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Селина Н.Г., Прохоров В.Т., Дмитриенко Н.А., Рева Д.В. Исследование и анализ возможностей отечественных производителей по обеспечению военнослужащих Арктики востребованной продукцией (сообщение 1)

Selina N.G., Prokhorov V.T., Dmitrienko N.A., Reva D.V.
Research and analysis capabilities of domestic manufacturers to
provide military products demanded Arctic (1 message)

В сообщении 1 проведены исследования по созданию костюма для защиты от холода военнослужащего, находящегося в условиях Арктики. В основу создания теплозащитной одежды для эксплуатации в условиях Арктики должен быть положен научный принцип, учитывающий физиологию теплообмена человека с окружающей средой. При разработке теплозащитной одежды следует выполнять требования к теплоизоляции всех областей тела. С увеличением толщины пакета материалов утепляющей одежды повышается практически только температура кожи тех областей тела, которые защищены (туловище, плечо, бедро)

Ключевые слова: костюм, военнослужащий, в условиях Арктики, холод, холодовой стресс, охлаждение, теплозащитная одежда

Селина Надежда Геннадьевна

Аспирант

Донской государственный технический университет

г. Шахты-500, ул. Шевченко, 147

Прохоров Владимир Тимофеевич

Доктор технических наук, профессор

Донской государственный технический университет

г. Шахты-500, ул. Шевченко, 147

Дмитриенко Надежда Алексеевна

Кандидат педагогических наук, доцент

Донской государственный технический университет

г. Шахты-500, ул. Шевченко, 147

In the message 1 researches on creation of a suit for protection against cold of the serviceman who is in conditions of the Arctic are conducted. The scientific principle considering physiology of heat exchange of the person with environment has to be the basis for creation of heat-shielding clothes for operation in the conditions of the Arctic. When developing heat-shielding clothes it is necessary to fulfill requirements to thermal insulation of all areas of a body. With increase in thickness of a package of materials of the warming clothes practically only temperature of skin of those areas of a body, which zakshchishchena increases (a trunk, a shoulder, a hip)

Key words: a suit, serviceman, in the conditions of the Arctic, cold, holodovaya stress, cooling, heat-shielding clothes

Selina Nadezhda Gennadevna

Graduate

Don state technical university

Shakhty-500, Shevchenko st., 147

Prohorov Vladimir Timofeevich

Doctor of Engineering Sciences, Professor

Don state technical university

Shakhty-500, Shevchenko st., 147

Dmitrienko Nadezhda Alekseevna

Candidate of Pedagogic Sciences, Associate Professor

Don state technical university

Shakhty-500, Shevchenko st., 147

Рева Дарья Валерьевна

Аспирант

Донской государственный технический
университет

г. Шахты-500, ул. Шевченко, 147

Reva Daria Valerievna

Graduate

Don state technical university

Shakhty-500, Shevchenko st., 147

The largest Russian vertically integrated holding of light industry "BTK holding" at the opening of the XIX International Exhibition of State Security "Interpolitex" presented the latest developments in the enrichment of "smart" fabrics and their application in the guard form the police, the form for special forces as well as for special rapid reaction groups.

These developments multiply the degree of protecting human bodies in various weather conditions, including extreme climate zones, and flame resistance; providing people with comfort and easy care.

Due to the producing special clothes and "smart" fabrics for it, the Ministry will provide a large supply of uniforms for their employees.

"BTK holding" demonstrates entire production process of modern high-tech molds for the policemen, beginning from the development and producing "smart" fabrics at plants of Rostov region and Barnaul Melange plant in Altai, the process of tailoring products at the factories of BTK in 10 regions to the ready made samples of protective properties of "smart" fabrics, as:

- Easy and warm: clothes for special groups, protect from low temperatures, wind, snow, moisture, they are created with the use of ultra-thin hydrophobic insulation fibers that do not retain moisture and quickly get dry. The suit is durable, lightweight and compact;

insulated winter suit, which is 1.5 kg lighter, and 30% smaller than is used today

- Warm and dry: demi-season suit created with using modern membrane material, which provides a high level of thermal insulation and water vapor permeability, temperature regulation, and has a high degree of strength due to the special weave "rip-stop" and the polyamide;

- Dry and comfort a windproof suit, which protects from heavy rain and strong wind, due to the use of modern membrane material and glued seams, it has a high water vapor permeability, lightweight and compactability;

