

Smart And Safe Work Wear Clothing-SWW



Survey of End-user feedback on Current Work Wear

Introduction

Evaluation of the currently produced clothing, as the objective of this task, was accepted by the project partners with the intention of increasing the practical use and getting satisfaction with a particular product of workwear clothing by selected pilot groups of users. With this in mind, project partners developed information and opinions on the wearing of workwear by these groups. The activities were carried out jointly by research units and producers of workwear. The assessment was made on the basis of a questionnaire prepared by the Project Leader. The subject of the evaluation of individual project partners was:

- clothing for soldiers (Latvia and Estonia),
- workwear clothes for construction workers (Poland)
- workwear clothes for chemical process industry (Finland)
- overalls for rescue workers: chemical protection and firefighter suits (Lithuania).

Surveys included two parts: the first concerned the user profile characteristics; and the second included questions about user experience resulting from product dimensions and product fit to the figure. The assessment drew attention to the durability of materials used in the production of clothing. An important problem in the construction of clothing is also the non-adjustment of ergonomic requirements to reduce the onerousness associated with the performance of specific movements during use.

All information regarding the study was treated as confidential. The results were analyzed and systematized in order to determine the characteristics of the products. Acquired knowledge is a decisive factor in the further design and construction of products.

General conclusions for the assessed clothing products:

- there is a need to design and produce garments for women and men,
- users report that the worn clothing is too loose,
- user expect different clothing for the summer and winter season (currently the areal density of the materials used qualifies them for the autumn and winter period),

and the most important conclusions of individual partners/end users:

- low strength of the base material (for example too fast rubbing of trousers in the crotch) - Latvia, Estonia, therefore the tests for material evaluation have been extended,
- quality of used additives (buttons, zippers, rubber bands) - Finland, Poland,
- length of the sleeves, trouser legs not always consistent with the need - Latvia, Poland,
- changes in the location of the pockets, flaps - Finland, Poland,
- increase the size of the pockets and change of cuffs fastening - Poland.

In the case of a Lithuanian partner, the problem reported by the manufacturer of suits was presented, which reported the need to develop a new design due to the high material consumption for the product, and thus its considerable weight.

The results of the evaluation of the produced clothing covered by the project were presented by all project performers in graphical and descriptive form with suggestion for improved design.

CONTENT

FINLAND

1. SURVEY AND FINDINGS 5
2. DEVELOPMENT OF PRODUCTS BASED ON THE SWW-SURVEY 15

LATVIA

3. SURVEY AND FINDINGS 19
4. DEVELOPMENT OF PRODUCTS BASED ON THE SWW-SURVEY 24

LITHUANIA

5. SURVEY 27
6. DEVELOPMENT OF PRODUCTS BASED ON THE SURVEY 28

ESTONIA

7. SURVEY AND FINDINGS 31
8. DEVELOPMENT OF PRODUCTS BASED ON THE SURVEY 38

POLAND

9. SURVEY AND FINDINGS 43
10. DEVELOPMENT OF PRODUCTS BASED ON THE SURVEY 51



1. SURVEY AND FINDINGS

Survey and scanning was performed at Boliden Kokkola company representing chemical industry workers. 50 workers, which is ~10% of the personnel were scanned, 23 of them were women, 27 men. According to statistics, 19% of Boliden's staff are women and 81% men (Boliden 2015). In order to correspond to the gender distribution of the factory, women should have been 10 and men 40. As invitation to the scanning process was volunteer, the participation result shows that women are more interested in knowing their own dimensions than men and women are more interested in quality of working clothing than men are.

In order to increase practical use and satisfaction in wearing workwear, an online survey was created to ask the employees' satisfactory in connection with the scanning study. For this purpose, Webropol online survey tool was chosen. Webropol has tools for analysis of both numerical data and qualitative text answers. The aim of the study was to give answers to three main points: fitting and sizing, functionality and safety.

The questionnaire included both multiple-choice questions and open questions, where the employees could answer according to their own opinion. The survey was conducted by interviewing participants. By interviewing, the survey was carried out more quickly than if each participant had filled out the questionnaire themselves. An interview also provided more open comments on work clothes. This method of filling the questionnaire needed a fast typist. The industrial partner in this project carried out the interviews; this way they received direct feedback from employees on working clothes.

The results of scanning and survey are determining factors for design and construction of new workwear as well as reflection of measurement silhouettes and application of new measurements. The proposed changes to the workweares are presented in this report.

In this study, it was more closely studied whether there are differences in satisfaction with workwear between men and women. Therefore, the three main points were examined in more detail – sizing and fitting, functionality and security. This report includes the findings of the questionnaire made for the persons in connection to the bodyscanning. New measurement tables were developed after the scanning survey and changes to the workers' workwear were made based on the summary of the questionnaire. The proposed changes are presented at the end of the report.

1.1 Background information of participants

Table 1. Questions 1, 2, 3 and 8; the participants' age, gender, weight and workwear size

1. Date of birth Year.month.day	2. Gender	3. Weight	8. Your workwear garment size	
			The upper part of clothing (shirts, jackets etc.)	The lower part of the clothing (trousers, skirts)
1980.10.02	F	-	46/M	50/-
1972.03.10	M	91	54/xl	54
1975.10.06	F	55	xs	34
1991.07.01	F	00	xxs/s	36
1978.04.07	F	57	s	36
1973.01.27	M	73	52/	52/
1967.08.01	M	82	50	-
1985.09.17	M	72	52/M	527M
1968.08.13	M	86	52/M	52/M
1975.02.27	M	72	48/	48/
1972.09.22	F	70	42	42
1965.12.22	M	93	56/XL	56/XL
1967.01.02	M	87	56/L	56/L
1982.06.23	M	80	52/L	52/L
1958.09.25	M	-		
1971.02.01	M	132	58/XXXL	58/XXXL
1984.01.25	M	100	52/L	54/
1980.07.07	F	63	34/	34
1957.02.19	F	57	--	-
1966.10.29	F	51	34/pienin koko	34
1971.01.31	F	77	36/	40
1968.12.09	F	107	46	XL
1981.10.27	F	54	32	XS
1983.04.07	F	67	36/38	S/38
1981.09.11	F	-	38/50/S	50/M
1967.07.04	M	85	50/L/M	50/L
1979.05.12	F	72	48/M	48/-
1980.08.22	M	112	58/XXL	58/XXL
1987.07.11	M	80	52/	52/
1975.03.02	M	103	54/XL	54/56
1971.11.16	M	93	54/XL	54/XL
1964.06.10	M	87	54	52
1976.03.02	M	150	62/XXXL	62/XXXL
1974.03.20	M	104	54	-
1969.02.21	M	88	52/XL	52/L
1967.08.21	F	66	38	38
1972.05.20	F	59	M48	M46
1976.01.28	F	67	S	N40
1973.02.19	M	85	M/M	M50/M
1967.12.11	F	63	N36	38
1964.01.23	F	63	XS/S	38/S
1974.01.08	M	70	48/M	50/M
1976.03.24	F	58	XS	36
1972.12.18	F	55	M46	38
1954.06.10	M	108	XL	-
1983.06.06	M	76	52/M	52/M
1969.07.31	M	-	-	-
1977.11.01	F	72	52/L	52/L
1972.11.21	M	71	48/M	48/M

Weight of the person was just asked, not weighted. In retrospect, the weight could have been weighed, and a person's body mass index calculated. The BMI compares the relationship between length and weight and indicates whether your weight is normal to your height. However, the body mass index does not tell the whole truth about your weight. Especially if a person has a lot of muscles, the body mass index may show fairly overweight, even though the weight actually comes from the muscles and not from fat tissue. The BMI also ignores the difference between men and women. The body mass index is therefore only indicative.

The users were asked about the size of their working clothes, separately the size of their trousers and jackets. One person in a leading position said that he does not use wear work clothes, so he only responded to the background information questions, not on workwear issues. The questionnaire was designed so, that if you answered that you did not wear work clothes, the program jumped directly to the last question regarding the permission to use the data anonymously in possible further studies.

1.1.1 Occupational group

Question was about the participants' occupational status. More than half of participants were indicating themselves as office workers, but they also need to wear protective clothing as their work at the industrial halls, not in separate office buildings.

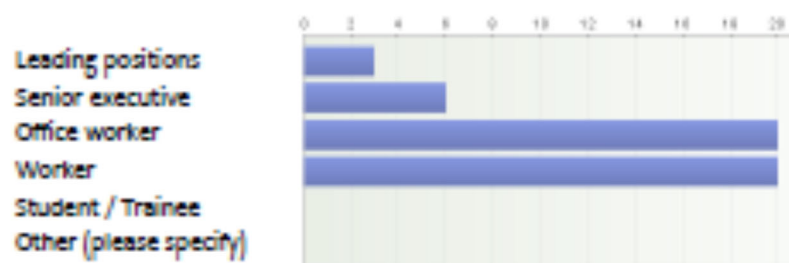


FIGURE 1. Question 4; your occupational group (N=49)

1.1.2 Department

Most of the participants were working on production departments. Fourteen respondents reported that they were working in other departments than the ones given. Twelve of them defined their own job. Most of the laboratory workers are women. Strong representation of the lab shows that women are more interested in their own measurements and work wear than men are.



FIGURE 2. Question 5; Department (N=49)

1.1.3 Work movements

In the framework of their work, the workers reported following movements:

In the framework of their work, the workers reported following movements:



FIGURE 3. Question 6; In the framework of my work, I need to do following movements

1.1.4 Using workwear

All employees moving in the factory area must be equipped with CE-marked helmets and workwear. Host is responsible for visitors' equipment. (Boliden 2015) Only one of 50 persons told, that he is not using workwear. His position is in management.

1.1.5 Workwear garment size

In question number 8 was asked about the worker's workwear garment size. Those sizes are tabulated in the same table as the participants' background information (Table 1, page 2). Some of the participants were still using the older model of workwear from an earlier supplier, so the measurements and functionality probably differ from each other between the old and new models.

1.2 Evaluation of workwear

This section discusses employees' satisfaction with current workwear. In practice, these questions provide answers how the employees find the workwear's fit, functionality and safety. They have given feedback on what they think does not work. Additionally, in this section, we got users' suggestions for improving working clothes.

1.2.1 Sizing and fitting

The first question about sizing and fitting was a multiple-choice question, where the employees needed shortly evaluated the current workwear's sizing and fitting for them.

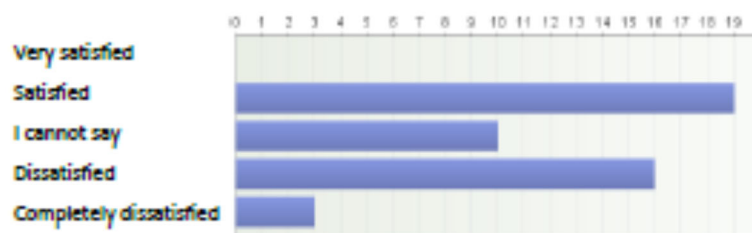


FIGURE 3. Question 9; How would evaluate the current suitability of workwear, when it comes to SIZING and FITTING for you?

This question and answers led to a more profound study; is there a difference between men and women in satisfaction to the workwear? All together men respondents seemed to be more critical of their workwear than women are. The trend line in the figure 6 shows men's dissatisfaction. The trend of women's trend line is the opposite.

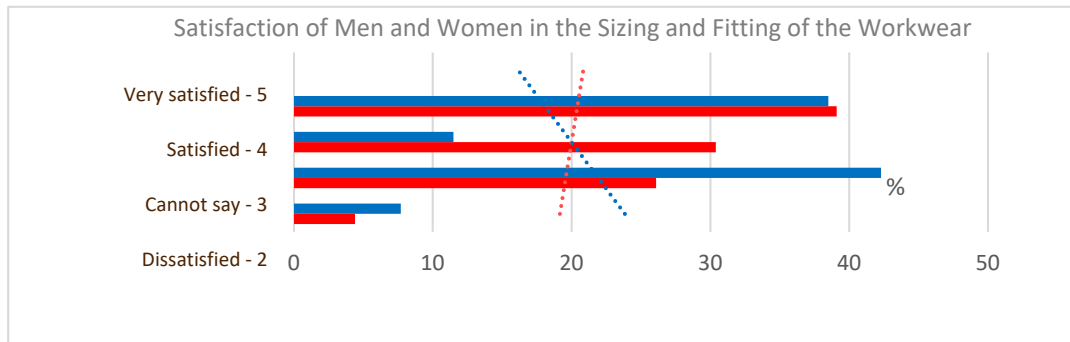


Figure 6. The satisfaction among men and women in sizing and fitting of the workwear

The unexpected phenomenon of the figure is explained by the fact that the majority (61.5%) of the men are working in production departments whilst as much as 65% women are working as white-collar workers. The more you need to move in work the more functionality you want from your workwear. However, 59% of all respondents rated grade 3 or 4 for sizing and fitting of their workwear.

1.2.2 End users' suggestions for improvements to sizing and fitting

Next question was an open question where the respondents could freely express their opinions and provide suggestions for development. Question 10 was: "If you see any room for improvement in sizing or fitting, feel free to comment below. (E.g. garment's looseness/tightness, sleeve and pant leg lengths etc.)" The answers are listed below.

