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MUNDARIJA

THE IMPACT OF COMPUTERIZATION OF TRACTOR CONTROL SYSTEMS ON THE OPERATOR'S WORKING CONDITIONS

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Annotation. The issues of changing and clarifying the requirements for the organization of workplaces and the labor process of drivers operating a modern computerized tractor are discussed. It is shown that with the introduction of computer and satellite systems for controlling a tractor and its engine, dispatching operations performed in the field in online mode using global satellite and local monitoring and control systems, a new approach to the organization of the workplace and the process of work and rest of a tractor driver is also required. The analysis of possible problems with providing conditions for maintaining the health of the tractor driver during computerization of control, the use of video terminals and unmanned aerial vehicles is carried out.

Keywords: labor protection, agriculture, operator, workplace, satellite, sanitary and hygienic requirements.

ВЛИЯНИЕ КОМПЬЮТЕРИЗАЦИИ СИСТЕМ УПРАВЛЕНИЯ ТРАКТОРОМ НА УСЛОВИЯ РАБОТЫ ОПЕРАТОРА

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Аннотация. Обсуждаются вопросы изменения и уточнения требований к организации рабочих мест и трудового процесса водителей, управляющих современным компьютеризированным трактором. Показано, что с внедрением компьютерных и спутниковых систем управления трактором и его двигателем, диспетчеризации операций, выполняемых в полевых условиях в онлайн-режиме с использованием глобальных спутниковых и локальных систем мониторинга и управления, необходим новый подход к организации рабочего места и процесса труда и отдыха тракториста. также требуется. Проведен анализ возможных проблем с обеспечением условий для поддержания здоровья тракториста при компьютеризации управления, использовании видеотерминалов и беспилотных летательных аппаратов.

Ключевые слова: охрана труда, сельское хозяйство, оператор, рабочее место, спутник, санитарно-гигиеническая требования.

ТРАКТОРЛАРНИ БОШҚАРУВ ТИЗИМЛАРИНИ КОМПЬЮТЕРЛАШТИРИШНИНГ ОПЕРАТОРНИНГ ИШ ШАРОИТЛАРИГА ТАЪСИРИ

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Аннотация. Мақолада тракторларнинг бошқарув тизимини компютерлаштиришнинг операторни иш шароитларининг яхшиланиши натижасида меҳнат унумдорлигини ортиши масалалари муҳокама қилинади. Тракторни бошқариш учун сунъий йўлдош тизимларини жорий етиш, сунъий йўлдош ва маҳаллий мониторинг ва бошқарув тизимларидан кенг фойдаланган ҳолда онлайн режимда масофадан туриб диспетчерлик операциялари бажариш, оператор учун тракторнинг техник ҳолати, иш бажарадиган жой тўғрисида маълумотларни олишга шароит яратади. Шунингдек, тракторни бошқараётган операторнинг соғлиги, иш ўрнининг санитар-гигиеник ҳолати, ҳамда у ердаги зарарли ва хавфли омилларнинг мавжудлиги тўғрисида маълумотларни олиш имконияти мавжуд бўлади.

Калит сўзлар. меҳнатни муҳофаза қилиш, қишлоқ хўжалиги, оператор, иш жойи, сунъий йўлдош, санитария-гигиена талаблари

Introduction. The need to ensure the country’s food security requires the rapid development of modern technologies, which is unthinkable without the maximum digitalization of control systems for technological lines, machine and tractor units [10]. The digital transformation of agriculture, the introduction of computer control systems for tractors and their engines, machine-tractor units and combines, dispatching operations performed in the field online using global satellite and local systems (unmanned aerial vehicles), the use of satellite driving systems, monitoring and control systems require a new approach to the organization of the workplace places and process of work and rest of the tractor driver [17]. At the same time, we should not forget about the problems of technosphere safety and, above all, labor protection of tractor drivers [1].

According to the All-Russian Research Institute of Labor Protection, the structure of occupational morbidity in the agricultural sector is formed mainly by workers of two professions – tractor drivers-agricultural machinists (48.8%) and machine milking operators (31.3%). At the same time, it should be noted that the frequency of primary disability of tractor drivers (farmers) of agricultural production is 1.7 times higher than in the industry as a whole [2,3].

In the process of conducting a special assessment of workplaces according to working conditions, it was found that the drivers of an agricultural tractor are exposed to a complex of unfavorable production factors [4[. These include unfavorable microclimatic conditions, dustiness of the air, increased noise and vibration levels, contact with fuels and lubricants, high physical exertion, irrational work and rest regime and nervous and emotional stress. Each of these factors individually or in combination has a harmful effect on the body of the tractor driver and, as a result, on his health [5,6].

