УДК 631.3-1/-9

4.3.1. Технологии, машины и оборудование для агропромышленного комплекса

ПРАКТИЧЕСКИЕ ОСНОВЫ ОЧИСТКИ, МОЙКИ УЗЛОВ И ДЕТАЛЕЙ ТРАКТОРОВ В УСЛОВИЯХ МАСТЕРСКОЙ С УЧЕТОМ ТРЕБОВАНИЙ БЕЗОПАСНОСТИ

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Данная статья посвящена практической проблеме обеспечения эффективного и безопасного процесса очистки, мойки узлов и деталей тракторов на ремонтных предприятиях с учетом требований безопасности труда. На примере трактора ХТЗ-150К-09 определены способы и методы очистки узлов и деталей. Качество этого этапа напрямую влияет на производительность последующего ремонта, затраты ресурсов и условия труда персонала. Предлагаемый методический подход, основан на расчетах и подборе оборудования. Операции по очистке и мойке повышают производительность труда при проведении ремонтных работ, снижают трудовые и материальные затраты и улучшают условия труда ремонтников. При выполнении некоторых технологических операций, требуется ручной труд. На участке мойке и очистке, на рабочего воздействуют неблагоприятные вредные и опасные производственные факторы. Определены организационные мероприятия, направленные на снижение воздействия на работников факторов трудового процесса. Таким образом, необходимо заметить, что очистка и мойка деталей требует большого количества мероприятий, направленных

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4.3.1. Technologies, machinery and equipment for the agro-industrial complex

PRACTICAL PRINCIPLES OF CLEANING AND WASHING TRACTOR COMPONENTS AND PARTS IN A WORKSHOP ENVIRONMENT, TAKING INTO ACCOUNT SAFETY REQUIREMENTS

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This article addresses the practical challenge of ensuring an effective and safe cleaning and washing process for tractor components and parts at repair facilities, taking into account occupational safety requirements. Using the HTZ-150K-09 tractor as an example, methods and techniques for cleaning components and parts are identified. The quality of this stage directly impacts the productivity of subsequent repairs, resource costs, and personnel working conditions. The proposed methodological approach is based on calculations and equipment selection. Cleaning and washing operations increase labor productivity during repairs, reduce labor and material costs, and improve working conditions for repair workers. Some process operations require manual labor. In the washing and cleaning area, workers are exposed to unfavorable harmful and hazardous production factors. Organizational measures aimed at reducing the impact of work process factors on workers are identified. Thus, it should be noted that cleaning and washing parts requires a large number of measures aimed at organizing highly productive and safe work.

на организацию высокопроизводительного и безопасного труда

Ключевые слова: ОЧИСТКА, МОЙКА, РЕМОНТ, ОБОРУДОВАНИЕ, РАБОЧЕЕ МЕСТО, УЗЛЫ И ДЕТАЛИ ТРАКТОРОВ, МАСТЕРСКАЯ, МОЮЩИЕ РАСТВОРЫ, МОЕЧНО-ОЧИСТИТЕЛЬНОЕ ОБОРУДОВАНИЕ, БЕЗОПАСНОСТЬ

Keywords: CLEANING, WASHING, REPAIR, EQUIPMENT, WORKPLACE, TRACTOR UNITS AND PARTS, WORKSHOP, CLEANING SOLUTIONS, WASHING AND CLEANING EQUIPMENT, SAFETY

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Introduction. Cleaning a tractor of contaminants is the initial stage of the repair process. Practical guidelines for cleaning and washing tractor components, such as the HTZ-150K-09, in a workshop environment include consideration of contaminant classification.

The classification of contaminants is based on the mechanism of their formation and the specifics of their removal during cleaning of machines, units, assemblies, and components. The assignment of certain contaminants to specific surfaces should be considered arbitrary, but it will help inform the selection of cleaning agents and process modes.

Pollution is divided into external pollution (soil particles, plant residues, old paint coatings, etc.) and internal pollution (oils, resinous deposits, etc.) [1, 2]

The general classification scheme of tractor contaminant types based on their physical and mechanical properties is shown in Figure 1.

