Hazard identification and occupational risk management of a tractor driver at an agricultural production

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Abstract. The profession of an agricultural tractor driver is one of the most common professions in agriculture. There is a high level of occupational injury rates among machinists and drivers of vehicles, which is associated with dangerous and difficult working conditions and the specifics of the work. The purpose of the study is to identify hazards and assess occupational risks in the workplace. The scientific objective of the study is to improve the safety of tractor drivers based on the methodology of assessment and management of occupational risks. Based on the results of identification of risk-forming factors in the workplace, the work presents a register of hazards, the results of an assessment of occupational risks before and after measures to reduce the impact of hazards. The obtained data of the conducted research can be used for all similar jobs in agricultural production. The comprehensive approach proposed in the work to the assessment and management of occupational risks is aimed at improving the labor protection system, increasing the protection of employees, prevention and prevention of injuries at work.

1 Introduction

Agriculture of the Russian Federation is one of the main branches of the economy and is the basis for the development of related sectors. The health and well-being of the country's citizens depend on the development of the agricultural sector. In addition, the agricultural sector significantly affects the infrastructure of rural areas, providing rural residents with jobs. Agriculture plays an important role in our country's economy and provides 3.7 – 3.9% of GDP. Thus, according to Rosstat, in 2022 about 4.5 million people were employed in agriculture, or 6.3% of the total number of people employed in the economy [1-3].

According to the Federal Service for Labor and Employment, the profession of tractor driver of agricultural production is one of the most common and sought-after professions (4.1%) in agriculture. The main type of professional activity: operation of tractors,

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combines and agricultural machines in conditions of agricultural production. The main purpose of the professional activity of a tractor driver is the performance of mechanized work in accordance with agrotechnical requirements, maintenance of tractors, combines, agricultural machinery and maintenance of the technical condition of mechanization facilities. Labor functions include: tillage; fertilization; performing pre-sowing soil preparation and mechanized work on caring for crops; performing harvesting and loading and unloading, transport and stationary work; maintenance during the use and storage of tractors, combines and agricultural machinery, as well as other types of work [4-6].

Currently, occupational injury rates among agricultural workers continue to remain at a high level. Drivers and drivers of vehicles account for about 14.4% of injuries. This is primarily due to dangerous and difficult working conditions, the specifics of the work, and the high level of violations of safety and labor protection requirements in the workplace [3].

2 Materials and Methods

In order to increase labor productivity and reduce injury rates, the priority direction of state policy is to protect workers from hazards, improve working conditions and preserve health. Proper analysis of hazards and the consequences of their impact on employees makes it possible to manage occupational risks in the workplace [7-8].

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Analysis of the literature data has shown that in the process of work, agricultural workers are exposed to the combined effects of a wide range of harmful production factors. The factors are different for specific professions, differ in levels, duration of exposure and are determined by the characteristics of agricultural labor. Thus, work on tractors, combines and various agricultural machinery when performing mechanized work is accompanied by noise and vibration, a significant excess of the concentration of dust and gases in the working area of machine operators. The assessment of working conditions according to the degree of harmfulness and danger of factors of the production environment, the severity and intensity of the labor process made it possible to classify the working conditions of an agricultural tractor driver as harmful of the 1st, 2nd and 3rd degrees (class 3.1, class 3.2, class 3.3). Harmful working conditions are risk factors for the development of general and occupational diseases of workers, including agriculture. The main place in the morbidity structure of machine operators is occupied by diseases of the peripheral nervous system, neuromuscular and musculoskeletal system, cardiovascular pathology, chronic nonspecific lung diseases, diseases of the gastrointestinal tract. It has been established that the nature of diseases has a certain relationship with the working conditions of workers [1, 3, 8].

Production risks are characterized by a variety of causal factors, of which two of the most important can be distinguished: dangerous working conditions and dangerous actions in the workplace. In this regard, one of the important principles of occupational safety management, maintenance and repair of agricultural machinery is risk assessment and management. When compiling the register of risk-forming factors, the risk matrix of the risk-forming factor was used. When developing the matrix, a point system of probability values and consequences of risk-forming factors was used, the numerical values of which are set in points from 0.2 to 1 and determined by expert analysis [9, 10].

