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Combat Individual Protection System Evaluation of Functional Replay Thermal Resistance R_{ct}, Water Vapour Resistance R_{et} and Water Vapour Permeability Index i_m

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***Abstract*. Researchers from National Armed Forces (NAF) of the Republic of Latvia in cooperation with researchers from Riga Technical University (RTU) have evaluated quality of the Combat Individual Protection System (CIPS) of the National Armed Forces of the Republic of Latvia for the functional replay of thermal resistance R_{ct}, water vapour resistance R_{et} and water vapour permeability index i_m. In order to protect the soldier in cold weather environment, researchers divide the soldier's body into the groups, such as the upper body (including arms without hands), lower part of the body (legs without feet), neck and head. Following level of compliance of the CIPS quality of maximum layering R_{ct}=3 clo was indentified and fully compliant with requirements of the climatic region C0-C1 according to NATO AECTP-230 "Climatic conditions" area temperature -6^0C until -32^0C. Water vapour resistance identified within a range of 4.5 to 52.5 m^2Pa/W depends on layering. Water vapour permeability index i_m identified within the range of 0.05 – 0.65 depends on layering. Future work plan has been established on increasing the quality level of CIPS to be compatible with C2-C4 climatic region.**

***Keywords:* combat clothing, NATO climatic regions, thermal resistance, water vapour resistance, water vapour permeability index.**

I. Introduction

National Armed Forces of the Republic of Latvia (NAF) has developed the Combat Individual Protection System (CIPS), providing protection against artificial and natural threats soldiers face in the military operations areas worldwide. Researchers from the National Armed Forces of the Republic of Latvia in cooperation with researchers from Riga Technical University (RTU) have started to improve the program of the CIPS.

According to the recent research [1] performed by NAF in cooperation with RTU, the highest priority of thermal resistance has been identified by passive experiment, expert aprior ranking and following mathematical proceeding. NAF operates worldwide [2] in different climatic conditions. Basic NATO requirements for clothing systems against extreme cold environment [3] and hot environment [4] set up a basis for the development of clothing system against the above-mentioned threats. NATO ACCP-1 [5] describes the physical evaluation process of combat clothing systems.

In case of improper clothing system, cold weather leads to more casualties than artificial threats such as bullets, fragments, explosion overpressure, bladed weapons, etc.

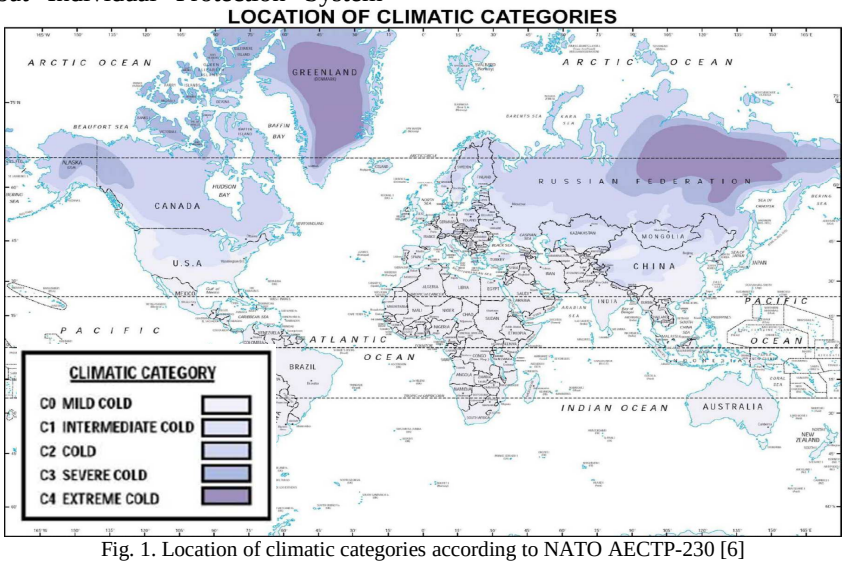

Fig. 1. Location of climatic categories according to NATO AECTP-230 [6]

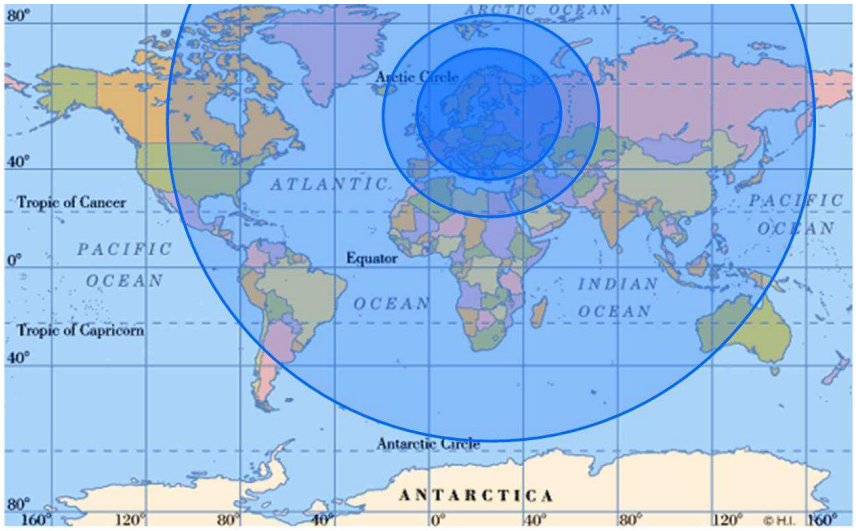

Fig. 2. Concept of national defence [7]

II. Climatic zones

NATO has defined five different climatic categories and their locations (Fig.1.). Climatic category of cold climates is divided into four parts: C0 – mild cold, C1 – intermediate cold, C2 – cold, C3 – severe cold and C4 – extreme cold.