The choice of method for cleaning parts depends on the type of contamination, the design of the material of the parts, the volume of production, specialization and other factors [3-12].

The novelty of this study lies in its comprehensive approach to designing a parts cleaning and washing area for the HTZ-150K-09 tractor model, integrating equipment calculation methods with a detailed analysis of risk factors and measures to mitigate them. This approach also demonstrates a reduction in labor costs and an increase in economic benefits.

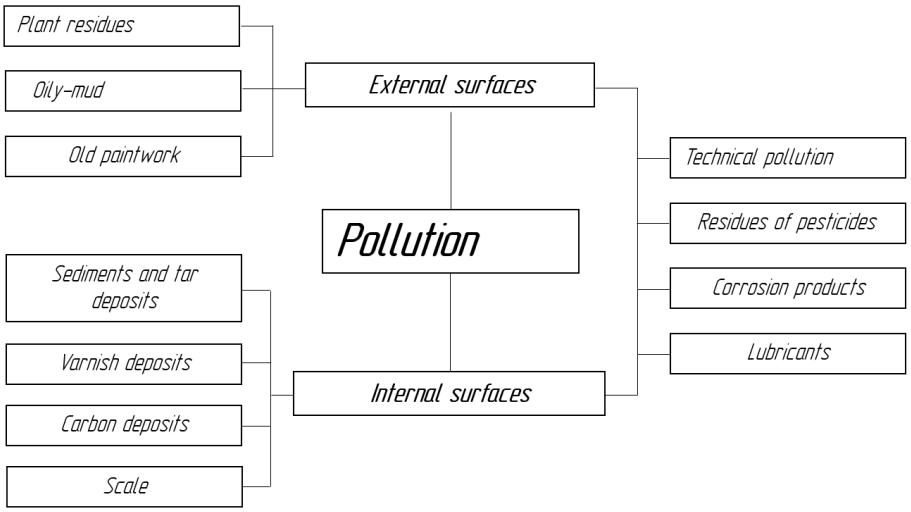


Figure 1 – Classification of tractor surface contaminants by physical and mechanical properties

When selecting a cleaning method, it's important to consider the most cost-effective approach, the most efficient technology, and the required cleaning quality. As an example, we present a classification of cleaning methods for the components of the HTZ-150K-09 tractor (Figure 2).

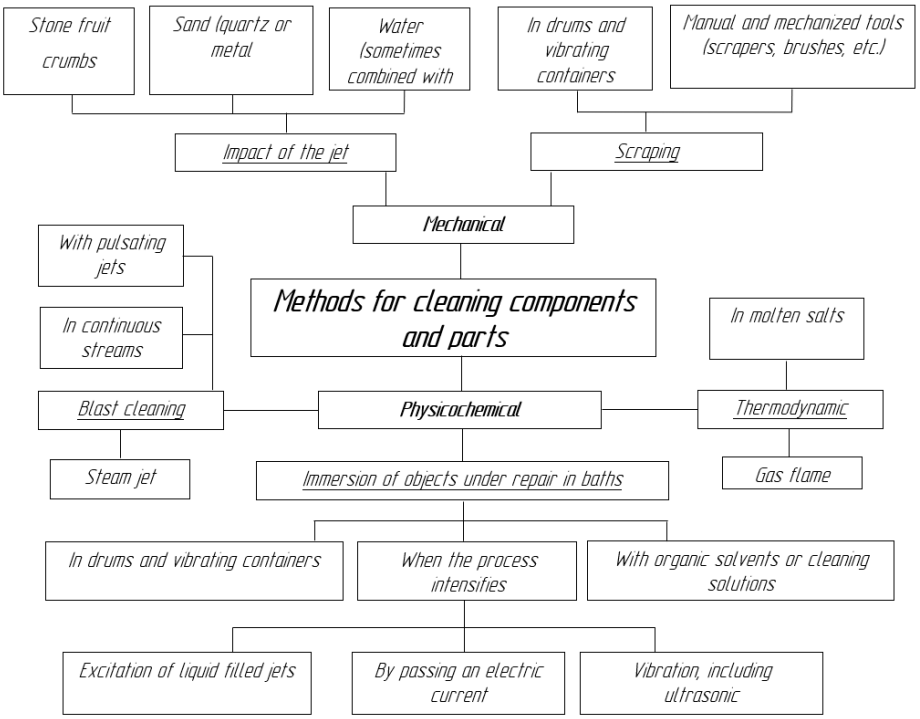


Figure 2 – Classification of cleaning methods for components and parts of the HTZ-150K-09 tractor