Trousers:

- pant legs are too short, 7 opinions
- just enough long pant legs for a person 174 cm, 1
- one of the 8 persons says he has to extend the pant legs
- pant legs are too long, 5
- something else about the legs to complain, but no explanation, 3 persons
- legs are too wide, 2
- legs are too tight on upper thigh girth, 1 (woman)
- trousers waist is too tight, 3 persons, two of which say that the rubber band back on the waist is too tight
- one must lift the trousers when getting up from sitting position because of the rubber band, 1
- waist is big compared to the hip, 2
- 1 person complains the waist, but doesn't explain more
- crotch seam cannot withstand movements, 1 (he suspected of choosing the wrong size)
- the position of the knee pocket (for padding) is not always good for a short person

In general, the trousers were considered too loose compared to the waistband circumference.

Jacket:

- too long sleeves, 3
- too short sleeves, 2
- too wide sleeves, 1
- too loose jacket, 5
- too tight on hips, 6

The jacket was considered loose, but too tight on the hip. The hip circumference was the most criticized thing in the jacket. Some of the answers were short and hardly explainable like "sizing, length/circumference". Three of the respondents wished to have own models and sizing for women. Four respondents preferred the former jacket model better. Choosing the right size from the available model was difficult because the sizing was different from the former models from another deliverer.

1.2.3 Functionality of current workwear

Functionality in this context means e.g. flexibility of fabric, details (fastenings, pockets, loops for e.g. tools, keys, etc.). The picture of the current workwear is shown on the cover page.

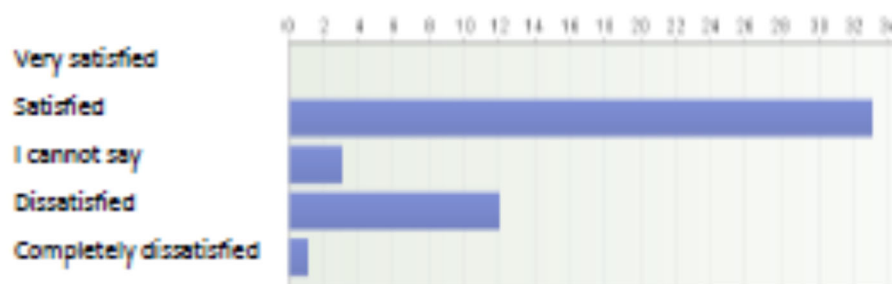


FIGURE 7. Question 11; How would you evaluate the FUNCTIONALITY of your current workwear?

The workwear was rated very functional. Nevertheless, the users had many development suggestions on the next question. The figure below shows that women were more satisfied also on the functionality of the workwear (Fig. 8).

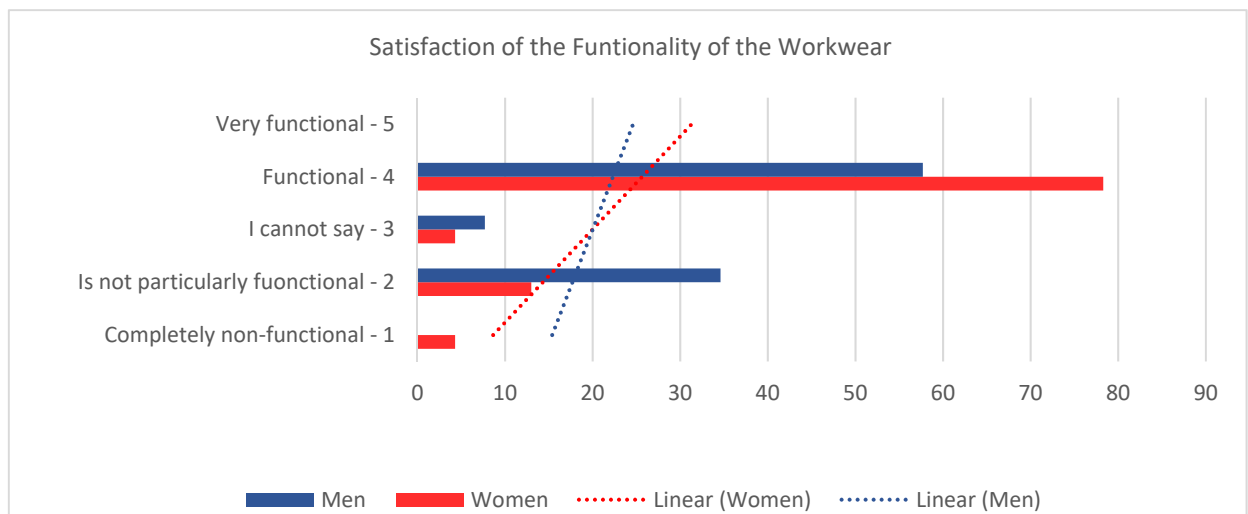


Figure 8. The satisfaction of the functionality of the workwear between men and women

1.2.4 End users' suggestions to improve current workwear's functionality

In question number 12, the end users could bring out their opinions and ideas about the workwear's functionality. The question was: "If you have any ideas or suggestions concerning how your workwear's functionality could be improved, please indicate them here: (E.g. the flexibility of the fabric, the details [fastenings, pockets, loops for e.g. tools, keys, etc.] etc.)" The respondents' opinions are divided and listed below.

Materials:

- the old model and material of the trousers were nicer, 1
- the reflective tape deteriorates (in use as well as when washing), 3
- the reflective tape come away from the garments, 1
- the reflective materials dazzle when welding, 1
- the material should withstand hot zinc, 2
- the winter jacket is too dark, poor visibility, 1
- materials could be more breathable, 6
- woollen underwear material would absorb moisture, 1
- acid and fire resistant, 1

Pockets:

- a pocket or a loop for the walkie-talkie, 3
- the mobile pocket is too narrow
- thigh pocket: one would be is enough (1), tears off easily (1), are situated too low (1)
- a hammer loop could be on both legs, 1
- a pocket for the pen instead of a loop, 1
- a card-size pocket, 1
- a pocket for a knife, 3
- wider flaps for lower pockets on the jacket, 2

Fastenings:

- Velcro is a “toy”
- zippers are weak, 1
- no snap fasteners to the jacket, zippers instead, 1

1.2.5 Chest pocket in undershirt

The question about the need of the pocket in the undershirt had caused disagreement between the personnel of our partner company for such a long time that it had become a joke. Now the managing director got a good chance to resolve it, even though 2-pieced outfit was chosen to be developed.

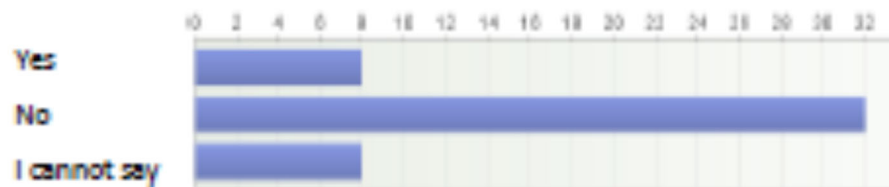


FIGURE 9. Question 13. Do you need/use the chest pocket of the underwear?

1.2.6 Safety of current workwear

The respondents were asked to evaluate their current workwear’s safety (Fig. 10). The workwear users were surprisingly satisfied with the safety of their workwear. Over 81% of the end users were either satisfied or very satisfied with the safety of the workwear. However, if about 10% (5 of 48) of employees feel that security of their workwear needs to be improved, then something must be done.

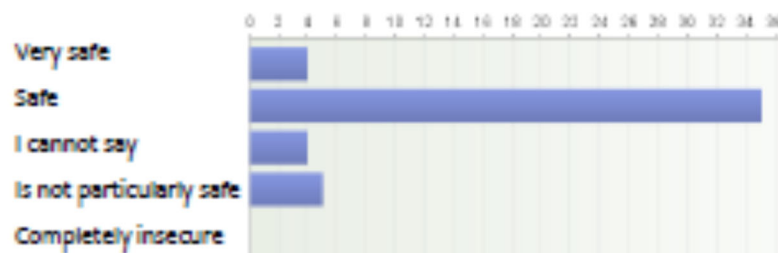


FIGURE 10. Question 14; How would evaluate your current workwear's SAFETY?

Satisfaction between men and women in safety of the workwear was explored with interest. Men and women appeared to have very consistent views on this issue.



Figure 11. The satisfaction of the safety of the workwear between men and women

1.2.7 End users' suggestions to improve current workwear's safety

Question 15 was: "What kind of changes could be done with your workwear in order to make it even safer? (E.g. protection against heat, fire, chemicals, cold or rain, increased visibility, etc.)". The respondents were asked to report deficiencies and to propose improvements. They could find changes that might make their workwear even safer:

- fire resistance when needed
- zinc-resistant material, 5
- getting caught, for example, from the thigh pocket, causes danger
- for a tall and slim person the clothing is too loose → getting caught in door handles etc.
- the material is sweaty and sticky → breathability
- fastness to washing for the reflective tape, 2
- there could be more and better reflectors, 3

The resistance for molten and hot zinc was clearly the most worrying thing (f=5). Molten and hot zinc causes burns even through the garment. Another thing that causes concern is the number of washings and their impact on the functionality of the materials. Some answers were suitable for also to the question of workwear's functionality and safety.

1.2.8 Integrating IT and intelligence into workwear

The last question was about the IT and intelligence in workwear. The question was an open question, where the employees could describe needs of intelligence or present their own ideas. Many of the respondents left this question open, but we got some answer to the question 16, which was "What kind of IT system or "intelligence" would you add to your workwear to improve it?"

- RFID for monitoring the amount of washing or the need of washing, 7
- RFID/sensors to locate a person (in case of emergency) or to inform of the arrival of a person to his/her working area , 4
- technology that alerts you of occupational hygiene, air purity, noise level or gas, 2

The most worrying thing seemed to be that workwear materials' functionalities weaken during washing. Overall, the employees' ideas associated with RFID and sensors.

2. DEVELOPMENT OF PRODUCTS BASED ON THE SWW-SURVEY

Basic on comments of end-users and analysis of 3D body scanning results changes to be made in work wear are suggested.

2.1 Changes made in jacket's prototype

The end users' suggested improvements for the new jacket were combined (sizing, fitting, functionality and safety, not to forget design). The improvements were realized introducing following changes:

1. New measurement table based on the body scanning study was created and sized with letter codes from XS – XXXL (the size range can be expanded from both ends)
2. The very masculine form of the jacket was made narrower on the waist. The hip circumference was kept unchanged, but the side seams were fitted with a wedge and a zipper to get more ease to the hip.
3. The straight sleeve was shaped to be narrower and the side seam was raised from the armpit.
4. Two small darts were put to the sleeve to make it slightly pre-bent.
5. The sleeve cap was raised and the shoulder seam was shortened.
6. The surface of the high visibility color was added on the sleeve.
7. The hem was lengthened in the middle back.
8. The lower reflector strip was moved next to the waistband.
9. New, more spacious breast pockets (Fig.13)

Some of the changes were made outside the employees' open answers. These changes can only be expected to add the functionality.

