Запобігання та ліквідація надзвичайних ситуацій

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TECHNOLOGIES FOR IMPROVING FILTERING SYSTEMS FOR THE NEUTRALIZATION OF HAZARDOUS CHEMICAL SUBSTANCES

The analysis of existing filtering systems of the NATO and Russian Federation, which protect the personnel and the civilian population from different types of hazardous chemical substances, is carried out. It is established that there are no such filters that protect against all types of hazardous substances. Therefore, it is proposed to retrofit the construction of collective protection systems on armored vehicles and stationary objects by additional installation of a mesh coated with a layer of catalytic material that will neutralize different types of chemically hazardous substances due to photocatalytic air purification by titanium oxides. Work continues on using oxide catalysts on titanium alloys to improve the collective defense system for stationary structures and armored vehicles for effective neutralization of hazardous chemical substances.

Keywords*: filtering system, individual protective equipment, titanium oxide, hazardous chemical substances, personnel, respiratory organs.*

Introduction

Problem statement. In modern condition of use of weapons of mass destruction by terrorist oraganization, the armed conflict in Syria, during which chemical weapons were used, the aggravation of the situation in the East of Ukraine, where a large number of chemically dangerous objects are located, violation of the UN International Convention on the Prohibition of the Use of Chemical Weapons by some countries, there is a high probability of subversive and terrorist acts committed by sabotage and reconnaissance forces with the use of extremely hazardous substances.

There are more than 1,5 thousands chemically dangerous objects on the territory of Ukraine, whose activity is related to the production, use, storage and transportation of hazardous chemicals, and more than 22 million people live in the areas of their location. The danger of functioning of these objects of economic activity (chemically dangerous objects) is related to the probability of accidental emissions (spillages) of a large number of hazardous chemical substances outside the objects, because many of them retain 3–15 daily supplies of chemicals. That is why each subsequent emergency situation may be related to the spillage or emission of hazardous chemical substances (hereinafter – HCHS) into the air [1].

Throughout his life man is constantly faced with a significant amount of hazardous substances that can cause different types of diseases and health disorders. Particularly dangerous are chemicals, which, depending on their practical use, can be divided into industrial poisons that are used in production (solvents, dyes) and are a source of threat of acute and chronic intoxications (mercury, lead, aromatic compounds, etc.), pesticides that are used in agriculture to kill weeds and rodents (herbicides, rodenticides), household chemicals (food additives, sanitation and hygiene products).

Increasing the potential danger in Ukraine can lead to serious consequences, so it is necessary to know how to protect ourselves from this threat [2].

Purpose of the article: to analyze the existing filtering systems of the respiratory organs of neighboring countries and develop requirements for collective protection systems that will neutralize hazardous chemical substances.

The analysis of recent researches and publications.

AVEC CHEM s.r.o. company is a member of the Defence and Security Industry Association of the Czech Republic (DSIA) and Czech Health & Safety Alliance and provides protection for rescuers, civil defense and industrial workers in more than 40 countries. All products are certified according to European and NATO standards. Filter systems protect against hazardous

chemical substances and are divided into 5 categories (Fig. 1): particulate, gas, combination, specialized, NBC (nuclear, biological, chemical).

The filter canister P3 R (Fig. 1(1)) is designed for the protection against harmful particles and biological threats and protects against bacteria, viruses, microbes, spores.

The police filter canister P-CAN Compact (Fig. 1(2)) in connection with suitable respirator provides protection against solid and liquid particles, pepper spray (OC), smoke-producing substances, radioactive particles, bacteria and rickettsia, fungi, toxins, viruses, Riot Control agents (law-enforcement), such as bromoacetone, CS, CR, CN, CNC, CNS, CA substances, organic compounds of arsenic – diphenyldichlorarsine, diphenylcyanoarsine, adamsite, diphenyldichlorarsine, ethyldichlorarsine, methyldichlorarsine, and vapours of organic substances with a boiling point above 65° C, etc.