Methods for removing contaminants depend on their type and are summarized in Table 1.

Table 1 – Methods for removing contaminants from tractors

Cleaning methods surfaces	Inorganic pollution	Oils and lubricants	Asphalt-resin deposits	Carbon deposits	Corrosion products	Old paint
Mechanical						
Hydrodynamic (high-pressure jets)	+	+	+	-	-	-
Mechanized (glass spheres, stone fruit chips, metal sand)	-	-	-	+	+	-
Vibroabrasive	-	-	+	+	+	-
Physicochemical						
Blast cleaning	+	+	+	-	-	+
Immersion cleaning	+	+	+	-	+	+
Combined cleaning (immersion + jet)	-	-	+	-	+	+
Ultrasonic cleaning	-	+	-	+	+	-
Chemical-thermal						
Alkaline melt	-	-	+	+	+	-

When using the tractor cleaning methods listed in Table 1, it is advisable to use detergents. The brands and compositions of general-purpose detergents used by repair shop workers are presented in Table 2.

Table 2 – Composition of general-purpose technical detergents

Name	Brand and composition of detergents, % by weight						
	Labomid		MS				Pace
	101	203	6	8	15	16	100A
Soda ash Na2CO3	50	50	40	38	44–32	40	40.5
Trisodium phosphate Na3PO4 12H2O	-	-	-	-	-	-	20
Sodium tripolyphosphate Na5P3O10	30	30	25	25	22	26	16
Sodium metasilicate Na2SiO3 9H2O	16.5	10	29	29	28	28	20
Sintanol DS-10	3.5	8	6	-	-	-	1.5
Urea	-	-	-	-	-	-	2.5
Synthamide-5	-	-	-	8	-	-	-
Alkyl sulfates	-	2	-	-	-	-	-
Oxyphoz-B	-	-	-	-	6–8	-	-
Syntamid-510	-	-	-	-	-	4	-
Oxyphosis KD	-	-	-	-	-	-	0.5

Blast and immersion cleaning are the most widely used methods in repair work. These methods form the basis for the development of various cleaning

methods, and we use them as a guide when selecting cleaning and washing equipment for a specific area of the workshop, which ultimately boils down to its calculations.

Purpose of the research. To analyze modern methods, techniques for cleaning and washing tractor components and parts, evaluate their effectiveness, and identify promising areas for further research.

Materials and methods. *Calculation of washing and cleaning equipment.*During vehicle repair, cleaning is performed in several stages: exterior cleaning, assemblies, and components. Washing machines and equipment of various types and designs are used for each stage.

Washing machines and periodic machines of the OM-1438A and OM-8036 types are used primarily for external washing and cleaning in specialized enterprises.

The number of periodic washing machines is determined by the following formulas [7, 13]:

for external washing and cleaning of assembled vehicles:

$$N_M = \frac{\sum W_{ОД}}{\Phi_{ДО} q_М K_М}, \text{ pcs.} \quad (1)$$

for washing and cleaning assemblies and parts:

$$N_C = \frac{\sum Q}{\Phi_{ДО} q_Ч K_{ЗМ}}, \text{ pcs.} \quad (2)$$

Where $\sum W_{ОД}$ – annual optimal-effective program of the enterprise, pcs;

$\sum Q$ – total weight of assemblies and parts to be cleaned, t;

$\Phi_{ДО}$ – actual annual operating time of the washing machine, h;

$q_М$ – washing machine capacity, pcs/h;

$q_Ч$ – hourly productivity of the washing machine, t/h;

$K_М$ – coefficient taking into account the use of the washing machine over time, $К_М = 0.85$ [2];

$K_{ЗМ}$ – coefficient taking into account the degree of loading and use of the washing machine over time, $К_{ЗМ} = 0.65–0.75$ [2].

