RETROSPECTIVE ANALYSIS OF PERSONAL PROTECTIVE EQUIPMENT, THEIR PURPOSE, AND CLASSIFICATION

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Abstract: *The article examines the history of the origin and development of filtering and insulating gas masks, filter-type personal protective equipment, as well as the development of various types of skin protection products made of insulating materials based on synthetic rubbers.*

Keywords: *insulating skin personal protective equipment, rubber, polyethylene, toxic chemical, rubberized fabric, light radiation, collective protective equipment.*

Considering the history of the creation and development of protective equipment, it can be said that the evolution and improvement of the theory and technology of individual and collective protection means are directly influenced and closely interconnected with the development of the type of weaponry against which they are designed to protect. Each new achievement in the field of chemical weapons and other weapons of mass destruction immediately impacted the development of protective equipment technology. Conversely, each improvement in protection spurs offensive technology to seek out new means of attack.

The history of the inception and development of protective equipment should be attributed to the period of World War I. The combat use of mass destruction weapons by the German army, specifically chlorine, on April 22, 1915, led to the emergence of the first protective equipment. Troops began to produce and use cotton-gauze bandages soaked in a solution of hyposulfite, soda, and glycerin in water. Later, wet gas masks in the form of multilayer gauze half-masks (face masks) with protective goggles were created.

With the appearance of new toxic chemicals (hereinafter referred to as TC), the impregnation of wet gas masks became more complex, and their design was improved. However, wet gas masks operating on the principle of chemical interaction could not provide protection against chemically inactive substances. This issue was rationally addressed by Russian chemist Nikolay Dmitriyevich Zelinsky, who proposed using dispersed activated charcoal with a developed porous structure to absorb TC vapors. The principle of TC absorption by charcoal in the gas mask box, proposed by N. Zelinsky in 1915, was based on the physical phenomenon of adsorption. From that moment, adsorption, a simple and universal method of absorbing TC vapors, firmly entered the technology of protective equipment.

The necessity of having skin protection equipment in the troops was identified after the Germans used mustard gas in 1915. The first samples of skin protection equipment were protective suits made primarily of oiled and treated fabrics. This was the initial period of skin protection equipment development, and their protective and operational properties were still quite imperfect.

Systematic development of skin protection equipment began in the first half of the 1920s, with more intensive development occurring from the late 1920s to the early 1930s. This development followed two main directions. One direction was the development of insulating (air-tight) materials and the creation of skin protection equipment of various designs based on them.

The first officially adopted example of such protective equipment for the Soviet army was a sample of hermetically sealed insulating clothing - a jumpsuit made of treated fabric. It was adopted together with rubber gloves.

An important stage in the development of various types of skin protection equipment from insulating materials was the use of synthetic rubbers for these purposes. Rubberized protective fabrics based on synthetic rubbers were found suitable for the production of insulating-type protective clothing.

Between 1931 and 1937, fabric was developed using butadiene rubber type SR-01 (synthetic rubber, first sample). After the war, the formulation and technology for fabric production changed. The SR-01-K fabric was developed, and later the MFS-01 (modernized first sample) fabric.

The use of new synthetic rubbers, especially saturated ones (polyisobutylene, butyl rubber), which are significantly more impervious to toxic substances (hereinafter referred to as TS) than sodium butadiene rubber, allowed for lighter protective fabrics and products made from them. In 1944, a lightweight protective suit L-1 was developed based on rubberized protective fabric VKSh-151 (vistane fabric) with a polyisobutylene coating.