- Cool in the heat: T Shirt for police officers with a special rank of police, made with the use of technology of "BTK comfort" is water-repellent finish (attached to a single-layer fabric with hydrophobic and hydrophilic properties at the same time: provides moisture absorbtion from the inside and water repellency to the front) and "black ice" the finishing that allows being cool in the sun, to ensure a high level of comfort in hot weather;

- Fire protection: a fireproof suit can protect people from fire due to the property of modacrylic fiber preserving a high strength, air permeability, fire resistance and high hygienic characteristics due to the presence of cotton in the composition;

fireproof suit provides effective protection due to refractory and water repellent fabric finish, as well as the availability of complete fire-resistant underwear;

- No rustling: due to specific activities of special forces we need to reduced noise characteristics of the material (to rustle), to meet the aim allows us to use the structure

of the membrane, the presence of ventilation holes provide ventilation and lightning of the body, and due to the use of modern membrane material, a lot of glued seams and waterproof zippers as the best protection against heavy rain and wind are used.

There are thirty kinds of fabrics, water and muddyproof, vapor permeability, fire resistance, self-cleaning, high visibility, and so on, the production for import-substituting materials and fabrics produced by the only Russian plant of "smart" fabrics.

The Rostov region, Barnaul and Altai Territory melange plant.

"Today we are proud to introduce revolutionary products made in Russia, allowing to provide not only comfort but also maximum protection for police officers performing tasks in cases of emergency. Separately, we note that, thanks to the country's largest production base and vertical integration, "BTK Holding" we provide the entire production process. This allows us to guarantee high quality at every stage of production and to offer products at competitive prices", – commented the Deputy Director General of "BTK holding" Arina Slynko.

The urgency of the problem of creating a suit for protection from the cold is confirmed by numerous studies in this area carried out by domestic and foreign scholars [1]. Currently, one of the directions of the costumes for the conditions of Arctic region is supposed to be a professional clothing, particularly clothing for the needs of the federal government. Survival in the polar regions is directly dependent on keeping and preserving bodies' warmth. This is only possible to design a special suit.

The first requirement to the suit in Arctic is layering. The top layer should be moisture-resistant, the middle layer must contain wool fibers (preferably) or a synthetic inner layer to allow good breathability properties. The requirement for the second layer it should be comfortable. This ensures adequate air circulation and does not cause overheating of the body of a soldier.

The package includes clothing, protective bulletproof helmet, clothing for chemical and biological protection, warm clothes, a rescue bag, tent and a parachute.

This clothes should ensure the protection and survival in a variety of climatic and combat conditions.

Currently, due to the new conditions the quality, effectiveness of protective clothing are the main requirements for different purposes and, above all, the Army protective clothing, must be improved quickly and revolutionary, using the latest advances in the field of polymeric materials and technologies. According to US scientists, research results are available in the press, the use of modern protective clothing in the US Army allowed them to reduce by 15% casualties in dangerous places.

It confirms that the creation of favorable conditions for soldiers in extreme conditions, should work systematically, actively and purposefully by scientists' efforts from many countries, including the active participation of the leading research centers in the United States, France, Germany, Japan, South Korea, China, India, the military men turn out to be in extreme conditions, the workers and employees have worked for many years in the Far North, and their experience will be useful in creating a comfortable set of clothes. It should be noted that all technologies used in the production of modern clothing for the military men have dual purpose and can be used in various fields of science, technology and everyday life. Using the dual-using technologies are typical practice for all developed countries, military personnel.

The cold is one of the harmful environmental factors of human exposure. Reactions to cold can be both functional and pathological: disease, loss, death.

At low temperatures, a person may experience cold stress. The cause of cold stress may be cooling process of the whole body or parts of it, usually the face and respiratory organs, hands, feet. At the same time various types of cold stress generated due to a combination of climatic factors, physical activity, clothing, and others. The main types of cold stress are:

- Cooling of the whole body;
- Cooling of limbs;
- Cooling of the skin (convective);
- Cooling of the skin (conductive);
- Respiratory cooling.

Combinations of climatic factors are:

- The air temperature, mean radiant temperature, air mobility, physical activity, relative humidity, clothing;

Table 1. The cooling wind factors represented as the equivalent temperatures of cooling are taken to evaluate the combined effect of low air temperatures and wind speeds