Table 1

List of hazardous chemical substances

No. for	Chemical name	Designation
1.	2-chlorobenzalmalononitrile (tear gas)	CS
2.	Dibenzoxazepine (algogen)	CR
3.	Chloroacetophenone	CN
4.	30% solution of chloroacetophenone in chloroform	CNC
5.	Bromobenzyl cyainde	CA
6.	Mixture of 23% chloroacetophenone, 38,4% chloropicrin in chloroform	CNS
7.	Cyanogen chloride	CK
8.	Diphenylcyanoarsine	DC
9.	Ethyldichloroarsine	ED
10.	Methyldichloroarsine	MD
11.	Diphenylchloroarsine	DA
12.	Mustard gas	H
13.	Sulfur mustard	HD
14.	T- mustard gas	HN1
15.	Q- mustard gas	HN2
16.	Nitrogen mustard	HN3
17.	Lewisite	L
18.	Phosgene	HL
19.	Diphosgene	DP
20.	Chloropicrin	PS
21.	Hydrogen cyanide	AC
22.	Arsine	SA
23.	Sarin	GB
24.	Cyclosarin	GF
25.	Soman	GD
26.	Tabun	GA
27.	IVA	GV
28.	VX	VX
29.	Amiton	VG
30.	Edemo	VM

Fig. 1. NATO's filtering systems for protection against chemicals that are hazardous

The NBC-1/SL filter (Fig. 1(3)) in combination with a full-face mask provides reliable protection against solid and liquid aerosols, smoke-producing substances, radioactive particles, bacteria, viruses, vapours of organic and inorganic acids, hydroxides, organic solvents with a boiling point above 65° C, ammonia, amines, acid gases, agricultural chemical combustion products, tear-producing, irritant, choking, blister and nerve agents, e.g. bromoacetone, CS substance, organic compounds of arsenic, phosgene, hydrogen cyanide, cyanogen chloride, mustard gas, organophosphates – sarin, IVA, VX and other toxic substances, e.g. benzene, toluene, vinyl chloride, fluorine, hydrogen fluoride, sulphur oxides, phosgene, phosphoric acid and its organic derivatives, chloroacetic acid, nitric acid, aldehydes, mixtures of inorganic acids and organic substances, etc.

The NBC-2/SL filter canister (Fig. 1(4)) in connection with suitable respirator or PAPR provides protection against solid and liquid particles, pepper spray, smoke-producing substances, radioactive particles, bacteria and rickettsia, fungi, toxins, viruses, riot control agents, blister agents, chocking agents, blood agents, nerve agents, incapacitants, herbicides, pesticides and TIC, such as bromoacetone, CS, CR, CN, CNC, CNS, CA substances, organic compounds of arsenic – diphenyldichlorarsine, diphenylcyanoarsine, adamsite, diphenyldichlorarsine, ethyldichlorarsine, methyldichlorarsine, mustard gas, sulphur mustard gas, T-mustard gas, Q-mustard gas, nitrogen mustard gases, lewisite, mixed mustard gas, phosgene, diphosgene, chloropicrin, hydrogen cyanide, cyanogen chloride, arsine, G-agents: sarin, cyclosarin, soman, tabun, IVA, V-agents: VX, VR, VE, VG (amiton), VM and toxic industrial chemicals such as: fumes of organic or inorganic acids, hydroxides, organic solvents with the boiling point above 65 °C, ammonia, amines, inorganic and acid gases, agricultural chemical combustion gases, other toxic substances, e.g. benzene, toluene, vinyl chloride, fluorine, hydrogen fluoride, sulphur oxides, chloracetic acid, aldehydes, etc.

The NBC-3/SL filter canister (Fig. 1(5)) in connection with suitable respirator or PAPR provides protection against solid and liquid particles, pepper spray

(OC), smoke-producing substances, radioactive particles, bacteria and rickettsia, fungi, toxins, viruses, riot control agents, blister agents, chocking agents, blood agents, nerve agents, incapacitants, herbicides, pesticides and TIC, such as bromoacetone, CS, CR, CN, CNC, CNS, CA substances, organic compounds of arsenic – diphenyldichlorarsine, diphenylcyanoarsine, adamsite, diphenyldichlorarsine, ethyldichlorarsine, methyldichlorarsine, mustard gas, sulphur mustard gas, T-mustard gas, Q-mustard gas, nitrogen mustard gases, lewisite, mixed mustard gas, phosgene, diphosgene, chloropicrin, hydrogen cyanide, cyanogen chloride, arsine, G-agents: sarin, cyclosarin, soman, tabun, IVA, V-agents: VX, VR, VE, VG (amiton), VM and toxic industrial chemicals such as: fumes of organic or inorganic acids, hydroxides, organic solvents with the boiling point above 65° C, ammonia, amines, inorganic and acid gases, agricultural chemical combustion gases, other toxic substances, e.g. benzene, toluene, vinyl chloride, fluorine, hydrogen fluoride, sulphur oxides, chloracetic acid, aldehydes, mixtures of inorganic acids, and organic substances, mercury vapours, etc.

