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ABOUT THE POSSIBILITY OF JUSTIFIED DECISIONS ON THE CHOICE OF MATERIALS FOR COMFORT SUITS FOR ARCTIC EMPLOYEES

Abstract: *The article presents the results of research on the creation of a suit and accessories to protect employees from the cold in the Arctic. When developing a heat-protective clothing set, the authors draw attention to the fact that the requirements for thermal insulation of all areas of the body should be met. Particular attention must be paid to protecting the hands and face. Considering that previously conducted studies on the choice of a package of materials for knee pads and elbow pads did not ensure the formation of comfortable conditions for servicemen in the Arctic when they were in climatic zones with low temperatures, the authors developed a software product that allows the manufacturer to reasonably choose a set of materials for a suit along with accessories that guarantee servicemen comfortable conditions during the entire period of its service in climatic zones with low temperatures.*

Key words: *thermal protective clothing, accessories, cooling, materials package, employees, Arctic conditions, software product, mathematical models, comfort, boundary value problem, climatic zones, time of exposure to low temperatures.*

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Introduction

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An extensive program for the development of the Arctic required from costume manufacturers a substantial justification for the choice of a package of materials to ensure that those employed when working in climatic zones with low temperatures provide them with comfortable conditions. Therefore, it is understandable that heightened attention to the Arctic of all of Russia, which is provoked by the desire of the leaders to equip it and make the life of employeescomfortable,able to fulfill their statutory duties at the proper level. One of the main conditions for the performance of these tasks is the formation of a suit for employees, in which they will really have access to all the actions that are formed by the conditions for their work, and at the same time they will be guaranteed a comfortable state during the entire time they are in climatic zones with low temperatures.

The main tasks in the field of development of science and technology for the development of the Arctic will be achieved through the following set of measures:

a) development and implementation of a comprehensive program of fundamental and applied research for the development of the Arctic, including in the field of industrial robotics, supercomputer modeling, geocryology (permafrost science), glaciology, geology, geomorphology, mineralogy, oceanology, geophysics, unmanned transport systems, remote sensing Land, renewable and portable energy sources, medical care and methods of accelerated adaptation to Arctic conditions, industrial hygiene and occupational medicine, Arctic biology and biotechnology, Arctic ecology, hydrometeorology, construction on permafrost, integrated navigation and communication facilities;

b) development of an international research program (including expeditionary ones) of the state of the Arctic ecosystems, global climatic changes and the study of the Arctic;

c) formation of a register of critical technologies for the development and sustainable development of the Arctic, creation of a mechanism for coordinating their development and financing;

d) construction of a drifting ice-resistant self-propelled platform and research vessels for the purpose of research and study of the Arctic;

e) performing hydrographic research to ensure the safety of navigation, as well as long-term hydrographic research, including deep-water research, to study the underwater environment;

f) ensuring the creation of new functional and structural materials necessary for the implementation of economic activities in the Arctic;

g) creation of a system of scientific and educational centers in key areas of fundamental and applied research in the interests of developing the Arctic;

i) development of a system for monitoring, assessing and forecasting the development of science and technology in the Arctic zone.

Main part

The urgency of the problem of creating a suit for protection from the cold is confirmed by numerous studies in this area, conducted by domestic and foreign scientists. Currently, one of the directions for developing a suit for the Arctic conditions is the field of professional clothing, in particular, clothing for the needs of the federal authorities. Survival in the polar regions directly depends on the consumer's body temperature, more precisely, its preservation. And this is only possible with a suit.

The first requirement for a suit in the Arctic is layering.

The top layer should be moisture resistant, the middle layer should contain woolen fibers (preferably), or synthetic, the inner layer of the suit should have good air permeability. The second requirement is that the suit must be comfortable. This is ensured by sufficient air circulation and does not provoke overheating of the soldier's body. The set of equipment for the Arctic serviceman includes clothing, a protective bulletproof helmet, chemical and biological protection clothing, warm clothing, a rescue bag, a tent and a parachute. Such a kit should provide protection and survival in a variety of climatic and combat conditions.