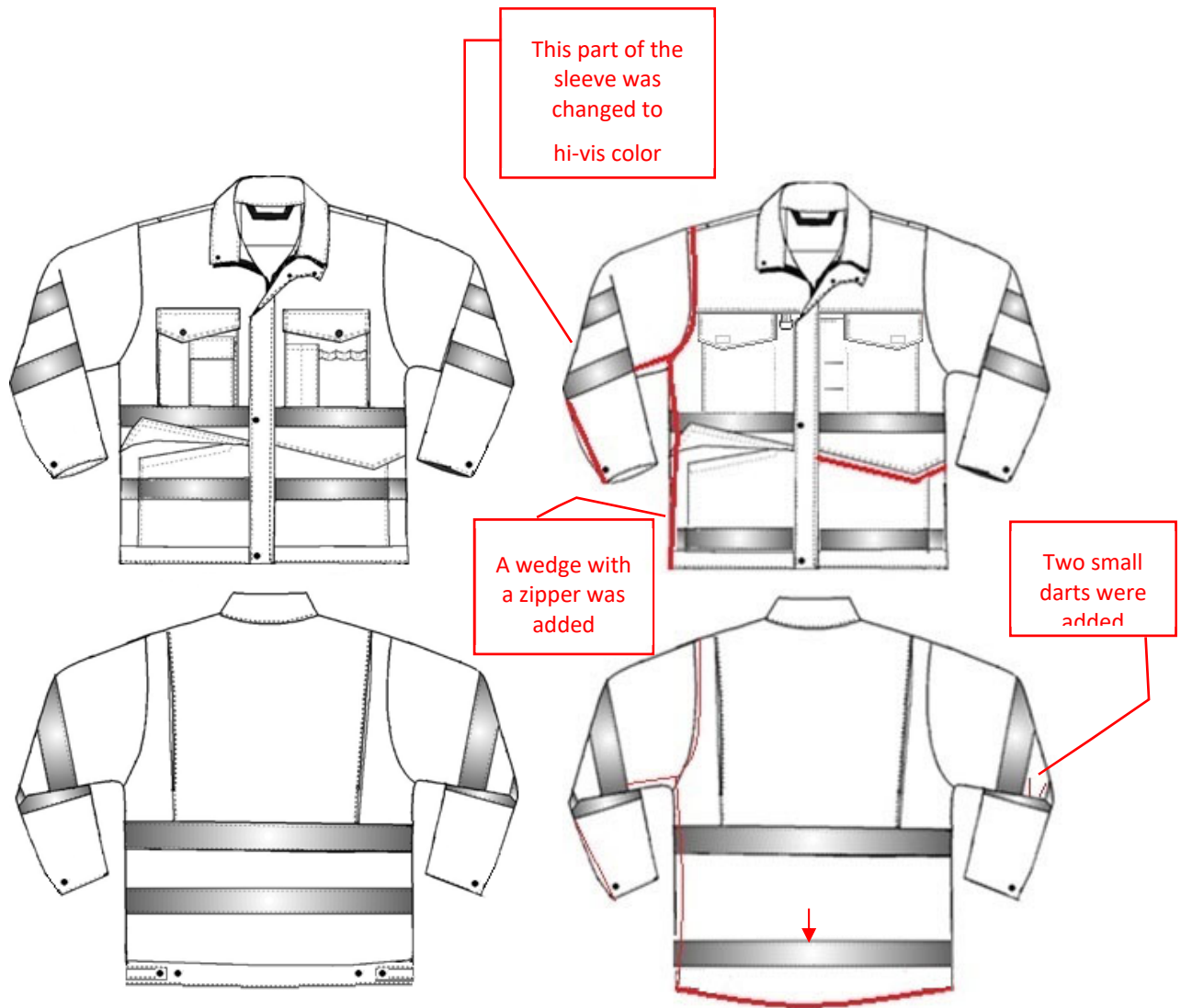
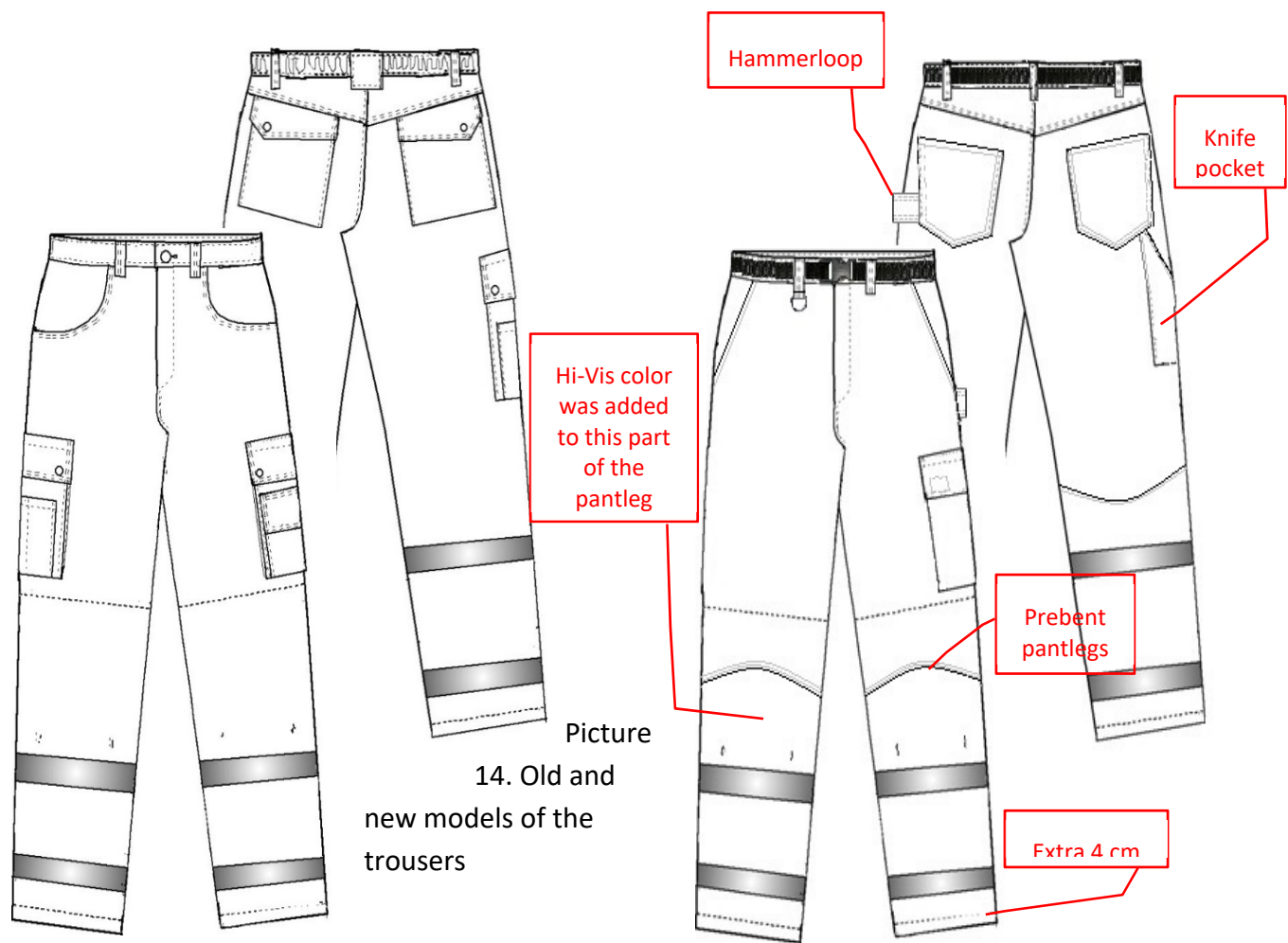


Figure 13. Old and new models of the jacket

2.2 Changes made in trousers' prototype

1. New measurement tables based on the bodyscanning study were created differently for men and women: 2 length groups for men, 1 for women.
2. 4 cm extra hem at leg opening to be opened if needed.
3. Hi-Vis fabric added.
4. A hammer loop was added to the left.
5. Slightly pre-bent pantlegs.
6. A knife pocket was added.
7. The other thigh pocket was removed. The pleat was removed from the front of the other thigh pocket and the snap fastener was changed to Velcro.
8. The rubber band back on the waist was removed and replaced with a belt and a plastic snap buckle.



SOURCES

Boliden 2015. Yhteiskuntavastuun raportti.

http://www.boliden.com/Documents/Press/Publications/Sustainability%20Reports/Boliden_Kokkola_2015_lowres.pdf

EN 13402-1: Terms, definitions and body measurement procedure

EN 13402-2: Primary and secondary dimensions

EN 13402-3: Measurements and intervals



Interest of human complex protection from various influencing factors while doing work is increasingly growing. One of those protection means is workwear. Increasing demands, influence on work clothing improvement process in order to reach the required level of end-user protection.

MATERIALS AND METHODS

In order to provide soldiers with clothing appropriate to their requirements, researchers split the research in phases: end user survey- questionnaire and interview and testing of current materials and construction of the clothing.

The end user survey

The end-user survey was selected as one of the qualitative research methods. The survey provides an opportunity to find out the user experience wearing combat uniforms and their faults, thus enabling the researchers to improve the said battle dress.

Human body 3D scanning

Prospective users were measured by non-contact Human Body 3D scanning (Vitus Smart XXL). The acquired measurements will serve as the basis of anthropometrical data for development of new-generation workwear prototypes.

Testing of fabric properties

Fabric properties were analysed in the research – tensile strength and elongation, tearing strength, Martindale abrasion resistance, pilling resistance, rigidity, thermal and water vapour resistance were determined and connectivity testing of articles was carried out.

Testing of constructive and technological solutions

The analysis of trouser crotch connections of field uniform was carried out by determining tensile strength and elongation of the trouser crotch connections.

3. SURVEY AND FINDINGS

The project was aimed at development of comfortable and safe workwear. Based on the said aim, a target group (end users) was selected and a survey was conducted to find out attitude of the end-users to their workwear on the subject of comfort, safety and functionality.

The Latvian National Armed Forces (NAF) was selected by Latvian researchers as a target group. Through the survey the researchers studied the attitude of end-users to the part of a set of the field uniform consisting of a jacket and trousers that serve as a basic battle-dress with unified camouflage pattern to ensure masking in the NIR range. Fabric of battle-dress is impregnated against insects (for wearing during international operations in Afghanistan)¹. According to the NAF, the set of the field uniform is a part of soldier's personal protection system, which also includes a bullet and harness system, boots, military armour head-piece and clothes for protection against mass destruction weapons.

Components of the field uniform have a number of operational tactical requirements set out by NAF authorities, such as the least possible mass, ability to provide soldier combat capability

¹ http://www.mil.lv/Personalsastavs/Apgade/Forma/Lauka_formas_terps/Lauku_formas_terps.aspx

in the temperature range from -30 °C to + 50 °C in all climatic zones and terrains. Also, in development of field uniforms, latest achievements in the military textile industry must be applied².

3.1 General information

The number of respondents who participated in the survey total to 122 individuals – both males and females aged 18 to 50 years. The majority (64%) of respondents were males aged 18 to 25 years.

Military ranks of the respondents were also determined for more complete information and understanding of what the respondent is engaged in. The majority or 69% of respondents discharged functions of Private First Class. Private First Class is granted to a soldier not earlier than after a three-month of military service, or as an award³, which shows that the majority of respondents participate in the active service, and their uniforms must withstand a fairly high load while actively moving.

Moves like dropping to knees, crawling, knee spreading, stretching, etc. affect the durability of clothes – both of the fabric and the garment connections are to withstand a certain amount of breaking, tearing and friction load. Whereas comfort is ensured by proper fabric properties and constructive solutions of the wear.

3.2 Assessment of workwear

To understand how the respondents assess their workwear, questions on the fit, specifics of a model, as well as its functionality and desired improvements were asked.

The fit to the size of each particular wearer of the uniform is highly important. Most respondents (71%) are satisfied with the fit of their field uniforms, however when answering the question on what changes they would like to introduce to uniforms, only 43% of the respondents acknowledged that the uniform fits them well and they do not want to change anything in it. Current trend shows that the respondents would like to change both the roominess and the fit of the wear (Figure 2.1), which is confirmed by the fact that 26% of the respondents indicated that their uniforms currently feel either too tight or too loose (Figure 2.2.).

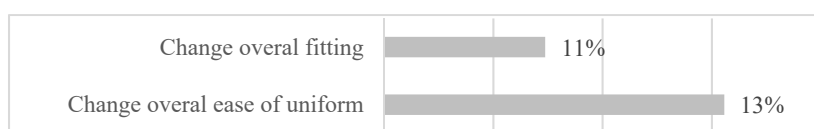


Figure 23.1. Preferred changes in the extent of the fit

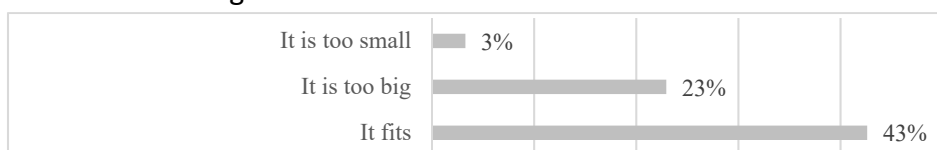


Figure 2.2. The fit of uniforms to body composition

² http://www.mil.lv/lv/Personalsastavs/Apgade/Forma/Lauka_formas_terps.aspx

³ http://www.mil.lv/lv/Militarais_dienests/Dienesta_pakapes/Pakapju_pieskirsana.aspx

A trend was also observed in the fact that 8% of respondents wanted to extend both sleeves and trouser legs (Figure 2.3.). The same applies to the preference of shorter sleeves (7%) and trouser legs (10%). The minority of respondents would like to change the length of jacket, while 18% of respondents want to change the overall fit of the clothing so that it does not interfere with the work-related movements.

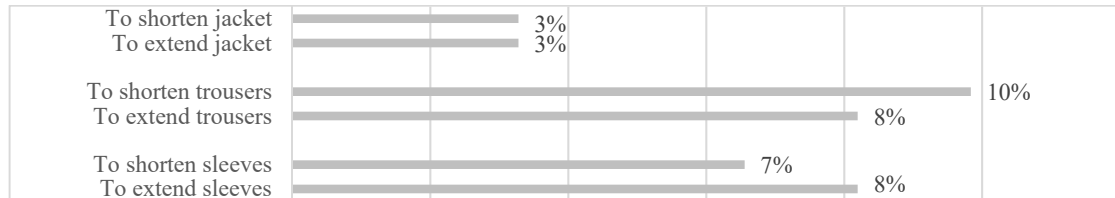


Figure 2.3. Preferred changes in the length of articles and their parts

To an additional question regarding possible changes in sizes, it was noted that it is generally difficult to find jackets and trousers of appropriate sizes, and the suggestion to this is to introduce more sizes.

In the course of the research, it was important to learn also the attitude of respondents towards the model of the field uniform. The majority of respondents (85%) like the existing model of work wear.

Whenever the respondents were asked to describe in a free manner what they would like to change in their work wear, regardless of whether the question was asked about the fit, the model, or functionality, the respondents in all cases more spoke on issues related to fabric quality, constructive and technological solutions in certain parts of their wear. Moreover, in all sections responses recurred, indicating that the said defects are highly important and indeed impede performance of their duties.

Most frequently answers referred to trouser crotch, which, in certain conditions and in certain movements, tend to tear rather easily. Recommendations such as securing stitches, making crotch stretchy, changing the cut of crotch, using more durable fabric for sewing trousers, increasing the crotch-size, etc. were mentioned.

In regard to functionality of field-dress sets it was found that in general respondents (77%) are satisfied with functional solutions of their uniform, however, some respondents (23%) consider the uniform to be not fully functional or even malfunctioning.

When asked about possible improvements in functional solutions of their uniforms, many of the answers were related to the aforesaid faults in constructive and technological solutions, as well as to the choice of fabric. For example, 72% of the respondents would like to increase fabric strength, and 62% think that the fabric should be stretchier (Figure 2.4.). The respondents would have liked the fabric to have better colour durability, as well as water-repellence.