Wind speed, m / s	Air temperature, ° C											
	10	4,4	-1,1	-6,7	-	-	-	-	-	-	-	-
	Equivalent cooling temperature, ° C											
1	2	3	4	5	6	7	8	9	10	11	12	13
calm	10	4,4	-1,1	-6,7	-	-	-	-	-	-	-	-
2,2	8,9	2,2	-2,8	-8,9	-	-	-	-	-	-	-	-
4,4	4,4	-2,2	-8,9	-	-	-	-	-	-	-	-	-
6,6	2,2	-5,6	-	-	-	-	-	-	-	-	-	-
8,8	0	-7,8	15,6	-	-	-	-	-	-	-	-	-
11,0	-1,1	-8,9	-	-	-	-	-	-	-	-	-	-
13,2	-2,2	-	-	-	-	-	-	-	-	-	-	-
15,4	-2,8	-	-	-	-	-	-	-	-	-	-	-
17,6	-3,3	-	-	-	-	-	-	-	-	-	-	-
A speed of wind that is greater than 17.6 m / s, provides little additional effect of a slight risk	Less than 1 hour with dry skin. Maximum danger in the apparent safety.				The growing danger. The risk of frostbite for 1 minute.				The great danger. Frostbite occurs within 30 seconds.			

- The air temperature, the mobility of air;
- The temperature of the surface of the garment;
- Temperature, physical activity [2].

To assess the possible cooling of unprotected parts of the body we used wind index (WCI, W / m²) defined by the formula:

$$WCI = 1,16 \cdot (10,45 + 10\sqrt{V_{ar} - V_{ar}}) \cdot (33 - t_a), \quad (1)$$

where V_{ar} – air velocity, m / s;

t_a – temperature, ° C.

Table 1 provides a cooling wind factor, presented as equivalent temperature cooling, which plays an important role in cooling the human body in Arctic.

Table 2 presents the wind index, "cooling temperature" and the effects of their unprotected parts of the body.

The most obvious effect of cold exposure in the open area is the cooling of the body tissue (superficial and deep), and the range of general and / or local discomfort teplooschuscheny lesions to varying degrees.

Effects of cold stress depend on the level of compliance of clothes and human energy meteorological parameters of the environment in which he operates, duration, health, the body's sensitivity, the area of the body which has been cooled.

Cooling of face and respiratory cause contraction of blood vessels, resulting in increased blood pressure, and physical comfort.

Moderate cooling can cause discomfort and thermal discomfort.

Table 2. The wind index, "cooling temperature" and the effects of them on human's skin

The wind index, W / m ²	"Cooling temperature», ° C	Effect
1200	-14	very cold
1400	-22	bitter cold
1600	-30	frostbite unprotected parts of the body
1800	-38	within 1 hour of
2000	-45	frostbite unprotected parts of the body
2200	-53	within 1 minute
2400	-61	frostbite unprotected parts of the body
2600	-69	within 30 seconds

Effect of cold stress on the person due to the intensity of cold stress (cooling of tissue).

The result of the intensity of extreme cold stress is called hypothermia.

The results of the intensity I of a degree of cold stress are:

- Local damage – freezing, numbness;
- damage without freezing;
- Pain;
- Functional damage;
- Acute cardio respiratory effects;

- Deterioration of health;
- discomfort;
- The heat balance.

The discomfort may decrease activity, connected with the problems associated with the emotional stress, the need to focus and increase the risk of professional accidents and injuries. Furthermore, cooling of tissue may lead to a decrease in physical activity that contributes the risk of accidents.

Energy costs are increased in the cold. This is due to the decrease in activity caused by the cooling, as well as the growth of energy intensity of work as a result of the use of heavy clothes. The latter can be viewed as an additional increase in the energy intensity of the work, which is about 3% with an increase in weight of clothing for 1 kg or 4% as each additional layer in the set of clothes. In general, frost effect can lead to reduced activity, increased sickness and related cold lesions [1].

When being cold man, the change in his motor activity, coordination and violates may happen and perform precise surgery is the development of inhibitory processes in the cerebral cortex, which may cause injury. Activity is decreased by 1.5% per degree of temperature reduction fingers.

The decreasing in body temperature, muscle's temperature can lead to decreasing the level of metabolism.

These changes reduce the peoples' coordination and could lead to an increase in accidents, particularly in combat missions in the cold. The sensitivity of the receptor changes with the temperature of the skin. Thus, when the skin temperature is about 20 ° C, it is 1/7 of the normal.

We know that in the winter morbidity and mortality from respiratory diseases are increased [2].

Taking into account that cold exposure has adverse effects on respiratory function, it is recommended to plan activity so as to avoid or minimize a very high degree physical activity while working in the cold. Some cases, especially with people suffering from respiratory diseases, the protection of the face can reduce or prevent respiratory distress and other symptoms.