The OF-07 filter canister (Fig. 1(6)) in connection with suitable respirator provides protection against solid and liquid particles, pepper spray (OC), smoke-producing substances, radioactive particles, bacteria and rickettsia, fungi, toxins, viruses, riot control agents, blister agents, chocking agents, blood agents, nerve agents, incapacitants, herbicides, pesticides and TIC, such as bromoacetone, CS, CR, CN, CNC, CNS, CA substances, organic compounds of arsenic – diphenyldichlorarsine, diphenylcyanoarsine, adamsite, diphenyldichlorarsine, ethyldichlorarsine, methyldichlorarsine, mustard gas, sulphur mustard gas, T-mustard gas, Q-mustard gas, nitrogen mustard gases, lewisite, mixed mustard gas, phosgene, diphosgene, chloropicrin, hydrogen cyanide, cyanogen chloride, arsine, G-agents: sarin, cyclosarin, soman, tabun, IVA, V-agents: VX, VR, VE, VG (amiton), VM and toxic industrial chemicals such as: organic solvents with a boiling point above 65° C, inorganic substances, acid gases, ammonia, amines, agricultural chemical combustion products, benzene, toluene, vinyl chlorine, fluorine, hydrogen fluoride, sulphur oxides, organic phosphorous compounds, chloroacetic acid, nitric acid, aldehydes, mixtures of inorganic acids and organic substances, etc.

The OF-07M filter canister (Fig. 1(7)) in connection with suitable respirator provides protection against solid and liquid particles, pepper spray, smoke-producing substances, radioactive particles, bacteria and rickettsia, fungi, toxins, viruses, riot control agents, blister agents, chocking agents, blood agents, nerve agents, incapacitants, herbicides, pesticides and TIC, such as bromoacetone, CS, CR, CN, CNC, CNS, CA substances, organic compounds of arsenic – diphenyldichlorarsine, diphenylcyanoarsine, adamsite, diphenyldichlorarsine, ethyldichlorarsine, methyldichlorarsine, mustard gas, sulphur mustard gas, T-mustard gas, Q-mustard gas, nitrogen mustard gases, lewisite, mixed mustard gas, phosgene, diphosgene, chloropicrin, hydrogen cyanide, cyanogen chloride, arsine, G-agents: sarin, cyclosarin, soman, tabun, IVA, V-agents: VX, VR, VE, VG (amiton), VM and toxic industrial chemicals such as: organic solvents with a boiling point above 65° C, inorganic substances, acid gases, ammonia, amines, agricultural chemical combustion products, benzene, toluene, vinyl chlorine, fluorine, hydrogen fluoride, sulphur oxides, organic phosphorous compounds, chloroacetic acid, nitric acid, aldehydes, mixtures of inorganic acids and organic substances, etc.

The A2B2E2K2HgNOCOSXP3 D R (Fig. 1(8)) filter canister provides protection against solid and liquid aerosols, smoke-producing agents, radioactive particles, microorganisms, fibres (e.g. asbestos), fumes of organic or inorganic acids, hydroxides, organic solvents with the boiling point above 65 °C, ammonia, amines, inorganic and acid gases, agricultural chemical combustion gases, tear, irritant and other toxic substances, e.g. benzene, toluene, vinyl chloride, fluorine, hydrogen fluoride, sulphur oxides, bromoacetone, nitogen oxide, nitrogen dioxide, carbon monoxide, phosgene, cyanogen chloride, phosphoric acid and its organic derivatives, chloracetic acid, aldehydes, mixtures of inorganic acids and organic substances, mercury vapours, etc.

The REACTOR P3 R (Fig. 1(9)) filter canister is designed for the protection against mercury vapours, radioactive iodine, organic compounds of iodine (iodomethane), radioactive particles, etc. The filter is also available in variant HG-REACTOR P3 R [3].

Protective filters in connection with full face masks, half masks, respirators provide reliable respiratory protection against a wide range of hazardous and toxic substances.

In the Russian Federation, filter systems, which protect against hazardous chemical substances, are divided into the following classed: anti-gas filters Class 1,2; combined filters Class 1, 2, 3; anti-gas special filters; anti-aerosol (or particle) filters. Class 1 anti-gas filters are divided into six types (Fig. 2).