Currently, in connection with the new conditions for the presence of employees in the Arctic regions, the quality, efficiency of protective clothing for various purposes and, first of all, army protective clothing, is being improved very quickly and revolutionary, using the latest advances in the field of nanomaterials and technologies. According to American scientists, whose research is available in the open press, the use of modern protective clothing in the US Army has allowed them to reduce casualties in hot spots by 15%. Discomfort can cause a decrease in activity, especially in relation to solving problems associated with neuro-emotional stress, with the need to concentrate, and also increase the risk of occupational accidents and injuries. Moreover, cooling of tissues can lead to decreased physical activity, which contributes to the risk of accidents.

Cooling of a person, both general and local (especially of the hands), contributes to a change in his motor activity, disrupts coordination and the ability to perform precise operations, causes the development of inhibitory processes in the cerebral cortex, which can be the cause of injury. With local cooling of the hands, the accuracy of the combat mission decreases; activity decreases by 1.5% for each degree of decrease in the temperature of the fingers.

The above means that a set of thermal protective clothing intended for work in open areas, in particular in climatic regions I A and I B ("special" and IV climatic zones), must include protective equipment for the face and respiratory system.

The hands and feet play an important role in thermoregulation, being specific heat exchangers between the body and the environment. The state of thermal comfort is provided at a foot skin temperature of 29–31 ° C and a heat flux of 52–87 W / m2. The thermal resistance of the tissues remains within the range of up to 0.3 clo. The creation of clothing for protection from the cold in climatic region IA is a very difficult task, since the thermal insulation capacity of clothing is largely determined by the thickness of the package of materials, an increase in which may be one of the reasons for a decrease in human performance. It is very difficult to provide the necessary protection against cooling of the surface of the head (including the face), hands, feet, due to the low efficiency of their insulation.

The use of materials with low air permeability and closed construction for protection from wind exposure can lead to the accumulation of moisture in the garment and reduce its thermal insulation, especially when performing intense physical work.

Taking into account the peculiarities of climatic conditions (cooling of the face, respiratory organs) and the real possibility of creating clothes for carrying out activities, the duration of continuous stay in the cold was taken to be no more than 2 hours for climatic region IA and 1 hour for region IB. In this case, it was taken equal to 52 W h / m2, which corresponds to the lower limit of the permissible thermal state.

For climatic regions I A and I B, the value of the weighted average heat flux from the surface of the human body should be 98.0 and 107.0 W / m2, respectively. Taking this into account, to ensure a given thermal state of a person at a temperature of relatively calm air (–24.4 ° C –41.0 ° C), the thermal insulation of the kit should be 0.560 and 0.668 ° C · m2 / W, respectively.

In real conditions, the amount of thermal insulation is influenced by the wind factor, as well as by physical activity. The above values should be adjusted for corrections for combined exposure to wind and physical activity for a set of clothing that includes an insulated overalls or jacket with trousers (or semi-overalls).

Taking into account the average of the most probable wind speed values in the climatic region IA (6.8 m / s), for the manufacture of an insulated suit, you should choose a top material that has low air permeability (approximately 7 dm3 / m2 s), but sufficient moisture permeability (≥ 40 g m2 / h). For region IB, it is advisable to use materials of the same breathability due to the large temperature difference between the outside air and under clothes.

Based on this, heat-protective clothing should have thermal insulation of 0.709 ° C m2 / W (4.6 klo) and 0.728 ° C · m2 / W (4.7 klo) (1 klo = 0.155 ° C · m2 / W).

Previous studies on the assessment of selected materials for the formation of overhead bags on the knee and elbow joints of employees for their suitability to ensure their comfortable state and prevent their chronic diseases - arthritis and arthrosis - using the software developed by the authors did not confirm the formation of a comfortable state of employees.