TABLE I

SUMMARIZED TEMPERATURE AND HUMIDITY CYCLES WORLDWIDE

Category	Meteorological	
	Temperature (C°)	Relative Humidity (%)
A1	32 to 49	8 to 3
A2	30 to 44	44 to 14
A3	28 to 39	78 to 43
B1 7 days	24	100
B1 358 days	23 to 32	88 to 66
B2	26 to 35	100 to 74
B3	31 to 41	88 to 59
C0	-6 to -19	Tending to saturation
C1	-21 to -32	Tending to saturation
C2	-37 to -46	Tending to saturation
C3	-51	Tending to saturation
C4	-57	Tending to saturation
M1	29 to 48	67 to 21
M2	25.5 to 35	100 to 53
M3	-23 to -34	Tending to saturation

Latvia is situated in the region between C0 and C1. On the basis of the concept of national defence (Fig.2.), soldiers must be prepared to carry out the mission also outside these zones. Areas C2 - C4 are considered to exhibit the Arctic climate, where the temperature is significantly reduced.

The objective of the research is to find out climatic categories, where Soldier Individual Protection System works.

III. Testing methodology

Clothing details were divided into the four areas of the body - upper body (arms without hands), lower body (legs without feet), head and neck. Measurements were carried out with the equipment Permetest (FIG.3.)

Fig. 3. Permetest – compact Skin Model type fast tester

Permetest measures both parameters characterizing the thermal comfort: thermal and water-vapour resistance.

On the basis of these data it is possible to calculate the water vapour permeability index by the equation (1).

$$i_m = \frac{60 R_{ct}}{R_{et}}, \quad (1)$$

IV. TESTING RESULTS

A. Upper Body (Arms without Hands)

All measurements were measured at clothing parts which are used at the bottom of the body.

In the first table is visible water vapor resistance, but in second table thermal resistance. Both of these data, you can see in a graphical representation in figure 4 and 5.

From results of the measurements, we can calculate water vapor permeability index, which indicates how comfortamble clothing or clothing assembly will be (table 4). Index ranges from zero to one and while this number is closer to 1, the cloth or clothing assembly counts more qualitative. Water vapor permeability index displayed graphically (see Figure 6).

TABLE 2.

WATER VAPOUR RESISTANCE, UPPER BODY

R_{et}	1		2		3		4		5		6		7		8		9		10	
Upper body (arms without hands)	2nd level underwear		2nd level underwear		2nd level underwear 3rd level underwear		2nd level underwear 3rd level underwear		2nd level underwear 3rd level underwear		2nd level underwear		2nd level underwear 3rd level underwear		2nd level underwear 3rd level underwear		2nd level underwear Cold weather jacket		2nd level underwear Cold weather jacket	
			3rd level underwear		Cold weather jacket		Cold weather jacket Snugpak hooded		Cold weather jacket Gore-Tex jacket		Gore-Tex jacket		Snugpak hooded		Gore-Tex jacket		Snugpak hooded		Gore-Tex jacket	
	%	m²Pa/W	%	m²Pa/W	%	m²Pa/W	%	m²Pa/W	%	m²Pa/W	%	m²Pa/W	%	m²Pa/W	%	m²Pa/W	%	m²Pa/W	%	m²Pa/W
1st measurement	70.9	4.5	34.6	16.7	20.8	35.7	13.5	5.7	13.4	58.8	24.4	28.4	17.0	39.5	18.9	39.6	16.5	43.5	16.6	48.2
2nd measurement	72.8	4.1	35.8	15.7	17.6	40.2	13.2	55.1	12.7	59.2	26.0	26.2	16.9	42.2	19.3	39.4	16.0	44.1	15.3	49.6
3rd measurement	72.5	4.2	34.2	16.1	18.2	37.7	13.7	53.0	13.4	57.5	25.6	26.8	18.0	39.7	17.5	39.6	15.8	44.1	15.6	49.0
Average	72.1	4.2	34.9	16.2	18.9	37.8	13.4	53.9	13.2	58.5	25.4	27.1	17.3	40.5	18.6	39.6	16.1	43.9	15.8	49.0
Average m²Pa/W	4.2		16.2		37.8		53.9		58.5		27.1		40.5		39.6		43.9		49.0	
Coefficient of variation %	1.4	4.2	2.3	3.2	9.1	5.9	1.8	2.0	3.4	1.5	3.3	4.3	3.4	3.8	5.2	0.3	2.3	0.8	4.2	1.6

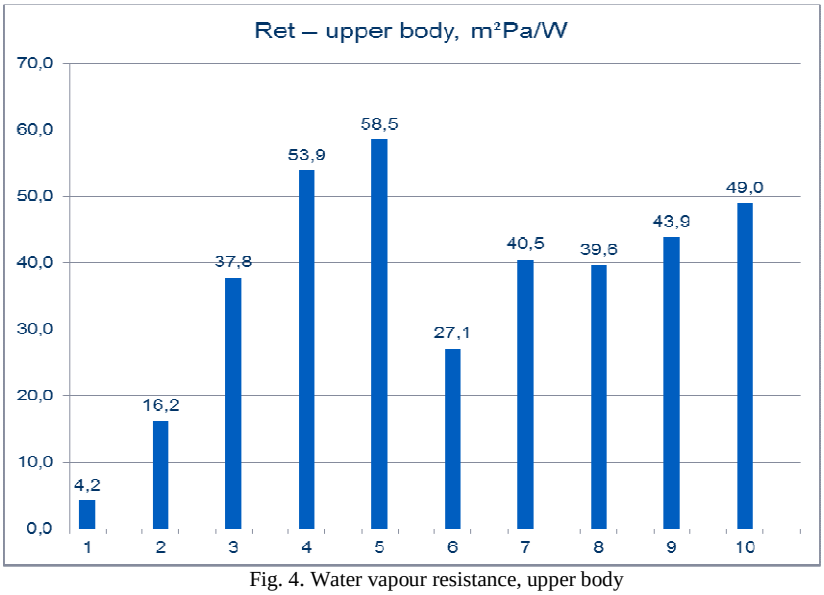

Fig. 4. Water vapour resistance, upper body

TABLE 3.