The total mass of assemblies and parts subject to washing and cleaning at various stages of the repair process is calculated using the formula: $\sum Q$

$$\sum Q = Q_1 W_1 \beta_1 + Q_1 W_2 \beta_2 + \ldots + Q_i W_i \beta_i, \text{ T} \quad (3)$$

Where $Q_1, Q_2 \ldots Q_i$ – mass of individual objects included in the program, t;

$W_1, W_2 \ldots W_i$ – the number of individual objects included in the program;

$\beta_1, \beta_2 \ldots \beta_i$ – a coefficient that takes into account the share of the mass of assemblies and parts to be washed from the total mass of each object.

For tractors $\beta = 0.45 – 0.55$, for engines $\beta = 0.75 – 0.85$.

Conveyor type washing machines AKTB, OM-4267, OM-2839 are used in repair facilities for washing and cleaning assemblies and parts.

The number of conveyor washing machines is determined by the formula:

$$N_{KM} = \frac{\sum Q}{\Phi_{ДО} q_Ч K_{ЗМ}}, pcs. \quad (4)$$

Where $q_Ч$ – hourly productivity of the conveyor machine, t/h [8];

$K_{ЗМ}$ – coefficient taking into account the degree of loading and use of the machine conveyor speed, $К_{ЗМ} = 0.45–0.55$ [2].

The hourly productivity of conveyor washing machines is taken from the technical characteristics of the washing machine.

Wash tanks are used in repair facilities for washing and cleaning body parts – frames, rear axle housings and gearboxes, removing old paint and varnish coatings from cabins and components, as well as removing stubborn carbon deposits and scale from cylinder heads, blocks and other components.

The number of baths for cleaning body parts is calculated using the formula: N_{MB}

$$N_{MB} = \frac{Mt}{\Phi_{ДО} Z K_B}, \text{ pcs.} \quad (5)$$

Where M – number of body parts subject to cleaning by boiling per year, pcs;

t – duration of boiling one batch of parts, h;

$\Phi_{ДО}$ – actual annual operating time of the bath, h;

Z – number of parts simultaneously loaded into the bath, pcs;

K_B – bath utilization coefficient by time, $К_В = 0.95–0.96$.

The cleaning time for one part depends largely on the degree of contamination and the cleaning agent used. Thus, the boiling time for one part or one batch of parts in the AM-15 detergent is 10–15 minutes, in the MS-6 and MS-15 detergents – 10–20 minutes, in the Labomit-315 detergent – 10–15 minutes. The duration of removing old paint and varnish coatings in a caustic soda solution is 40–50 minutes [2, 11, 12, 13, 14].

If washing baths are designed to remove stubborn carbon deposits from small parts or to de-preserve parts, then their number is determined by the formula:

$$N_B = \frac{\sum Qt}{\Phi_{ДО} g K_{ЗВ}}, \text{ pcs.} \quad (6)$$

Where $\sum Q$ – annual total weight of parts to be cleaned in the bath, t;

t – duration of cleaning one batch of parts, h;

g – weight of one bath load (taken from technical specifications), t;

$К_{ЗВ}$ – coefficient taking into account the degree of loading and use of the bath over time, $К_{ЗВ} = 0.65 – 0.75$.

Results and discussion. Based on the completed calculation, it is possible to select equipment for work places, using the example of a section for cleaning the HTZ-150K-09 tractor.

Approximate list of equipment at the workstations of the disassembly and

washing section for cleaning the HTZ-150K-09 tractor. Exterior cleaning workstation. This workstation is used for accepting the tractor for repairs and for exterior cleaning.