Knowing about the importance of evaluation and prediction of the thermal state of a person in specific circumstances of his life, including dependence of clothing insulation and energy expenditure level on the basis of mathematical-statistical analysis of the experimental data presented multiple regression equation (2), which allows us to determine the integral index of cooling conditions (IPUO, points), taking into account the influence of factors: air temperature (t_i ° C), wind speed (V , m / s), thermal isolation of sets of clothes (I_k , clo; 1 clo = 0,155 ° C • m² / W), the level of energy expenditure (Q_m W / m²) [2].

$$\begin{aligned} \text{IPUO} = & 73,882 - 0,60361 tB + 1,3096 \cdot V - 9,1985 \cdot I_k \\ & - 0,15527 qM, \end{aligned} \quad (2)$$

The equation to determine the risk of cooling (after a person got cold) and the probability of its realization.

To reduce the risk of cooling insulation overalls and / or physical activity should be increased. So, if the energy consumption to perform physical work will amount to 145 W / m² (Category IIB), and thermal insulation clothes clo – increases to 5, the value IPUO 31.8, ie, increase the probability of ignored risk (0.6).

To determine the risk assessment from the standpoint of cooling damage (frostbite) exposed areas of the body, especially the face, which can occur at low air temperature and wind, given the multiple regression equation (3). IPUOO Index (in points) to determine the level of risk of frostbite:

$$\text{IPUOO} = 34,654 - 0,4664 \cdot \text{TV} + 0,6337 \cdot \text{V}, \quad (3)$$

wherein tB – temperature, ° C;

V- wind speed, m / s.

According to the calculation the air at a temperature of -25 ° C and a wind speed of 2 m / s we can see critical risk of frostbite of the body, the probability of which increases with the wind speed and decreasing air temperature. Catastrophic risk of frostbite (within 30 seconds) can occur with probability of 0.5 at a temperature of -35 ° C air and a wind speed of 10 m / s and at air temperature of about -40 ° C and -45 ° C respectively at a flow rate 6 winds / m and 3 m / s.

The above mentioned means that a set of heat-shielding clothes designed to work in an open air in cold climatic regions IA and I B ("special" and IV climate zone), should include face protection and breathing apparatus.

Hands and feet play an important role in thermoregulation, as heat exchanging the environment. Status heat comfort is provided at a temperature of the skin is 29-31 ° C and a thermal stream is 52-87 W / m². The thermal resistance of tissues can be preserved to a maximum of 0.3 clo.

Studies carried out by a number of authors [2] have shown that an increase in the designing warm footwear will increase average temperature of human skin (from 32,0 ± 0,30 to 33,5 ± 0,32 ° C) and decrease average flow (from 90.3 ± 4.0 to 57.0 ± 0,32Vt / m² (≈ 40%)). Reducing the overall heat loss may occur due to thermal insulation shoes can make 17,1 ° C.

Heat loss may happen in this convection and radiation from the surface of different portions of the human body during cooling:

- a) Head 19.0 watts (12%)
- b) Hands 44.4 watts (31%)
- c) The body of 36.0 watts (25%)
- d) W 49.0 Feet (32%)
- e) All persons 148.4 W (100%)

The amount of insulation shoes can have a significant impact on the overall heat loss and the surface temperature of the human body. This means that the development of heat protective clothing should comply with the requirements for thermal insulation of all areas of the body. With increasing the thickness of the package materials as warming clothes practically increase in protected areas of the skin temperature of the body (torso, shoulder, hip) [3]. There is only a slight increase in temperature of the skin of the hands. The change in temperature depending on the degree of warming of

the surface of the body but it is not practically observed. There is a definite correlation between the total thermal state the body and the degree of cooling of a particular area of the body, in particular in, feet and hands. At the same time a last insulation has a significant impact on the overall heat transferring[4].

The following estimation of skin temperature in the range and its corresponding different observation

– Thermal observation is is a amount of "cool" corresponds to the average temperature of the skin of the foot 25,6 ° C, and its range of 26,3-24,8 ° C;

– Thermal observation demonstrates the amount of "cold" to the average temperature of the skin of the foot 21,5 ° C and a range of it is 20,3-23,0 ° C.

Clothing, physical activity, external heating of various types, operation are effective ways of resistance cold stress, if this person has relevant knowledge and experience. However, adequate protection of body can be achieved, by reducing the activity. For example, clothing is a factor increasing physical activity, reducing the field of view, to hear and others.

In this regard, monitoring clothing, levels of physical activity (weight, rhythm), interruptions to heat the signs of safety and practical tools in the Arctic.