THERMAL RESISTANCE, UPPER BODY

Rct	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Upper body (arms without hands)	2nd level underwear	2nd level underwear 3rd level underwear	2nd level underwear 3rd level underwear Cold weather jacket	2nd level underwear 3rd level underwear Cold weather jacket Snugpak hooded	2nd level underwear 3rd level underwear Cold weather jacket Gore-Tex jacket	2nd level underwear Gore-Tex jacket	2nd level underwear 3rd level underwear Snugpak hooded	2nd level underwear 3rd level underwear Gore-Tex jacket	2nd level underwear Cold weather jacket Snugpak hooded	2nd level underwear Cold weather jacket Gore-Tex jacket
	m²mK/W	m²mK/W	m²mK/W	m²mK/W	m²mK/W	m²mK/W	m²mK/W	m²mK/W	m²mK/W	m²mK/W
1st measurement	38.1	115.2	298.2	450.9	254.6	23.1	451.3	115.4	386.5	205.6
2nd measurement	38.1	122.8	294.8	481.1	248	26.3	443.6	102.0	345.3	202.1
3rd measurement	33.6	115.5	281.0	450.0	252.4	23.4	418.3	10.9	438.8	206.4
Average	36.6	117.9	291.6	460.7	254.3	24.3	437.7	107.1	420.0	204.7
Average m²K/W	***0.04***	***0.12***	***0.29***	***0.46***	***0.25***	***0.02***	***0.44***	***0.11***	***0.42***	***0.20***
Average (clo)	***0.24***	***0.76***	***1.88***	***2.97***	***1.64***	***0.16***	***2.82***	***0.69***	***2.71***	***1.32***
Coefficient of variation %	*7.0*	*3.7*	*3.2*	*3.8*	*1.1*	*7.3*	*3.9*	*6.8*	*3.6*	*1.1*

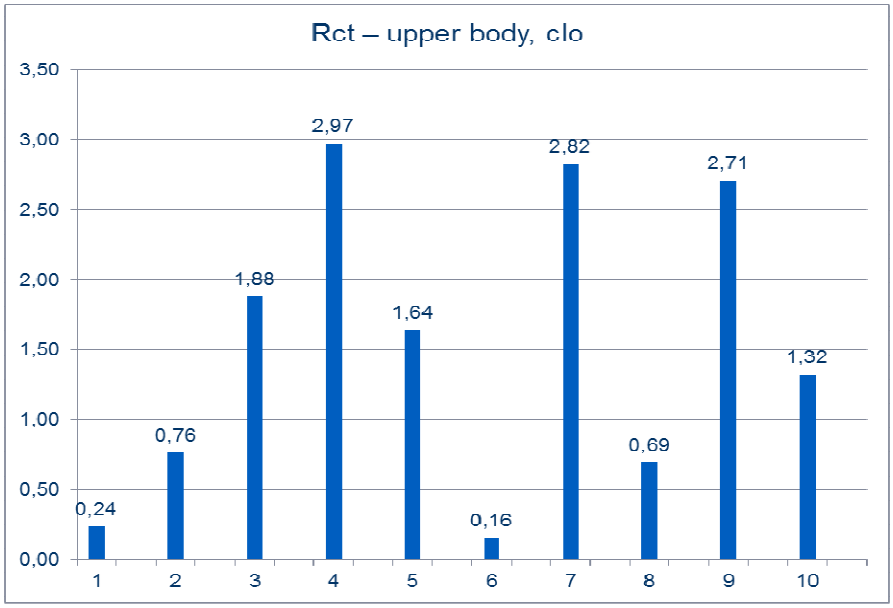

Fig. 5. Thermal resistance, upper body

TABLE 4

WATER VAPOUR PERMEABILITY INDEX, UPPER BODY

IM	1	2	3	4	5	6	7	8	9	10
UPPER BODY (ARMS WITHOUT HANDS)	2nd level UNDERWEAR	2nd level UNDERWEAR	2nd level UNDERWEAR	2 nd level UNDERWEAR	2nd level UNDERWEAR	2nd level UNDERWEAR	2nd level UNDERWEAR	2ndlevel UNDERWEAR	2nd level UNDERWEAR	2nd level UNDERWEAR
			3RD LEVEL UNDERWEAR	3RD LEVEL UNDERWEAR	3 RDLEVEL UNDERWEAR		3 RDLEVEL UNDERWEAR	3 RDLEVEL UNDERWEAR	COLD WEATHER JACKET	COLD WEATHER JACKET
		3RD LEVEL UNDERWEAR	COLD WEATHER JACKET	COLD WEATHER JACKET	COLD WEATHER JACKET	GORE-TEX JACKET	SNUGPAK HOODED	GORE-TEX JACKET	SNUGPAK HOODED	GORE-TEX JACKET
				SNUGPAK HOODED	GORE-TEX JACKET					
IM = 60RCT/RET	*0.52*	*0.44*	*0.46*	*0.51*	*0.26*	*0.05*	*0.65*	*0.16*	*0.57*	*0.25*

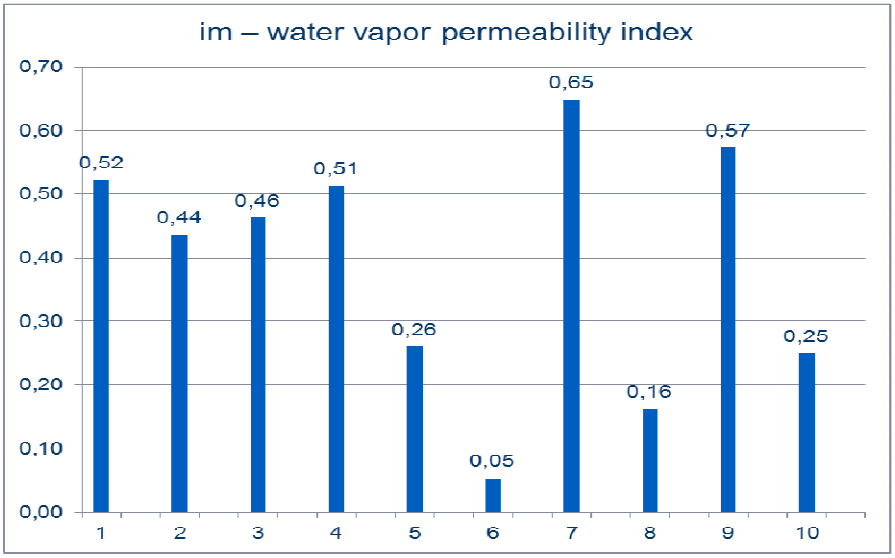

Fig. 6. Water vapor permeability index, upper body

B. LOWER BODY (LEGS WITHOUT FEET)

Similar to the upper part of the body, also in this case, the measurements were made for clothing parts used at the bottom of body. Results are shown in Table 5 and 6 and graphics are shown in Fig. 7 and Fig. 8. Water vapour permeability index results are shown in Table 7 and Fig. 9.