The calculated value of the risk value in the matrix (qij) is calculated using the formula:

$$q_{ij} = B_i * P_j \quad (1)$$

where B_i is the probability of a risk-forming factor;

P_j are the consequences of the risk-forming factor.

3 Results

As part of the procedure for assessing and managing occupational risks at the workplace of an agricultural tractor driver, the identification of risk-forming factors was carried out and a register of hazards was compiled [8, 10].

Table 1 shows a fragment of the register of hazards (risk-forming factors), in which the hazards are systematized, a description of the dangerous event is given and identification numbers are assigned to each of the events. According to the specifics of the work, hazards at the workplace of a tractor driver were divided into the following types: mechanical (*Mc* identifier); electrical (*El* identifier); chemical (*Cm* identifier); APFD (*Af* identifier); severity and intensity of the labor process (*Lp* identifier); noise (*Ns* identifier); vibration (*Vb* identifier); transport hazards (*Tr* identifier) [10, 11].

Table 1. Register of hazards (risk-forming factors) in the workplace (fragment)

№	ID of the risk-forming factor	Name of the risk-forming factor	Probability (Pi) (in points)	Consequences (Cj) (in points)	qij	Risk level
Mechanical hazards (*Mc*)						
1	Mc1	Falling when tripping and/or slipping	0.4	0.6	0.24	Medium
2	Mc2	Danger of falling from a height	0.4	0.6	0.24	Medium
3	Mc3	Danger from moving parts of machinery	0.4	0.6	0.24	Medium
4	Mc4	Danger of bumping into a piercing surface	0.4	0.6	0.24	Medium
5	Mc5	Danger of getting tangled in wires	0.4	0.6	0.24	Medium
6	Mc6	Danger of crushing	0.4	0.6	0.24	Medium
7	Mc7	Danger of cargo falling	0.4	0.6	0.24	Medium
8	Mc8	The danger of cutting, cutting off body parts	0.4	0.6	0.24	Medium
9	Mc9	Danger of cuts to body parts	0.4	0.6	0.24	Medium
10	Mc10	Risk of injury to materials (raw materials, snow, ice, etc.)	0.4	0.6	0.24	Medium
Electrical hazards (*El*)						
11	El1	Danger of electric shock due to direct contact	0.4	0.6	0.24	Medium
-	-	------	--	---	---	---
52	Tr5	The danger of overturning the vehicle during work	0.6	0.8	0.48	High
The total value of the risk ($q_{Rregister}$)					14.16	

The total value of the risk of occurrence of all risk-forming factors $q\_R_{register}$ is determined by the formula:

$$q_{Rregister} = \sum_{n=1}^{n} q_{ij} \quad (2)$$

where n is the number of risk-forming factors according to the registry.

When compiling the register, 52 risk-forming factors were identified, the total value of which was $q_{Rregister}$=14.16.

The arithmetic mean $q_{Rregister}$ of the n possible risks, it is:

$$\bar{q} = \frac{14.16}{52} \approx 0{,}27$$

The sample variance $s^2(q_{Rregister})$ for the identified risk-forming factors is calculated using the formula:

$$s^2(q_{Rregister}) = \frac{1}{52-1}((0.24-0.27)^2 + (0.24-0.27)^2 + (0.24-0.27)^2 + (0.24-0.27)^2 + (0.24-0.27)^2 + (0.24-0.27)^2 + \cdots + (0.48-0.27)^2) \approx 0.008$$

The sample variance of the average value of the risk-forming factors $s^2(\bar{q})$ is calculated using the formula:

$$s^2(\bar{q}) = \frac{0.008}{52} = 0.0002$$

The standard uncertainty of the URregister of a random variable of a possible risk-forming factor is calculated using the formula and is

$$\text{URregister} = \sqrt{s^2(\bar{q})} = \sqrt{0.0002} = 0.0141 \approx 0.01$$

Thus, the additional coefficient in the calculation of occupational risk in the workplace was 0.01.