The authors continued the search for new materials, including those made using nanotechnology from the groups of hot-melt adhesive cushioning materials (TKPM), the characteristics of which are given in Table 1.

The paper considers the process of cooling the surface tissues of the knee and elbow of a serviceman when exposed to low temperatures.

The characteristics of the materials under study are shown in Table 1.

Table 1 - Characteristics of a package of materials for the protection of knee and elbow joints using hot-melt interlining materials (TKPM).

Model	Package materials	Thickness, mm	Heat conductivity coefficient λ, W / m · ° C
1	2	3	4
Model 1	cotton linen	0.9	0.044
	Wool sweater or pants	2.4	0.027
	Nylon lining	1.6	0.042
	Thinsulate insulation (one main layer) Gasket materials: 1. TKPM "Picardy" 1242/17 2. TKPM "Kufner" R171G57 3. TKPM "Kufner" B141N77 4. TKPM AKR-622 / AKR218	6.0 1,2 1,3 2.1 3.5	0.044 0.041 0.031 0.021 0.009

	Arctic-tech - outer layer (85% PE + 15% cotton)	1.8	0.041
	Arctic-tech (knee pad or elbow pad)	1.8	0.041
Model 2	Thermal underwear	1.76	0.039
	Wool sweater or pants	2.4	0.027
	Nylon lining	1.6	0.042
	Thinsulate insulation (two main layers) Gasket materials: 1. TKPM "Picardy" 1242/17 2. TKPM "Kufner" R171G57 3. TKPM "Kufner" B141N77 4. TKPM AKR-622 / AKR218	 12 1,2 1,3 2.1 3.5	 0.036 0.041 0.031 0.021 0.009
	Arctic-tech - outer layer	1.8	0.041
	Foam rubber - damper	2.2	0.027
	Arctic-tech (patch pocket)	1.8	0.041

For the description, a mathematical model is built in the form of a boundary value problem:

$$\frac{\partial T_i}{\partial t} = a_i \left(\frac{\partial^2 T_i}{\partial r_i^2} + \frac{2}{r_i} \frac{\partial T_i}{\partial r_i} \right) + \frac{q_{iv}}{c_i \rho_i}, \quad i = 1, 2, \ldots n,$$

$$T_1(0,t) \neq \infty; \quad \lambda_n \frac{\partial T_n}{\partial r_n}(R_n, t) + \alpha(T_n(R_n, t) - T_c) = 0;$$

$$T_{i-1}(R_{i-1}, t) = T_i(R_{i-1}, t);$$

$$\lambda_{i-1} \frac{\partial T_{i-1}}{\partial r_{i-1}}(R_{i-1}, t) = \lambda_i \frac{\partial T_i}{\partial r_i}(R_{i-1}, t), \quad i = 2, \ldots n.$$

Initial conditions, where t is time; Ti is the temperature of the i-th layer; i = 1, ... n; Tc -, ambient temperature; ci - coefficient of heat capacity of the i-th layer; ai - coefficient of thermal diffusivity of the i-ro layer; ρi - density of the i-ro layer; λi - coefficient of thermal conductivity of the i-ro layer; qiv is the volumetric density of the heat flow of the i-ro layer; α is the coefficient of heat transfer from the surface of the skin or protective layer (hair, hat); fi (ri) - initial temperature of the i-ro layer. $T_i(r_i, 0) = f_i(r_i)$

The solution to the problem is in the following form

$$T_i(r_i, t) = \sum_{k=1}^{\infty} D_k(t) X_{k,i}(r_i),$$

where are the eigenfunctions of the corresponding boundary value problem:

$$X_{k,i}(r_i) = \frac{1}{r_i} \left(A_i \sin\left(\frac{\mu_k r_i}{\sqrt{a_i}} \right) + B_i \cos\left(\frac{\mu_k r_i}{\sqrt{a_i}} \right) \right)$$

$$\frac{\partial^2 X_i}{\partial r_i^2} + \frac{2}{r_i} \frac{\partial X_i}{\partial r_i} + \frac{\mu^2}{a_i} X_i = 0,$$

$$X_1(0,t) \neq \infty; \quad \lambda_n \frac{\partial X_n}{\partial r_n}(R_n) + \alpha X_n(R_n) = 0;$$

$$X_{i-1}(R_{i-1}) = X_i(R_{i-1});$$

$$\lambda_{i-1} \frac{\partial X_{i-1}}{\partial r_{i-1}}(R_{i-1}) = \lambda_i \frac{\partial X_i}{\partial r_i}(R_{i-1}).$$