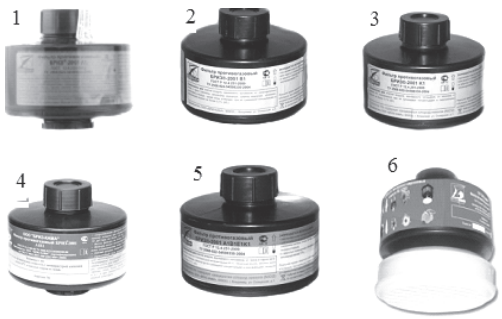

Fig. 2. Anti-gas filters Class 1

The anti-gas filter A1 (Fig. 2(1)) is designed to purify polluted air from the vapors and gases of hazardous chemicals. Both classes of filters are used only for a volume fraction of free oxygen not less than 17 %.

The anti-gas filter B1 (Fig. 2(2)) is designed to purify polluted air from gases and vapors of inorganic substances such as halogens, hydrogen sulfide, hydrogen cyanide, cyanogen chloride, carbon disulfide excluding carbon monoxide.

The anti-gas filter K1 (Fig. 2(3)) is designed to purify polluted air from ammonia and organic ammonia derivatives.

The anti-gas filter A1E1 (Fig. 2(4)) without particle filter is designed to purify polluted air from vapors of organic substances having a boiling point greater than 65° C, acid gases and vapors and is used in connection with a mask filter (with a full face mask).

Table 2

Characteristics of anti-gas filters Class 1

Filter type	Time of protective action on the test substance, min, not less than				
	Cyclohexane (conc. 3.5 mg/L)	Chlorine (conc. 3.0 mg/L)	Hydrogen sulfide (conc. 1.4 mg/L)	Sulfur dioxide (conc. 2.7 mg/L)	Ammonia (conc. 0.7 mg/L)
A1	70				
B1		20	40		
K1					50
A1B1E1	70	20	40	20	
A1B1E1K1	70	20	40	20	50

The anti-gas filter A1B1E1K1 (Fig. 2(5)) without particle filter is designed to purify polluted air from vapors of organic substances having a boiling point greater than 65° C, gases and vapors of inorganic substances with the exception of carbon monoxide, acid gases, ammonia and amines vapors.

The anti-gas filter FA-2002 (Fig. 2(6)) provides reliable protection of the human respiratory systems from aerosols of different nature (dust, smoke, and mist) at their total concentration not more than 15 MPC and at oxygen content in the air not less than 17 % vol.

Anti-gas filters Class 2 are divided into eight types. The anti-gas filter A2 (Fig. 3(1)) is designed to purify polluted air from vapors of organic substances with a boiling point greater than 65° C (benzene, xylene, toluene, gasoline, kerosene, halogenated organic compounds, nitro compounds of benzene and its homologues, esters, alcohols, ketones, aniline, tetraethyl lead, phosphorus and organochlorine pesticides (OCPs).

The anti-gas filter B2 (Fig. 3(2)) is designed to purify polluted air from gases and vapors of inorganic substances (halogens, hydrogen sulfide, hydrochloric acid, cyanogene chloride, carbon disulfide) excluding carbon monoxide.

Fig. 3. Anti-gas filters Class 2

The anti-gas filter E2 (Fig. 3(3)) is designed to purify polluted air for acid gases and vapors (sulfur dioxide, hydrogen sulfide, hydrogen chloride, phosphine, arsine).

The anti-gas filter K2 (Fig. 3(4)) without particle filter is designed to purify polluted air from ammonia and amines vapors.

The anti-gas filter B2K2 (Fig. 3(5)) without particle filter is designed to purify polluted air from gases and vapors of inorganic substances, ammonia and amines.

The anti-gas filter A2B2E2K2 (Fig. 3(6)) is designed to purify polluted air from gases and vapors of organic substances with a boiling point greater than 65°C (benzene, xylene, toluene, gasoline, kerosene, halogenated organic compounds, etc.); inorganic substances (halogenes, hydrogen sulfide, hydrogen cyanide, cyanogens chloride, carbon disulfide with the exception of carbon monoxide); acid gases and vapors (sulfur dioxide, hydrogen sulfide, hydrogen chloride, phosphine, arsine, etc.), as well as from ammonia and organic ammonia derivatives.