The purpose of the research is to identify possible changes in the working conditions of tractor drivers during the computerization of workplaces and to develop proposals for changing the requirements for sanitary rules for the device of tractors.

Materials and methods. With a special assessment of workplaces according to the working conditions of tractor drivers, the highest class of harmfulness is noted according to the indicators “labor intensity” from the group “emotional stress”. This is due to the fact that the drivers of an agricultural tractor are responsible for the functional quality of the main work, which affects the efficiency of agricultural business (for example, the deepening of seeds when sowing 1 cm deeper than optimal reduces the yield by almost 10%.), In addition, during the work there is a risk to the own lives of tractor drivers, and there is also a share of responsibility for the safety of other people.

However, even without additional psycho-emotional stress, working conditions on agricultural machinery are assessed as tense by the factor of perception of signals (information), since they require the perception of signals with a subsequent comprehensive assessment of all production parameters (information) characterizing not only actions to control equipment as a vehicle, but also actions to maintain the specified parameters of the technological process [7]

Therefore, when conducting a special assessment of working conditions at the workplace of a tractor driver, it is necessary to assess the nature of the work performed on agricultural machinery as harmful labor of class 3.1 - work in time-deficit conditions, since sowing and harvesting take place in a short time,

Results and discussion. When assessing sensory loads, it should be taken into account that labor activity when working on agricultural machinery is characterized by significant concentration and switching of attention and load on the analyzer functions. The levels of such indicators of the intensity of sensory loads as the duration of concentrated observation, the density of signals, the number of production facilities for simultaneous observation may vary depending on the type of work performed and the brand of equipment.

In the process of working on mobile agricultural machinery, tractor drivers experience a load on the hearing aid when it is necessary to perceive signals and sound information about the operation of machinery and the course of the technological process. Increased noise levels in the cabins are a hindrance to their perception, which increases the intensity of work.

Based on the results of the assessment of workplaces by working conditions [8,9], it can be concluded that the working conditions of a tractor driver on traditional machines are harmful in terms of the severity and intensity of the labor process (Class 3). Among the most significant parameters for assessing the work of a tractor driver as harmful Class 3 of the 2nd degree, the degree of risk to one's own life and the degree of responsibility for the safety of other persons should be noted (Table 1).

When switching to computerized equipment, the nature of work and the type of loads change. Most of the listed harmfulness and danger factors (noise, vibration, dustiness, gas contamination, microclimate parameters) are sharply reduced to acceptable levels when using tractors and combines with sealed cabins and air conditioning systems. The presence of on-board computers greatly facilitates the operator functions of the tractor driver. This is due to the continuous monitoring of critical parameters of the main (most complex and expensive) units and assemblies with an indication of their exceeding the permissible limits and emergency automatic shutdown (taking into account safety);

continuous monitoring of parameters (states), the output of which beyond the optimal limits (transition to unacceptable states) significantly reduces the resource of the main units and nodes (for example, clogging of filter elements) with an indication of the need to change operating modes or carry out extraordinary maintenance;

accounting of the tractor's operating time from the moment of the last maintenance with an indication of the value of the permissible operating time until the next planned maintenance (for a given maintenance periodicity) [9].

And the use of autopilots (satellite driving systems) removes the load from the tractor driver to maintain an ideal route, so that other phases of work can be performed even more efficiently. But it must be borne in mind that with the introduction of satellite driving, the monotony of the production environment increases, the monotony of stimuli and a small number of elements (techniques) for switching controls and maintaining the course of the technological process. A great contribution to the load of

Table 1.

A sample from the protocols of a special assessment of workplaces according to the working conditions of a tractor driver.

Indicators of the severity of the labor	The actual value of the indicator	Class of working conditions
process		
4.1 Intelligent loads	Solving simple tasks according to the instructions	2nd class
4.1.1 Content of the work	Perception of signals with subsequent correction of actions and operations.	2nd class
4.1.2 Perception of signals (information) and their evaluation	Processing, execution of the task and its verification	2nd class
4.1.3 Distribution of functions according to the degree of complexity of the task	Work according to the established schedule with the possibility of its correction in the course of activity	2nd class
4.1.4 Nature		
of the work performed	75	3.2 class
4.2 Sensory loads	102	2nd class
4.2.1 Duration of concentrated observation (in % of shift time)		
4.2.2 The density of signals (light, sound) and messages on average for 1 hour of operation	Is responsible for the functional quality of auxiliary work (tasks). Entails additional efforts on the part of higher management	3.1 class

the visual organs and the feeling of monotony is also made by the blades of the harvesting machinery spinning in front of the eyes for many hours, continuously "running" monotonous types of stubble, plowed soil or masses of grain ears.