When analyzing the effect of the selected materials (Figure 1, 2), which are recommended for the formation of packages on the elbow and knee joints, we can confidently conclude that the Arctic serviceman will be guaranteed protection against arthrosis and arthritis.

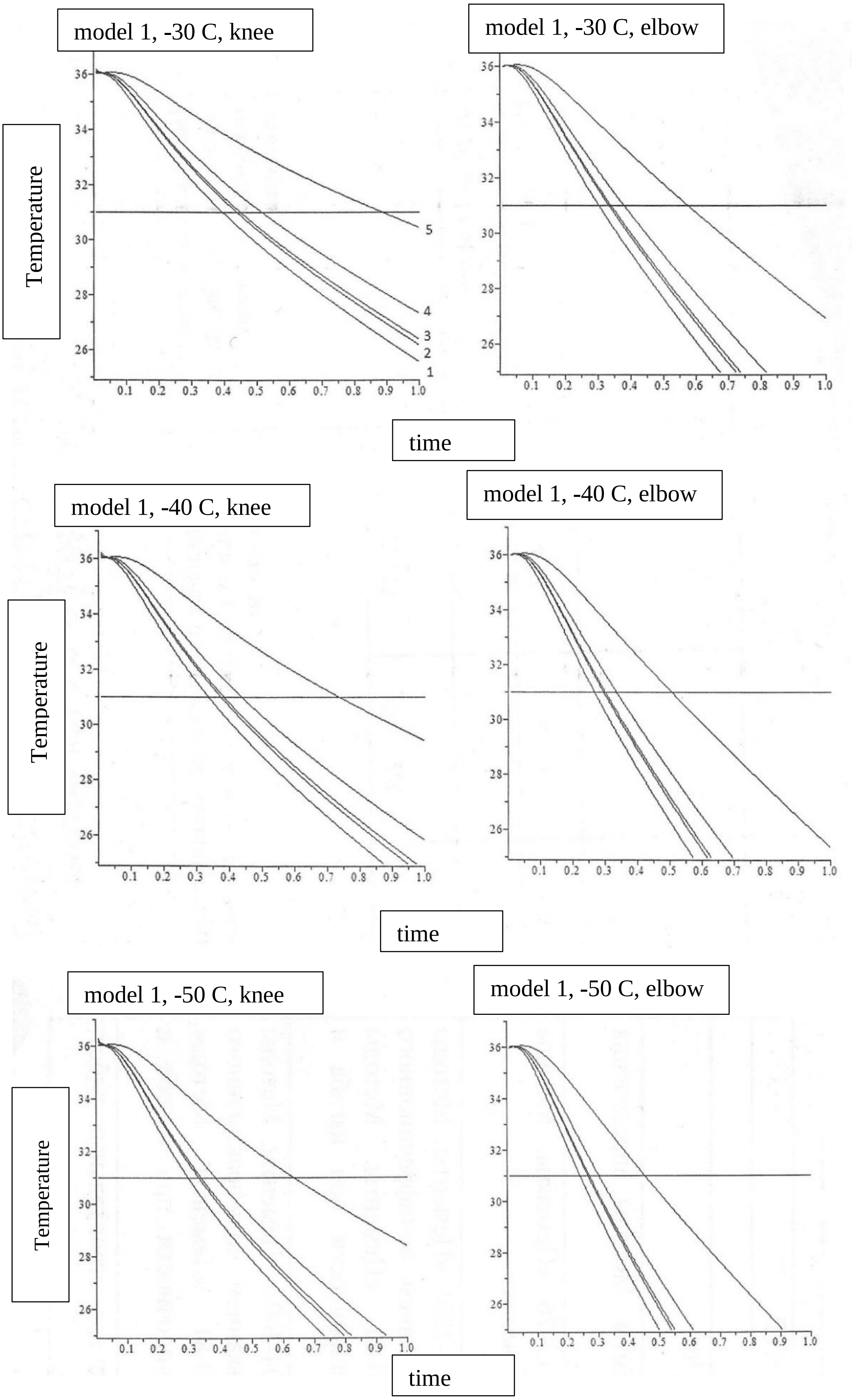

Figure 1 - Characteristics of the state of comfort of the skin of the elbow and knee of a serviceman when he is in the zone with a temperature of –30 ° C, –40 ° C, –50 ° C for a package of materials of model 1, where the curves: 1 - without cushioning material, 2 - TKPM " Picardies "1242 \ 17, 3 - TKPM" Kufner "R171G57, 4 - TKPM" Kufner "B141N77, 5 - TKPM AKP-622 \ AKP218

