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IMPROVING THE SYSTEM OF RISK MANAGEMENT TO ENSURE THE SAFETY OF PRODUCTION PROCESSES

The paper discusses the issues related to development of the system of professional risks management on railway transport. The possibility of modernizing the existing system of labour protection management has been demonstrated in close relationship with the methodology of resource and risk management at all stages of the life cycle of facilities and equipment on the basis of reliability analysis (URRAN).

***Keywords**: risk management, labour protection management system, URRAN.*

Currently, the railway network witnesses the implementation of methodology for managing resources and risk management at all stages of the life cycle of facilities and equipment on the basis of reliability analysis (URRAN) [1,2,3,4,5], which is a basic for the management of the company's operations. One of the objectives of the implemented methodology is risk management of facilities and equipment of railway infrastructure, and the realization of this objective will allow in a much more effective way to prevent the occurrence of adverse events.

An important component of the labour protection management system (LPMS) is professional risks. In 2011, Article 209 of the Labour Code of the Russian Federation adopted the concept of a professional risk, i.e. the probability of causing harm to health from exposure to harmful or hazardous factors in the performance of duties of the employee under an employment contract, or in other cases stipulated by the Labour Code and other federal laws. With this in mind, to meet the challenges of modernizing the system of labour protection management, the board of JSC "Russian Railways" has decided to move from a reactive system to a proactive labour protection management system based on the analysis and evaluation of professional risks.

As part of the practical implementation of this strategy of LPMS modernization, RZD is currently realizing a number of pilot projects on the sites of the Oktyabrskaya Railway and the Gorkovskaya Railway, the Central Directorate for Track Repair, the branch of JSC "Russian Railways" in the Oktyabrskaya Directorate for track repair.

Analysis of the results of the pilot projects shows a significant difference in the approaches to the assessment of professional risks at the level of business units. As the analysis of foreign methodology also shows, expert methods are to a greater extent the basis for assessment of professional risks in relation to employment.

The latter makes it important to coordinate the methodology implemented by URRAN with the results of worldwide practices and developments that are used as part of pilot projects.

For risk assessment, URRAN's methodology assumes defining the reliability parameters of the estimated object on the basis of available statistical data on the occurrence of adverse events [2]. One of the basic quantitative characteristics of the reliability is a failure rate defined as:

$$\tilde{\lambda}(t) = \frac{n(\Delta t)}{N_{cp}\Delta \mathrm{t}}, \quad (1)$$

where $N_{cp} = \frac{\mathrm{N}_i + N_{i+1}}{2}$ is the average number of properly working products on the interval Δt; N_i is the number of products in good working order at the beginning of the interval Δt; N_{i+1} is the number of products in good working order at the end of the interval.

In the case of professional risk assessment, the rate of accidents will be calculated as follows:

$$\lambda^{нс} = \frac{t}{N_{cp}\Delta T}, \quad (2)$$

where t is the number of accidents, ΔT is the observation interval, N_{cp} is the average number of employees during the observation interval.

So, as for the Octyabryaskaya Directorate for Track Repair, the rate of accidents per business units over ten years is shown in Table 1.

Table 1. Rate of accidents per the Directorate's business units

Business unit	Total accidents, t	Fatal accidents, tc	Average number of employees, N	Rate of accidents per unit, λ	Rate of fatal accidents per unit, λc
OPMS-1	0	0	357	0	0
OPMS-8	0	0	247	0	0
PMS-28	3	2	235	0,001160542	0,000773694
PMS-29	0	0	308	0	0
PMS-75	2	1	314	0,000579039	0,000289519
PMS-77	9	1	353	0,002317796	0,000257533
PMS-82	6	0	273	0,001998002	0
PMS-83	0	0	218	0	0
PMS-88	8	0	338	0,002151694	0
PMS-199	1	0	242	0,000375657	0
PMS-263	4	0	348	0,001044932	0
PMS-283	0	0	325	0	0
PMS-292	1	1	157	0,000579039	0,000579039
Total:	34	5	4346	0,000711208	0,000104589

The last row shows the rate of accidents in general for the Directorate, and the colour of the cells of the last two columns says about the level of their values in relation to the average rate of accidents. Fig. 1 shows a graphical interpretation of the results of the calculation.