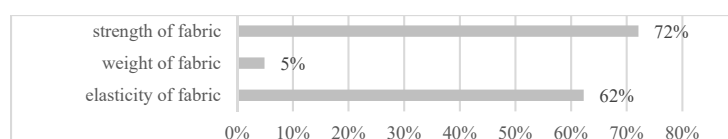


Figure 2.4. Preferred changes in fabric of field uniforms

Similarly, respondents would like to introduce changes in fasteners – preferring zip-fasteners or touch and close (Velcro) fasteners to buttons. It should be noted that buttons are used in pockets and fronts of trousers of the field uniform, and respondents have repeatedly said that button clasp and buttons are inconvenient. 75% of the respondents replied that they do not button-up their pockets.

59% of the respondents feel it is important for them to reinforce elbow and knee areas. The free-form responses showed that this is needed not only because these parts of garments easily wear out, but also for protection of knees and elbows against various types of injuries. Individual respondents are dissatisfied with location and type of pockets. The free-form responses stated necessity to reinforce pocket corners and to widen trouser side pockets.

The respondents were also asked to express their views on the use of individual elements of field uniforms. The answers show that 77% of the respondents do not use pocket-loops, while 75% do not use buttons of their pockets, which is in line with the above information, where respondents suggested replacing buttons by touch and close fasteners. In regard to adequacy of pocket width, 80% of the respondents replied affirmatively, as well as 80% of the respondents said that the width of belt loops is sufficient.

To the question whether respondents use suspenders, 92% of the respondents answered in the negative, however 57% regarded suspender band as necessary. Some of the respondents are not satisfied with the location of suspender loops and they would like to have more loops located in different places thus allowing the use of different suspenders.

When asked if there are any unnecessary details in the field dress, responses of the respondents were disagreeing. As the question on unnecessary details in jackets were answered by a very small percentage of the respondents, the responses are viewed as insignificant. In regard to trousers, tendency show that flaps on backs of trouser legs are detaining and unnecessary (indicated by 27% of the respondents). Similarly, a small part of the respondents viewed ties at the bottom of trouser legs as detaining.

A part of the respondents also provided answers in free form and informed the research team that they use elements of their garments in accordance with the specifics of the task. All of the elements are not used on daily basis, however there are times when they are needed, which generally means that all the elements are being used, as each of them is intended for its own purpose, pockets are never enough.

Asked about what defects the respondents have observed in their field uniforms (Figure 2.5.), 80% of them indicated that they have observed loss of colour, 75% observed wearing and 72% - tear. All of the above-mentioned defects indicate the material properties that are inappropriate to the conditions of use. Similarly, 34% of the respondents noted that they have observed broken seams, which could be a sign of fragile connections in the places where the most strength can be detected during wearing, as well as weak threads (Figure 2.5.).

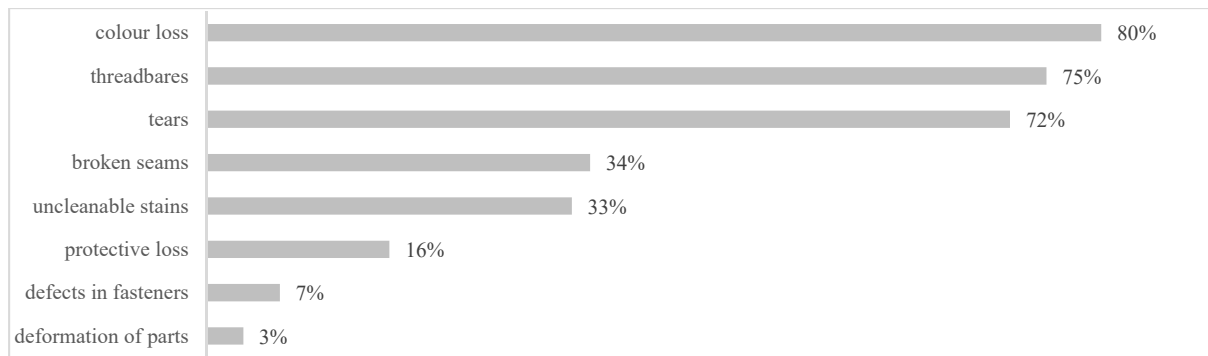


Figure 2.5. Defects observed in field uniforms

Providing additional information on defects found in the jacket of field uniform, respondents mentioned that tears and/or wear were found in elbow and shoulder areas, sleeve bottoms, sleeve and breast pockets, fastening edges, bottom edges, and shoulders. While the loss of colour is observed in all parts of the product subjected to rubbing – in pockets, fastening edges, waist area, bottom edges, elbows, sleeve bends, and sleeve bottoms. Non-removable stains are found in those parts of the uniform which are often touched by hands, close to surface of the body or exposed to rubbing, such as collars, sleeve bottoms, fasteners, waist lines, elbows.

Information on defects found in trousers repeatedly leads to a conclusion that the most defects are observed in crotch area. 66% of the respondents indicate that tears tend to appear in the crotch area, some of the respondents indicate top of step stitch, trouser fastening, knee area, area of belt loop attachments, pocket corners, leg bottoms. Trousers also wear out in areas most exposed to rubbing, for example, in the front of thighs, fastening, in the back crotch, knee bending area, leg bottoms, and pockets flaps. 51% of the respondents had observed wear outs on knees.

Ripped up seams were observed in the crotch, sometimes in fastening, buttock pads, while the loss of colour - on knees, in the front of thighs, in the buttocks area and in knee joint area. A part of the respondents indicate that colour loss occurs throughout the product. Non-removable stains both in jackets and trousers appear in places subject to rubbing, contact with the body or direct contact with external factors such as leg bottoms, knees and butt area. In regard to the loss of protective properties of trousers, the respondents pointed out knee area, or indicated that protective properties tend to loose throughout the entire product.

3.3 Summary of the survey results

The survey was aimed at learning the attitude of end-users to their daily work wear in order to allow researchers to understand what potential changes should be introduced into this kind of wear. Below are the most striking trends:

- 1) Unsatisfactory **quality of fabric** used for manufacturing field uniforms. The respondents regard it as not strong, breathable, and stretchy enough, colour durability and friction resistance is insufficient.

- 2) **Constructive and technological solutions in crotch stitches** of trousers are poor. The respondents consider that it is necessary to change the design of trousers to fit the body of end-user, as well as to use different (more durable) connections for trouser front crotch.
- 3) It is necessary to **reinforce knee and elbow pads** to protect the product from effects of friction (fabric) and to protect connections from injuries (put-in padding), to reinforce sleeve bottoms and leg bottoms to protect the product against the effects of friction.
- 4) **Button fastening** should be replaced by zip fastener.
- 5) **The way of adjusting waistband** should be changed by replacing band by elastic band or touch and close fastener (Velcro).
- 6) **Back pocket flaps should be removed**; button fastener on pockets flaps or back pockets should be given up.
- 7) **The fit** of field uniforms must be ensured.

4. DEVELOPMENT OF PRODUCTS BASED ON THE SWW-SURVEY

Designing of protective clothing is a complex process in every step of which various possible factors that can affect proper fulfillment of the standard requirements and end-user satisfaction with the product should be regarded. According analysis of existing uniforms (combat set), the amendments, updates and benefits of the new combat set is provided and implemented in new prototype.

4.1 New design of jacket

- 1) Lowered hemline
- 2) Elongated back hemline for more comfort when bending down
- 3) Lowered neckline in the front for more comfort
- 4) Elbow reinforcement pocket opening from the outside of jacket
- 5) Zipper closure on front and sleeve pockets

4.2 New design of trousers

- 1) Lowered waistline
- 2) Wedge insert in the crotch area for more comfort and flexibility
- 3) Double seam in the crotch area using more durable threads
- 4) Increased crotch width
- 5) Slant front pockets for easier and more ergonomical use
- 6) Removed back pockets (after many comments and claims from soldiers – they don't use them)
- 7) Zipper closure on thigh pockets – easier and more quiet to use
- 8) Knee reinforcement pocket opening from the outside of trousers
- 9) Removed calf pocket



Shoulder yoke



Lowered neck line



Changed pockets – size, configuration



Changed pockets on the sleeves



Lowered hem line at back

Size at the hem is adjustable



Patterns divided and adjusted, ventilation openings (circle) added
Fold at the back for ease of movements



Changed shape and size of elbow pads



Changed shape of side pockets
Fastening changed – buttons to zipper
Waistband fastening changed – button to velcro



Side pannel added

Removed calf pockets



Wedge shaped insert at the crotch
Changed seams and technology of the crotch



Changed shape and size of the back pockets, changed flap and its fastening



Changed shape and size of the back pockets, removed flap

Elastic band added at the back waistband



Changed shape and size of knee pads



5. SURVEY

5.1 Background information:

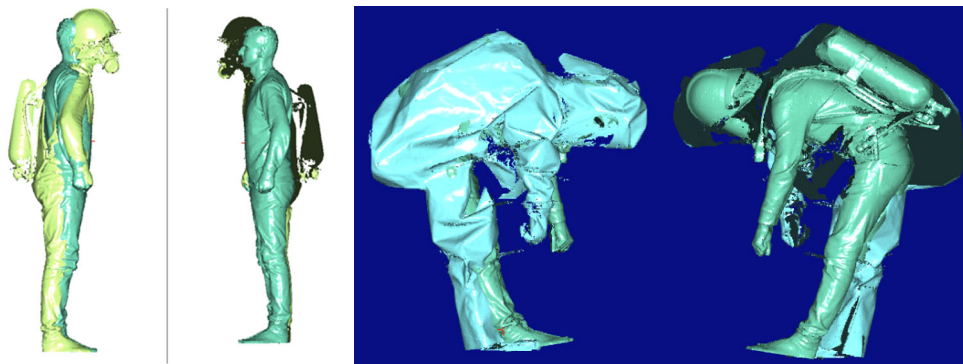
- Age groups:
 - 20-30 – 28%
 - 31-40 – 28%
 - 41-50 – 42%
- All male
- Garment size:
 - S -3%
 - M – 24%
 - L – 32%
 - XL – 32%
 - XXL – 8%
- Occupational group:
 - worker – 92%
 - leading position – 5%
 - driver – 3%
- Movements for working position:
 - All types(standing, sitting, getting down on the knees, bending down, crawling, stretching/reaching out

5.2 Evaluation of workwear:

- Current suitability of work wear in terms of sizing and fitting:
 - Satisfied – 86%
 - I cannot say – 8%
 - Dissatisfied – 5% (fog on the visor, not comfortable donning of the gloves, too tight upper part of the suit)
- Current suitability of work wear in terms of design:
 - Satisfied – 86 %
 - I cannot say – 3 %
 - Dissatisfied – 11 % (too long sleeves, missing pockets)
- Current functionality of work wear:
 - Satisfied – 67%
 - I cannot say – 11%
 - Dissatisfied – 22% (fog on the visor, not comfortable donning and doffing of the suit (one person could not get out of the suit without help of other person), zipper is very difficult to close, small loops or pockets for inside of suit for small devices are required, no possibility to use communication device)
- Safety of current suit:
 - Safe – 54%
 - Is not particularly safe – 22% (referring to previous comments about dissatisfaction, improve visibility, improve protection against heat and chemicals)
 - I cannot say – 24%

6. DEVELOPMENT OF PRODUCTS BASED ON THE SURVEY

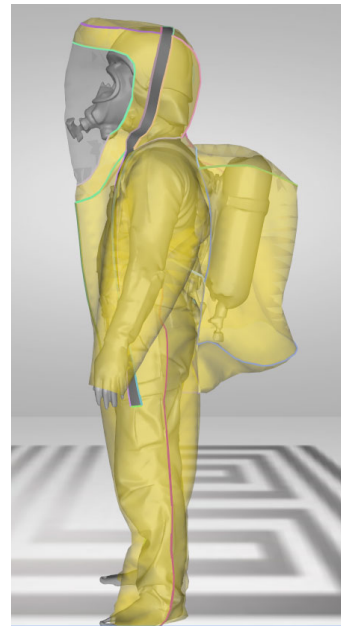
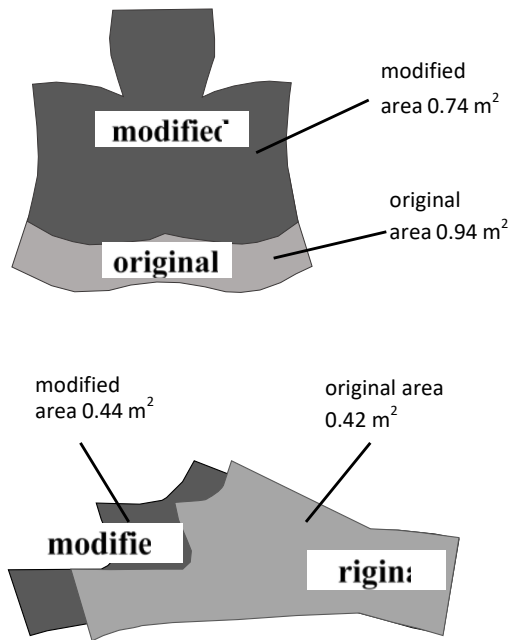
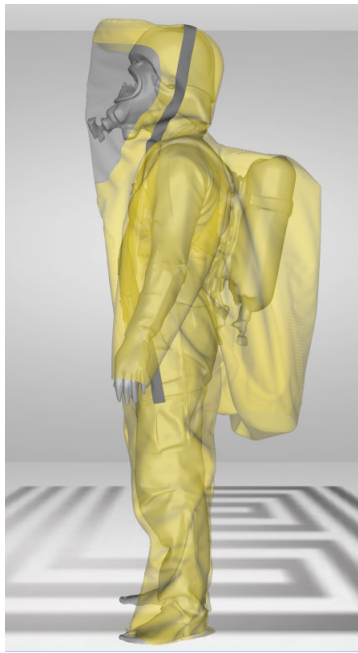
VUAS has developed very valuable methodology for virtual design of garments for chemical protective clothing for e.g. firefighters. It must be noted, that such clothing is worn on fully dressed human body, which is usually equipped with the gear, adding additional requirements for the fit of the clothing. Thus, the digitalized method using commercially available software for generation of prototypes for various purposes was developed. The steps in garment design consist of 3D scanning of the human body with or without gear and also in different movements when appropriate, 2D pattern creation, material consumption calculation and virtual fitting of the virtual garment created based on 2D pattern. All the process assists in creating better fitting, more comfortable garment.