On the other hand, the nature of the tractor driver's work in comfortable conditions with the use of satellite driving and computerization of the control processes of a machine-tractor or harvesting unit approaches the nature of the work of non-production workers, whose work is characterized by a long monotonous tense position, low motor activity with significant visual loads when working in video terminals. But if an employee deals only with a computer in the office and at the same time, in accordance with the requirements of labor protection, must work no more than 6 hours a day with regular breaks for 15 minutes every 45 minutes, then the tractor driver, simultaneously with monitoring the video terminal (or, already often, two or three), must visually monitor the condition fields, plants, perform manipulations with a set of levers or joysticks and a steering wheel when turning the unit and bringing it to a new position (Fig.1).

Figure 1. Workplace of an agricultural tractor driver.

Moreover, the working day of the tractor driver significantly exceeds the standard 8 hours and reaches 12-14 hours without days off during peak periods (sowing, harvesting), i.e. there is no way to restore accumulated fatigue, attention, efficiency: it is impossible to allow breaks for intra-shift rest due to the threat of soil moisture loss during sowing or grain shedding when harvesting. Not only is the working day of a tractor driver (farmer) significantly increased, but it also has a very high density: according to the results of time–lapse studies - up to 95% [10,11].

As a result, when switching to modern technology, new types of risks arise due to the combination of the traditional tension of the tractor driver with the tension of the dispatcher and the operator of a personal computer.

The working conditions behind the video terminal are the opposite of those that are familiar to the eyes of a tractor driver. (Fig. 2).

In a traditional tractor, the driver perceives mainly reflected light, and the objects of observation are continuously in the field of view for at least a few seconds. When working behind the tractor driver's video terminal, one has to deal with self-luminous objects and a discrete (flickering with high frequency) image (Fig.2), which increases the load on the eyes. If we add to this such common factors as the sharp contrast between the background and the symbols, the unusual shape of the symbols, different than when reading a book, the direction of view, glare and reflections on the screen, changing with each turn of the tractor, it becomes clear why almost every user is familiar with unpleasant sensations.

Figure 2. Glare and reflections on monitors in the process of changing the position of the tractor relative to the Sun.

Intense visual work causes visual disturbances "ocular" (pain, heartburn and pain in the eyes, redness of the eyelids and eyes, pain in the brow, etc.) and "visual" (a veil in front of the eyes, double objects, flickering, fatigue during visual work), which can cause headache, increased neuropsychiatric stress, decreased performance [12].

Results and discussion. In the Rules on Labor Protection in Agriculture, it is noted that when carrying out work related to the impact of harmful and (or) hazardous production factors on workers, the employer is obliged to take measures to exclude them or reduce them to the permissible level of exposure established by the requirements of labor protection.

But the technical level of modern video terminals does not allow to completely exclude the impact of the above factors. These effects on the organs of vision of tractor drivers must be minimized by regulating a number of parameters.

The guidelines "Hygienic assessment of tractors and agricultural machines" also do not take into account the introduction of monitors into the control system of machine-tractor units, displaying many types of information that should be available and instantly perceived for timely adoption and implementation of a decision on the management of a machine-tractor unit. Along with these, the practice of combining machine -tractor units appears. with unmanned aerial vehicles. Moreover, in the near future, part of the field technological operations, such as sowing, fertilization and plant protection products, etc. they will perform unmanned aerial vehicles, which will require the creation of new or additions to existing standards and sanitary rules for the safety and security of both tractor drivers and operators of unmanned aerial vehicles (and possibly a combination of these professions).

It does not take into account the presence of video terminals

in the tractor cab and a new document in force since 2017: "The system of occupational safety standards. Cabins and workplaces of operators of tractors and self-propelled agricultural machines. General safety requirements". The standard applies to cabins and workplaces of tractor drivers, self-propelled agricultural machines, universal energy vehicles (hereinafter referred to as machines) and establishes safety requirements for the design of cabins and their equipment, sanitary and hygienic and ergonomic requirements for the workplaces of tractor drivers.

In our opinion, the documents regulating the requirements for the workplace of a tractor driver should specify the main parameters of the image on the video terminal screen: brightness, contrast, size and shape of signs, screen reflectivity, presence or absence of flickering. In addition, standards characterizing the shape and dimensions of the working field of the screen, geometric properties of signs, etc. should be included.

In addition to the above, it should be borne in mind that when automating the control of machine-tractor units and the removal of control parameters on video terminals, the need for additional movements of the tractor driver to monitor the condition of aggregates, soil, crops, etc. is reduced. Therefore, it is possible to predict the appearance of new types of occupational diseases in tractor drivers, similar to those already detected in the listed higher than non-production workers.