Table 3 – List of equipment for the tractor external cleaning workstation

Name and brand equipment	Dimensions, mm	Quantity	Square (equipment units), m2	Power, kW
Monitor washing machine Karcher HDS-797C	600x400x500	1	0.24	2.2
Rack ORG-14168-05-230A	1400x500x2365	2	0.7	-
Container OPT-8461	830x640x720	2	0.53	-
Fuel collection container	700x700x1000	1	0.49	-
Oil collection container	500x500x800	1	0.25	-
Jib crane KPK-0.5	R=3 m.	2	0.09	1.2

The tractor wash station is assembled. The following tasks are performed at the stations: disassembling the tractor before rewashing, and washing.

Table 4 – List of equipment for the assembled tractor wash station

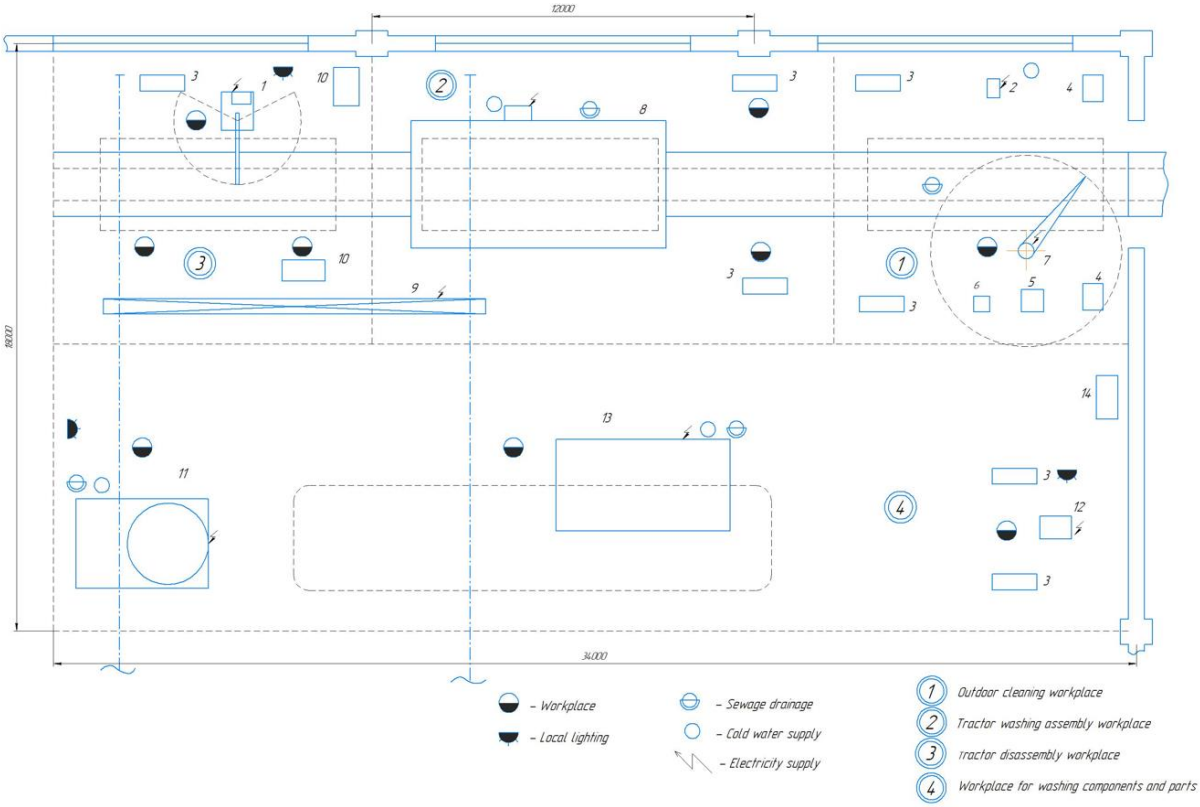
Name and brand equipment	Dimensions, mm	Quantity	Square (equipment units), m2	Power kW
Tractor wash machine OM-4886	8000x4000x5000	1	32	12
Rack ORG-14168-05-230A	1400x500x2365	2	0.7	-
Electric hoist TE-200P-511	-	1	-	21

Workstation for washing parts and assemblies. This workstation is used to wash assemblies, units, and parts.