6.1 New Design of CPC

A graphical analysis of the changes of the typical measurements of human shapes and CPC costumes was made by comparing them in the vertical resting state (standing) and in working positions. On the basis of obtained results three optimized constructions of CPC costume were developed:

1. with a back basket that smoothly transits into the piece of back thigh;
2. with a widened back detail covering gas cylinder;
3. with a joint detail of hood and back basket.



Material consumption after back bag shortening became less by 0.18 m², what resulted in more comfortable CPC suit as it became lighter by 95 g.

Material consumption before shortening was 78.62 % (marker length 4,90 m; marker width 1.47 m); for shortened back bag was 76.10 % (marker length 4,70 m; marker width 1.47 m).



7. SURVEY AND FINDINGS

Questionnaire report provides an overview of some demographic indicators of Estonian military, evaluation of military uniform - general satisfaction of current uniform and improvement suggestions.

Number of scanned Estonian military servicemen is 300 people and number of answered questionnaires is 142.

Questionnaire was divided in two categories:

- Background information – contained of 5 questions
- Evaluation of workwear - contained of 6 questions

The questionnaires were filled in two different ways. Some were filled on paper while 3D scanning was in place and others were submitted by Google Forms (because of the small time frame the military servicemen were given for 3D scanning).

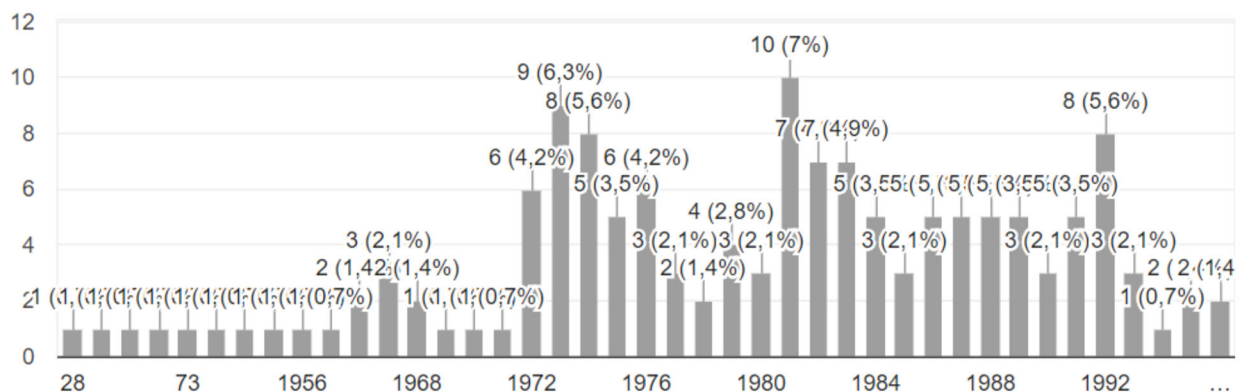
We made some corrections to SWW original questionair according to Estonina Military requests and changed/added some of the work movements according to the military needs.

7.1 Background information

Background information includes age, sex, occupational status, uniform size and main movements in the workplace.

Date of Birth

Most of the servicemen and women who participated in questionnaire were born between 1972 and 1992



7.1.1 Occupational groups

There are different occupational groups in Estonian military who share the same uniform:

- Compulsory military servicemen
- Professional servicemen
- Reserve Force servicemen

- Defense league

QUESTIONNAIRE ANSWERS BY OCCUPATIONAL GROUP

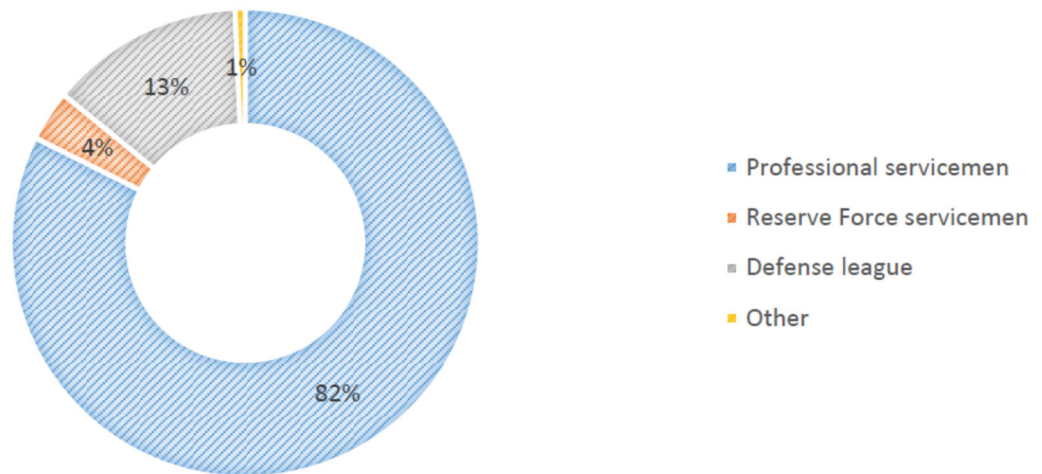


Chart 2 Division by occupational group

7.1.2 Workwear garment size

Workwear garment size question shows the most problematic aspect of Estonian military uniform sizing. Most of the soldiers don't know the size of their uniforms. There is also several different combinations and uniforms with different sizing systems in use at the military. Below you can see the answers of servicemen and women about their jacket, pants and underwear size.

Table 1 Estonian Military Uniform Jacket size

180/96 (13)	108 (2)	190	ei ole tuvastatav, kulunud	188-92	190 / 112	176-108	164-88-76
- (8)	180-104 (2)	185	170-112	179/96	190 / 120	182-104	M176-182
L (8)	XL (2)	184-100	Kulunud	178/120	190/104	M 172	170/88
180/104 (5)	ära kulunud (2)	160	170 /80/88	ei ole enam näha	52	100	190-96
170/96 (4)	164 (2)	92	170	160-88	M/50	Pole ju oluline	185/ei saa aru
50 (3)	182/96 (2)	178/180	xxl	182-96	170-104	164/88/76	S (numbrit ei ole näha, pesus ära kulunud)
182 (3)	190/96 (2)	62 XXXL	ei tea	182/96/84	158/80	176	Mis numbrit siia vaja kirjutada on?
180-96 (3)	188/96	176/88/76	L-XL	60	176-182	194-104-92	170/104
36 (2)	11	188/88 või 192/96	180/88	104	182-100	110	
M (2)	48	200-128	182/104	180-187-96	170-96	160-96	
160/88 (2)	34	188	188/ 112	96	178-110	188-52	
54 (2)	50/188	170/100 pikkus	170-88	200/120	190-104	85-88-104	

Table 2 Estonian Military Uniform pant size

- (10)	54 (2)	36	33	188/112	Ei oska vastata	104	176
L (7)	ei tea (2)	182-104	180/88/104	50	90/100/108	176-182	188
75/76/92 (5)	75/80/96 (2)	93	170 pikkusele	110	176-100-88	178-100	194-112-102
80/80/96 (5)	108 (2)	80/96	ei ole tuvastatav, kulunud	170-96	85/80	193	106
80/84/100 (3)	XL (2)	34/32	70/92/106	188-92	90 / 92 / 108	80/96/112	182/90
80/76/92 (3)	85/84/100 (2)	69/64	Kulunud	85-84-100	180/96	32/32	188-50
80-80-96 (3)	75/84/100 (2)	92	182	178/105	85 / 104	192-x	85-88-104
34 (2)	ära kulunud (2)	62 XXXL	?	ei ole enam näha	190/104	172 M	48
175 (2)	164 (2)	M	38	168-82	M/50	85	80-72-88
170 (2)	52 (2)	28R	xxl	182/96/84	170-104	170/96	85/80/86
180 (2)	188/104/92	188/88 või 192/96	L-XL	170/104	80/92/108	Pole ju oluline	182-96-84
75/72/88 (2)	W72L73	120	182/86	96	158/80	100/100/90	185/kadunud nr

S, pikkusele 180 cm (numbrit ei ole näha, pesus ära kulunud)

Mis numbrit siia vaja kirjutada on?

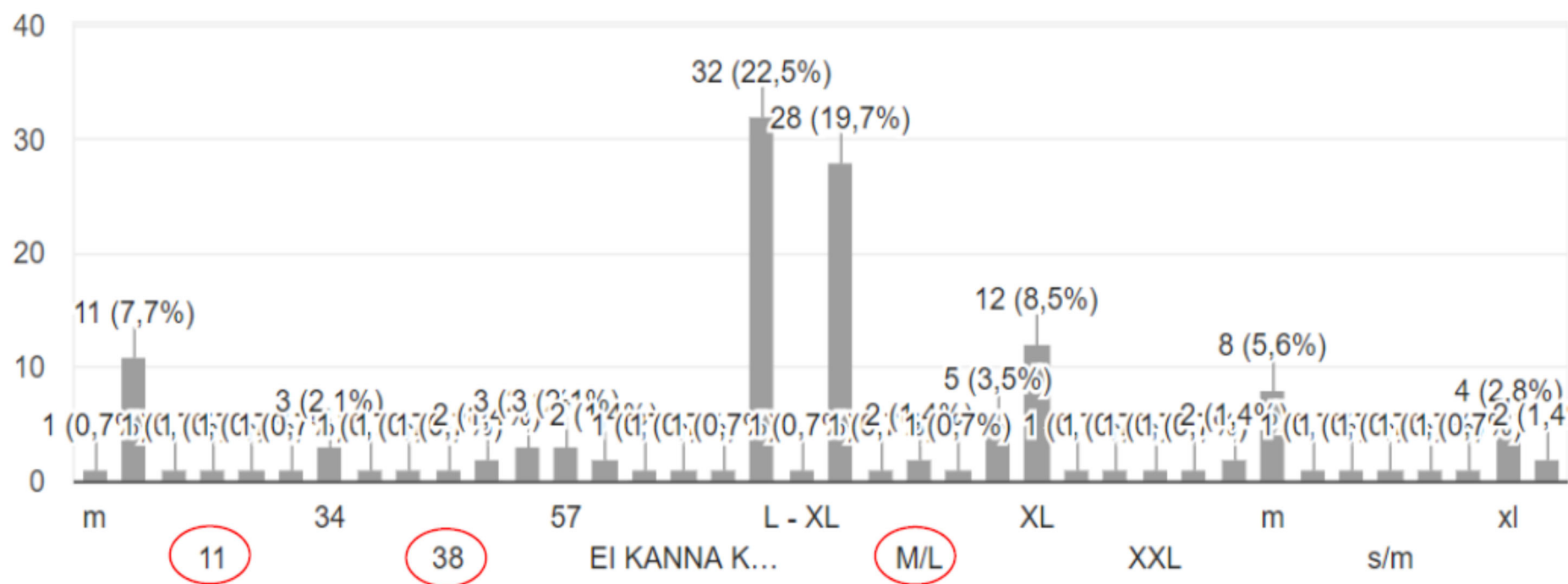
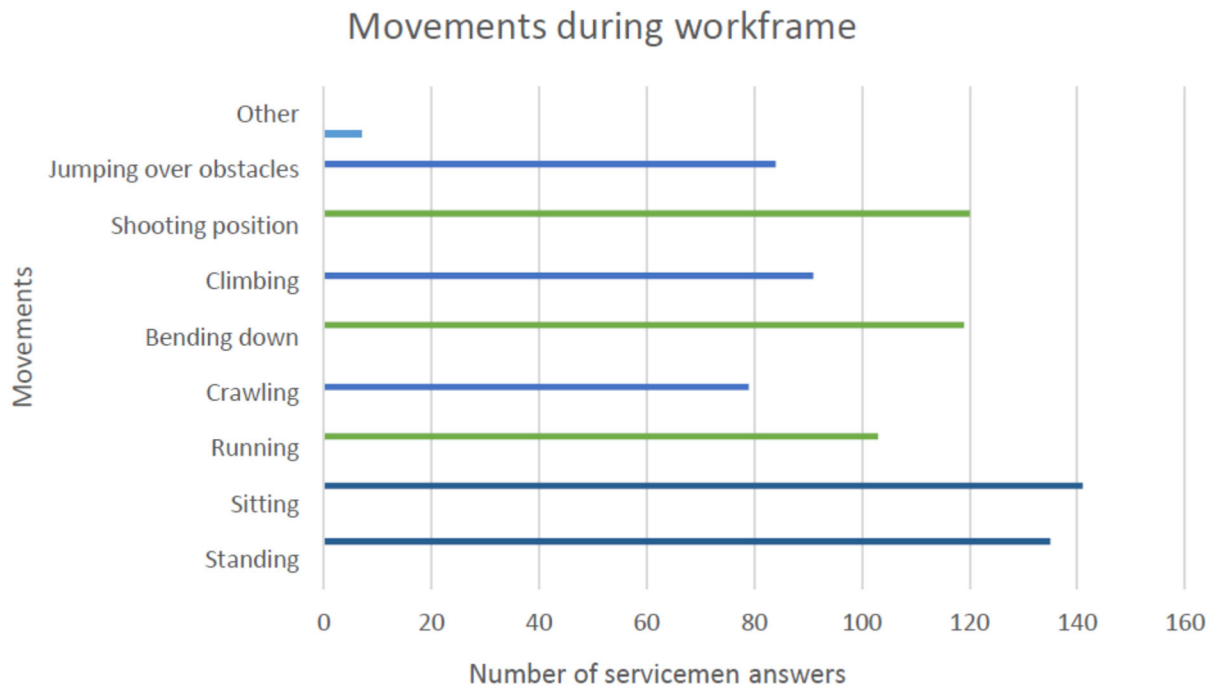


Chart 3 Estonian military underwear sizes

7.1.3 Movements during work

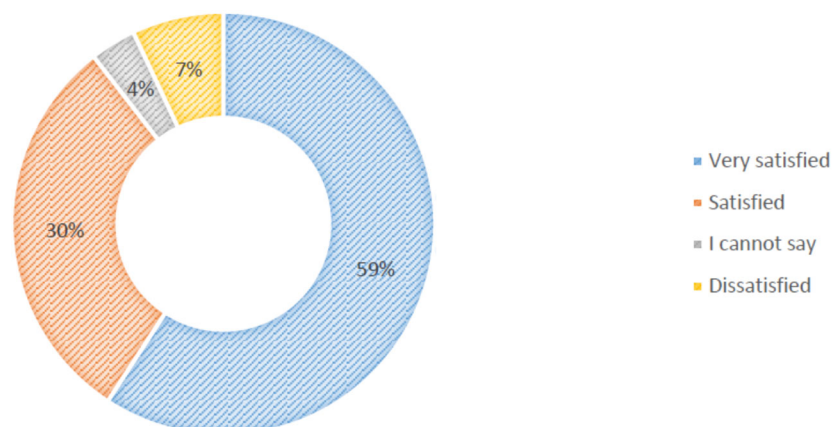
We made some corrections to SWW original questionair according to Estonina Military requests and changed/added some of the work movements according to the military needs.