The post-war development of skin protection equipment is characterized by the further improvement of formulations and manufacturing technology of rubberized fabrics (SR-01-K based on SKV, MSC-01-K, MVKSH-151, NMF based on blends including butadiene rubber, polychloroprene, and polyisobutylene, etc.), as well as the design of protective clothing. These fabrics are still used today for the production of protective overalls, lightweight protective suits, and protective stockings. An important stage in the development of protective materials was the creation of fabrics based on butyl rubber. The efforts to improve skin protection equipment resulted in the adoption in 1958 of the all-army protective cloak OP-1, which remains a multipurpose protective tool and is part of the all-army protective kit (APK) (OP-1 cloak, protective stockings, and gloves). In the 1970s, work was carried out to modernize and improve butyl rubber-based fabrics for the manufacture of cloaks and stockings on a semi-nylon textile base, to enhance their durability (BCK and BC-UT fabrics, T-15).

The first samples of gloves were also made from rubberized fabric. Later, more advanced gloves with better protective and operational properties, made

of butyl rubber without a textile frame, were developed.

The second direction in the development of skin protection equipment was the creation of filtering (airtight) protective clothing. In terms of sanitary and hygienic properties and appearance, it is similar to ordinary military uniforms and, unlike insulating clothing, can be worn constantly. The development of such clothing, known as impregnated uniforms (and underwear), began in the 1930s. In 1937, the Soviet army adopted impregnated uniforms with U-12 impregnation, whose protective properties were based on the principle of absorption

of TS vapors by impregnation components.

In 1952, the Soviet army adopted impregnated uniforms treated with the "DG" formulation based on chloramine, which had sufficiently high protective properties against mustard gas vapors and provided some protection against

VX-type TC aerosols. The need to protect the skin not only from TC but also from the light radiation of a nuclear explosion posed complex challenges

in developing protection means for continuous or long-term periodic wear. These challenges led to the development of multi-layered filtering protective clothing samples.

One such sample is the all-army integrated protective suit (hereinafter referred to as AIPS), adopted in 1969 and subsequently modernized into versions like AIPS-M, AIPS-D, KZO, KZO-L. All these versions are filtering-type skin protection means, providing protection not only from TS but also from the light radiation of a nuclear explosion. Additionally, to ensure protection from the light radiation of a nuclear explosion (hereinafter referred to as LRNE), the protective suit KZS was adopted in 1975.

Collective protection means also appeared during World War I as a means of group chemical protection. The first developments of collective protection means in our country date back to 1926-1928 when the properties of earth filters were studied, and designs for wooden filters equipped with bellows and loaded with activated carbon, chemical absorbent, and anti-aerosol cotton filter were proposed.

From 1928 to 1931, the development and production of sealing and filter ventilation systems by the industry began, as well as equipping fortified area structures with these systems.

In 1934-1935 and later, the industry produced various types of absorbent filters, fans, ventilation units of different capacities, and oxygen-regenerative installations. The first attempts to equip mobile objects with collective protection means (headquarters buses, sanitary vehicles, and wagons) in the USSR date back to 1933-1935.

The improvement of collective protection measures and the refinement

of several operational issues were carried out during the war, starting in 1943, and in the post-war period. With the emergence of nuclear weapons, the importance of collective protection measures significantly increased, and the requirements for them expanded simultaneously. There arose a need to protect troops from various damaging factors of nuclear, chemical, and biological weapons.

Currently, the troops are equipped with various filter ventilation units designed for equipping both permanent and special construction facilities, as well as various field-type military structures. Particular attention is given to creating collective protection means for mobile objects of automotive and armored vehicles, allowing personnel to operate without protective equipment inside the objects. For these purposes, various types of filter ventilation units, kits, and installations (FVA-100/50, FVA-50/25, FVK-75, FVK-200, FVUA-100, FVUA-100A, tank FVU-100 and FVU-200) were developed. For non-sealed automotive and armored vehicles, collector-type filter ventilation units (FVU-3.5, FVU-7, FVU(A)-15, FVU-20) were created.

Thus, as a result of the work of several generations of workers, scientists, and engineers, the Armed Forces currently possess the necessary means of individual and collective protection.

In the field of development and improvement of individual protection means, the following directions are considered promising:

Development of methods that model the physical, physicochemical, and physicomechanical processes occurring during the combat operation

of individual protection means, testing methods, and evaluation of the protective properties of individual protection means using TC and BS simulators.