Table 5 – List of equipment for the workplace for cleaning and washing tractor parts and assemblies

Name and brand of equipment	Dimensions, mm	Quantity	Square (equipment units), m2	Power, kW
Cleaning machine OM-1366G-GOSNITI	2800x4150x3100	1	11.62	7.5
Machine for washing hardware OM-910G	1000x500x800	1	0.5	1.5
Washing machine OM-4267 with overhead conveyor	15000x4400x3200	1	66	8
Rack ORG-14168-05-230A	1400x500x2365	2	0.7	-

Figure 3 shows the layout of the workshop area with the arrangement of the selected equipment at the workstations.



1 – stand for pressing out hinge pipe axles; 2 – monitor washing machine "Karcher" HDS-797C; 3 – rack ORG-14168-05-230A; 4 – container OPT-8461; 5 – tank for collecting fuel; 6 – tank for collecting oils; 7 – jib crane KPK-0.5; 8 – machine for washing tractors OM-4886; 9 – electric hoist TE-200P-511; 10 – metalworker's workbench ORG-5365; 11 – cleaning machine OM-1366G-GOSNITI; 12 – machine for washing hardware OM-910G; 13 – washing machine OM-4267 with overhead conveyor; 14 – fire shield

Figure 3 – Technological layout of the disassembly and washing area tractors HTZ-150K-09

The quality of cleaning and washing of units and parts of HTZ-150K-09 tractors depends on the correct selection and calculation of the amount of washing and cleaning equipment, which, in turn, will directly affect the quality of work performed and personnel productivity [15]. In addition, the introduction of such modern washing equipment as the Karcher HDS-797C monitor washing

machine into the technological process, all other things being equal, will allow for annual savings due to a decrease in the labor intensity of repairs at the disassembly and washing area. Using literary sources [1, 2, 6, 8, 10, 12, 14, 17] and route maps, which indicate the name, category and time of work, time standards for disassembling and washing tractors, a decrease in labor intensity was established from 25.2 man-hours to 24.2 man-hours. A decrease in labor intensity will allow for an overall increase in the annual tractor repair program. Thus, if the initial program volume is 200 units, then in the designed version, the workshop will be able to handle a volume of 350 units. Then, using established methods for calculating the economic efficiency of implementing the proposed equipment, the annual savings from reduced labor costs will be approximately 400,000 rubles, the net present value will be 1,300,000 rubles, with a payback period of 2.5 years.

Thus, under real-world operating and storage conditions, machines are subject to the deposition of various contaminants on their surfaces. The primary cause of this deposition is the environment. According to the technical process for machine repair, the list of repair tasks includes external cleaning and washing of machines, units, and components, as well as cleaning and washing of individual parts after disassembly of units and components. Cleaning and washing operations increase labor productivity during repair work, reduce labor and material costs, and improve working conditions for workers.

According to SP 2.2.3670-20, when performing technological operations in the washing and cleaning area, the worker is exposed to unfavorable harmful and hazardous production factors (Figure 4).

The process of washing and cleaning units, components, and parts is accompanied by the evaporation of cleaning solutions, which contain substances harmful to the body. Inhaling air containing cleaning solution vapors, which may contain toxic and irritating substances, can cause the development of fibrotic impurities in the lungs, irritation of the respiratory tract, and general intoxication of

the body [16].