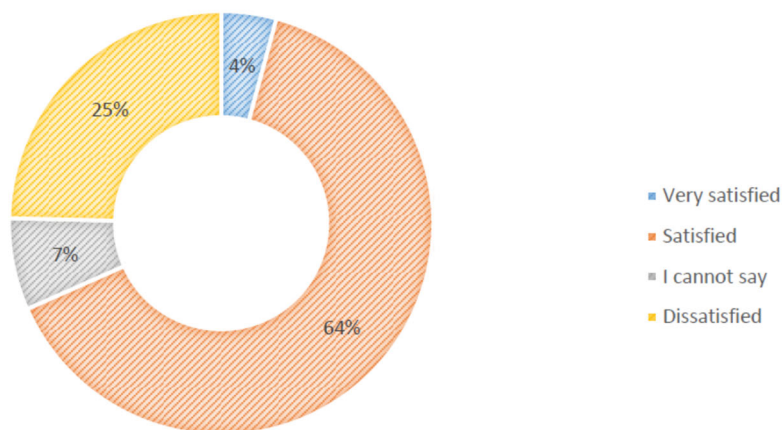
7.2 Evaluation of workwear

Evaluation of workwear is divided into sizing and fitting, uniform pattern-construction suitability, uniform functionality and safety, suggestions and problematic areas.

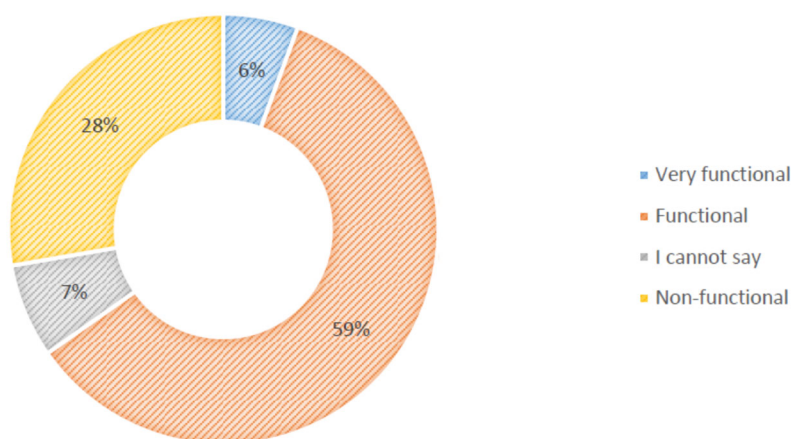
FITTING AND SIZEING



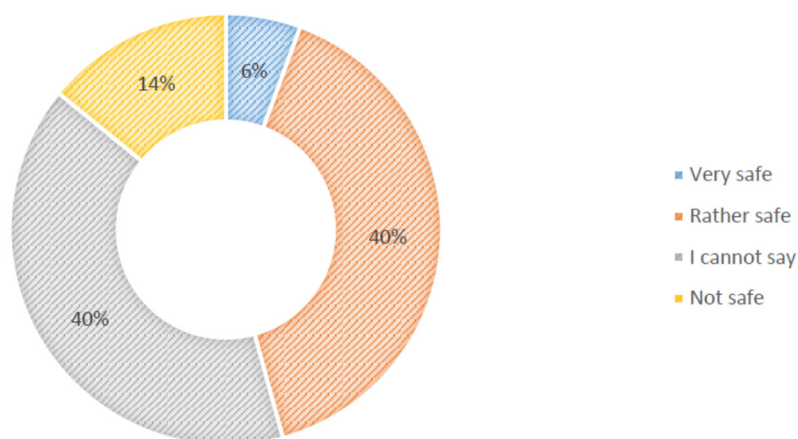
UNIFORM PATTERN-CONSTRUCTION
SUITABILITY



UNIFORM FUNCTIONALITY



UNIFORM SAFETY



7.3 Summary

Most common problems and suggestions concerning uniforms as answered by military servicemen:

- Most common problem is that the uniforms are too loose, sleeves are too short and too wide
- Pants crotch tears easily
- Uniform is too hot in the summer and doesn't breathe enough – air permeability.
- Need for better fitting – fitted jackets, pants with lower waistband, longer sleeves.
- Female soldiers should have their own uniform
- Difficult to roll up the sleeves
- There were some suggestions to integrate elbow and knee protections into the uniforms
- Soldiers would like more water-resistant uniforms and quick drying materials
- More elastic fabric
 - Also soldiers would like to have more zippers instead of buttons and velcro

8. DEVELOPMENT OF PRODUCTS BASED ON THE SURVEY

To improve functionality, safety and comfortability of the uniform the opinions of the end user group has been taken into consideration.

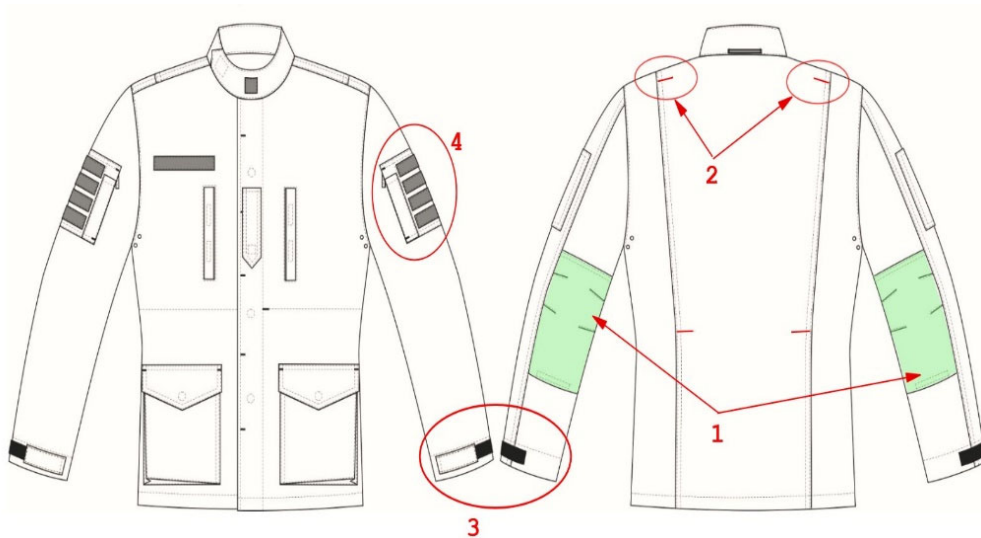
Based on the survey the most common problems and suggestions concerning uniforms as answered by military servicemen:

- Most common problem is that the uniforms are too loose, sleeves are too short and too wide
- Pants crotch tears easily
- Uniform is too hot in the summer and doesn't breathe enough – air permeability.
- Need for better fitting – fitted jackets, pants with lower waistband, longer sleeves.
- Female soldiers should have their own uniform
- Difficult to roll up the sleeves
- There were some suggestions to integrate elbow and knee protections into the uniforms
- Soldiers would like more water resistant uniforms and quick drying materials
- More elastic fabric
- Also soldiers would like to have more zippers instead of buttons and Velcro

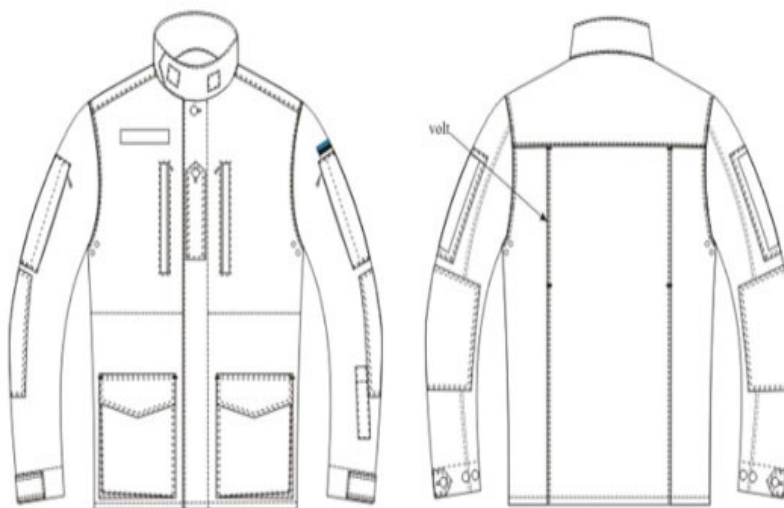
Focusing on the below problems and during the great and innovative design work, new prototype of uniform of Estonian Defense Force and Marine has been designed.

8.1 New design of jacket

1. Darts were added to elbow details for more ergonomic shape. Openings for reinforcement were added for more comfort and protection.
2. Jacket's back detail yoke was uncomfortable and didn't allow needed movements, it was redesigned into pleated vertical seams with bar tackers for pleats near shoulders and waistline.
3. Velcro fasteners were added to sleeves for better adjustment.
4. Velcro fasteners were added to sleeves for military emblems.



New and improved version of Estonian Defense Force and Marine uniform jacket

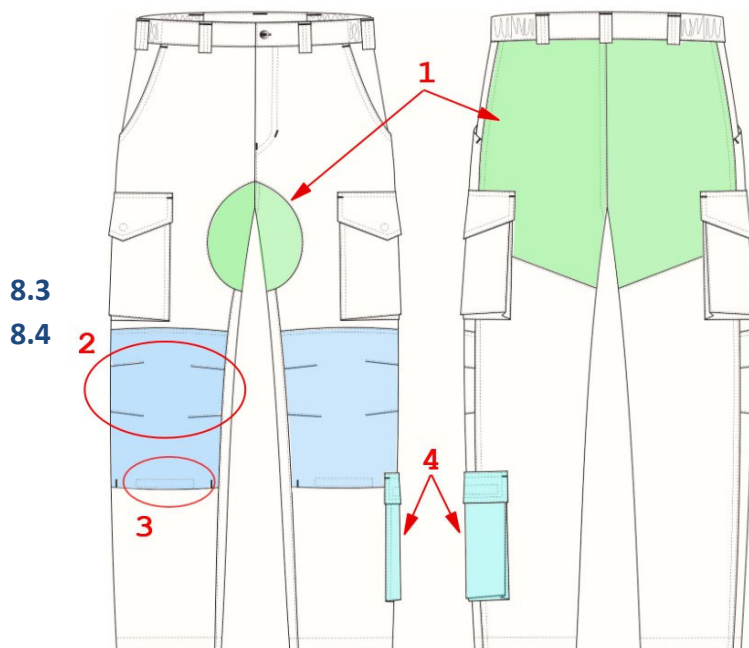


Old version of Estonian Defense Force and Marine uniform jacket

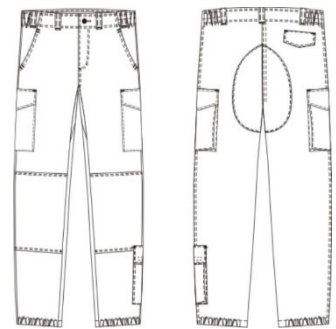
8.2 New design of trousers

Description of changes to the trousers:

1. Trousers front and back details were changed to the shape that helps to reduce tension in crotch and buttock area while performing different movements.
2. Knee details were elongated and location was changed to cover all kneeling positions. Also darts were added for more ergonomic shape.
3. Knee reinforcement openings were added for more comfort and protection.
4. Pocket on the left lower outer seam is redesigned to fit med-pack comfortably.



New improved version of Estonian Defense Force and Marine uniform trousers



Old version of Estonian



Introduction

The functionality of clothing must be linked to the aesthetic appearance, drapeability and fitability, compilation of these features is a determining factor in its quality.