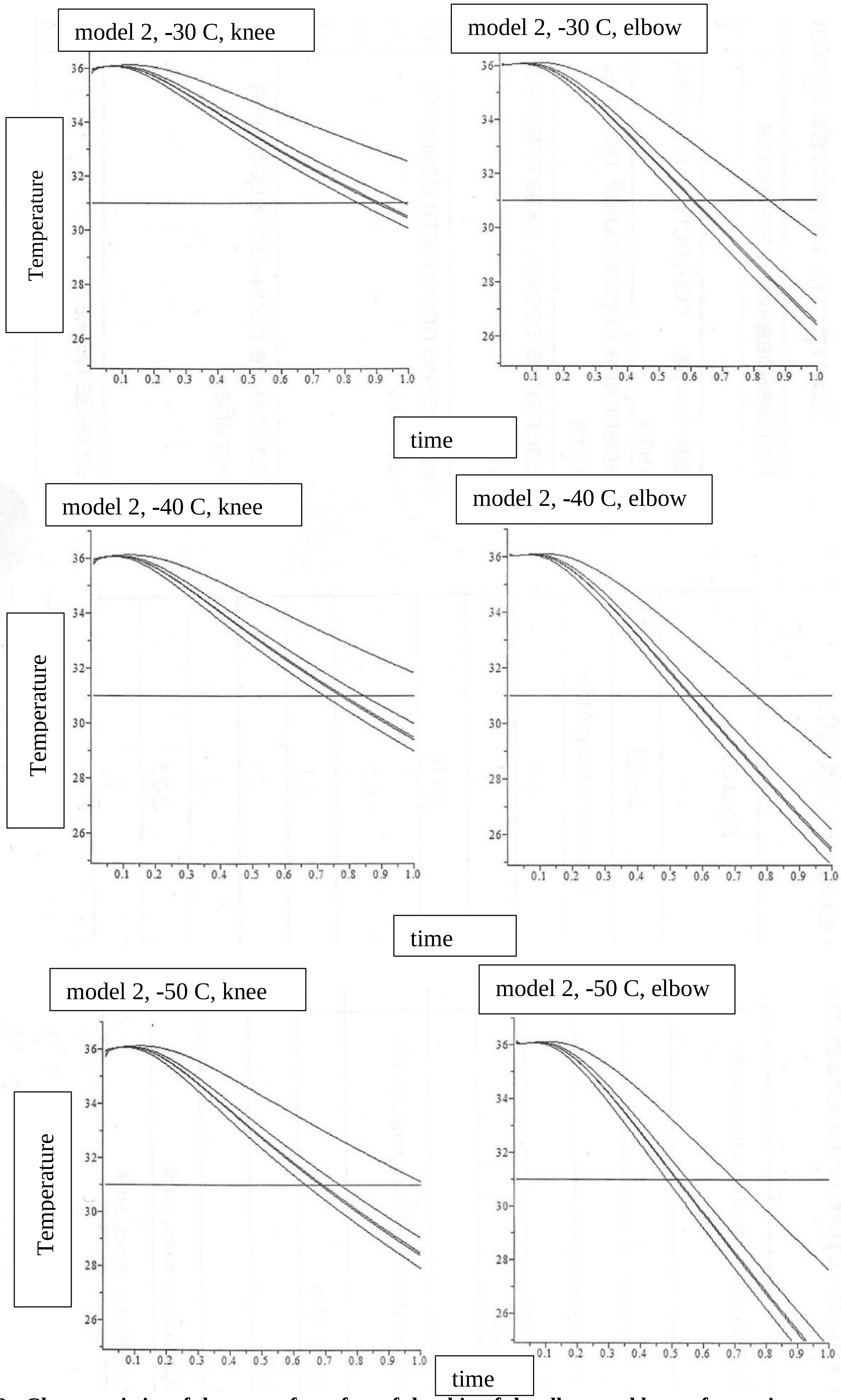

Figure 2 - Characteristics of the state of comfort of the skin of the elbow and knee of a serviceman when he is in the zone with a temperature of -30 ° C, -40 ° C, -50 ° C for a package of materials model 2, where the curves: 1 - without cushioning material, 2 - TKPM " Picardies "1242 \ 17, 3 - TKPM" Kufner "R171G57, 4 - TKPM" Kufner "B141N77, 5 - TKPM AKP-622 \ AKP218

Conclusion

The analysis of the obtained results confirmed the effectiveness of the software product for a reasonable choice of a package of materials for the overhead parts of a suit of an Arctic serviceman in order to form comfortable conditions when he is in areas with low temperatures.

Thus, the software product creates the opportunity for the manufacturer to manufacture a suit set that provides the user with comfort and perform his duties for the entire time specified by him, and the developers of new materials - to have the main characteristics of new materials in order to confidently provide users with all the requirements for a suit set. for military personnel.

The main tasks in the field of ensuring the protection of the population and the territories of the Arctic zone from natural and man-made emergencies are achieved through the following set of measures:

a) identification and study of the risks of natural and man-made emergencies, methods of their prevention;

b) development of technical means, technologies and equipment for carrying out emergency rescue operations and extinguishing fires, development of the aviation park, aviation infrastructure and aviation rescue technologies in order to ensure the protection of the population and territories, reduce the response time to emergencies, taking into account the tasks to be solved and naturally -climatic conditions of the Arctic zone;