The anti-gas filter A2B2E2 (Fig. 3(7)) is designed to purify polluted air from gases and vapors of organic substances with a boiling point greater than 65° C (benzene, xylene, toluene, gasoline, kerosene, halogenated organic compounds, etc.); inorganic substances (halogens, hydrogen sulfide, hydrogen cyanide, cyanogens chloride, carbon disulfide with the exception of carbon monoxide); acid gases and vapors (sulfur dioxide, hydrogen sulfide, hydrogen chloride, phosphine, arsine, etc.).

The anti-gas filter K2P3 (Fig. 3(8)) is designed to purify polluted air from aerosol particles of slightly toxic substances contained in dust, smoke or mist, as well as from ammonia and amines.

Table 3

Characteristics of anti-gas filters Class 2

Filter type	Time of protective action on the test substance, min, not less than				
	Cyclohexane (conc. 17.5 mg/L)	Chlorine (conc. 15.0 mg/L)	Hydrogen sulfide (conc. 7.1 mg/L)	Sulfur dioxide (conc. 13.3 mg/L)	Ammonia (conc. 3.5 mg/L)
A2	35				
B2		20	40		
K2					40
A2B2E2	35	20	40	20	
A2B2E2K2	35	20	40	20	40

The combined filter A1P1 (Fig. 4(1)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from vapors of organic substances with a boiling point greater than 65° C (benzene, xylene, toluene, gasoline, kerosene, halogenated organic compounds, nitro compounds of benzene and its homologues, esters, alcohols, ketones, aniline, tetraethyl lead, phosphorus and organochlorine pesticides).

The filter body is made of special plastic material and equipped with a particle filter from a filter material and an absorbing layer (charge) from the sorbent.

The combined filter B1P1 (Fig. 4(2)) is designed to purify polluted air from aerosol particles, slightly hazardous substances contained in dust, smoke or mist, as well as from inorganic gases and vapors (halogens, hydrogen sulfide, hydrochloric acid, cyanogen chloride, carbon disulfide) excluding carbon monoxide.

Fig. 4. Gas-aerosol filters Class 1

The combined filter E1P1 (Fig. 4(3)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from acid gases and vapors (sulfur dioxide, hydrogen sulfide, hydrogen chloride, phosphine, arsine).

Table 4

Characteristics of combined filters

Filter type	Breathing resistance, Pa, not more than	Time of protective action on the test substance, min, not less than		Substance
	At a constant flow rate 30 L/ min	At a constant flow rate 95 L / min	Time of protective action on the test substance, min, not less than	
A1P1	160	610	70	Cyclohexane at a concentration of 3,5 mg /L
B1P1	160	610	40	Hydrogen sulfide at a concentration of 1,4 mg /L
E1P1	160	610	20	Sulfur dioxide at a concentration of 2,7 mg /L
K1P1	160	610	50	Ammonia at a concentration of 0,7 mg /L
A1E1P1	160	610	70	Cyclohexane at a concentration of 3,5 mg /L
			20	Sulfur dioxide at a concentration of 2,7 mg /L
A1B1E1P1	160	610	70	Cyclohexane at a concentration of 3,5 mg /L
			40	Hydrogen sulfide at a concentration of 1,4 mg /L
			20	Sulfur dioxide at a concentration of 2,7 mg /L
A1B1E1K1P1	160	610	70	Cyclohexane at a concentration of 3,5 mg /L
			40	Hydrogen sulfide at a concentration of 1,4 mg /L
			20	Sulfur dioxide at a concentration of 2,7 mg /L

The combined filter K1P1 (Fig. 4(4)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from ammonia and amines.

The combined filter A1E1P1 (Fig. 4(5)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from vapors of organic substances with a boiling point greater than + 65 °C, acid gases and vapors.

The combined filter A1B1E1P1 (Fig. 4(6)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke

or mist, as well as from vapors of organic substances with a boiling point greater than +65° C, inorganic gases and vapors (excluding carbon monoxide), acid gases and vapors.

