented approach for tower crane operators implemented through IT-technologies using Web-applications on safety management under the tower crane operation based on the hazard analysis and risk assessment in gamut, algorithmically associated with the electronic block key of its local security system, are determined.

Discussion and Conclusions. The application of a risk-based approach in the "personnel-machinery-production environment" system at the facilities running tower cranes through the introduction of IT-technologies will ensure the proper operation of all departments and each participant of the operation, as well as provide Supervisory bodies with an opportunity to access information on the operation for the implementation of control and supervision functions remotely.

Введение. В статье рассматривается возможность применения риск-ориентированного подхода в системе «персонал-механизмы-производственная среда» на объектах, использующих башенные краны посредством внедрения IT-технологий, обеспечивающих открытое взаимодействие персонала, руководящего состава эксплуатирующих организаций и государственных надзорных органов в целях снижения уровня аварийности.

Материалы и методы. Приведен пример опасного производственного объекта, эксплуатирующего башенные краны. Использованы материалы анализа состояния эксплуатации башенных кранов в условиях действующего законодательства в области промышленной безопасности, выявлена необходимость инноваций и преобразований, одним из составляющих методов которых является риск-ориентированный подход, позволяющий реализовать все необходимые уровни контроля.

Результаты исследования. Определены этапы внедрения риск-ориентированного подхода для машинистов башенного крана, реализованного посредством IT-технологий с использованием Web-приложений по управлению безопасностью при эксплуатации башенного крана на основе анализа опасностей и оценки риска в цветовой гамме, алгоритмически связанной с электронным ключом блокировки его локальной системы безопасности.

Обсуждение и заключения. Применение риск-ориентированного подхода в системе «персонал-механизмы-производственная среда» на объектах, эксплуатирующих башенные краны посредством внедрения IT-технологий, позволит обеспечить надежное функционирование всех подразделений и каждого участника работ по эксплуатации, а также предоставит возможность надзорным органам получать доступ к информации по эксплуатации для осуществления контрольно-надзорных функций дистанционно.

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Keywords: risk-based approach, National Supervisory Authority, risk assessment, tower cranes, subdivisions of operating enterprise, crane operator.

Ключевые слова: риск-ориентированный подход, государственный надзорный орган, оценка риска, башенные краны, подразделения эксплуатирующего предприятия, машинист крана.

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Introduction. The first decades of the XXI century were marked by serious achievements in science and technology, modernization and improvement of digital technologies, production processes and engineering capacities of the production potential of Russia, which serves to strengthen the economy of the state and to improve the living standards of the citizens.

Against the background of the above achievements and prospects, issues of the operational safety and the professional competence of personnel at the production facilities, as well as supervision of the safe operation of hazardous production facilities (HPF), are challenge problems.

The HPF condition as a whole is estimated by such indicators as accident rate and injury. The level of safety of the HPF is under the state control and is supported by Federal Law No. 116 [1]. Since its adoption in 1997, there has been a transition from the deterministic to probabilistic risk assessment. New techniques for analyzing technically challenging and hazardous objects are introduced [2]; it is supposed to evaluate them by the parameters of risk, survivability and safety (Fig. 1).

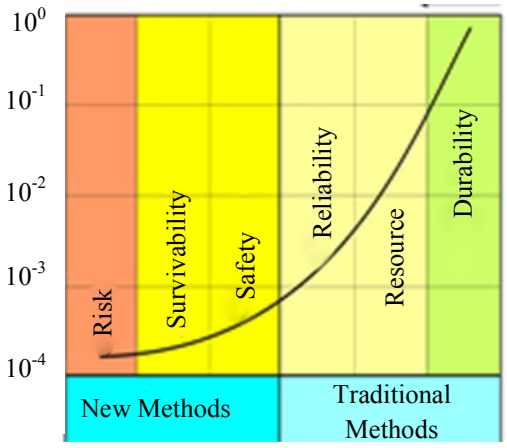


Fig. 1. History of development of methods for calculating HPF

Research Results. Consider HPF running lifting devices, in particular, tower cranes. At present, such an object is ranged in the fourth hazard class (low hazard). In this regard, it is exempted from periodic inspections by the federal executive authority in the field of industrial safety, and the responsibility for complying with the industrial safety requirements rests in full with the owner or operator. The discussion of adequacy of the internal control over compliance with industrial safety requirements without the participation of supervisory authorities was held at different levels.

The recent rise in accidents and injuries at the facilities running tower cranes, has led to the tightening of administrative measures, namely:

- Order of Rostekhnadzor No. 146 of April 12, 2016, changes the Federal norms and rules for lifting devices under the operation of tower cranes. Article No. 141 assigned for the participation of an inspector of Rostechnadzor in the commission for decision-making on the possibility of bringing tower cranes in operation[3];
- Instruction of the Government of the Russian Federation No. АХ-П9-682 of February 8, 2017, "On the organization and conduct of unscheduled inspections of the enterprises running tower cranes from 2017 to 2019" regulates the procedure of random checks.

Additionally, the draft law proposes to classify enterprises using tower cranes to the third hazard class. This will allow for scheduled oversight activities against these facilities every three years. The operating organizations themselves also consider this measure appropriate.