Search for new, including unconventional, methods of air purification and regeneration, promising protective materials, sorbents, catalysts, combined filtering materials, etc.

Development of materials that provide comprehensive protection against modern and potential weapons based on chemical, biological, and physical principles of damaging action.

Development of an integrated system of technical protection means based on the principles of dynamic protection and individual and collective life support systems.

Exploration of ways to introduce new methods of air purification into individual protection means (molecular sieves, plasma electric discharges, nuclear, track, and other semipermeable membranes, etc.).

Development of new, more efficient, and cost-effective methods of air regeneration based on the use of devices with chemically bound oxygen and solid oxygen sources.

The maintenance of combat readiness of troops in conditions of the enemy's use of weapons of mass destruction (hereinafter referred to as WMD)

or participation in the elimination of consequences of accidents at nuclear power plants (hereinafter referred to as NPP) and chemical industry facilities is ensured by implementing measures for radiation, chemical, and biological (hereinafter referred to as RCB) protection of troops, among which the use of technical means protecting personnel from the damaging factors of a nuclear explosion, toxic chemicals, and bacterial agents plays an important role.

The most crucial place among them belongs to the means of individual and collective protection designed to provide direct protection for personnel. Skillful and timely use of these means can almost completely eliminate the damage

to personnel from chemical and bacteriological weapons, significantly weaken the impact of the light radiation of a nuclear explosion (hereinafter referred to as LRNE), protect personnel from radioactive dust contamination, reduce the effectiveness of being hit by incendiary substances, and protect against hazardous chemicals (hereinafter referred to as HC). Moreover, an important role is given to providing personnel and units with necessary individual and collective protection means and maintaining them in constant readiness for use.

Radiation, chemical, and biological protection involves organizing and implementing a series of measures aimed at minimizing the effects of weapons of mass destruction and maintaining the combat readiness of troops, rear survivability, and ensuring the successful completion of assigned tasks.

Personal and collective protective equipment provides direct protection for personnel.

The most important tasks addressed using modern individual and collective protection means include:

protection from the damaging factors of nuclear weapons;

protection from chemical weapons of a potential enemy;

protection from biological weapons;

protection from incendiary substances.

Based on their purpose, individual and collective protection means can be divided into the following groups:

1. Protection means against weapons of mass destruction:

for Armed Forces personnel;

for civilians.

2. Protection means against toxic chemicals and radioactive substances for personnel of radiation and chemically hazardous facilities.

3. Protection means for personnel of emergency rescue units (groups).

In the system of measures for protecting personnel and civilians under conditions of radiation, chemical, and biological contamination during combat actions involving weapons of mass destruction, as well as in the event of the destruction of radiation and chemically hazardous facilities in wartime and peacetime, technical individual and collective protection means play an important role.

Protective equipment serves two main purposes:

Protecting personnel from inhalation, skin-blistering, and skin-resorptive effects of harmful substances and ionizing radiation of radionuclides present in contaminated air, on the surfaces of moving objects of armaments and military equipment, and on contaminated production equipment and products.

Maintaining the working capacity of personnel.

The fulfillment of the first task is determined by the level of protective properties and reliability of the protective equipment, as well as the training of military personnel, emergency rescue squads, and industrial personnel in the skillful and timely use of protective equipment.

The fulfillment of the second task is determined by the level of ergonomic characteristics of personal protective equipment (PPE) and living conditions in collective protection facilities (CPF). This is reflected in the quality and time of performing tasks in PPE, as well as in the presence of personnel in moving objects of armaments and military equipment, and in the premises of stationary objects.

The common requirements for PPE and CPF are the complete sheltering of personnel from the direct effects of nuclear explosion factors, contaminated atmosphere, and contaminated surfaces, as well as the equivalence of protection of the components of the individual protection equipment complex.

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