Development of a universal kit for rapid detection of aggressive chemicals, rocket fuel components and uranium components and uranium compounds in various environments.

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Abstract. The materials of the article are devoted to the issues of ecology and safety at enterprises and railway transport. The urgency of developing a universal kit for rapid detection of aggressive chemicals, rocket fuel components and uranium compounds in various environments is due to the fact that the presence on the surface and in water can lead to poisoning and chemical burns of working personnel and the public. It is also caused by the need to make managerial decisions when eliminating the consequences of accidents at food and related industries. The article discusses the methods of rapid detection of aggressive chemicals and suggests scientific, methodological and technological approaches to the development of a universal set of tools for group rapid detection of aggressive chemicals and uranium compounds in water and on the surfaces of objects using aerosol devices with original indicator formulations. The place of research is Moscow and the Moscow region

1 Introduction

In the state policy of the sphere of national security of the Russian Federation, a significant direction is to ensure the chemical and biological safety of employees of enterprises and the population, thereby representing a set of coordinated measures of the civil defense forces and the forces of the unified state system for the prevention and liquidation of emergency situations. These actions are aimed at providing radiation, chemical and biological protection of the population in the face of the threat of natural and man-made emergencies, as well as in the event of dangers arising from military conflicts or as a result of these conflicts [1].

In accordance with the Action Plan for the implementation of the updated version of the Concept of Radiation, Chemical and Biological Protection of the population, it is planned to develop modern methods and effective technologies in the field of HCB protection

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(hereinafter - the Plan). This plan will contain information about new methods for determining water contamination with hazardous chemicals.[1]. Acidic and alkaline substances, as well as oxidizing agents and reducing agents, are usually considered as aggressive chemicals (hereinafter - AHV).

Currently, field chemical laboratories (AL-4M, AL-5, PCL-1, PCL-2, PCL-54M, PLVS, MPHL.) are used to detect contamination (contamination) of water. The negative factor of these laboratories is that only poisons and toxic substances can be determined with their help.

The detection method may include indicator wipes of the "Deicont-chlorine" type [2]. But they cannot be applied at temperatures below 5 °C.

Also, universal indicator paper was previously used for detection on the surface and in water, but there was not enough sensitivity to determine the pollutant.

All methods of detecting AHS currently have the same short shelf life, which is a maximum of 12 months and a one-time use and a limited temperature regime.

The advantages of the developed kit are that the creation of a set of aerosol devices will ensure multiple use, greater mobility, accessibility for use for various purposes, that is, it will quickly detect aggressive chemicals of various types on large surfaces of various objects, and will also ensure the preservation of operability for 2 years.

The solution of this problem is possible by improving existing and developing new means and methods of rapid detection of water pollution, primarily by aggressive chemicals, which was the purpose of this study

2 Objects and methods of research

Oxidizing agents include: nitric acid, concentrated sulfuric acid, calcium hypochlorite and others.

Aggressive toxic reducing agents include dimethylhydrazine derivatives, in particular heptyl rocket fuel (asymmetric dimethylhydrazine).

Acidic substances include strong (sulfuric, nitric, hydrochloric and others) and weak (acetic, formic and others) acids.

Alkaline substances include strong (potassium hydroxide, sodium hydroxide and others) and weak (ammonium hydroxide and others) bases.

Let's consider the characteristics of some aggressive emergency chemically hazardous substances.

Hydrazine and its derivatives, such as monomethylhydrazine (methylhydrazine), 1,1-dimethylhydrazine (asymmetric dimethylhydrazine, NDMG), etc., are widely used in economic activities in the production of plastics, dyes, herbicides and medicines [1-3]. This substance is actively used in rocket and space activities, in which these compounds are used as components of highly efficient rocket fuel. Being an extremely toxic substance of the first hazard class and having the ability to accumulate in natural ecosystems, as well as give other highly toxic and carcinogenic products (hydrazine, methylhydrazine, nitrosodimethylamine, tetramethyltetrazene, etc.) during decomposition, 1,1 dimethylhydrazine is considered as one of the main factors causing the environmental danger of rocket and space activities.

There are also problems in the process of turnover of oxidizing substances (bromine, sulfuric acid, etc.) as they are highly flammable and toxic. In this regard, these substances are transported and stored in special containers, as they are highly toxic and in case of emergency situations can lead to severe infection and death of people.