The need for transformation and innovation in the field of industrial safety has come to a head. Significant measures are as follows: the introduction of a risk-based approach during the organization and implementation of all types of state control (supervision) from 2018 (introduced by Federal Law No. 246-FZ of July 13, 2015) [4]; using the information and communication technologies to perform the duties in an electronic form during the implementation of state control (supervision). The regulating document is the Decree of the Government of the Russian Federation No. 482 of April 21, 2018, "On the State Information System of "Typical Cloud Solution to Automation of Control (supervisory) Activities" [5].

The following tasks of the state policy in the field of industrial safety are formulated, among other documents, by the Decree of President of the Russian Federation "On the Fundamentals of the State Policy of the Russian Federation in the Field of Industrial Safety for the Period to 2025 and for the Future" of May 06, 2018: introduction of a risk-oriented approach under organizing the federal state control (supervision) in the field of industrial safety; annulment of obsolete, redundant and duplicate industrial safety requirements [6].

The operation of tower cranes is carried out, as a rule, at construction sites geographically distant from the workplaces of managers and experts, which allows the crane operator to make autonomous decision on the work commencement and performance. Periodic on-site visits of specialists responsible for the operable state do not allow for an objective situation assessment, which leads to numerous emergencies and injuries.

The functions of a tower crane driver, indicated in the production instruction, presuppose a certain algorithm of his actions before work starting, related to the determination of the technical readiness of the crane for safe operation.

The statistics of most accidents with tower cranes and the results of their investigations reflect the failed state of cranes (nonoperable condition of separate units), which is not recorded in the duty log during the inspection of the crane operator. Consequently, a specialist responsible for the operational condition of the lifting device has no information of it because of non-compliance with the instructions by a crane operator. The enterprise management learns about the incidents that have already happened as fait accompli — during the investigation of the causes of accidents (injuries).

Multi-level control and interaction of all participants engaged in the industrial safety under the operation of tower cranes (Fig. 2) can be considered the only solution to safety problems.

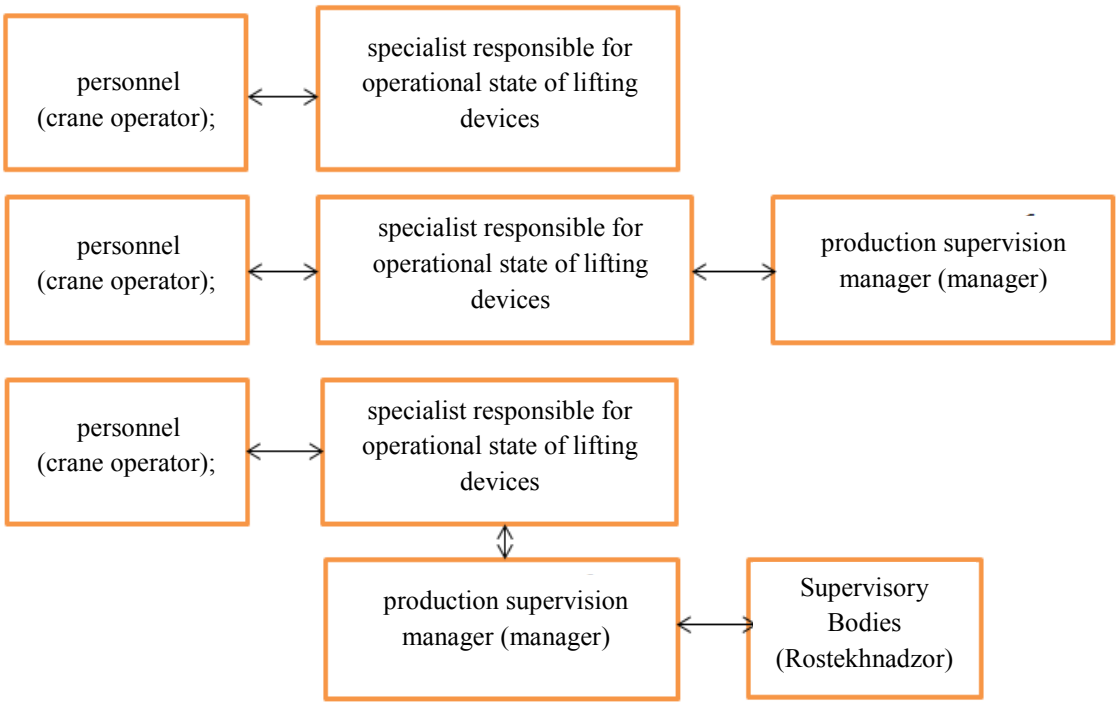


Fig. 2. Personnel and managers interaction algorithm

The application of a risk-based approach provides the methods of organization and implementation of all levels of control, including measures of preventive control of the compliance with safety requirements concerning facilities operating tower cranes. This approach can be implemented through IT technology using Web applications. These applications help to manage safety when operating a technical facility based on hazard analysis and risk assessment in color gamut. An algorithmic connection with the electronic block key of the local safety system is made. Thus, the compliance with the standards established by law in the field of HPF industrial safety is ensured through the remote technologies.