So, the working position of the driver of an agricultural tractor "sitting" is accompanied by a static load of a significant number of muscles of the legs, shoulders, neck and arms, which is very tiring. The muscles are in a reduced state for a long time and do not relax, which worsens blood circulation.

As a result, there are painful sensations in the arms, neck, upper legs, back and shoulder joints. In addition, working "sitting" leads to a decrease in muscle activity - inactivity. In the absence of movement, there is a decrease in oxygen consumption by the tissues of the body, the metabolism slows down. This contributes to the development of atherosclerosis, obesity, can cause myocardial dystrophy, chronic headache, dizziness, insomnia. And this is the risk of an increase in errors and accidents.

Quite often, tractor drivers began to have a cold from the air conditioner. This is due to the fact that the driver of an agricultural tractor has to leave the cabin, in which the temperature is 18-20 degrees and go out into the field to adjust, clean working organs, refuel sprayers, etc.

When the tractor driver returns to the cabin, a sharp hypothermia of the body occurs with subsequent illness. The course of such a cold is very similar to the usual viral colds, but it also has its own characteristics.

The cause of this disease is also air conditioners, in which water condensate constantly accumulates in a mixture with organic dust, which is quite a lot in the field, and legionella bacteria can develop in it. The way out is to monitor the regular cleaning of air conditioning ducts, timely replacement of filters, the use of carbon and bactericidal filters.

In the design of the tractor cab air conditioning, it is necessary to introduce a forced temperature restriction in the range of 22-24 ^{0}C, which will simultaneously reduce the fatigue of the tractor driver and increase his productivity.

In addition, satellite driving systems that have already become familiar allow you to work at night, which stimulates the desire of employers to maximize the use of equipment and reduce peak work periods due to this, in order to have time to retain moisture during spring sowing, prevent grain shedding during harvest and meet the optimal time for sowing winter crops.

But at the same time, threats to the tractor driver are increasing due to the failure of personal biorhythms, which also leads to increased fatigue, decreased attention and memory impairment.

Conclusions

In connection with the above , it is necessary:

1. Provide requirements for the parameters of monitors and their placement in the working area of the driver of an agricultural tractor. At the same time, take into account that working with the monitor can occur both in sunny weather, and with varying light levels depending on the direction of movement of the tractor, and at night. The problem can be solved by sound (speech)

Table 2.

Some normalized visual parameters of video terminals

Parameters	Acceptable values
The brightness of the sign or background (measured in the dark)	are 35-120 cd/m2
Contrast	From 3:1 to 1.5:1
Temporary instability of the image (flickering)	More than 90% of observers 16-60 should not be recorded
Angular size of the sign	
The ratio of the width of the sign to the height	0.5-1.0
Screen reflectivity (glare)	not more than 1%

accompaniment of critical information.

The reflectivity of the screen should not exceed 1%. To reduce the amount of glare and facilitate concentration, the monitor body should have a matte monochrome surface (light gray, light beige tones) with a reflection coefficient of 0.4-0.6, without shiny details and with a minimum number of controls and inscriptions on the front side.

The main normalized visual characteristics of monitors and the corresponding permissible values of these characteristics are presented in Table 2. But these parameters need to be clarified in connection with the above features of the tractor driver's work.

It is also important to provide for the location of the monitor in the tractor cab directly in front of the eyes. The highest point of the screen should be just below eye level.

2. The labor protection services of agricultural enterprises using fundamentally new mechanization systems, computer and satellite technologies in field farming need to take into account changes in the types of hazards and hazards of the tractor driver.

When conducting a special assessment of workplaces, it is necessary to take into account the presence of new factors in the labor process. Moreover, working conditions in tractors with monitors, tractors with satellite driving systems and in the same models without these systems cannot be considered as similar and should be considered as independent objects.

Measures to prevent fatigue should be developed and implemented, aimed at removing fatigue in time, preventing deep stages of fatigue and overwork of tractor drivers, accelerating the restoration of attention, strength and efficiency.

Moreover, it is necessary to take into account peak loads during the preparation of sowing and sowing. harvesting, which makes it practically impossible to adhere to the standard working day in certain periods of the year.

This means that it is during these periods that labor protection services, field managers should be especially active and monitor compliance by tractor drivers with hygienic requirements that reduce fatigue and overwork.

To prevent fatigue of tractor drivers, it is necessary to develop and apply specific methods, which include means of restoring the functional state of the visual and musculoskeletal system, reducing inactivity, as well as a set of exercises for the eyes, hands and spine to improve cerebral circulation.

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