TABLE 5.

WATER VAPOUR PERMEABILITY, LOWER BODY

RET		2	3	4	5	6	7	8	9	10	11	12
LOWER BODY (LEGS WITHOUT FEET)	2ND LEVEL UDERWEAR	2ND LEVEL UDERWEAR	2ND LEVEL UDERWEAR	2ND LEVEL UDERWEAR	2ND LEVEL UDERWEAR	2ND LEVEL UDERWEAR	2ND LEVEL UDERWEAR	2ND LEVEL UDERWEAR	2ND LEVEL UDERWEAR	2ND LEVEL UDERWEAR	COLD WEAHER PANTS	COLD WEAHER PANTS
			3RD LEVEL UNDERWEAR	3RD LEVEL UNDERWEAR	3RD LEVEL UNDERWEAR		3RD LEVEL UNDERWEAR	3RD LEVEL UNDERWEAR	COLD WEAHER PANTS	COLD WEAHER PANTS		
		3RD LEVEL UNDERWEAR	COLD WEAHER PANTS	COLD WEAHER PANTS	COLD WEAHER PANTS	GORE-TEX PANTS	SNUGPAK PANTS	GORE-TEX PANTS	SNUGPAK PANTS	GORE-TEX PANTS	SNUGPAK PANTS	GORE-TEX PANTS
				SNUGPAK PANTS	GORE-TEX PANTS							

	%	M²PA/W	%	M²PA/W	%	M²PA/W	%	M²PA/W	%	M²PA/W	%	M²PA/W	%	M²PA/W	%	M²PA/W	%	M²PA/W	%	M²PA/W	%	M²PA/W	%	M²PA/W
1st measurement	70.9	4.5	34.6	16.7	25.8	28.2	17.1	40.8	15.0	48.2	24.4	28.4	20.3	34.3	18.9	39.6	19.5	35.0	19.3	41.7	21.8	40.3	20.6	38.2

2nd measurement	72.8	4.1	35.8	15.7	24.1	26.8	15.2	47.7	14.6	49.9	26.0	26.2	19.7	36.2	19.3	39.4	17.9	33.8	16.9	43.0	19.2	47.6	19.8	35.7
3rd measurement	72.5	4.2	34.2	16.1	24.0	27.1	17.3	41.6	16.1	46.9	25.6	26.8	18.2	39.6	17.5	39.6	18.1	38.7	17.3	44.1	21.9	39.7	19.1	37.4
Average	***72.1***	***4.2***	***34.9***	***16.2***	***24.7***	***27.3***	***16.4***	***43.4***	***15.2***	***48.4***	***25.4***	***27.1***	***19.4***	***36.7***	***18.6***	***39.6***	***19.0***	***35.9***	***17.8***	***52.5***	***21.0***	***42.5***	***19.8***	***37.2***
Average m²Pa/W	***4.2***		***16.2***		***27.3***		***43.4***		***48.4***		***27.1***		***36.7***		***39.6***		***35.9***		***52.5***		***42.5***		***37.2***	
Coefficient of variation %	1.4	4.2	2.3	3.2	4.1	2.7	7.2	8.7	5.4	3.1	3.3	4.3	5.6	7.3	5.2	0.3	5.1	7.1	7.2	2.5	7.4	10.3	3.7	3.5