Table 3. Topography of the heat flux from the surface of the human body, in%, assess their thermal observation as "comfort"

Kind of clothes	Posture	Areas of the body						
		head	torso	shoulder	brush	thigh	shin	stop
Without clothes	Standing	13,1± 0,93	29,5± 0,73	12,2± 0,64	5,0± 0,47	19,0± 1,5	12,8± 1,0	8,4± 0,34
"Room" clothing	Standing	15,8± 4,2	28,5± 1,25	11,5± 1,25	5,5± 0,44	17,8± 1,0	13,7± 1,0	7,2± 0,4
Insulated cover	Standing	17,7± 0,71	24,6± 0,63	10,4± 0,8	6,6± 0,55	18,8± 0,7	14,7± 0,8	7,2± 0,6
"Space" clothing	Walking (170 W/M2)	18,1	21,8	7,8	6,4	20,6	16,9	8,4
Insulated costume: jacket and p / overalls	Walking (170 W/M2)	19,5	25,1	9,7	6,9	16,2	15,5	7,1

To estimate the thermal state of a person and to develop measures of preventing overheating and overcooling we can be use data and criteria given in MUK 4.3.1895-04 "Evaluation of the thermal state of the body we need to justify hygienic requirements for microclimate of jobs and prevention measures cooling and overheating, "approved to be 03.03.04 M3 of Russia., Provided that the weighted average does not come from the top or bottom border.

Thermal state of man is divided into: the optimum allowable, maximum permissible and impermissible. The optimum thermal condition is characterized by the absence of local or general discomfort. Permissible thermal state of man is characterized by minor local or general discomfort. Limiting thermal state of man is characterized by severe local or general discomfort that limits the activity. It is unacceptable thermal condition characterized by excessive cooling leads to disruption of health. To estimate

man's thermal state for the purpose of normalization of microclimate parameters to be used and criteria given in [2]. Table 4 presents the criteria for optimal warm condition.

Table 4. Criteria for optimal warm human condition

Thermal energy consumption of the human condition, W / m ²	Energy consumption, Вт/м ²				
	69	87	113	145	177
1. The body temperature rectally, T_p , °C	37,1-37,2	37,237,3	37,3-37,5	37,4-37,6	37,5-37,7
2. The average skin temperature (*), T_k , °C	32,5-33,5	32,1-32,8	31,6-32,5	30,9-32,0	30,2-31,4
3. Change in warm (*), ΔQ_{me} кДж/кг	35,3-35,8	35,3-35,8	35,3-35,8	35,3-35,8	35,3-35,8
4. Change thermal conditions (*), Δ кJoule /kg	$\pm 0,87$				
5. The increase in heart rate (*), Δ ЧСС, уд/мин	до 6	7-10	11 - 18	19-25	26-32
6. moisture resistance, ΔP , g/h	до 80	до 100	до 120	до 150	до 180
7. warmth sense (*), T_o , balls	4,0	4,0	4,0	4,0	4,0
8. The difference among temperatures of breast skin and foot, $(T_{k2} - T_{kc})$, °C	2-4	2-4	not typical		

* - The most significant figures; ** - But it is relative to other levels of thermal criteria can be determined by interpolation

Consider the task of creating a feature clothing for cold protection in an open area in relation to climatic regions IA and IB. Climate region IA (are "special") includes Arctic areas isles, the Arctic Ocean, the eastern part of the tundra. Region I B (IV climate zone) consists of Eastern Siberia. Kamchatka, Sakhalin and the northern coast of the Sea . This whole area is characterized by severe weather conditions. The first of these characteristics with strong winds, the second – especially in low temperatures combined with lower wind speeds.

Creating clothes for cold protection for a climatic region IA is a very difficult task, because the heat insulating function of clothes is determined by the thickness of the package materials, an increase of which can be one of the reasons for the decreasing human activity. It is of great complexity provide the necessary protection of a body f head , hands, feet, because of low efficiency of their insulation. Application of materials with low air permeability and a closed design are used to protect against wind but it may lead to the accumulation of moisture in the clothes and reduce its insulation, especially performing intense physical work [1].

In this regard, the creation of clothing of cold protecting should proceed from the specific conditions of its operation and the reality of achieving the necessary protection, regulating to prevent the cooling duration of cold.

At the same time problems with provision clothes should have characteristics as insulation, weight reduction, heat regulation and mass in accordance to the environment are solved by limiting the time spent out of doors, we should bear physiological criteria, in selecting appropriate materials and the development of rational design.