Sodium hydroxide (food additive E524, caustic soda, sodium hydroxide, caustic soda). This substance is toxic, destroys the mucous membrane and causes severe skin burns. When

working with this substance, it is necessary to wear special clothes, glasses and gloves, since contact with the substance in the eyes most often leads to loss of vision.

The development of a universal rapid detection kit for aggressive chemicals, rocket fuel components and uranium compounds is necessary to help identify a specific aggressive chemical and its subsequent elimination.

3 Results and their discussion

The solution to this problem is possible by improving existing and developing new means and methods of rapid detection in various environments, primarily with aggressive chemicals. And also for the possibility of assessing the contamination of objects, samples of food and emergency chemicals.

The scientific novelty of the work was to create a universal set of express detection and group identification of aggressive chemicals, rocket fuel components and uranium compounds in water.

The practical significance of the work consisted in the development of indicator compositions for aerosol devices and a mock-up of a set of tools for rapid detection of aggressive chemicals, rocket fuel components and uranium compounds in various environments.

Ensuring chemical safety in railway transport, at enterprises of food and related industries and the population is one of the priorities of state policy in the field of national security of the Russian Federation.

Thus, the development of an express detection kit for aggressive chemicals is proposed, aimed at providing radiation, chemical and biological protection of the population in the face of the threat of natural and man-made emergencies, as well as in the event of hazards arising from military conflicts or as a result of these conflicts.

Universal Chemical Express laboratory for indicating the presence of aggressively chemically hazardous substances (UHL) (hereinafter – AHS) and uranium compounds on the surface and in water.

The kit for detecting AHS and uranium compounds consists of a case with a liner, 6 push-button spray pumps (2), decontaminated filters (3) (100 pieces), 6 aerosol devices, 5 water containers, labels, a pen and a notebook:

- aerosol device AU-2 this device is used for the detection of alkaline substances in various environments;
- aerosol device AU-3 this device is used to detect acidic substances in various environments;
- aerosol device AU-5 this device is used for the detection of reducing agents in various environments;
- aerosol device AU-6 this device is used for the detection of oxidizing substances in various environments;
- aerosol device AU-9/1 this device is used to convert uranium compounds into soluble salts;
- aerosol device AU-9/2 this device is used to detect soluble salts of uranium compounds in various media.

AU with indicator formulations should provide at least 50 detection of contamination of the surfaces of objects with a single charge of the formulation.

The designated shelf life with indicator formulations should be at least 2 years.

The set of aerosol devices must be resistant to the following climatic influences:

- temperature from minus 40 ° C to plus 50 ° C;
- cyclic temperature changes from minus 10 ° C to 50 ° C;
- relative humidity from 45% to 75%;

- atmospheric pressure from 86 kPa to 106 kPa (from 645 mmHg to 794 mmHg);
- frost and dew.

Aerosol devices included in the UHL, in the presence of contamination of the AHS surface, provide a visual indication effect with reliable information about the detected substances of the AHS group and uranium-containing compounds in accordance with the standard applied on the aerosol device for a period of no more than 1 minute.

All products for the development of a universal kit for rapid detection of aggressive chemicals, rocket fuel components and uranium compounds in various environments.

The appearance of the case for placing a universal set of tools in the open position is shown in Fig. 1

Patents for inventions were previously obtained for indicator compositions for the detection of NDMG and oxidants [3,4].

The difference of the aerosol device is that it is easy to use, the ability to control large, including hard-to-reach analyzed areas with one package. Spraying of the indicator formulation is carried out by repeatedly pressing the spray head of the aerosol device. For detection, the operator does not need contact with the examined surface, since spraying is carried out at a distance of 10-15 cm from the surface on the windward side. The appearance of an indicator effect in accordance with the standard applied to the aerosol device indicates the presence of the specified type of AHS on the surface.

Fig. 1. The appearance of the case for placing a set of tools in the open position.