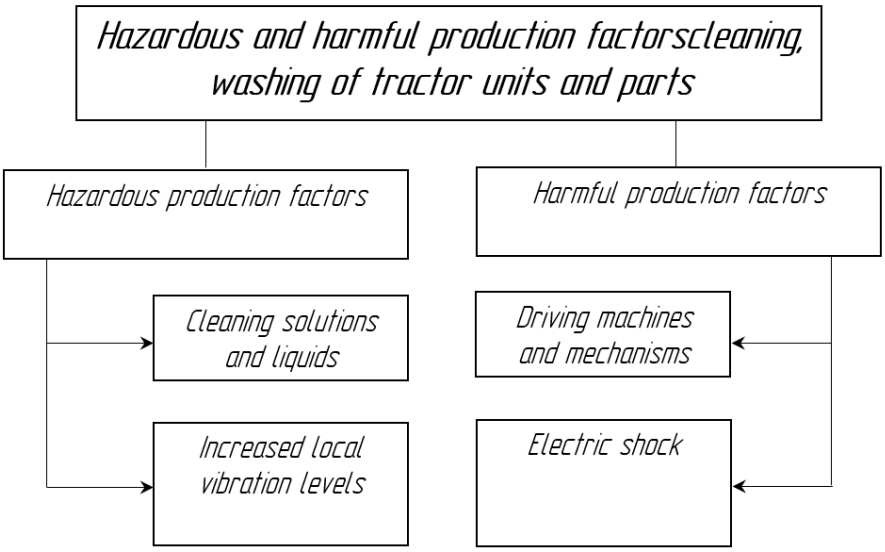


Figure 4 – Hazardous and harmful production factors when cleaning and washing tractor units and parts

Cleaning solutions and liquids used in the workplace are classified as hazard class 4 (low-hazard substances). The maximum permissible concentration (MPC) of harmful substances in the air of the work area should be no more than 10 mg/m³ due to the use of supply and exhaust ventilation in accordance with GOST 12.1.007-76. If the MPC in the area does not exceed the permissible limits, the use of personal protective equipment in the workplace is not required [16, 17].

A high-pressure device is used for pre-cleaning parts. The spray gun generates localized vibration of 3 m/s², which impacts the operator's hands. Localized vibration damages the capillary system of the hands, reducing blood circulation in the fingers and the nutrition of the skin and nails [18]. According to GOST 12.1.012-2004, the permissible vibration level is 2 m/s²; anti-vibration gloves are mandatory for protecting the worker's hands.

According to GOST 12.1.030-81, protective grounding must be installed at the workplace to protect workers from electric shock when touching non-

current-carrying metal parts that may become energized due to insulation damage. The grounding device at the site must meet all requirements for grounding electrical installations.

According to GOST 12.0.003-2015, the washing and cleaning area contains hazardous production factors associated with the handling of dismantled engine parts, components, assemblies, and units. These factors may strike a worker when moving them using a crane or a mobile trolley. There is also a risk that a part or other heavier object may break loose from its slings and, under the force of gravity, fall on a worker, causing serious injury or death.

Anyone authorized to operate a crane must be over 18 years of age, have no medical contraindications, and have completed theoretical and practical training, knowledge, and skills testing in operating the crane and slinging loads in accordance with established procedures. Furthermore, the worker must wear personal protective equipment, including protective clothing, boots with protective caps, gloves, a hard hat, and goggles, in accordance with regulations [18].

The enterprise must have an up-to-date fire extinguishing plan, firefighting equipment, evacuation exits, primary fire extinguishing equipment, a fire alarm, and an evacuation plan to a safe area from the premises [16, 18].

The process of washing and cleaning parts generates wastewater containing suspended solids, oils, petroleum products, and detergent components, including synthetic surfactants (SSAs). To prevent environmental pollution, the workshop must be equipped with a mechanical wastewater treatment system that utilizes water in a recirculating cycle. Such systems remove the bulk of suspended solids, oils, and petroleum products from wastewater, but do not remove SSAs. These accumulate in recirculating systems, where they are then collected and disposed of [18].

Conclusions. Therefore, it should be noted that cleaning and washing of HTZ-150K-09 tractor components and parts in a workshop depends on the quality of the washing and cleaning equipment, which affects the quality of re-

pair work. It has been established that the use of modern washing equipment will reduce the labor intensity of disassembling and washing HTZ-150K-09 tractors from 25.2 man-hours to 24.2 man-hours, increase the annual repair program, and achieve annual cost savings of approximately 400,000 rubles, a net present value of 1,300,000 rubles, with a payback period of 2.5 years.

It should also be noted that cleaning and washing tractor parts requires a large number of measures aimed at strict compliance with occupational safety and environmental protection standards.

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