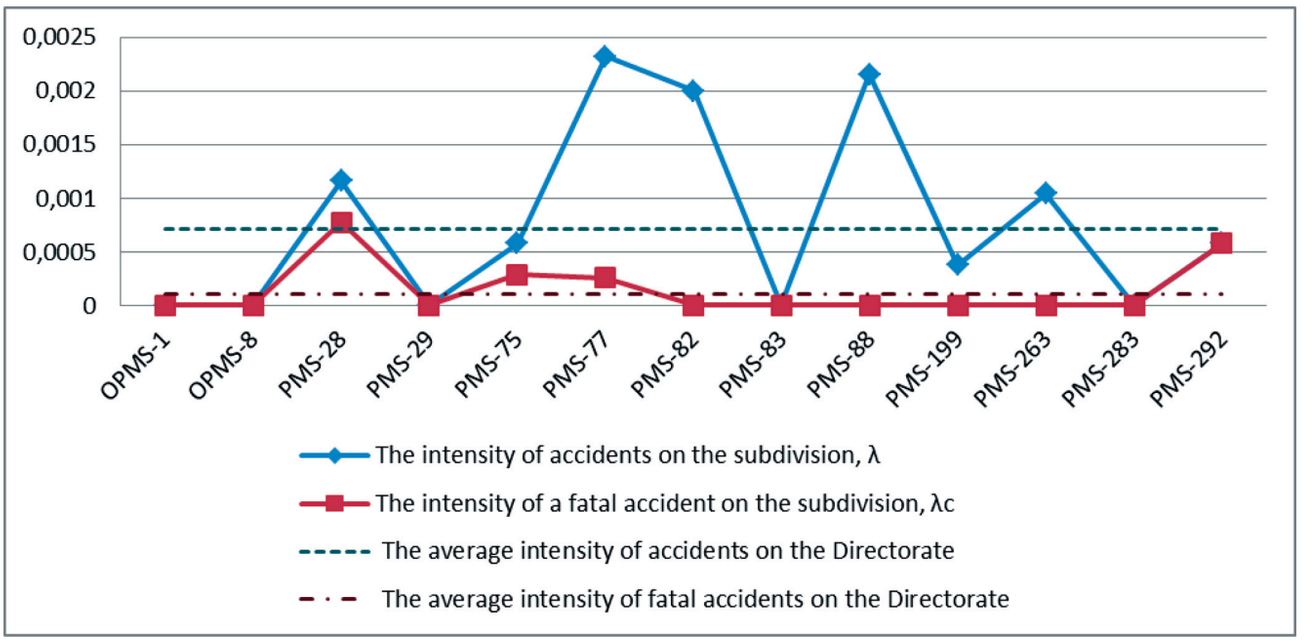

Fig. 1. The rate of accidents per the Directorate's units

The dynamics of changes in the rate of accidents per the Directorate for an eleven-year period is shown in Table 2, and the graphical interpretation of the calculation is shown in Fig. 2.

Table 2. Changes in the rate of accidents

Year	Total accidents, t	Fatal accidents, tc	Average number of employees, N	Rate of accidents per unit, λ	Rate of fatal accidents per unit, λc
2000	4	1	4339	0,000921871	0,000230468
2001	5	2	4111	0,001216249	0,0004865
2002	0	0	4318	0	0
2003	5	1	4442	0,001125619	0,000225124
2004	5	0	4395	0,001137656	0
2005	5	0	4471	0,001118318	0
2006	1	0	4463	0,000224065	0
2007	2	0	4512	0,000443262	0
2008	4	1	4670	0,000856531	0,000214133
2009	1	0	4176	0,000239464	0
2010	2	0	3908	0,000511771	0
Total:	34	5	4346	0,000711208	0,000104589