The next stage was an assessment of occupational risk in the workplace based on the theory of standard uncertainty (Method 1) and an assessment of occupational risk based on the materials of the SOUT (Method 2) [11].

Table 2 shows the results of the assessment of occupational risks for the workplace of an agricultural tractor driver.

Table 2. Assessment of occupational risks for the workplace of an agricultural tractor driver

Assessment of occupational risk according to Method 1								
Risk-forming factor	Severity of the damage	C_{im1}	Probability	B_{nm1}	P_{nm1}	R_{nm1}	R_{RISK}	The amount of risk in the risk-forming factor group
Mc1	ON	0.03	H	0.27	0.0412	0.0012	**0.18**	**0.0246**
Mc3	S	0.13	H	0.27	0.0412	0.0054		
Mc4	S	0.13	H	0.27	0.0412	0.0054		
Mc6	S	0.13	H	0.27	0.0412	0.0054		
Mc9	N	0.06	M	0.2	0.0305	0.0018		
Mc10	S	0.13	H	0.27	0.0412	0.0054		
El2	N	0.06	L	0.13	0.0198	0.0012		0.0012
Cm1	S	0.13	H	0.27	0.0412	0.0054		0.0108
Cm2	S	0.13	H	0.27	0.0412	0.0054		
Af1	S	0.13	H	0.27	0.0412	0.0054		0.0162
Af2	S	0.13	H	0.27	0.0412	0.0054		
Af3	S	0.13	H	0.27	0.0412	0.0054		
Tp1	S	0.13	H	0.27	0.0412	0.0054		0.0162
Tp2	S	0.13	H	0.27	0.0412	0.0054		
Tp 3	S	0.13	H	0.27	0.0412	0.0054		
Sm1	S	0.13	H	0.27	0.0412	0.0054		0.0540
Vb1	S	0.13	H	0.27	0.0412	0.0054		0.0108
Vb2	S	0.13	H	0.27	0.0412	0.0054		

Or1	S	0.13	H	0.27	0.0412	0.0054		0.0162
Or2	S	0.13	H	0.27	0.0412	0.0054		
Or3	S	0.13	H	0.27	0.0412	0.0054		
Tr1	V	0.26	H	0.27	0.0412	0.0107		**0.0749**
Tr2	OV	0.52	H	0.27	0.0412	0.0214		
Tr3	OV	0.52	H	0.27	0.0412	0.0214		
Tr4	OV	0.52	H	0.27	0.0412	0.0214		
$U_{Rregister}$	-	-	-	**0.01**	-	0		
Assessment of occupational risk according to Method 2								
Risk-forming factor	Severity of the damage	C_{im2}	Probability	B_{nm2}	P_{nm2}	R_{nm2}	R_{SOUT}	The importance of risk
HM-OUT	OD	0.03	S	0.2	0.1149	0.00345	**0,05**	
APFD-OUT	OD	0.03	S	0.2	0.1149	0.00345		
SH-OUT	V2	0.13	V	0.27	0.1552	0.02017		
INFR-OUT	OD	0.03	S	0.2	0.1149	0.00345		
VO-OUT	OD	0.03	S	0.2	0.1149	0.00345		
VL-OUT	OD	0.03	S	0.2	0.1149	0.00345		
HEAV-OUT	V1	0.06	V	0.27	0.1552	0.00931		
VOLT-OUT	OD	0.03	S	0.2	0.1149	0.00345		
The total amount of occupational risk in the workplace, R_{FINAL}							**0.23**	

Risk calculations are based on the analysis of identified hazards, as well as the results of the SOUT. For each identified hazard, the risk level is determined in accordance with the significance scale. Within the framework of this study, the risk calculation is carried out using a five-level scale, where each of the five levels is assigned an appropriate weighting factor. This assessment system establishes a progressive increase in weight values depending on the level of possible negative consequences and the degree of probability of occurrence. Accordingly, the higher the weight value, the greater the damage and the more likely the rate of occurrence of a dangerous event [8-11].