One of the steps of introducing a risk-based approach will be the implementation of electronic checklists for meeting industrial safety requirements through individual mobile devices. At this, information on the fulfillment of the security requirements is sent in real-time via the Internet to individual mobile devices to the manager, specialists and service personnel (Fig. 3).

Fig. 3. Electronic checklists in the form of mobile applications

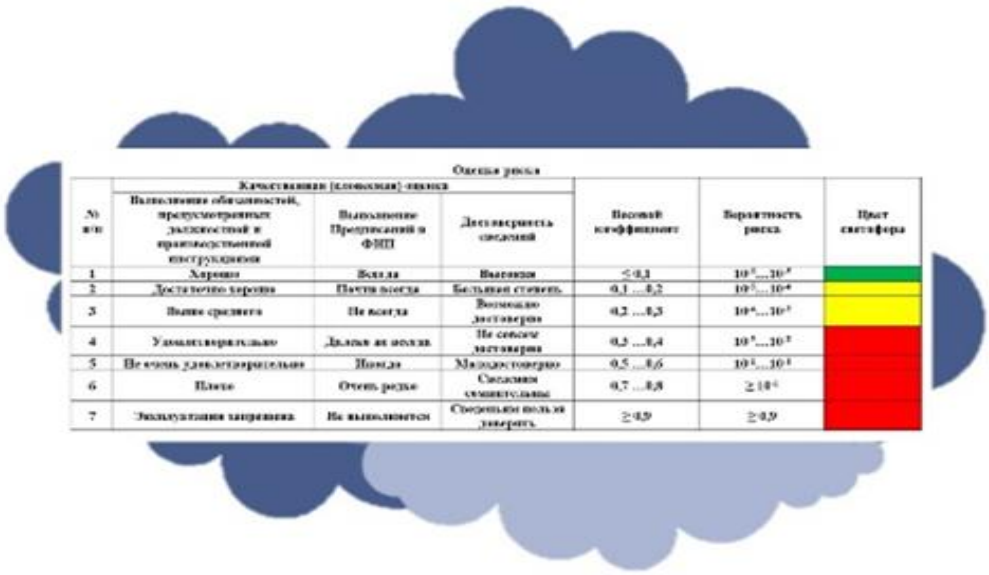
The next step involves monitoring and confirming the fulfillment of security requirements, determined by the duty and working instructions through individual mobile devices, where prompts in the form of tables on the controlled action and its scheduled time should popup (Fig. 4.)

Fig. 4. Mobile screen with popup checklists

The next step includes processing of the language data from managers, specialists and service personnel, as well as digital information obtained from the coordinate protection of the crane in the cloud space using a risk assessment algorithm based on the theory of fuzzy sets of L. A. Zade.

The software to assess risk under the crane operation is displayed as a color gamut, for example, of three colors according to the scheme:

- red - "work prohibited";
- yellow - "work permissive, actions required";
- green - "work permissive ".



№ п/п	Качественная (словесная) оценка			Весовой коэффициент	Вероятность риска	Цвет светофора
	Выполнение обязанностей, предусмотренных должностной и производственной инструкциями	Выполнение Предписаний и ФИП	Достоверность сведений			
1	Хорошо	Всегда	Высокая	<0,1	$10^{-5}...10^{-4}$	
2	Достаточно хорошо	Почти всегда	Большая степень	0,1 ...0,2	$10^{-4}...10^{-3}$	
3	Выше среднего	Не всегда	Возможно достоверно	0,2 ...0,3	$10^{-3}...10^{-2}$	
4	Удовлетворительно	Далеко не всегда	Не совсем достоверно	0,3 ...0,4	$10^{-2}...10^{-1}$	
5	Не очень удовлетворительно	Никогда	Малодостоверно	0,5 ...0,6	$10^{-1}...10^{0}$	
6	Плохо	Очень редко	Сведения сомнительны	0,7 ...0,8	$\geq 10^{0}$	
7	Эксплуатация запрещена	Не выполняется	Сведения нельзя проверить	≥0,9	≥0,9	

Fig. 5. Risk assessment under crane operation in color gamut

Crucially, the access to information on existing violations should be implemented using an appropriate login and password, which is confidential information. This will enable to establish causes of the unfavorable cases (accident, incident), as well as a concrete employee who has failed to fulfill his duty or working instructions (Fig. 6).

Fig. 6. Steps of displaying risk-based approach algorithm on mobile devices

One of the stages of the implementation of the risk-based approach is to monitor the crane operation by the video surveillance signal through a remote CCTV camera – a “black-box” recorder. Its signal is transmitted via the Internet to the cloud space where the video information is stored (Fig. 7).

Fig. 7. Displaying panorama of object on mobile device using video surveillance

Conclusion. The application of the risk-based approach in the "personnel-machinery-production environment" system at the facilities running tower cranes through the introduction of IT-technologies will ensure reliable operation of all departments and each participant of the operation. This will provide supervisors with the ability to remotely access to operating information for the implementation of the control and supervisory functions. Reducing the number of accidents and injuries during the tower cranes operation can be achieved only under the condition of open interaction of the personnel, management and supervisory authorities.

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