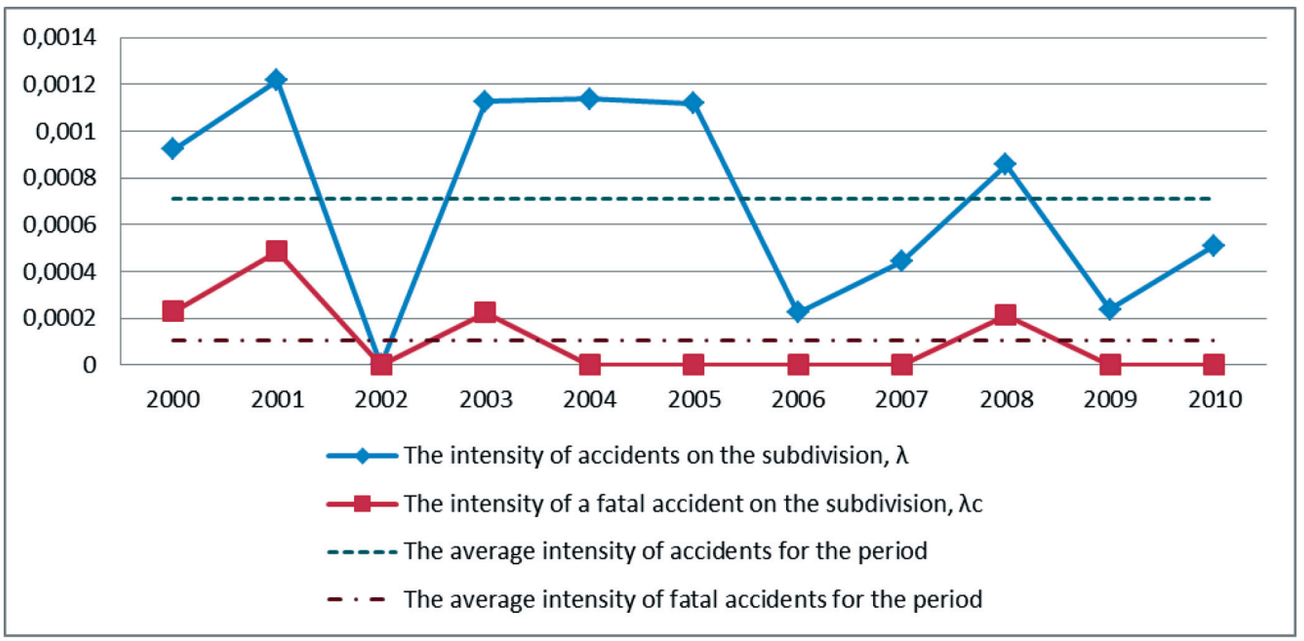

Fig. 2. Changes in the rate of accidents

As the practice has shown, the results of injury analysis are not much informative to identify cause-and-effect relationships at the level of structural units. Therefore, as part of a pilot project in all structural units of the Central Directorate for Track Repair, it was decided to take into account minor injuries which occur with a much higher frequency. The log template to register minor injuries is provided in Table 3. The rate of minor injuries is calculated by the formula:

$$\lambda^{м} = \frac{m}{N_{ср}\Delta T}, \tag{3}$$

where m is the number of suffered minor injuries.

The first results of the analysis are presented in Table 4 and Fig. 3.