Table 5

Characteristics of combined filters

Filter type	Breathing resistance, Pa, not more than		Time of protective action on the test substance, min, not less than	Substance
	At a constant flow rate 30 L/ min	At a constant flow rate 95 L / min		
A2P3	160	610	35	Cyclohexane at a concentration of 17,5 mg /L
B2P3	260	980	40	Hydrogen sulfide at a concentration of 7,1 mg /L
E2P3	260	980	20	Sulfur dioxide at a concentration of 13,3 mg /L
K2P3	260	980	40	Ammonia at a concentration of 3,5 mg /L
B2K2P3	260	980	40	Hydrogen sulfide at a concentration of 7,1 mg /L
			40	Ammonia at a concentration of 3,5 mg /L
A2B2E2P3	160	980	40	Hydrogen sulfide at a concentration of 7,1 mg /L
			20	Sulfur dioxide at a concentration of 13,3 mg /L
			35	Cyclohexane at a concentration of 17,5 mg /L
A2B2E2K2P3	160	980	40	Hydrogen sulfide at a concentration of 7,1 mg /L
			40	Ammonia at a concentration of 3,5 mg /L
			20	Sulfur dioxide at a concentration of 13,3 mg /L
			35	Cyclohexane at a concentration of 17,5 mg /L
A2B2E2K2P3	160	980	40	Hydrogen sulfide at a concentration of 7,1 mg /L
			6000	Mercury vapors at a concentration 13 ± 1 mg/L
			40	Ammonia at a concentration of 3,5 mg /L
			20	Sulfur dioxide at a concentration of 13,3 mg /L
			35	Cyclohexane at a concentration of 17,5 mg /L

The combined filter A1B1E1K1P1 (Fig. 4(7)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from vapors of organic substances with a boiling point greater than +65° C, inorganic gases and vapors (excluding carbon monoxide), acid gases and vapors.

Combined filters Class 2 are divided into nine types.

The combined filter A2P3 (Fig. 5(1)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from vapors of organic substances with a boiling point greater than + 65° C (benzene, xylene, toluene, gasoline, kerosene, halogenated organic compounds, nitro compounds of benzene and its homologues, esters, alcohols, ketones, aniline, tetraethyl lead, phosphorus and organochlorine pesticides).

The combined filter B2P3 (Fig. 5(2)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from gases and vapors of inorganic substances (halogens, hydrogen sulfide, hydrochloric acid, cyanogen chloride, carbon disulfide), with the exception of carbon monoxide.

Fig. 5. Anti-gas-aerosol filters Class 2

The combined filter E2P3 (Fig. 5(3)) is designed to purify polluted air from aerosol particles of highly hazardous substances contained in dust, smoke or mist, as well as from acid gases and vapors (sulfur dioxide, hydrogen sulfide, hydrogen chloride, phosphine, arsine).

The combined filter K2P3 (Fig. 5(4)) is designed to purify polluted air from aerosol particles of highly hazardous substances contained in dust, smoke or mist, as well as from ammonia and amines.

The combined filter B2K2P3 (Fig. 5(5)) is designed to purify polluted air from aerosol particles of highly hazardous substances contained in dust, smoke or mist, as well as from gases and vapors of inorganic substances, except for carbon monoxide, ammonia and amines.

The combined filter A2B2E2P3 (Fig. 5(6)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from vapors of organic substances with a boiling point greater than + 65° C, gases and vapors of inorganic substances, except for carbon monoxide and acid gases.

The combined filter A2B2E2K2P3 (Fig. 5(7)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from vapors of organic substances with a boiling point greater than + 65° C, gases and vapors of inorganic substances, except for carbon monoxide, acid gases, ammonia and amines.

The combined filter A2B2E2K2P3 (Fig. 5(8)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from vapors of organic substances with a boiling point greater than +65° C, gases and vapors of inorganic substances, with the exception of carbon monoxide, acid gases, ammonia, amines and mercury vapor.

The combined filter K3P3 (Fig. 5(9)) is designed to purify polluted air from aerosol particles of slightly hazardous substances contained in dust, smoke or mist, as well as from ammonia and amines.

Combined filters Class 3 are divided into three types.

The combined filter A3P3 (Fig. 6(1)) with a particle filter P3 is designed to purify polluted air from aerosol particles of highly hazardous substances contained in dust, smoke and mist, as well as from vapors of organic substances with a boiling point greater than +65° C (benzene, xylene, toluene, gasoline, kerosene, halogenated organic compounds, nitro compounds of benzene and its homologues, esters, alcohols, ketones, aniline, tetraethyl lead, phosphorus and organochlorine pesticides).

Fig. 6. Gas-aerosol filters Class 3

The combined filter B3P3 (Fig. 6(2)) with a particle filter P3 is designed to purify polluted air from aerosol particles of highly haza rdous substances contained in dust, smoke and mist, as well as from gases and vapors of inorganic substances (halogens, hydrogen sulfide, hydrochloric acid, cyanogen chloride, carbon disulfide) excluding carbon monoxide.