As an example, Figure 2 shows the appearance of aerosol devices and the nature of the indicative effects of aggressive alkaline chemicals, Figure 3 of acidic substances, Figure 4 of oxidative substances, Figure 5 of asymmetric dimethylhydrazine and ammonia, Figure 6 of uranium compounds.

a) b) c)

Fig. 2. a) AU-2 (front and rear view) and the indicative effect of various concentrations of alkaline substances (ammonia, sodium hydroxide); b) front view; c) top view

a) b) c)

Fig. 3. a) AU-3 (front and rear view) and the indicative effect of various concentrations of acidic substances (hydrochloric acid, nitric acid); b) front view; c) top view

a) b) c)

Fig. 4. a) AU-6 (front and rear view) and the indicative effect of various concentrations of oxidizing substances (nitric acid, concentrated sulfuric acid); b) front view; c) top view

a) b) c)

Fig. 5. a) OU-5 (front and rear view) and the indicative effect of different concentrations of NDMG; b) front view; c) top view

a) b) c)

Fig. 6. a) 9/2 (front and rear view) and the indicative effect of different concentrations of uranium nitrate; b) front view; c) top view

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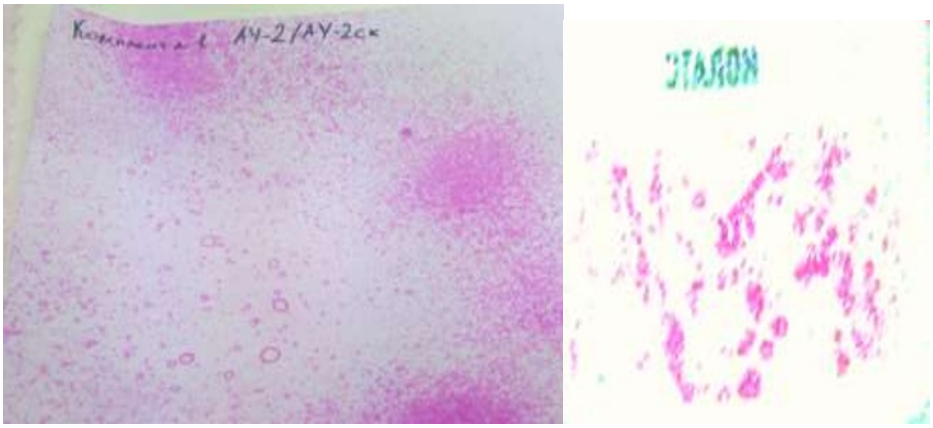

Fig. 7 The nature of the indication effect on the surface of the object from aggressive alkaline chemicals

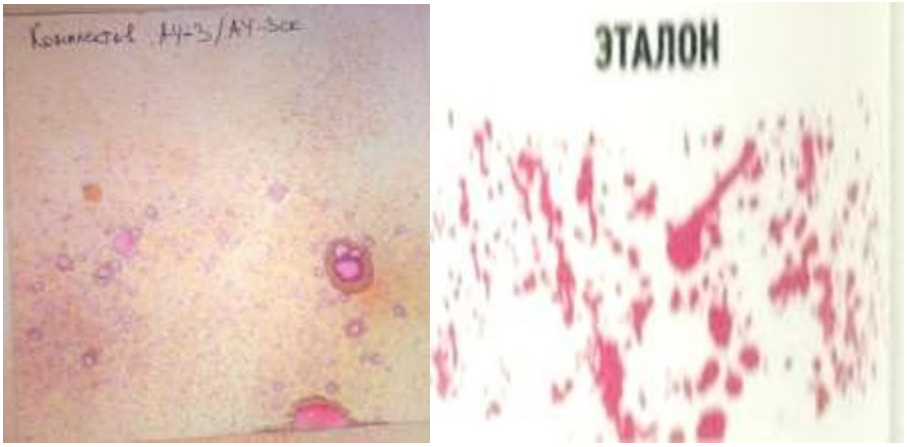

Fig. 8 The nature of the indication effect on the surface of the object from aggressive acidic chemicals

Fig. 9 The nature of the indication effect on the surface of the object from the NDMG