Table 3. Log of minor injuries

№	Position	Date and time of injury	Injury type (bruises, cuts, burns, stretch, etc.)	Circumstances of getting injured	Detail (according to the classifier)						Notes	Time spent on medical care
					Time of commencement of work	Appeal in honey. institution (yes / no)	Source (equipment, tools)	The operation (step) of those. process	Place (shop, haul)	cause		
1	2	3	4	5	6	7	8	9	10	11	12	13

Table 4. The rate of microtraumas suffered per occupations

Occupation	Microtrauma, *m*	Rate of microtraumas, λ
railroad fixer	92	0,053625554
motorman	38	0,022149685
locksmith	10	0,005828865
master	7	0,004080205
engineer	7	0,004080205
driver	6	0,003497319
serviceman	5	0,002914432
welder	3	0,001748659
conductor	3	0,001748659
foreman	2	0,001165773

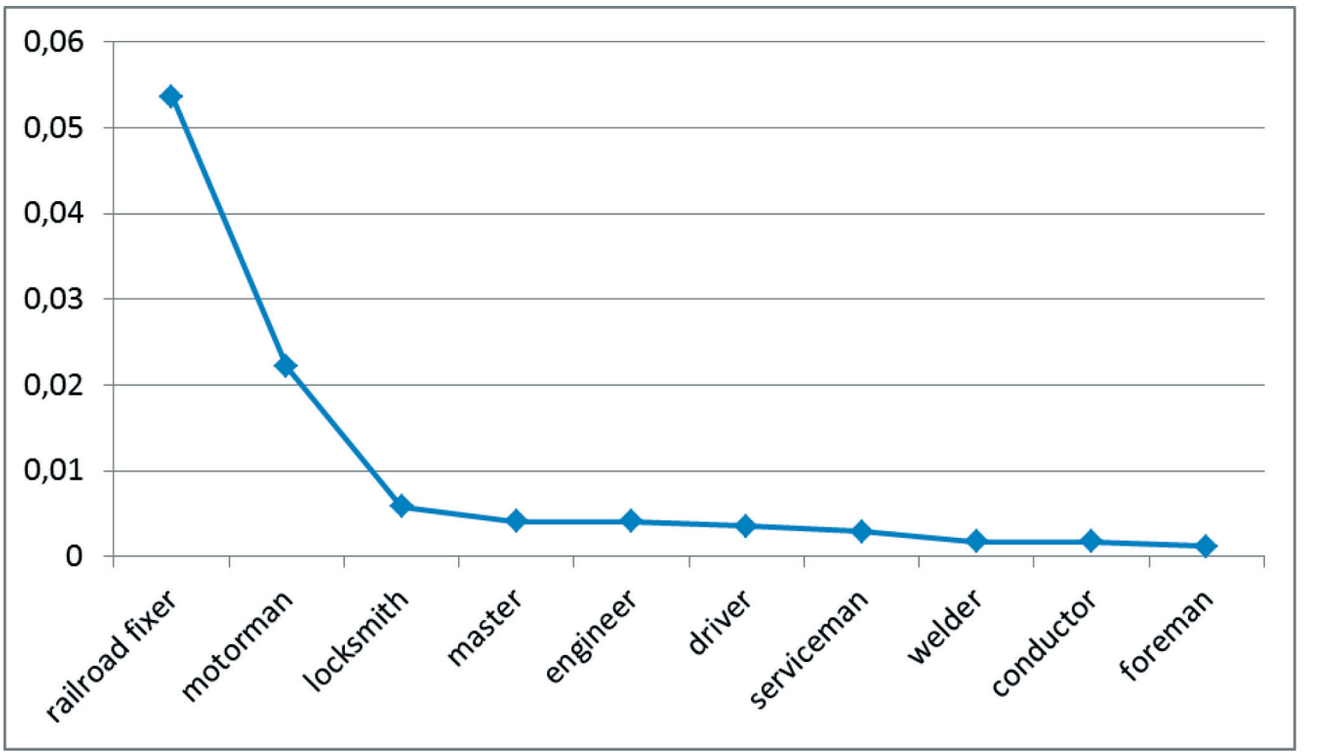

Fig. 3. The rate of microtraumas suffered per occupations

It is important to note that there is a clear correlation between injuries and minor injuries (microtraumas), which allows on the basis of much bigger amounts of data on minor injuries to predict and, therefore, prevent more serious accidents.