The particle filter FA-2002 (Fig. 8) is designed to purify polluted air from vapors of organic substances with a boiling point greater than 65°C (benzene, xylene, toluene, gasoline, kerosene, halogenated organic compounds, nitro compounds of benzene and its homologues, esters, alcohols, ketones, aniline, tetraethyl lead, phosphorus and organochlorine pesticides); halogens, hydrogen sulfide, hydrogen cyanide, cyanogens chloride, carbon disulfide excluding carbon monoxide, sulfur dioxide, hydrogen sulfide, hydrogen chloride, phosphine, arsine, ammonia and amine vapors [4].

Table 6

Characteristics of combined filters

Filter type	Breathing resistance, Pa, not more than		Time of protective action on the test substance, min, not less than	Substance
	At a constant flow rate 30 L/min	At a constant flow rate 95 L/min		
A3P3	280	1060	65	Cyclohexane at a concentration of 28 mg /L
B3P3	280	1060	60	Hydrogen sulfide at a concentration of 14,2 mg /L
K3P3	280	1060	60	Ammonia at a concentration of 7,0 mg /L

The combined filter K3P3 (Fig. 6(3)) with a particle filter P3 is designed to purify polluted air from aerosol particles of highly hazardous substances contained in dust, smoke and mist, as well as from ammonia and amines.

Anti-gas special filters are divided into two types. The anti-gas special filter SX (E2K1CO) (Fig. 7(1)) without particle filter is designed to purify the air that is inhaled by humans from acid gases and vapors (sulfur dioxide, hydrogen sulfide, hydrogen chloride, phosphine, arsine), from ammonia, amines and carbon monoxide at a total concentration of no more than 0,5 % vol. The filter is used with filtering gas masks that have no external or “supplied” air to the mask.

Fig. 7. Special gas filters

The anti-gas special filter AX (Fig. 7(2)) without particle filter is designed to purify the air from airborne hazardous gases and vapors of organic compounds with a boiling point lesser than 65 C, such as methane, ethane, butane, ethylene, acetylene, etc.

Table 7

Characteristics of anti-gas special filters

Filter type	Breathing resistance, Pa, not more than		Time of protective action on the test substance, min, not less than	Substance
	At a constant flow rate 30 L/min	At a constant flow rate 95 L/min		
E2K1CO	280	1060	20	Carbon monoxide (CO) at a concentration of 6,0 mg /L
AX	280	1060	50	Dimethyl ether at a concentration of 14,2 mg /L
			50	Isobutane at a concentration of 14,2 mg /L

Fig. 8. Particle filters

Exposition of basic material

Based on the analysis of the resulted material it is established that there are no such types of filters that protect against all types of HCHS. Therefore, it is necessary to formulate requirements for collective protection systems both on armored vehicles and stationary ones, which will protect against HCHS.

It is determined in [5] that human progress is impossible without the use of new technologies. With the development of technological progress and the emergence of modern technologies and materials special danger today is man-made disasters, especially disasters on chemically dangerous enterprises. At present, photocatalytic purification is considered to be the optimal method of air purification, where titanium oxides are used as a photocatalyst [6].

Increasing the effectiveness of collective protection systems from HCHS, the possibility of installing catalytic materials for the neutralization of toxins of different nature in the existing structure will enable to improve the performance characteristics of FVU without significant structural changes and substantial material costs.

Promising materials that are capable of effectively neutralize (decompose) toxins of different nature at high efficiency performance over a wide range of temperatures and corrosion resistance are heterogeneous systems of titanium alloys.

The proposed modernization approach involves the additional installation of a grille (mesh) coated with a layer of catalytic material in the absorbent filters of a collective protection system on armored vehicles (Fig. 9).

