MEASURING SELECTED PROPERTIES OF MATERIALS OF MILITARY CLOTHING FOR THEIR POSSIBLE INNOVATION

Jana Švecová[1], Radka Lopourová[1], Martin Novotný[1] and Antonin Havelka[2]

[1]*Faculty of Military Leadership, University of Defence in Brno, Kounicova 65, 662 10 Brno, Czech Republic*
[2]*Department of Clothing, Technical University of Liberec, Studentska 2, 461 17 Liberec, Czech Republic*
www.unob.cz, jana.svecova@unob.cz, radka.lopourova@unob.cz, martin.novotny5@unob.cz
www.tul.cz, antonin.havelka@tul.cz

Abstract: *The article deals with materials of service military clothing in the Czech Armed Forces (CAF) and their possible innovations. Useful properties were identified based on the results of a questionnaire survey in the field of satisfaction of soldiers with current military uniform. Properties as colourfastness, abrasion and pilling of materials became the subject of measurement experiment. The measurement took place in the Laboratory of Physiological Comfort of the Technical University of Liberec. The aim of the work was to create design possibilities for improving the application properties of materials. The results are a source of important information for the stage of design and innovation in the introduction of new service military uniform, leading to improved military equipment.*

Keywords: *abrasion, colourfastness, maintenance system, Martindale, military uniform, pilling, property measurement.*

1 INTRODUCTION

Military clothing has a long tradition and is influenced by a number of aspects, including gender, rank, type of activity performed, climatic conditions, level of protection, but also, for example, tradition. In order for textile materials to be used in the production of military uniforms, they must meet the requirements imposed on them during use, i.e. the purpose of the garment. Pre-specified useful and processing properties are placed on clothing materials, which are intended for their application on the market.

The Technical Specifications for Material for Personal Use of soldiers (TS MPU), which include military uniforms, set out the requirements associated with the requirements for the properties of the material used, design, dimensions and maintenance, including instructions for storage, marking and disposal of clothing.

The useful properties of the equipment material include those that are applied from the point of view of the consumer (soldier) in demanding conditions during the use of clothing. The characteristics of the equipment materials must be such that military clothing made from them performs all the required functions. They also have a psychological effect on its users. Useful properties are divided into four basic groups. It is durability and the possibility of maintenance, representative, aesthetic properties and clothing comfort. Equally important is the group of special properties, which are used mainly for certain garments requiring special treatment [1]. Durability is given by the resistance of the fabric to stress. It is the time for which the fabric is functional before it wears out and loses its properties. During use, the garment is exposed to a large number of external influences, both during wearing and maintenance. The fabric is gradually worn by light, sweat, abrasion, bending and stretching until it deteriorates. It can also lose its properties by improper washing and ironing [2]. Durability, maintenance, original appearance and properties are complicated by combinations of different clothing materials of different material composition, surface treatment such as coating. Adherence to the recommended product maintenance procedures is essential. The reason for the shorter service life is the use of atypical components or surface treatments of the material, which are prone to mechanical failure (abrasion). Garment products are made up of different types of fibers, so it is important to follow the most sensitive component of the whole system [3]. Aesthetic and representative characteristics are addressed in connection with the national tradition of uniforms and rank. The appearance of the fabric is influenced by the material used, the threads, the weave and its finishing. Tested properties include colourfastness, creasability, flowability, pilling resistance, and more. Abrasion and pilling resistance are key properties for textiles. These are the basic properties that determine the durability of the product and are the most common reasons for complaints about textiles, and therefore it is important to monitor them. Abrasion can characterized as a disturbance of the fabric surface. Abrasion occurs upon contact the fabric into contact with another fabric or rough surface. In this way,

the individual fibers are abrade, which then fall off, the bonding points are pierce and the fabric disintegrates. Abrasion resistance tests are simulation tests that imitate how long a fabric can withstand stress, i.e. abrasion, in practical use. Methods of abrasion testing are in the area, edge and random direction of the fabric [4]. The relation between abrasion resistance and fabric constructional parameters was found in the study [5]. The lint on the garment is manifest by lumps, which are the result of excessive wear or improper maintenance. The main factor here is the mechanical friction of textiles. It is a process in which the fibers are released from the fabric and their subsequent agglomeration and winding. The cream lumps are then tripe in the structure of the fabric, creating an unsightly impression. This phenomenon depends on the construction of the garment and the properties of the fibers and threads. This is a relatively common phenomenon in products made of synthetic fibers, most often polyester. Synthetic fibers are smooth and therefore easier to release from the base of the fabric. Thanks to its strength, it also holds better on the fabric. On the other hand, strength is one of the properties of textile fibers, which makes synthetic fibers more resistant to abrasion [1]. Three test methods for evaluating the abrasion or wear resistance of textile materials were compare in the study [6].