Paying attention to particular weather conditions and the real possibility of creating clothes for activities in cold environment let a person stay more than 2 hours for the climatic region IA and 1 hour for the region IB. Deficiency of heat in the body, in this case was taken to be $52 \text{ W} \cdot \text{h} / \text{m}^2$, which corresponds to the lower border of the permissible thermal state [2].

For climatic regions IA and IB the magnitude must correspond to 98.0 and 107.0 W / m^2 . Bearing in mind for condition at a relatively cold temperature is ($-24,4^\circ \text{C}$ and $-41,0^\circ \text{S}$), insulation shall be equal to 0,560 and 0,668 $^\circ \text{C} \cdot \text{m}^2 / \text{W}$. Taking into account the average of the most probable values of the wind speed in the climatic region IA (6,8 m / c), the manufactures are to choose the top material having a small air permeability ($\approx 7 \text{ dm}^3 / \text{m}^2 \cdot \text{s}$), but having sufficient moisture permeability ($\geq 40 \text{ g} \cdot \text{m}^2 / \text{h}$). The region IB is advisable to use materials For this reason, thermal protective clothing should be insulated 0,709 $^\circ \text{C} \cdot \text{m}^2 / \text{W}$ (4.6 clo) and 0,728 $^\circ \text{C} \cdot \text{m} / \text{W}$ (4.7 clo) (1 clo = 0,155 $^\circ \text{C} \cdot \text{m}^2 / \text{W}$). Given similar values of insulation we can design sets of clothing for regions IA n IB, C TSNIISHP it is known as uniform heat suit operating in specific conditions [2]. It consists of a jacket with a hood that has a valve to protect the face of the cooling and overalls- to protect the people. To ensure the freedom of movement (the slopes, sit-ups, show of hands, and others.), Table 5 shows that the thickness of the package materials of different sections of sets of clothing is designed to protect people in cold climatic regions IA and IB. In order to control heat-protective clothing performance we need to changes in meteorological conditions and physical work, a heater in a suit is represented by two layers. The use of special masks, consisted of one layer of flannel and windproof material tight to the surface of a person's face is well protected.

Table 5. The thickness of the package materials for different parts of the sets of clothing is designed to protect from in cold climatic regions IA and IB

Area body	The ratio of local human the thickness of the package materials to the weighted average	Climate region		
		Estimated value is, mm,		Fact for the IA IB
		IA	IB	
Head	0,49	9,1	9,6	10,0
Torso	1,31	24,2	25,5	25,4
Shoulder	1,24	22,9	24,2	23,9
Brush	0,66	12,2	12,9	8.0
Thigh	1,08	20.1	21,0	20,9
Shin	0,81	15,0	15,8	17,9
Foot	0,77	14,2	15,0	7,5
Average	-	18,5	19,5	19.0

Thus, the effect of cold on human's activity and, the criteria for optimum thermal condition for the person in the Arctic, the general requirements for materials and construction of heat-shielding clothes, are taken into account especially its design in its a general development of the suit for the soldier. Analyzing the results of studies we can come to the conclusion that to create comfortable conditions for the soldier we need to design appropriate clothing (jacket, overalls), and heat shielding shoes, gloves, headgear, protective mask on their faces. When designing a heat protective clothing it is necessary to consider all the factors together, affecting the status of a soldier in the Arctic region.

Clothing depending on climatic zones (regions) of the Russian Federation which is divided into four classes of heat-shielding properties as class protection clothes :

1st class of protection is protective clothes for the I – II climatic zone (region III);

2nd class of protection is intended for the III climatic zone (region II);

3rd protection class is aimed for the IV climatic zone (region IB);

Thermal protective clothing can be worn indoors and outdoors. Depending on the conditions the heat-shielding clothes may be different:

Table 6. Requirements for the quality of textile fabrics

Indicator	Significance	Test method
The surface density, g / m ² , not less than	200	GOST 3811-72
The content of natural or viscose fibers, %, at least	30	GOST 25617 83
Breaking load, N, not less than:		GOST 3813-72
basis	780	
duck	650	
Lacerating force, N, not less than		GOST 3813-72
basis	51	
duck	36	
Resistance to abrasion cycles, at least:		
For fabrics containing wool	4500	GOST 9913-90
For cotton fabric	3500	GOST 18976-73
for fabrics containing filaments	5500	GOST 18976
Water vapor permeability is mg / cm ² h at least	4,0	GOST 22900-78
Waterproof * mm of water. art., is at least	180	GOST 3816-81
Change of linear sizes after wet processing, %, is no more		GOST 3015
basis	-3,5	GOST 7.1-95
duck	±2,0	
Colour fastness to the physico-chemical effects:	Not lower group "strong"	GOST 12930-67
Laundry		GOST 9733.4-83
- Dry friction		GOST 9733.27-83
- Organic solvents (dry cleaning)		GOST 9733.13-83
The migration of the fibers through the tissues lining the top and no more	than two fibers in the area of 150 cm ²	GOST 25617, GOST 4659
Hygroscopic%, is at least	3	GOST 3816-81

- Suit – jacket and pants (or bib);
- Set – suit and vest;
- Suit and insulated underwear;
- Jumpsuit and vest;
- other options.