The requirement of the functionality of clothing is the ability to freely perform movements and activities by a man dressed in it. This is conditioned by the ergonomic construction of clothing with the use of appropriate size structural additives (clearances) in specific clothing locations and material properties. The dimensions of the human body and correctly chosen clearances in clothing, that is construction accessories (additives) are basic information for the design and development of ergonomic clothing.

Within the framework of this project, the Institute together with the manufacturer of workwear clothing KRYSTIAN company selected for further analysis a pattern of workwear clothing consisting of bib pants and a sweatshirt. A company was selected whose employees use the chosen workwear clothing model to conduct a questionnaire there.

During the implementation of the measurement session at the construction site, the employees of the Textile Research Institute that carried out this task conducted a survey among employees to obtain information on the conscious choice of clothing size and determine the needs of the respondents in terms of clothing fitability to the silhouette and satisfaction with the currently used work clothes.

The research process of pilot measurements related to the survey of users of workwear clothing and performed analysis of clothing was focused on improving the production of clothing to the needs of recipients and adapting them to the different silhouettes profiles. The reason for the lack of acceptance of protective measures is often the failure to take into account ergonomic requirements during their design.

The ergonomic design of clothing, especially protective clothing, reduces the discomfort caused by their use and reduces the nuisance associated with the movements during use, especially when it involves the performance of professional activities. Taking into account the principles of work ergonomics contributes to the increase in the comfort of use of employees dressed in properly chosen clothing.

9. SURVEY AND FINDINGS

Development of the results of surveys obtained during the measurements of employees of a construction company WARBUD

The results of the analysis of questionnaires obtained during non-contact measurements of silhouettes carried out within the SWW project are presented below. The group of people surveyed was made up of men of various shapes and different ages. Random selected employees of WARBUD were selected for the survey. The questionnaire form consisted of questions regarding general information and evaluation of the working clothing used so far by the employee. In the first part containing general information, employees answered the following questions: year of birth, gender, size of worn workwear or protective clothing, dividing the size of clothing into on the lower and upper part of body.

The next question concerned the definition of a professional group and determining the type of activity performed while performing professional activities.

Asked what movements the employee performs during his work (standing work, sitting, working on his knees, bending down, crawling, stretching / reaching)

In the next part, questions regarding preferences in the field of work / protective clothing were answered and the currently used clothing was assessed by answering further questions of the questionnaire.

1. Year of birth

Analysing the questions from part I General information, the age range of construction workers participating in the study was determined, the results are presented below on the graph (Figure 1).

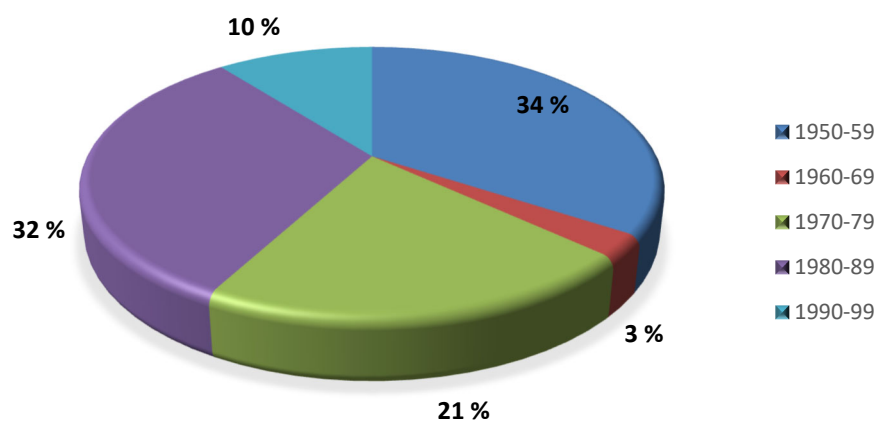


Figure 1. The age range of employees taking part in the survey

2. Question about the gender of the responder

Randomly selected 42 men from Warbud Company took part in the survey.

3. Question about the size of workwear clothing used by the respondent

Respondents were asked to provide their size:

- Upper part of workwear clothing (shirts, jackets, etc.);
- Lower part of workwear clothing (trousers);
- Size generally worn;

When asked what size of workwear clothing they receive most and use during work, the respondents answered using different markings.

Most often marks used in answers:

- literature S - 3XL;
- numerical – including 44, 56, but also 6, 30;
- mixed for example M,26;
- some respondents gave only growth they receive for example 170;

In several cases, due to the inability to read the size of the label of the currently used workwear clothing, no size was given or the size of the private clothing was given.

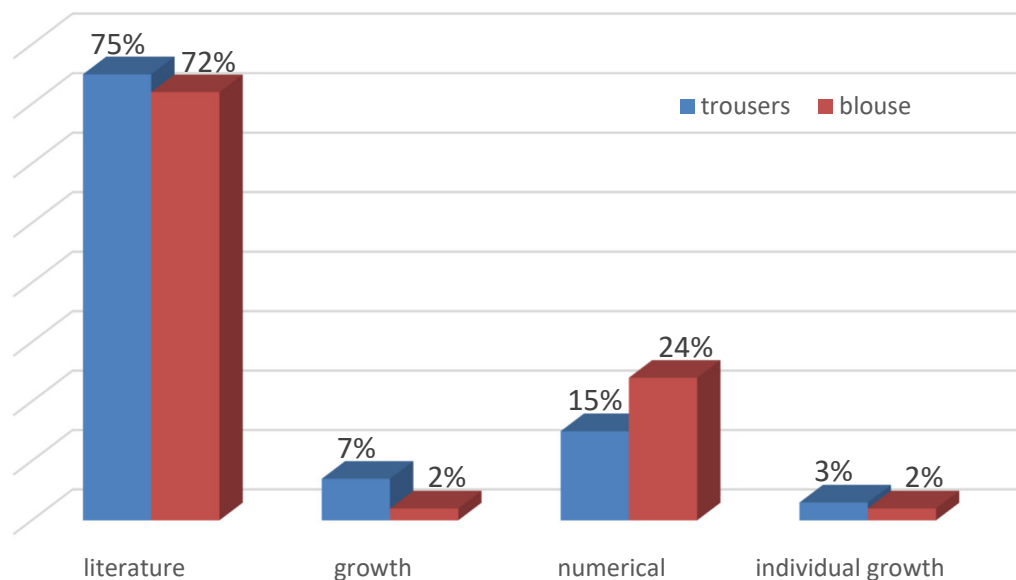


Figure 2. Sizes of workwear clothing worn by employees

4. Question about the professional group of the respondent.

In response to this question, the employees defined their professional group. Persons participating in the survey declared the professional group they belong to:

- Office workers
- Manual workers (drivers were also included in this group)

Some of the employees had two functions: an office and a physical worker. The results are shown below on the graph (Figure 3).

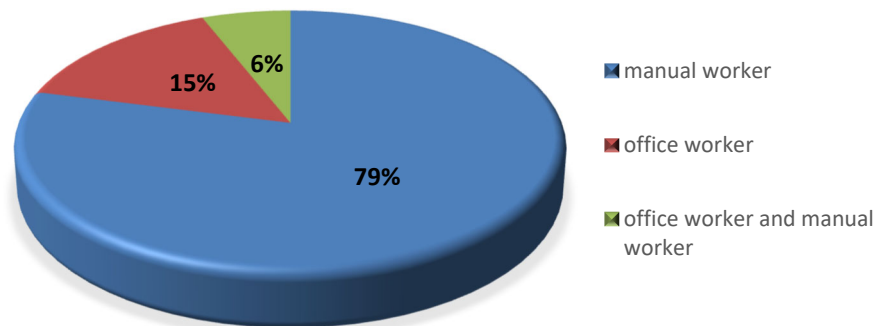


Figure 3. Professional group of surveyed employees

The employees selected in the questionnaire the most frequently performed movements and positions during the work. The most common position taken during work is standing and sitting - 21%. As the most frequent type of movement performed while performing professional duties, the respondents marked bending down (21%).

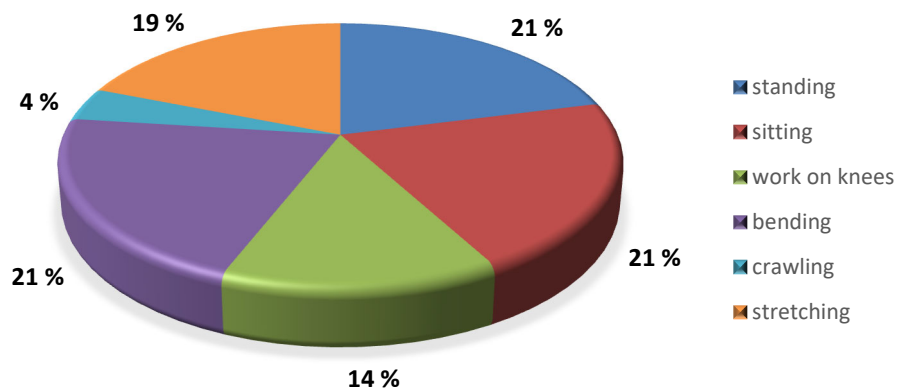


Figure 4. Most common position and movements performed by employees during the work

The second part of the survey concerned **evaluation of workwear clothing.**

On question 1 "How do you rate the current usefulness of workwear when it comes to size and fit to you", the respondents expressed their satisfaction with clothing in 27%.

Some people (64%) were not satisfied with the current clothing, and 9% declared total dissatisfaction with current workwear.

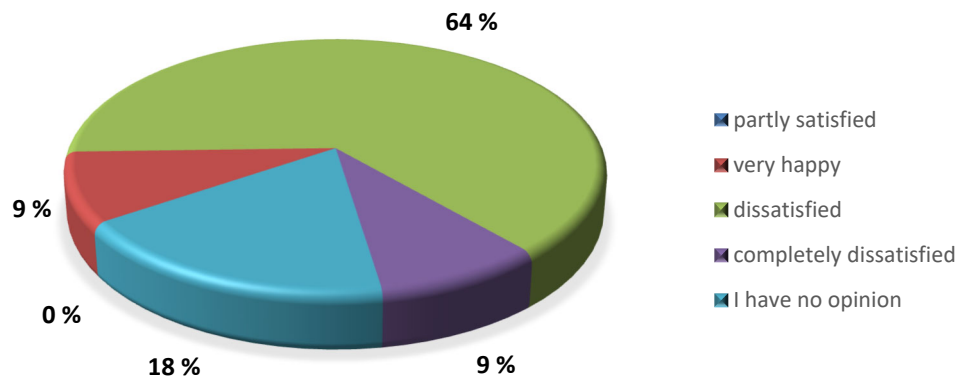


Figure 5. The chart shows the assessment issued by employees in relation to the clothing issued by the employees.

The questionnaire also included open questions, where construction workers could additionally put their comments on their work outfits. Among 42 surveyed employees, 10 people did not submit comments, 16 people did not answer the question, and 16 people submitted comments.

Below is a summary of the comments to the workwear clothing in which the surveyed employees currently work and suggestions for possible changes. Comments from the respondents were divided on the subject of fitability:

- the size of the clothing
- the elements of clothing to the figure.

Some of the respondents declared matching the size of the clothing, others had comments on the size of sweatshirts and trousers, the comments concerned both too loose workwear clothing, as well as too tight, including:

- clothing too loose,
- jacket too big,
- current trousers are too loose, too long trouser legs, trousers too long, too wide legs,
- trousers too tight at the waist, belt too slim

Suggestions and regarding possible changes in clothing proposed by the respondents were as follows:

- shorter sleeves, cuffs adjustment,
- trousers more tight in the legs,
- pockets at the wrong height, the cuts prevent insertion and extraction of things out of pocket,
- the phone pocket should be accessible from the outside,

- a loose sleeve in the shirt,
- looseness in the arms and elbows, wrist pullers,
- loose legs and sleeves,
- legs and sleeves too short for a height of 198 cm and too wide at the waist,
- in winter bib-trousers (gardeners type), in summer waist trousers

Summing up the most frequent comments, in which employees suggest the division into summer clothes with trousers to the waist and winter with trousers with a bitch, "gardeners" type.

They also suggest using larger pockets for easier access.

As part of the answer to the question "How do you evaluate the functionality of your current workwear?", The respondents rated their work clothes as follows:

As many as 81% rated worn workwear clothing as functional, 5% of respondents, as non-functional, only 9% of surveyed employees did not have an opinion on the question and did not answer.

The next question concerned the assessment of the suitability of the current model of workwear clothing while performing professional activity. The summary of the results is shown in the chart. (Fig. 6).

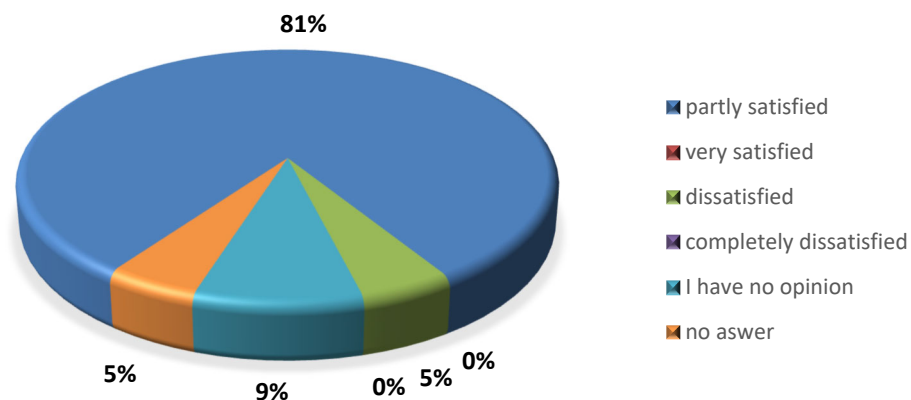


Figure 6. Evaluation of functionality of worn workwear

Answers to the question, "What changes would you like to make in the model?" (for example, one-piece / two-piece, short sleeve / long sleeve, coloured (colour suggestions) / neutral, smooth or patterned, etc.). The results of the surveys were as follows: 47% of users of workwear would like to introduce changes taking into account the use of additional functional or protective functions, adapted to the hazards present in the workplace. A graphical summary is provided in Figure 7.