c) improving the methods of protecting the population and territories, extinguishing fires and temporarily placing the population and the professional contingent in the Arctic conditions in the elimination of natural and man-made emergencies;

d) improving the methods of increasing the level of protection of critical and potentially hazardous facilities, ensuring the sustainability of their functioning in emergency situations in the Arctic;

e) improving the regulatory legal and regulatory framework in the field of protecting the population and territories, critical and potentially dangerous facilities from natural and man-made emergencies, in the field of fire safety, taking into account the specifics of facilities planned for construction in the Arctic zone;

f) development of systems for monitoring and forecasting emergency situations in the Arctic zone, including on the basis of receiving and processing space information;

g) development of an anti-crisis management system within the framework of a unified state system for the prevention and elimination of emergency situations;

h) development of the technical and tactical capabilities of the Arctic integrated emergency rescue centers in the prevention and response to emergencies by improving their structure and composition, base infrastructure and modern material and technical support, taking into account the tasks to be solved and the natural and climatic conditions of the Arctic zone;

i) organization and participation in exercises, trainings to check the readiness of the forces and means of the Arctic states to eliminate natural and man-made emergencies, including during the implementation of large economic and infrastructure projects;

j) development and establishment of requirements for rescue equipment and means of rendering assistance to preserve life and health in the event of radiation accidents and incidents in the Arctic zone.

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