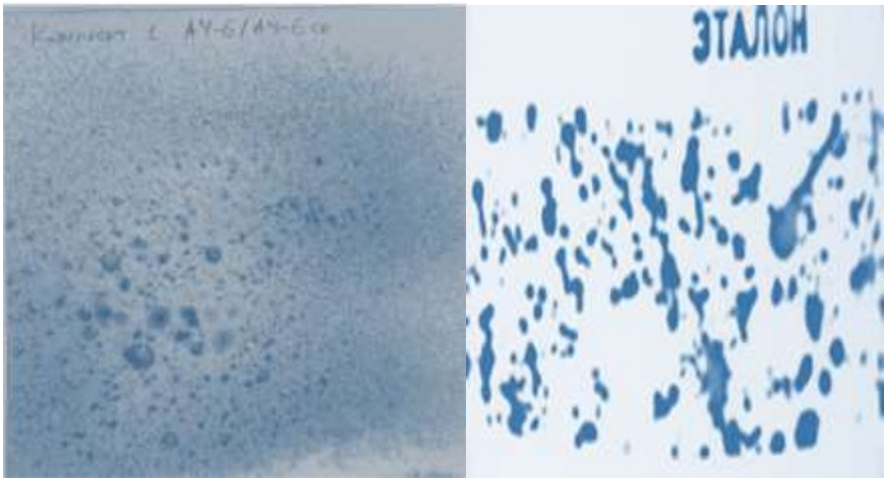

Fig. 10 The nature of the indicative effect and oxidative products

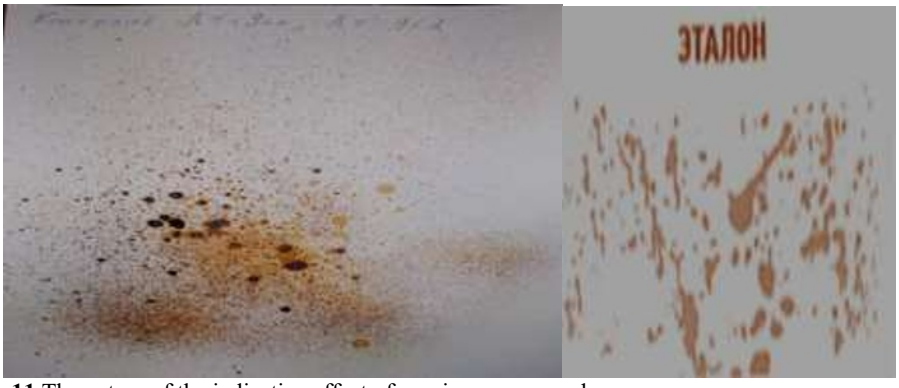

Fig. 11 The nature of the indicative effect of uranium compounds.

If the type of AHS contamination in the water is not known, then 4 water samples are taken and detected sequentially by all four above-mentioned aerosol devices, as indicated above.

If the color of the selected water sample masks the indication effect, then sampling is

carried out by immersion in water of de-salted filters or adding water to them and detection of water contamination is carried out on these filters.

Detection of the type of contaminant in the water is carried out by a combination of the emerging indication effect from four aerosol devices.

In the case of using one plastic or glass container, if an unknown AHOV is detected in the water after the first detection, the analyzed water sample is poured out, the container is washed three times with the test water and a second water sample is taken for the second detection. These operations are repeated four times with aerosol devices with different indicator formulations.

Thus, rapid group detection of the type of aggressive chemical substance is achieved, increasing sensitivity, multiplicity, safety and reliability of detection.

The relevance of this kit lies in the fact that this development will help

1. Determine the contamination of the surface, since in the presence of aggressive chemicals, a visual indication effect will be carried out with reliable information about the detected substances of the AHOV group and uranium-containing compounds in accordance with the standard applied on the aerosol device for a period of no more than 1 minute.

2. Determine as quickly and accurately as possible which aggressive chemical hazardous substance this compound belongs to.

4.The kit is designed to be able to work with vertical and inclined surfaces made of various materials. It will also be able to determine the substance in the presence of contaminants (fuel, oils, corrosion products).

5. The kit will help determine the oxidizer during precipitation or after dilution with surface waters. It also assumes the possibility of multiple use of a single aerosol device.

6. It will reduce the possibility of rapid spread across the study area and will help to quickly eliminate the source of chemical contamination

4 Conclusions

A model sample of a universal kit for rapid detection of aggressive chemicals, rocket fuel components and uranium compounds in various media is proposed.

The developed set of means for express detection of contamination of water and surfaces of objects and equipment is advisable to use in solving environmental issues and ensuring safety at enterprises and railway facilities.

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