The rate of occurrence of occupational diseases is calculated by the formula:

$$\lambda^{nз} = \frac{d}{N_{cp}\Delta T}, \tag{4}$$

where *d* is the number of occupational diseases.

Table 5 and Fig. 4 show the rates of occupational diseases according to the data [6].

Table 5. The rate of occurrence of occupational diseases per occupation

Profession	Rate of occurrence of occupational disease, λ
Machinists of track machines	0,0000326
Railroad fixers	0,00000279
Operators of railway crossing	0,000000617
Operators of trucks defectoscopic	0,000000378

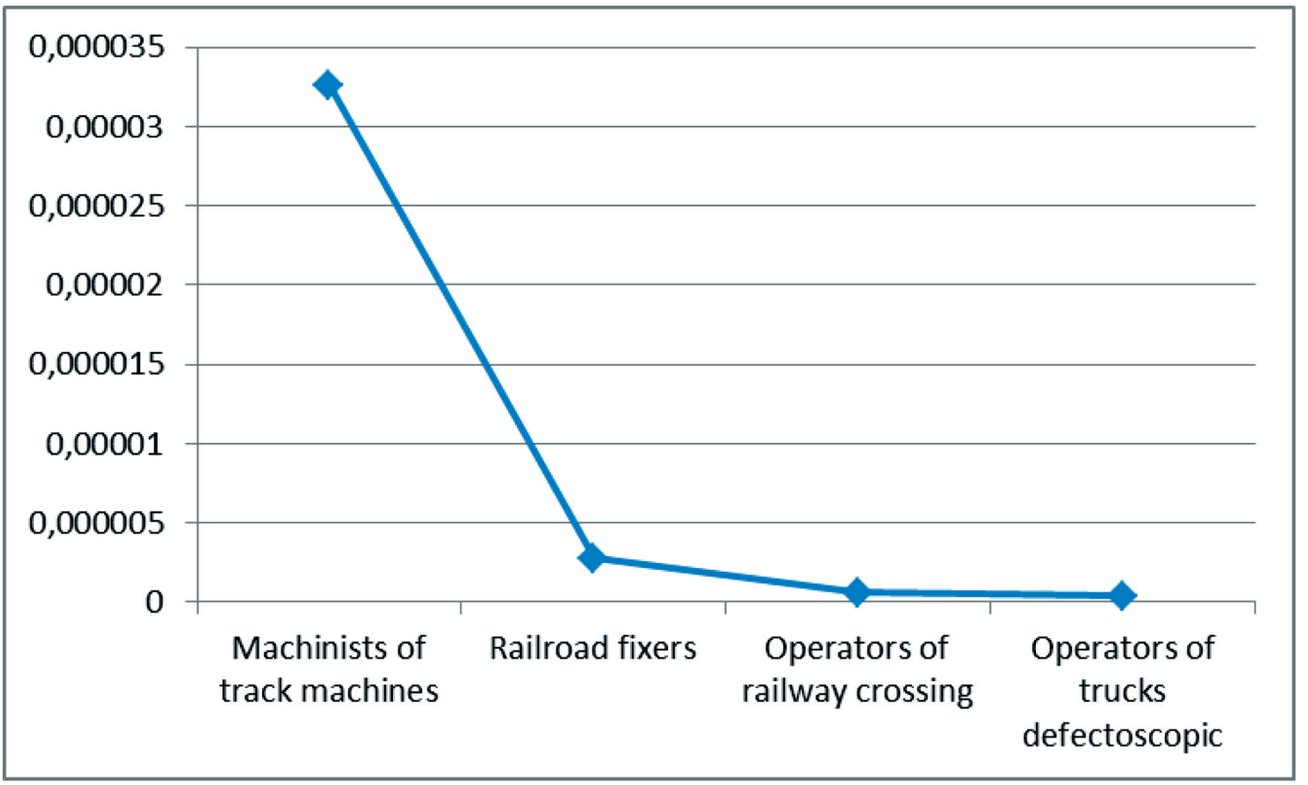

Fig. 4. The rate of occupational diseases

Damage resulting from the occurrence of undesirable events mentioned above may be evaluated as described in [7].