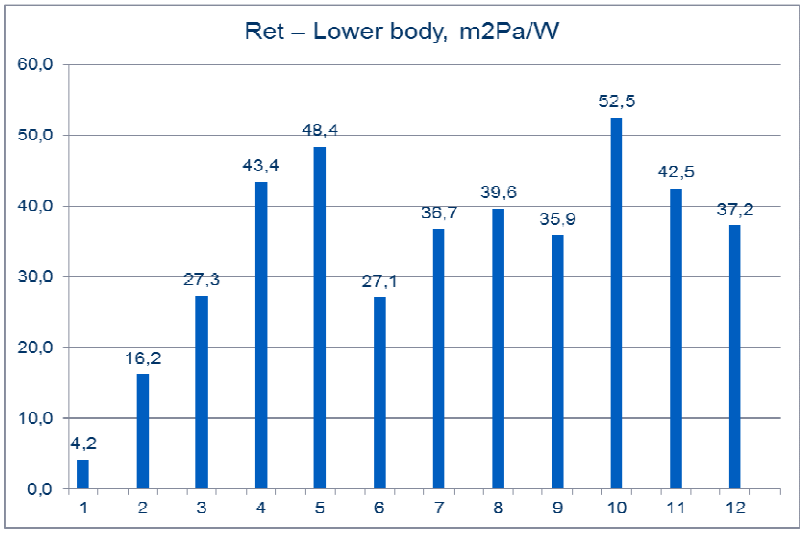

Fig. 7. Water vapor resistance, lower body

TABLE 6
THERMAL RESISTANCE, LOWER BODY

RCT	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
LOWER BODY (LEGS WITHOUT FEET)	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	COLD WEAHER PANTS	COLD WEAHER PANTS
			3RD LEVEL UNDERWEAR	3RD LEVEL UNDERWEAR	3RD LEVEL UNDERWEAR		3RD LEVEL UNDERWEAR	3RD LEVEL UNDERWEAR	COLD WEAHER PANTS	COLD WEAHER PANTS		
		3RD LEVEL UNDERWEAR	COLD WEAHER PANTS	COLD WEAHER PANTS	COLD WEAHER PANTS	GORE-TEX PANTS	SNUGPAK PANTS	GORE-TEX PANTS	SNUGPAK PANTS	GORE-TEX PANTS	SNUGPAK PANTS	GORE-TEX PANTS
				SNUGPAK PANTS	GORE-TEX PANTS							
	M²MK/W	M²MK/W	M²MK/W	M²MK/W	M²MK/W	M²MK/W	M²MK/W	M²MK/W	M²MK/W	M²MK/W	M²MK/W	M²MK/W
1st measurement	38.1	115.2	215.8	374.5	183.4	23.1	342.0	115.4	375.8	123.6	300.7	90.8
2nd measurement	38.1	122.8	212.7	377.1	182.5	26.3	352.5	102.0	376.1	135.6	281.3	97.9
3rd measurement	33.6	115.5	22.2	354.4	184.4	23.4	376.9	10.9	334.9	124.3	295.0	100.8
Average	36.6	117.9	216.9	368.7	183.5	24.3	357.1	107.1	362.2	127.8	289.0	96.5
Average m²Pa/W	***0.04***	***0.12***	***0.22***	***0.37***	***0.18***	***0.02***	***0.36***	***0.11***	***0.36***	***0.13***	***0.29***	***0.10***
Average (clo)	***0.24***	***0.76***	***1.40***	***2.38***	***1.18***	***0.16***	***2.30***	***0.69***	***2.34***	***0.82***	***1.86***	***0.62***
Coefficient of variation %	7.0	3.7	2.2	3.4	0.5	7.3	5.0	6.8	6.5	5.3	5.5	5.4

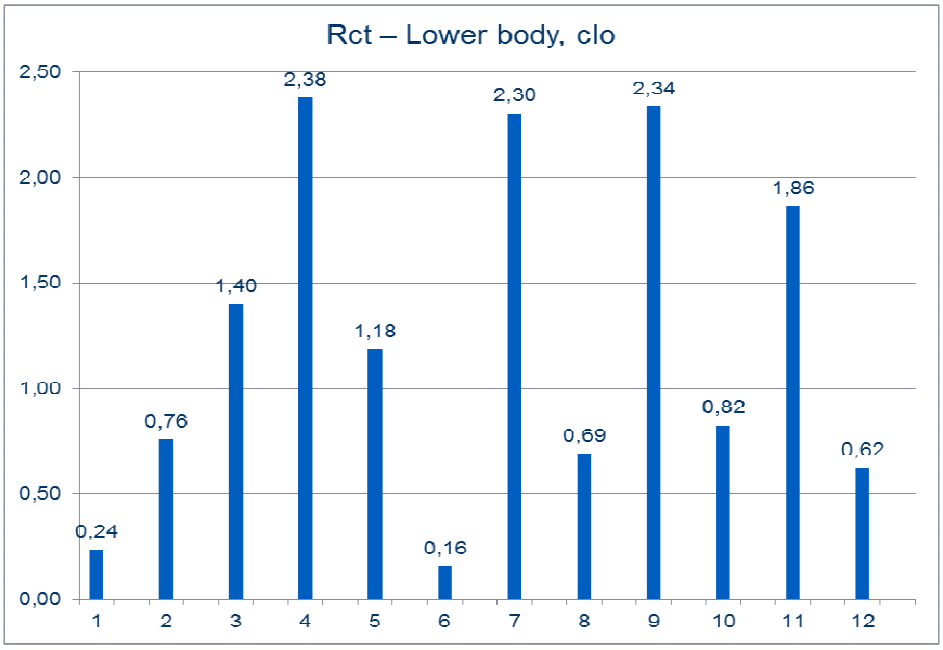

Fig 8. Thermal resistance, lower body

TABLE 7

WATER VAPOUR PERMEABILITY INDEX, LOWER BODY

im	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Lower body (legs without feet)	**LOWER BODY (LEGS WITHOUT FEET)**	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR 3RD LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR	2ND LEVEL UNDERWEAR COLD WEATHER PANTS	COLD WEATHER PANTS
			3rd level underwear	3rd level underwear	3rd level underwear		3rd level underwear	3rd level underwear	3rd level underwear	Cold weather pants		
		3rd level underwear	3rd level underwear	Cold weather pants Snugpak pants	Cold weather pants Gore-Tex pants	Cold weather pants	Gore-Tex pants	Snugpak pants	Gore-Tex pants	Snugpak pants	Gore-Tex pants	Snugpak pants
im = 60Rct/Ret	***0.5***	***0.4***	***0.5***	***0.5***	***0.2***	***0.1***	***0.6***	***0.2***	***0.6***	***0.1***	***0.4***	***0.2***

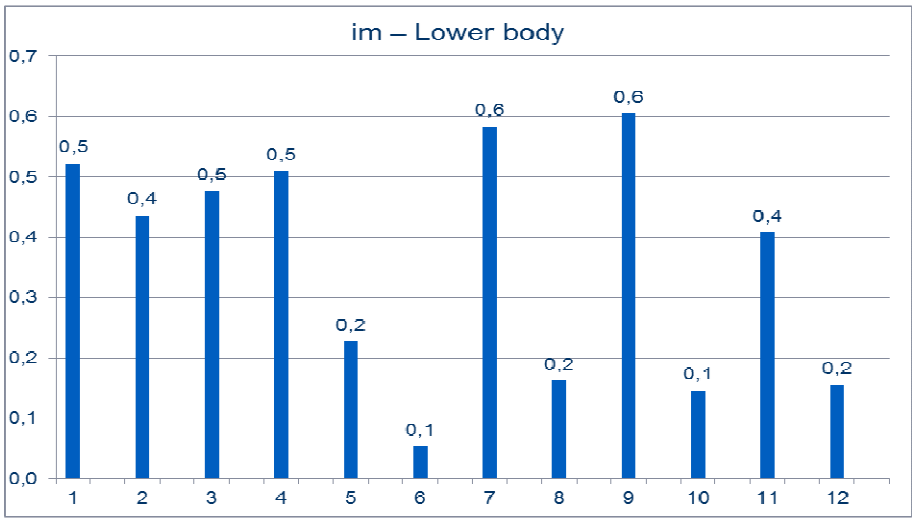

Fig. 9. Water vapor permeability index, lower body

C. Head

Water vapour resistance is shown in Table 8 and Fig. 10, thermal resistance in Table 9 and Fig.11, but water vapour permeability index in table 10 and Fig.12