Top fabric products must meet regulatory requirements in quality and purpose and have the necessary properties in accordance with these requirements [1].

For clothes manufacturing it is allowed to use natural fibers, fabrics and mixed (a mixture of natural fibers, man-made fibers (filaments). Fabrics can have different types of finishing and surface treatments: water-repellent, oil, oil and others.

Being outdoors for a long time the soldier may use the top layer of clothing made fiber if it is necessary.

The materials used for thermal protection must meet health and sanitation requirements [3].

Quality requirements for textile fabrics, used as a top layer of heat protective clothing are shown in Table 6.

Allowed decline of "water-resistant nature" to finish IN-U is not more than 30% after five washings (GOST 12.4.049-78) or after five dry-cleaning (GOST 21050).

The physical and mechanical properties of lining fabrics must meet the requirements specified in Table 7.

Table 7. The physical and mechanical properties of the tissue lining

Indicator	Significance	Test method
The surface density is, g / m ² , not less	110	GOST 3811-72
The content of natural viscose fibers,%, is not less than	50	GOST 25617-83
Breaking load, N, is not less: – on the basis	216	GOST 3813-72
-by duck	177	
Resistance to abrasion cycles, is at least	1500	GOST 18976-73
Hygroscopic%, is at least	10	GOST 3816-81
Water vapor permeability mg / cm ² h, is at least	4,5	GOST 22900-78
Colour fastness meets to the physico-chemical effects:	lower group "solid"	GOST 20272-96,
Laundry		GOST 9733.4-83
sweat		GOST 9733.6-83
Dry friction		GOST 9733.27-83
Organic solvents (dry cleaning)		GOST 9733.13-83

It may be used for the manufacturing lining, cotton, (such as flannel, bike).

As the insulation layer of clothing (if there are no special requirements) is allowed to use any type of insulation: so non-woven insulation, wool, fur, feather disconnected heater (filler) . The thickness or number of layers providing necessary thermal insulation properties of overalls may be different.

Heater (filler) should be layed out over the entire area of the goods.

Textile products, plastic and metal haberdashery, buttons, zippers, etc. Must be resistant to temperatures, ironing and dry cleaning.

Heat-insulating properties of clothing materials are determined by the thickness of the package, a large share belongs to insulate layer [4]. In the manufacturing process and using the product we must mention the impact of the complex factors may happen destroying the insulation layer thickness and it may be changed. The magnitude of insulation depends on its elastic properties, conditions and kinds of technological and operational impacts.

Heat-shielding properties of clothing can be characterized as the performance of the total thermal resistance and breathability properties of package materials. Heat-shielding properties of clothing materials package is determined by instrumental method in accordance with GOST 20489-75 Materials for clothes. Method for determining the total thermal resistance of clothes.

The total thermal resistance of the package clothing materials under natural convection, is $m^2 \cdot ^\circ C / W$, not less:

- a) Class 4 protection clothing (garments, 0.77; half-length product, 0.69);
- b) 3 class protection clothing (garments 0.83; half-length product, 0.80);
- c) Class 2 protection clothing (garments 0.64; half-length product, 0.57);
- d) Class 1 protection clothing (garments 0.51; half-length product, 0.50);

To ensure the quality of the established requirements of shelter in the package materials uncured windproof fabric (or cloth-type teak as we use it further) may be used. Meaning fabric windproof vapor permeability should be at least $45 \text{ g} / \text{m}^2 \text{ h}$.

Heat properties of a complete set of protective clothing is characterized by the rate of thermal insulation kit, is determined according to GOST R 12.4.185-99 as labor standards system. Personal protection from low temperatures. Methods for determining thermal insulation kit [3].

Thermal insulation of a complete set of clothing, depends on the operating conditions and must meet the requirements reflected in Table 8.