To obtain the final result of the assessment of occupational risk in the workplace, the sum of the risk values determined by Method 1 and Method 2 is calculated, which is expressed by the formula:

$$R_{FINAL} = R_{RISK} + R_{SOUT} \quad (3)$$

The final value of the occupational risk for the workplace – tractor driver-machinist of agricultural production was 0.23, which corresponds to a high risk on the scale of risk significance [11]. In accordance with the occupational risk management strategy, it is necessary to develop measures to reduce the impact of hazards in the workplace.

4 Discussion

In order to develop a set of measures to reduce the impact of risks, an analysis of the values of occupational workplace risk calculated using Methods 1 and 2 was carried out in order to establish the most significant group of risk-forming factors (dangerous events). For the workplace of a tractor driver of agricultural production (Table 2), the final value of occupational risk is 0.23, which includes the following groups of dangerous events (the proportion of the total value is indicated in parentheses): mechanical (0.0246), electrical (0.0012), chemical (0.0108), dust load (0.0162), severity and intensity of the labor process (0.0162), noise (0.054), vibration (0.0108), organizational shortcomings (0.0162), transport (0.0749).

Thus, groups of risk-forming factors have been identified: mechanical and transport hazards, which have the largest share in the total risk. Based on the analysis and in order to manage occupational risks, a set of measures has been developed to reduce the impact of identified hazards in the workplace, while the main focus is on the groups of factors for which the highest risk value has been established (Table 3) [12-13].

Table 3. Development of a set of measures to reduce the impact of risk in the workplace of an agricultural tractor driver

A group of risk-forming factors	Identificator of the risk-forming factor	Name of the risk-forming factor	Measures to reduce the impact of risk
MECHANICAL HAZARDS	Mc1	Falling when tripping and/or slipping	- fencing of trenches and pits; - installation of transitional bridges at the places of crossing the trenches; - use of shoes with non-slip soles
	Mc3	Danger from moving parts of machinery	- protection of elements of production equipment from the effects of moving parts, as well as flying objects, including the presence of clamps, locks, sealing and other elements
	Mc4	Danger of bumping into a piercing surface	
	Mc5	Danger of getting tangled in wires	
	Mc6	Danger of crushing	
	Mc7	Cargo drop	
	Mc8	Cutting, cutting off body parts	
	Mc9	Cuts to body parts	
	Mc10	Injury caused by discarded materials, raw materials, snow, ice	
TRANSPORT HAZARDS	Tr1	Hitting a person	- additional lighting of the work area at night; - drawing up a schematic plan indicating the permitted and prohibited directions of movement, turns, exits and exits
	Tr2	Overturning of the vehicle	- inspection ditches and overpasses must have dividers and guide (safety) ridges along the entire length or other devices that prevent vehicles from falling into ditches or from overpasses during their movement.
	Tr3	Falling from a vehicle	- application of signal colors and safety signs to

A group of risk-forming factors	Identificator of the risk-forming factor	Name of the risk-forming factor	Measures to reduce the impact of risk
			production equipment, controls and controls, structural elements, communications and other objects
	Tr4	Traffic accident	- checking the technical condition of vehicles and their units upon release to the line and return from the line - conducting pre-trip medical examinations

After the implementation of a set of measures to manage risks and reduce the impact of hazards, a re-calculation was carried out, on the basis of which an assessment of the effectiveness of the measures taken was given (Table 4).