TABLE 8

WATER VAPOUR RESISTANCE, HEAD

Ret	**1**		**2**		**3**	
Head	Cold weather hat		Cold weather hat		Cold weather hat	
			Snugpak hooded		Gore-Tex	
1st measurement	34.7	16.9	18.3	50.4	16.9	41.6
2nd measurement	32.9	17.2	17.0	57.2	18.8	38.1
3rd measurement	33.4	16.9	18.2	50.7	17.8	41.5
Average	***33.7***	***17.0***	***17.8***	***52.8***	***17.9***	***40.4***
Average m²Pa/W	***17.0***		***52.8***		***40.4***	
Coefficient of variation %	2.8	1.0	5.1	7.2	5.1	4.9

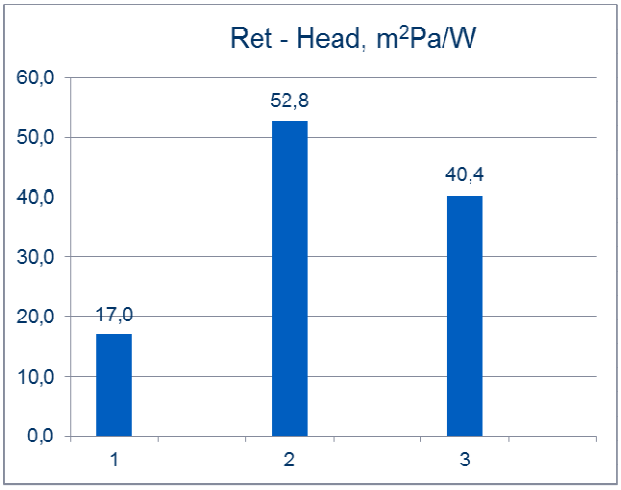

Fig. 10. Water vapor resistance, head

TABLE 9

THERMAL RESISTANCE, HEAD

Rct	**1**	**2**	**3**
Head	Cold weather hat	Cold weather hat	Cold weather hat
		Snugpak hooded	Gore-Tex
1st measurement	152.5	409.4	123.2
2nd measurement	155.8	364.4	124.7
3rd measurement	146.4	404.4	107.8
Average	151.6	391.7	117.9
Average m²Pa/W	***0.15***	***0.39***	***0.12***
Average (clo)	***0.98***	***2.53***	***0.76***
Coefficient of variation %	3.1	6.1	7.4

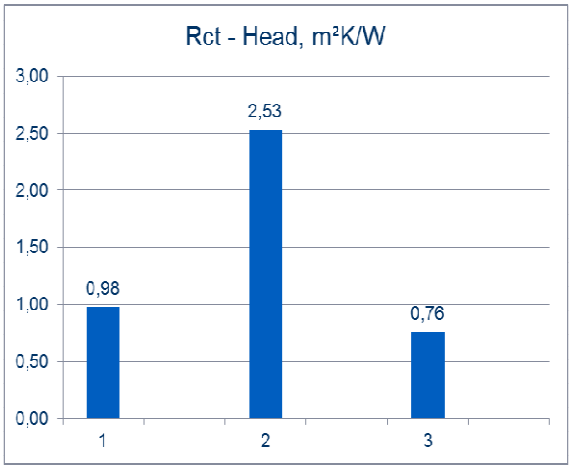

Fig. 11. Thermal resistance, head

TABLE 10

WATER VAPOUR PERMEABILITY INDEX, HEAD

im	**1**	**2**	**3**
Head	Cold weather hat	Cold weather hat	Cold weather hat
		Snugpak hooded	Gore-Tex
im = 60Rct/Ret	0.5	0.4	0.2

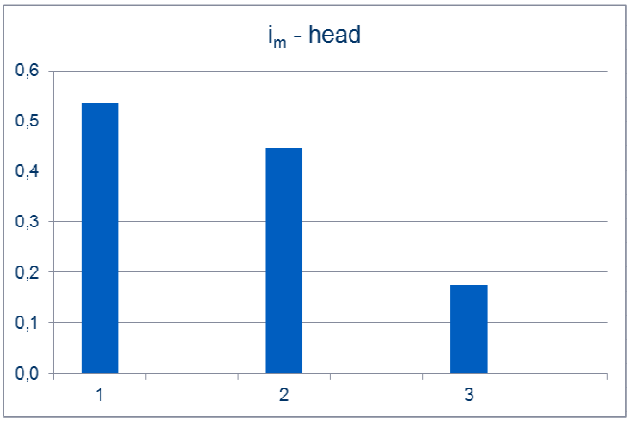

Fig. 12. Water vapor permeability index, head

D. Neck

Water vapour resistance is shown in Table 11 and Fig. 13, thermal resistance in Table 12 and Fig. 14, but water vapour permeability index in Table 13 and Fig. 15.

TABLE 11.