Table 8. Insulation of the complete set of clothes – R

Protection	Climatic zone (region)	Air temperature in winter months, $^\circ C$	wind speed during the winter months, m / s	Insulation sets of clothes, $R \text{ } ^\circ C \text{ m}^2 / W$			
				When the air permeability of the upper layers of clothing, dm^3 / m^2			
				10	20	30	40
4	«Special» (IA)	-25	6,8	0,669	0,714	0,764	0,823
3	IV (1B)	-41	1,3	0,744	0,752	0,759	0,767
2	III (II)	-18	3,6	0,518	0,534	0,551	0,569
1	II-I (III)	-9,7	5,6	0,451	0,474	0,500	0,528

Effective ratio functionality – is the comfort heat protective clothing is one of the most important characteristics of quality which is used now. It happened as the improvement of heat-shielding clothes for extreme emergency situations and above all, are to improve soldiers' military ammunition. The main functions of this type of clothing is associated with protection from various risks, dangers from hypothermia. Thermal protective clothing should be more ergonomic. In manufacturing heat-shielding clothes the comfort is sometimes neglected. So let us pay more attention to the high

and diverse functionality. The basis of modern heat-shielding clothes is made on the principle of ratio equality like functionality and comfort.

Functionality is the ability to perform certain functions, the practical utility and convenience [5].

Comfort (Eng. Comfort) means amenities, comfort. If the principles of functionality and comfort the heat protective clothing do not satisfy the person, he will experience physical exertion, heat stress, efficiency loss. There are many definitions for the word "comfort"; as for heat-shielding clothes the most suitable is a set of favorable environmental conditions (clothing, underwear space) for mental and physiological safety of man in hard environmental conditions. It is possible to say that comfort is the quality how a person feels under certain conditions.

Another focus of comfort clothes of materials (smoothness in tactile) in contact with skin.

Another factor affecting comfort – is the size of clothes, great size leads to discomfort (psychological).

Comfort – is a complex concept including physiological, sensory, social, cultural and psychological factors.

To create an effective heat protective clothing it is necessary to develop and have a reliable, science-based method of selecting the package materials. This can be solved with the help of modern achievements of thermal physics, mathematics, materials science, medicine, design, engineering and technology of clothing.

Properties of modern heat-shielding clothes are conditionally classified into basic, comfortable, protective and special.

Basic properties can characterize resistance to various strains, dimensional stability, density, sorption, light resistance, heat insulation.

Comfortable express the protection body from hypothermia, perspiration absorption, light weight, softness, hardness, color spectrum, antipilling, antimicrobial (viruses, fungi), odorless, anti-allergy

Choice is done on the criteria indicators, it is supposed to use them. In particular, it is determined by weather conditions, physical activity, the risk of reducing activities and the diseases development [3].

In order to prevent freezing (for example, in manufacturing heat-shielding clothes and Evaluation) criterial indicators characterizing the thermal state of the body as acceptable are used.

This is due to the task of maintaining optimum thermal state of the body though it is highly problematic because of the practical creating of heat protective clothing with the necessary heat insulation.

General requirements for heat-protective clothing done as a usual security state of heat exchange with the environment [2] are given below:

- Function protective clothing is to protect people from excessive heat dissipation;
- Insulating performance clothes should fit to the physical activities and meteorological conditions in which a person is supposed to operate;
- Insulation sets of clothes should be regulated;

- Inner layers of clothing should have good absorb sweat and moisture pabsorb-ing properties.
- Clothes should not cause overheating of the person; it promotes physical activ-ity, helps to withstand cold conditions;
- over warming of different areas of the human body should be considered as the overall thermal insulation and heat protective clothing insulation efficiency of each of them.

The basis of creating heat-shielding clothes for Arctic conditions must be based on a scientific principle, taking into account the physiology of heat exchange with the environment.

Requirements for the materials and construction of heat-shielding clothes in the Arctic are:

- The ability to protect with the help of the cooling package which is determined by thermo-physical parameters of the materials from which it is made, design, appear-ance (coat, jacket and trousers, overalls, etc.);
- Heat-shielding clothes package materials are produced from a base material, a warming pad and lining. If necessary, to reduce the air permeability of package mate-rials so waterproof gasket can be used which should be placed between the core ma-terial and a warming pad;
- The basic material (the coating, an outer layer) causes the appearance of cloth-ing and perform protective functions. It must have protective properties, the relevant conditions of activity, be resistant to mechanical stress, precipitation, exposure to light, various types of pollutants, easy to clean . It must be able to conduct moisture of underwear space environment and have an air permeability which is adequate to wind speed.

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Исследование и анализ возможностей отечественных производителей по обеспечению военнослужащих Арктики востребованной продукцией (сообщение 1)

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Research and analysis capabilities of domestic manufacturers to provide military products demanded Arctic (1 message)