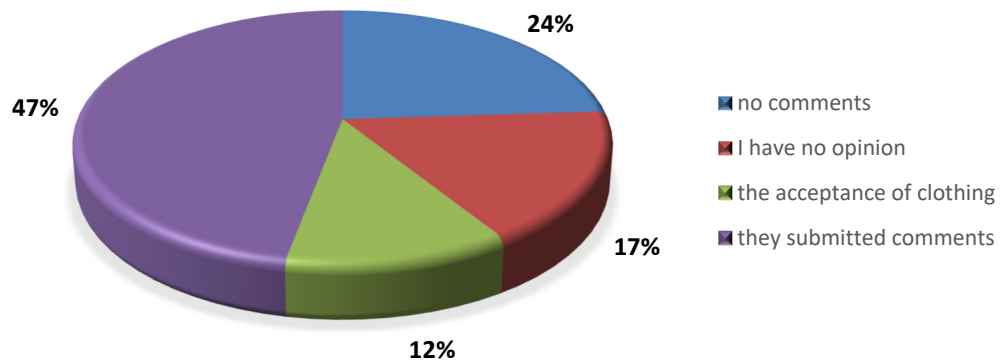


Figure 7. Graphical presentation of survey results concerned changes in the workwear clothing.

The comments of the respondents to this question concerned mainly the increase in waist clearance, the elimination of reflective material from trousers (according to the user when welding, light is reflected). The proposals concerned the use of patterned material and one-piece suits, or dungarees (trouser gardener type). The current form of workwear clothing suits to many of respondents and they do not suggest any changes for use in work clothes. Comments of the respondents regarding the work clothing model concerned the inclusion of the season of use in the selection of the type of clothing.

Most of the respondents who made comments prefer working two-piece clothing suggesting the use of a belt model in the summer period, and in the winter period dungarees (trousers gardener type).

Comments regarding the construction and technological area of clothing were as follows:

- the sleeves should be longer with a welt at the wrist,
- the need to adjust the wrists in the sleeves,
- reducing the width and length of trousers,
- runs on the elbows, knee reinforcements,
- the use of a hood in winter jackets,
- improving the quality of seams and materials.

4. How do you evaluate the functionality of your current workwear clothing?

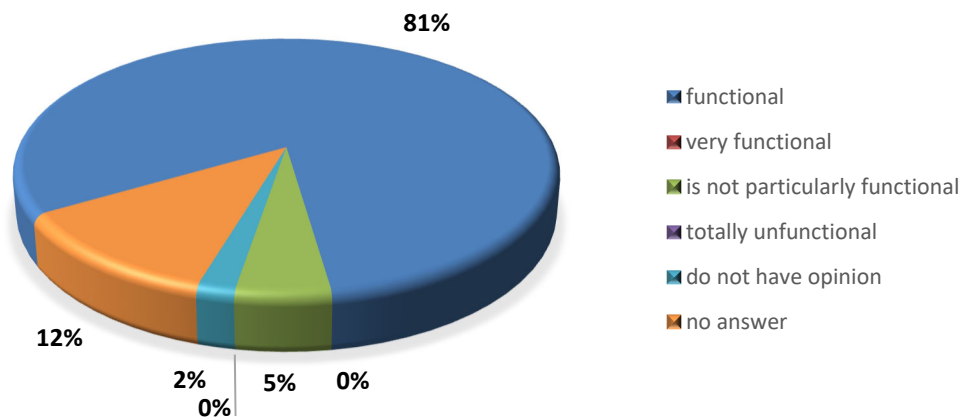


Figure 8. Evaluation of functionality of workwear clothing used by employees

Below are details of the respondents' comments regarding the functionalities of workwear clothing and suggestions for improving the functionality of work clothing:

- more airy from natural fibres, mainly in summer, with darker colours
- the use of more flexible, breathable, waterproof, winter warming, more colourful materials,
- more durable, reinforced fabrics, for example resistant to sparks,
- looser blouse, additional fastening under the neck in the shirt,
- use in blouse ZIP fasteners or snaps, cuts on the side with a zip (ventilation),
- larger cell phone pocket, additional pockets for keys,
- side pocket in the blouse in the side seam (too much behind) - suggested shift towards the front,
- phone pocket in the upper part (blouse), increasing the size of the pocket in a bib,
- pull-on cuffs, Velcro or rubber cuff
- two side pockets for carrying a measure and other instruments,
- instead of buttons, the slider in the fly,
- trousers fastenings with elastics gum remove the shirt, waist adjustment on both sides
- additional pockets in trousers on the side for tools, internal pocket for a mobile phone,
- the use of reinforcement on trouser legs (for example for welding),
- flexible when bending legs, around knees,
- additional pockets on trouser legs (there is only 1), there should be four pockets in the shirt (2 on top and bottom).

5. How do you assess the safety of your current workwear?

The majority of employees, as many as 81%, rated their clothing as a safe one, 5% as very safe. Some of the respondents (7%) did not have the opinion, while 5% rated the clothing as not particularly safe.

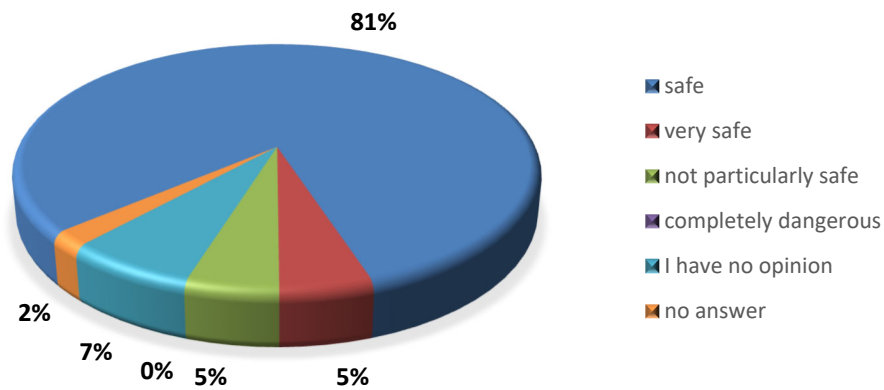


Figure 9. Assessment of workwear clothing safety.

Comments regarding safety mainly concerned the improvement of the clothing function dependent on the work performed and necessary at the security station, including protection against heat, rain, sparks, and cold fire. They also concerned the improvement of the strength of materials and clothing (for examples reinforcement in the step of trousers).

6. What type of information system or "intelligence" do you want to add to your workwear to improve it?

On the above question only 4 people from the respondents presented comments on the need to introduce IT solutions to clothing. The respondents proposed intelligent material reacting to temperature changes, introducing intelligent elements, for example for temperature control. Some believe that there is no need to enter any information systems in work clothes.

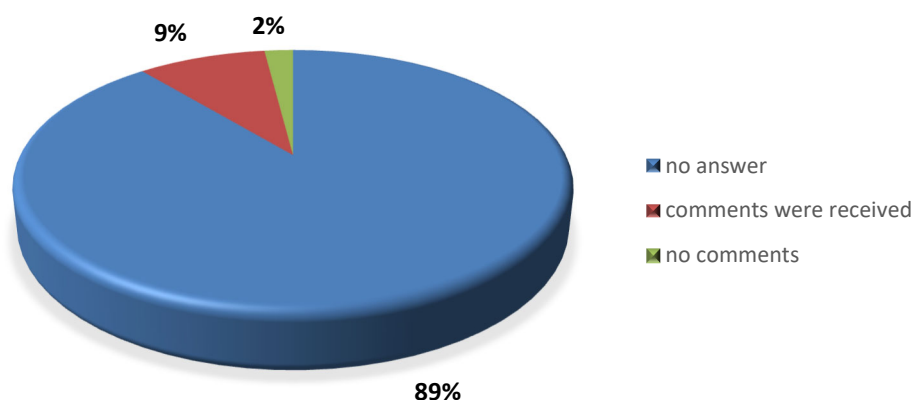


Figure 10. IT system in workwear clothing.

Summary of survey research

Surveys conducted in a group of employees made it possible to analyse and summarize the results of surveys. The summary made showed that the method of assessment depended on the type of work performed and the professional environment. Most users expect more fitting

clothes and functionality in terms of design and usage - comfort regardless of age or body type.

The evaluation of the current work clothes was a very subjective matter and depended on the model worn at the time of the dress test as well as the correctness of the selection of the current size of the outfit.

Due to the fact that at the time of the study, not everyone used Krystian clothing being the subject of dimensional and technological considerations, not all the comments discussed in this study may be considered in further designing of model and construction changes in the implemented project.

10. DEVELOPMENT OF PRODUCTS BASED ON THE SURVEY

After the analysis of the dimension and size of the selected clothing and the summary of the surveys carried out for the evaluation of the currently produced work wear clothing model, the direction of changes was determined in order to improve the fit-ability and functionality of the garments expected by the recipients. The analysis of the results showed the need to personalize the work clothes based on individual silhouette measurements, which will allow to increase the fit of the outfits to the silhouettes and improve the comfort of use in working conditions.

On the basis of obtained results of measurement, benchmarking and preferential, designed construction and technological solutions the modification of work wear of construction sector has been made.

10.1 New design of jacket

Applying changes in the shirt concerned: placing the lower pockets inlet and adding zippers, the shape of the upper pockets, collar fastening, additional ventilation holes under the arms, adjustable cuffs with Velcro fasteners, elongation of sleeves, reinforcements on the elbows, addition of profile sills on the elbows, panel tape, changes in the fabric with the predominant cotton composition.

1. Moving the inlet to the bottom pocket closer to the front centre edge to facilitate the use of pockets and adding zippers (spiral type).
2. Changing the shape of the upper pockets.
3. Changing the construction of the collar on the buttoned at the neck.
4. Execution of embroidered ventilation holes on the line of armpits (8 items)
5. Cuffs with sewn rubber and additional regulation of wrist circumference in the form of sewn-up trap fastened with self-splice tape (velcro or "velcro" type)
6. Extension of the sleeves by 2.0 cm.
7. Reinforcements on the elbows in the form of an additional layer of fabric.
8. Adding profiled sutures to the elbows, forming the convexity.

9. Application of a reflective panel tape
10. Changing the fabric, the use of a material with a cotton dominance.
11. Renouncement from the covered closure of the blouse, the use of durable, metal latches suitable for clothing used in the work environment

10.2 New design of trousers

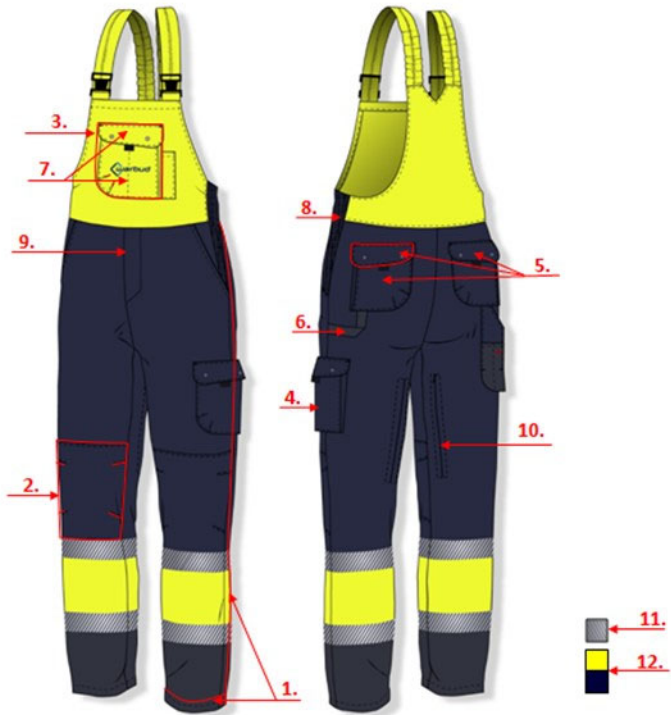
Changes in gardener-trousers included: a complete change in the design of trousers, the applied cut gives greater comfort and freedom of movement, narrowing and shortening of the legs, knee reinforcements and darts modeling the leg on the knee, another pocket fashion, adding a cargo pocket on the left thigh and a spatial pocket inch, adding the left pocket at the back and the strap, the hammer handle and the zippered pocket with the stitching in the middle creating a pocket for a mobile phone.

Trousers with bib / trousers gardener type after changes:

1. Narrowing and shortening of the legs.
2. Reinforcements on the knees and tucks modelling the leg on the knee.
3. Changing the fashion of the side pockets.
4. Adding a pocket to the left thigh and a spatial inch pocket.
5. Additional rear pocket. Pockets covered with straps.
6. Hammer holder.
7. A pocket on a bib zipper with a stitching in the middle creating a pocket for a mobile phone.
8. Side strip made of elastic fabric.
9. Gardeners trousers at the front zippered.
10. Moving the ventilation holes from the side seam to the back of the leg.
11. Panel tape.
12. Changing the fabric, the use of a material with a cotton dominance.



Sweatshirt after changes.



Trousers with bib / trousers after changes.