WATER VAPOUR RESISTANCE, NECK

Ret	**1**		**2**		**3**		**4**	
Neck	3rd level underwear		3rd level underwear Cold weather jacket		3rd level underwear Cold weather jacket Snugpak hooded		3rd level underwear Cold weather jacket Gore-Tex jacket	
1st measurement	54.5	9.2	31.0	32.4	12.5	58.1	13.7	56.7
2nd measurement	52.8	9.8	22.4	31.4	14.0	52.1	15.0	56.0
3rd measurement	53.4	9.5	22.2	31.0	14.6	49.8	14.1	53.5
Average	***53.5***	***9.5***	***22.0***	***31.6***	***13.7***	***53.3***	***14.3***	***55.4***
Average m²Pa/W		***9.5***		***31.6***		***53.3***		***55.4***
Coefficient of variation %	1.6	3.0	2.4	2.2	7.8	0.8	4.5	3.0

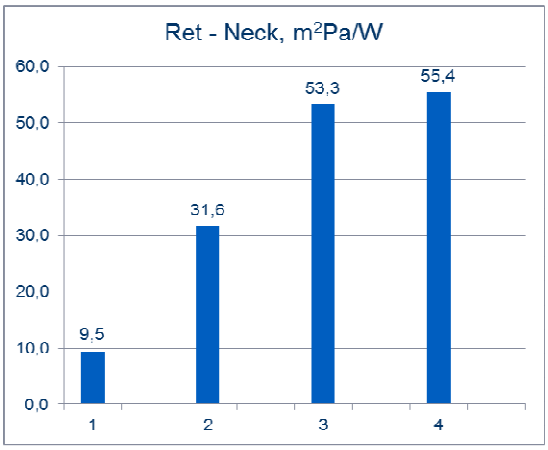

Fig 13. Water vapor resistance, neck

TABLE 12

THERMAL RESISTANCE, NECK

Rct	**1**	**2**	**3**	**4**
Neck	3rd level underwear	3rd level underwear Cold weather jacket	3rd level underwear Cold weather jacket Snugpak hooded	3rd level underwear Cold weather jacket Gore-Tex jacket
1st measurement	70.3	266.5	554.0	222.8
2nd measurement	82.3	269.1	563.9	223.4
3rd measurement	78.8	269.4	516.9	224.7
Average	77.1	268.3	544.9	223.6
Average m²Pa/W	0.08	0.27	0.5	0.22
Average (clo)	0.50	1.73	3.52	1.44
Coefficient of variation %	8	0.6	4.5	0.4

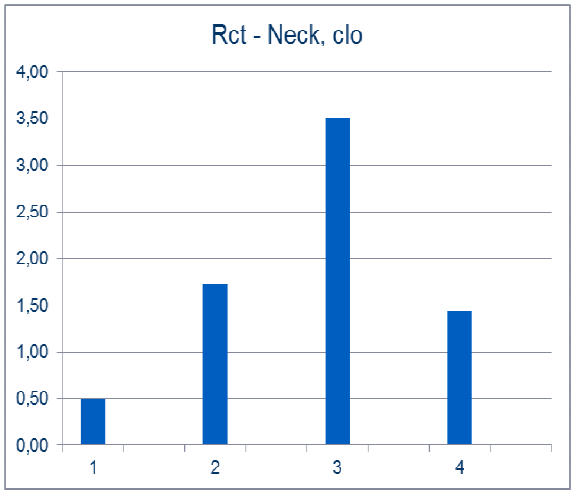

Fig. 14. Thermal resistance, neck

TABLE13

WATER VAPOUR PERMEABILITY INDEX, NECK

im	**1**	**2**	**3**	**4**
Neck	3rd level underwear	3rd level underwear Cold weather jacket	3rd level underwear Cold weather jacket Snugpak hooded	3rd level underwear Coold weather jacket Gore-Tex jacket
im = 60Rct/Ret	***0.49***	***0.51***	***0.61***	***0.24***

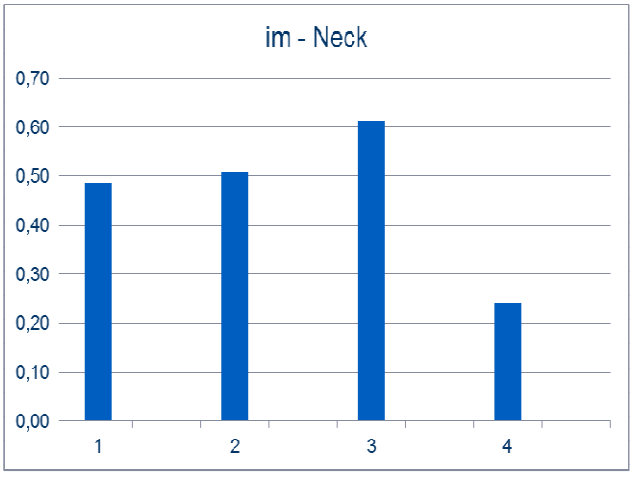

Fig. 15. Water vapor permeability index, neck

V. CONCLUSIONS

Individual soldier protection system complies with the quality of NATO AECTP-230 Latvian climatic regions C0 - C1 (up to 3 clo).

It is necessary to increase the level of quality of individual soldier protection systems in compliance with NATO AECTP-230 arctic climatic regions of C2 - C4 (3 to 4.5 clo)

At the same conditions laminates reduce RCT, increase RET and decrease im.

ACKNOWLEDGEMENT

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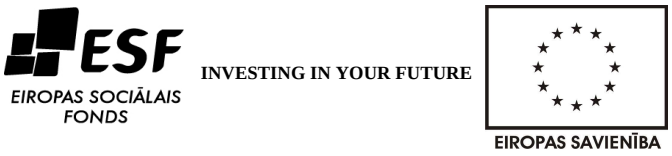

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Igors Šitvjenkins, Ausma Viļumsone, Una Zariņa, Iveta Ābele. Kaujas individuālās aizsardzības sistēma. Siltumizolācijas R_{ct} , ūdens tvaika pretestības R_{et} un ūdens tvaika caurlaidības i_m funkcionālo atsauču novērtējums