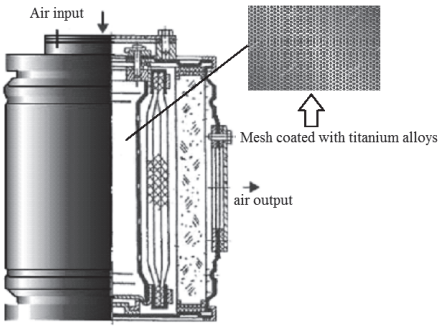

Fig. 9. Installation of a mesh coated with titanium dioxide in the collective protection system

Conclusion

According to the results of the analysis, it is established that there are no such types of filters that can protect against all types of HCHS, and the time of action in places of possible contamination in oxygen-breathing gas masks may not be enough. The existing systems of collective protection, both stationary and on armored vehicles, need to be improved by using a method of photocatalytic destruction of toxicants using titanium oxides as a catalytic material on porous or mesh carriers, with their further installation in existing absorber filters for the effective neutralization of HCHS.

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ТЕХНОЛОГІЇ ПОКРАЩЕННЯ ФІЛЬТРУВАЛЬНИХ СИСТЕМ ДЛЯ НЕЙТРАЛІЗАЦІЇ НЕБЕЗПЕЧНИХ ХІМІЧНИХ РЕЧОВИН

О.В. Галак, М.Д. Сахненко, О.В. Косарев, О.В. Брянкін, О.В. Лінивцев

Проведено аналіз існуючих фільтрувальних систем засобів індивідуального захисту органів дихання держав НАТО та Російської Федерації, які захищають особовий склад та населення від різних видів небезпечних хімічних речовин. Не існує таких типів фільтрів, які захищають від всіх видів небезпечних хімічних речовин. В сучасних умовах застосування терористичними організаціями зброї масового ураження, збройний конфлікт у Сирії, під час якого було застосовано хімічну зброю, загострення ситуації на Сході України де знаходиться велика кількість небезпечних хімічних підприємств, порушення деякими державами Міжнародної конвенції Організації Об'єднаних Націй про заборону використання хімічної зброї, існує висока вірогідність застосування диверсійно-розвідувальними силами, іншими незаконно утвореними антидержавними формуваннями здійснення терористичних актів та диверсій високотоксичних отруйних речовин в обсязі, що унеможливлює їх бойове застосування з метою ураження живої сили (населення, військ). Наведено рекомендіції покращення роботи фільтруючих систем від небезпечних хімічних речовин, за рахунок додаткового введення в конструкцію фільтровентиляційних установок (агрегатів), каталітичних матеріалів для знешкодження токсинів різної природи. Такий підхід дозволить без істотних конструкційних змін та суттєвих матеріальних витрат підвищити експлуатаційні характеристики фільтровентиляційних систем за рахунок додаткового встановлення у фільтр-поглинач решітки (сітки) з нанесеним шаром каталітичного матеріалу із оксидів титану. На поверхні TiO_2 можуть бути окислені (мінералізовані) до CO_2 і H_2O практично будь-які органічні речовини. Для подальшого уловлювання небезпечних хімічних речовин буде використовуватись фотокаталітичний метод очищення повітря, в якому в ролі фотокаталізатору використовуються оксиди титану. Триває робота щодо покращення системи колективного захисту стаціонарних споруд та бронетанкової техніки з використанням оксидних каталізаторів на титанових сплавах з подальшим удосконаленням для ефективної нейтралізації небезпечних хімічних речовин.

Ключові слова: *фільтрувальна система, засоби індивідуального захисту, оксид титану, небезпечні хімічні речовини, особовий склад, органи дихання.*

ТЕХНОЛОГИИ УСОВЕРШЕНСТВОВАНИЯ ФИЛЬТРУЮЩИХ СИСТЕМ ДЛЯ НЕЙТРАЛИЗАЦИИ ОПАСНЫХ ХИМИЧЕСКИХ ВЕЩЕСТВ

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Проведен анализ существующих фильтрующих систем государств НАТО и Российской Федерации, которые защищают личный состав и население от различных видов химически опасных веществ. Установлено, что не существует таких фильтров, защищающих от всех типов отравляющих веществ. Поэтому предложено дооборудовать конструкцию систем коллективной защиты на бронетехнике и стационарных объектов за счет дополнительной установки в фильтр-поглотитель решетки (сетки) с нанесенным слоем каталитического материала, который будет нейтрализовать различные виды химически опасных веществ за счет фотокаталитической очистки воздуха оксидами титана. Продолжается работа по использованию оксидних катализаторов на титановых сплавах что бы улучшить систему коллективной зашиты на стационарных сооружениях и бронетанковой техники для эффективной нейтрализации химически опасных веществ.

Ключевые слова: *фильтровальная система, средства индивидуальной защиты, оксид титана, опасные химические вещества, личный состав, органы дыхания.*