Table 4. Assessment of occupational risks for the workplace of an agricultural tractor driver after the introduction of a set of measures to reduce the impact of hazards

Assessment of occupational risk according to Method 1								
Risk-forming factor	**Severity of the damage**	**C_{im1}**	**Probability**	**B_{nm1}**	**P_{nm1}**	**R_{nm1}**	**R_{RISK}**	The amount of risk in the risk-forming factor group
Mc1	ON	0.03	H	0.27	0.0435	0.0013	**0.08**	0.0130
Mc3	N	0.06	H	0.27	0.0435	0.0026		
Mc4	N	0.06	H	0.27	0.0435	0.0026		
Mc6	N	0.06	H	0.27	0.0435	0.0026		
Mc9	N	0.06	M	0.2	0.0323	0.0019		
Mc10	N	0.06	M	0.2	0.0323	0.0019		
El2	N	0.06	H	0.13	0.0210	0.0013		0.0013
Cm1	S	0.13	H	0.27	0.0435	0.0057		0.0113
Cm2	S	0.13	H	0.27	0.0435	0.0057		
Af1	N	0.06	H	0.27	0.0435	0.0026		0.0109
Af2	N	0.06	H	0.27	0.0435	0.0026		
Af3	S	0.13	H	0.27	0.0435	0.0057		
Tp1	N	0.06	H	0.27	0.0435	0.0026		0.0078
Tp2	N	0.06	H	0.27	0.0435	0.0026		
Tp3	N	0.06	H	0.27	0.0435	0.0026		
Ns1	S	0.13	H	0.27	0.0435	0.0057		0.0570
Vb1	S	0.13	H	0.27	0.0435	0.0057		0.0013
Vb2	S	0.13	H	0.27	0.0435	0.0057		
Or1	N	0.06	H	0.27	0.0435	0.0026		0.0078
Or2	N	0.06	H	0.27	0.0435	0.0026		
Or3	N	0.06	H	0.27	0.0435	0.0026		
Tr1	S	0.13	M	0.2	0.0323	0.0042		**0.0071**
Tr2	ON	0.03	M	0.2	0.0323	0.0010		
Tr3	N	0.03	M	0.2	0.0323	0.0010		
Tr4	N	0.03	M	0.2	0.0323	0.0010		
$U_{Rregister}$	-	-	-	**0.01**	-	0		
Assessment of occupational risk according to Method 2								

Risk-forming factor	Severity of the damage	C_{im2}	Probability	B_{nm2}	P_{nm2}	R_{nm2}	R_{SOUT}	
Cm-OUT	OD	0.03	M	0.2	0.1149	0.00345		
APFD-OUT	OD	0.03	M	0.2	0.1149	0.00345		
Sh-OUT	V2	0.13	H	0.27	0.1552	0.02017		
Infr-OUT	OD	0.03	M	0.2	0.1149	0.00345	**0.05**	
Vo-OUT	OD	0.03	M	0.2	0.1149	0.00345		
Vl-OUT	OD	0.03	M	0.2	0.1149	0.00345		
Sev-OUT	V1	0.06	H	0.27	0.1552	0.00931		
Volt-OUT	OD	0.03	M	0.2	0.1149	0.00345		
The total amount of occupational risk in the workplace, R_{FINAL}							**0.13**	

The repeated calculation showed a decrease in the final value of occupational risk at the workplace of an agricultural tractor driver, from 0.23 (high) to 0.13 (medium), which confirms the effectiveness of the measures taken.

5 Conclusions

The paper presents the results of hazard identification and occupational risk management at the workplace of an agricultural tractor driver [10-11].

The implementation of the methodological approach presented in the work allowed:

- identify risk-forming factors and compile a register of hazards in the workplace,
- to carry out a risk assessment according to Method 1 and 2 and calculate the final value of the occupational risk characteristic of the profession of an agricultural tractor driver,
- for high-risk hazards, develop a set of measures to reduce their impact in the workplace,
- to evaluate the effectiveness of the proposed measures.

The obtained data of the conducted research can be used for all similar jobs in agricultural production. The integrated approach proposed in the work to the assessment and management of occupational risks is aimed at improving the labor protection system, increasing the protection of employees, which, in turn, will contribute to increasing productivity and labor efficiency, prevention and prevention of injuries in any production [14-15].

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