Latvijas Republikas Nacionālie Bruņotie spēki ir izveidojuši Kaujas individuālās aizsardzības sistēmu (KIAS), kura nodrošina aizsardzību pret mākslīgo un dabīgo apdraudējumu, ar ko karavīrs sastopas militāro operāciju rajonos visā pasaulē. Pētnieki no Nacionālajiem Bruņotajiem spēkiem sadarbībā ar pētniekiem no Rīgas Tehniskās universitātes ir uzsākuši KIAS pilnveidošanas programmu. Pamatojoties uz iepriekšējos pētījumos iegūtajiem rezultātiem, pētnieki ir uzsākuši KIAS pilnveidošanu katra funkcionālajā atsaucē. Viena no prioritārajām funkcionālajām atsaucēm, kam pētnieki ir pievērsuši uzmanību šajā pētījumā, ir KIAS siltuma izolācijas funkcionālā atsauce. Pētnieki ir izpētījuši KIAS siltuma izolācijas kvalitāti un to atbilstības līmeni NATO normatīvo dokumentu prasībām. Pētnieki ir veikuši eksperimentus uz vairāku KIAS ietilpstošu materiāltehnisko līdzekļu slāņu kombināciju dažādās ķermeņa daļās – galvā trijās kombinācijās, kaklā četrās kombinācijās, ķermeņa augšdaļā (rokas bez plaukstām) desmit kombinācijās, ķermeņa lejasdaļā (kājas bez pēdām) divpadsmit kombinācijās, ko t pielieto pret aukstumu un ķermeņa siltuma zudumu novēršanai. Par pamata apdraudējumu tika izvēlētas āra gaisa temperatūras klimatiskajās zonās C0, C1, C2, C3, C4 – kopējā diapazonā no – 6^0C līdz – 57^0C saskaņā ar NATO AECTP-230 „Climatic conditions", kas ietver sevī arī NATO STANAG 4573 „Design criteria for arctic clothing" prasības KIAS aizsardzībai līdz – 50^0C. Klimatiskās zonas C0 – C4 ietver sevī NBS operacionālos darbības rajonus, ko paredz Valsts Aizsardzības koncepcija. Saskaņā ar pētījumu rezultātiem KIAS kvalitātes līmenis atbilst klimatiskajiem reģioniem C0 – C1 – kopējā temperatūras diapazonā – 6^0C līdz – 32^0C. KIAS kvalitāte pieļauj sasniegt siltuma izolāciju līdz R_{ct} = 3 clo jeb 0,46 m²K/W pie attiecīgas KIAS ietilpstošo materiāltehnisko līdzekļu komplektācijas. Pie šādas komplektācijas pretestība ūdens tvaika izvadei ir 53.9 m²Pa/W, ūdens tvaika caurlaidības indekss i_m ir 0.51. KIAS siltuma izolācija kopumā variējama diapazonā no R_{ct} = 0.16 līdz 3 clo. KIAS ūdens tvaika pretestība variējama diapazonā no 4.2 līdz 58.5 m²Pa/W, savukārt ūdens tvaika caurlaidības indekss variējams no i_m = 0.05 līdz 0.65. Secināts, ka KIAS kvalitātes līmenis neatbilst klimatiskajām zonām C2 – C4, kam saskaņā ar ISO 11079 ir nepieciešama siltuma izolācija no 3 līdz 4.5 clo. Pētījumā konstatēts, ka pie vienādiem apstākļiem membrānas laminmāti samazina R_{ct}, palielina R_{et} un samazina i_m.

Игорь Шитвёнкин, Аусма Вилюмсоне, Уна Зарина, Ивета Абеле. Боевая Система Индивидуальной Защиты. Исследование функционального отклика теплоизоляции R_{ct}, сопротивления водяного пара R_{et}, индекса проницаемости водяного пара i_m

Национальные вооруженные силы (НВС) Латвийской Республики создали Боевую Систему Индивидуальной Защиты (БСИЗ), которая обеспечивает защиту от искусственных и естественных угроз с которыми солдат сталкивается в районах провидения операций по всему миру. Исследователи из Национальных Вооруженных сил совместно с исследователями из Рижского Технического Университета начали програму по улучшению боевой Системы Индивидуальной Защиты. Основываясь на результатах прошлых исследований, специалисты начали улучшение системы в каждом функциональном отклике. Специалисты исследовали уровни теплоизоляционного качества БСИЗ и их соответствие нормативам НАТО. Исследователи провели эксперименты на различных комбинациях материально-технических средств входящих в состав БСИЗ в различных частях тела – голова в трех комбинациях, шея – в четырех комбинациях, верхняя часть тела (руки без ладоней) в десяти комбинациях, нижняя часть тела (ноги без стоп) в двенадцати комбинациях, которые в основном применяют для защиты против холода и для предотвращения теплопотерь организмом радиацией. За основу вида угроз была принята температура воздуха в климатических зонах C0, C1, C2, C3, C4 – в общем диапазоне от – 6^0C до – 57^0C в соответсвии с NATO AECTP-230 „Climatic conditions", включающий в себя также NATO STANAG 4573 „Design criteria for arctic clothing" требования по БСИЗ до – 50^0C. Климатические зоны C0 – C4 включают в себя операционные районы НВС в соответствии с Государственной оборонной концепцией. В соответствии с результатами исследования качество БСИЗ соответсвует климатическим регионам C0 – C1 в общем диапазоне от – 6^0C до – 32^0C. Качество БСИЗ позволяет достичь теплоизоляции до R_{ct} = 3 clo или 0,46 m²K/W при соответствующей комбинации материально-технических средств, входящих в состав БСИЗ. В данной комбинации сопротивление выводу водяного пара составляет R_{et} = 53.9 m²Pa/W, индекс проницаемости водяного пара составляет i_m = 0.51. БСИЗ общая теплоизоляции изменяется в диапазоне R_{ct} = 0.16 līdz 3 clo. БСИЗ сопротивление выводу водяного пара составляет 4.2 до 58.5 m²Pa/W, в свою очередь индекс проницаемости водяного пара составляет i_m = 0.05 до 0.65. Был сделан вывод о необходимости повышения уровня качества БСИЗ для соответствия климатическим регионам C2 – C4, в которых уровень качества БСИЗ должен соответствовать от 3 до 4.5 clo. В исследовании также было установлено, что мембранные ламинаты при равных условиях снижают теплоизоляцию R_{ct}, увеличивают сопротивление выводу водяного пара R_{et} и уменьшают индекс проницаемости водяного пара i_m.