The data obtained as a result of calculation based on URRAN's methodology are used at central and regional levels (Fig. 5) for analysis and risk assessment.

However, the tasks related to analysis of working conditions at a workplace and addressed planning of activities for their improvement, which take into account real-world dangers existing at a workplace, can be qualitatively solved using expert methods that allow you to identify hazards for specific occupations of workers within a unit. In order to obtain a better result, workers and specialists of a unit should also be involved in the analysis process.

For expert analysis in the framework of a structural unit, one should form a working group of experts, including a chief engineer, labour engineer, production engineer and other specialists at the discretion of the head of a structural unit [6]. The elements of expert analysis are employee interviewing and sur-

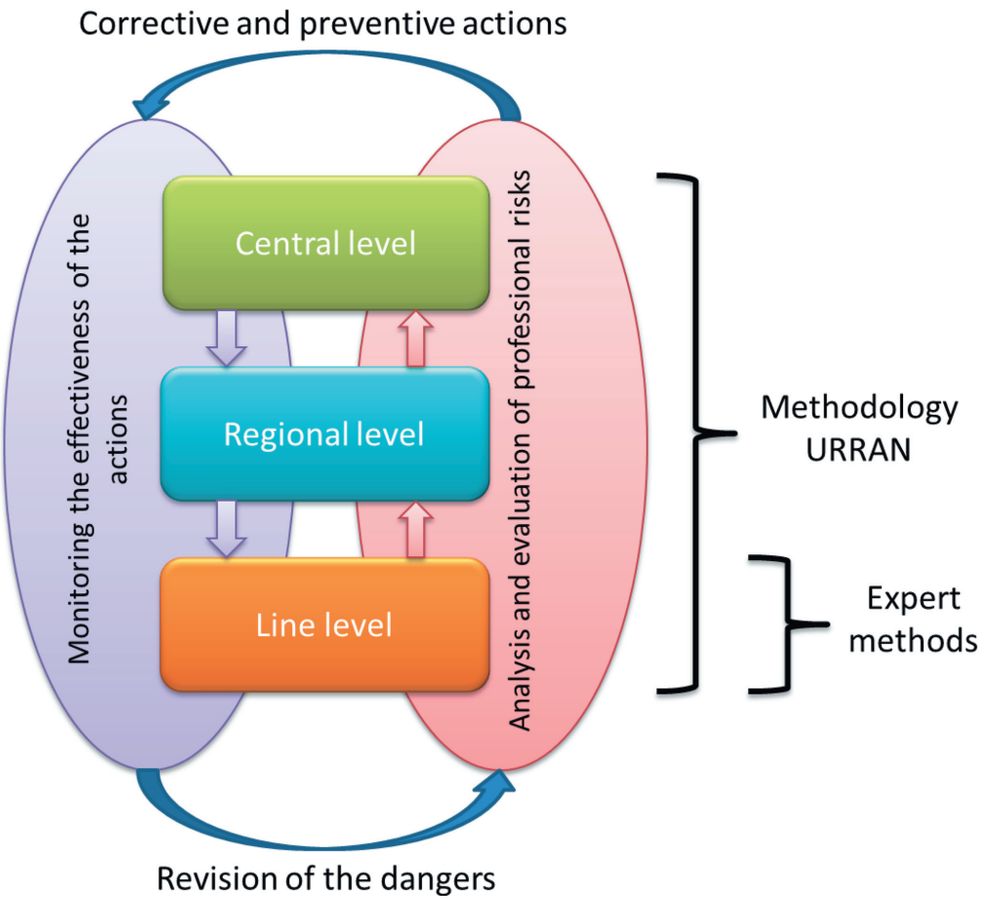

Fig. 5. Model of professional risk management

veillance protocols of a working group. Interviewing allows us to involve in these studies and consider the views and features of the personal characteristics of workers. Questionnaires contain the following categories of production activity components:

Table 6. Results of the survey

Hazard	Is there some danger (risk) – ?			
	Very dangerous	Danger-ous	Less dangerous	Not dangerous
Lack of work site protection	304	210	40	11
Non-use of uniforms, footwear, personal protective equipment	100	336	112	17
Lack of warning, protection signs	181	316	59	9
State of staff passes	55	331	159	20
Faulty tools, equipment	227	264	63	11
Weather conditions (snow, fog, rain, heat, high winds, etc.)	139	322	93	11
Noise, vibration	90	338	119	18
Bad lighting of work sites	194	291	77	3
Distractions at work (feeling sick, hurt, stress, etc.)	149	281	116	19
Fatigue	128	290	120	27
Unauthorized production work, which is not instructed	177	237	126	25
Not enough experience in manufacturing operations	154	293	108	10
Fire	424	72	56	13

- personal characteristics;
- exposure to dangerous and harmful production factors;
- injuries, minor injuries, diseases;
- organization of labour process, psychological conditions;
- organization of working time;
-realization of activities by the employer relating to labour protection and safety;
- training.

The example of processing the survey results is presented in Table 6.

Table 7. The example of the inventory of unacceptable risks

INVENTORY OF UNACCEPTABLE RISKS

APPROVED BY
Position:_____
Name:_____/_____
«____»_____20__.

Occupation	Hazard	Current risk	Corrective actions	Planned risk
Track repairman	Getting run over by rolling stock	25	Acquisition and installation of advanced warning systems (such as Minimel) and protection systems (ELOD-160) on work sites on double-track and multiple-track sections. Acquisition of safety helmets with voice stations built in headphones. Acquisition of megaphones, radio stations, automatic warning systems (in accordance with the technology of production works). Equipment work sites on double-track and sections and multiple-track sections with temporary protections and automatic warning devices. Increasing the number of signalmen in the unit. Training of signalmen.	16
	Fire in the traveling (residential) car	20	To repair of cars. To include acquisition of new cars for staff living and following vehicles into investment programs. Complete replacement of the fleet of residential cars and cars designed for “tour trips” (1973-1974 years of construction). Acquisition of gas analyzers. Treatment with fire-protection solutions. Equipping cars with total fire-extinguishing systems.	12
	Crushing hands or feet when performing loading and unloading	16	Acquisition of necessary amounts of hoisting equipment (yokes, shuttle devices, slings and the like) for track-laying cranes in compliance with the requirements for safe operation of the devices (RD 10-231-98). Conduction of joint workshops (track-laying machine driver, gantry crane driver, sling operator) related to use of signs and signals.	10
	…			

Members of the working group:

Position	Name	Signature

Preparation of a surveillance protocol helps to identify on the basis of expert opinions (the work of a working group) of the potential dangers lying in wait for the worker at a workplace.

Based on the results, the group of experts creates an inventory of risks, which are ranked by level (Table 7). For risks that are unacceptable, corrective and preventive actions shall be developed.

It should be noted that as part of the pilot projects, the traditional technology of introductory, primary and targeted briefings has been complemented with a map of risks formed on the basis of the obtained inventory of unacceptable risks.

To sum up the results of the researches made, we can conclude that the URRAN methodology should be used as the nucleus of the system for managing professional risks. It provides the possibility to effectively address the problems related to risk analysis and assessment, for subsequent development of corrective activities and monitoring of the effectiveness of their implementation. Also, combined with expert techniques that identify hazards and assess risks that await employees of a particular structural unit at their workplaces, it provides the opportunity to explore in a much deeper way cause-and-effect relationships stipulating some or other risks, in order to plan specific preventive activities.

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