The article is focus on the need to improve the useful properties and construction of the existing uniform, which in the opinion of soldiers is obsolete and has a number of poor material properties, which affect in particular the representative properties of clothing and durability. It was necessary to verify the functionality and suitability of the maintenance of existing military uniforms by measuring selected properties of materials. Based on the evaluation of the survey of soldiers' satisfaction with wearing the uniform, tests of colourfastness when dripping with water, resistance to pilling and resistance to abrasion before washing and after thirty washes performed on the Martindale device. The output is a proposal of possibilities to improve the useful properties of equipment components.

2 EXPERIMENTAL

The questionnaire of satisfaction of soldiers with using current military uniform was conduct in experimental part. Based on the results of the survey, the properties for measurement were identified. The aim of the experiment was to measure selected properties of samples of materials together with other suitable materials for the production of military uniforms. Determining the functionality of existing materials was the purpose of the measurement. Tests for colourfastness to water dripping, resistance to pilling, abrasion resistance before and after thirty washes were performed. These tests were performed under normal operating climatic conditions specified in the standards: air temperature 20±2°C and relative humidity 65±2%.

2.1 Materials

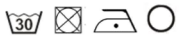
Two types of fabric samples used for the experiment, which used for the production of existing uniforms 97 (A) and 2005 (B). In addition, two types of fabric samples used (C and D), which are suitable for the production of suits and were selected as an alternative replacement for existing materials. Thirty-two test samples of the fabric were tested. Table 1 provides an overview of used materials of military uniforms and other used materials, including maintenance symbols, manufacturer and other information. Figure 1 shows examples of two types of military uniforms, whose material designation in Table 1 is marking A and B.

Figure 1 Examples of two types of military uniforms

2.2 Methods

The questionnaire of satisfaction of soldiers with the use of the current military uniform was conducted in February 2020. In the questionnaire was the sample of material A from the Table 1 indicated by the exact designation of the uniform 97. The examined sample of the Czech Armed Forces soldiers was 200 respondents.

Table 1 Overview of used materials of military uniforms and other used materials

Marking	Material composition	Thickness [mm]	Square mass [g/m^2]	Weave fabric	Maintenance system	Producer
A	45% wool, 55% polyester	0.59	315	Amplified atlas		VESTIMENTUM s.r.o. Czech republic
B	50% wool, 47% polyester, 3% elastane	0.24	210	Gabardine Multistage twill		Koutný spol. s.r.o. Czech republic
C	62% polyester, 32% viscose, 6% elastane	0.30	264	Gabardine Multistage twill		fabfab GmbH Gernamy
D	53% polyester, 43% wool, 4% elastane	0.15	205	Amplified atlas		fabfab GmbH Gernamy

Research question No. 1: Are the correct procedures followed when maintaining the equipment components of the uniform 97? Questions 5, 7 and 16 of the questionnaire survey assessed this question:
5. How do you maintain trousers 97?
7. How do you maintain the blouse 97?
16. How do you maintain the skirt 97?

Research question No. 2: Does the number of equipment components of the uniform 97 affect the frequency of maintenance? Questions 2, 3, 4, 6, 8, 15 and 17 from the questionnaire survey evaluated this question:
2. How often do you wear a uniform 97 at work?
3. How many pieces of blouse 97 (jacket) do you own?
4. How many pieces of trousers 97 do you own?
6. How often do you maintain your trousers 97?
8. How often do you perform maintenance on the blouse 97?
15. How many skirts 97 do you own?
17. How often do you maintain skirt 97?

Research question No. 3: Do soldiers perceive the comfort of wearing uniform 97 positively? This question evaluated by questions 9, 10 and 11 from the questionnaire survey:
9. Are you satisfied with the uniform 97 in terms of clothing design?
10. Are you satisfied with the uniform 97 in terms of the useful properties of the materials (i.e. resistance to pilling and abrasion, colourfastness...)?
11. Do you feel comfortable in the 97 uniform?

Research question 4: What would soldiers want to change to using and purchasing a uniform 97?

This question evaluated by questions 12 and 13 from the questionnaire survey:
12. What would you like to change on the uniform 97?
13. What would you like to change about purchasing a uniform 97?

The colourfastness test when dripping with water was performed according to the standard ČSN EN ISO 105-E07 (80 0145) [7]. Two samples of each type of material measuring 40 x 100 mm used. The first sample unloaded with water for comparison with the drip sample and the second sample for the test. The essence of the test was the incorporation of drops of distilled water by pipette into the test sample. After incorporating the water into the sample, a stain with a diameter of 20 mm formed. After 2 min, the change in hue at the edge of the stain evaluated according to a grey scale. The test sample air-dried at room temperature and the shade change re-evaluated according to the grey scale.

The determination of the inclination of fabrics for pilling by the Martindale method was performed according to the standard ČSN EN ISO 12945-2 (80 0837) [8]. Two samples from each type of material used before and after thirty washes, one for comparison and the other for testing. All prepared samples were washed in an automatic washing machine. A program for coloured laundry without prewash was chosen. The washing time was 120 minutes at 40° C. Wool and delicate washing gel was used for washing and no softeners were used. The squeeze was set at 800 rpm. The samples were knocked out and hung on a dryer so to the warp was in the vertical direction according to the ČSN EN ISO 6330 standard [9]. After drying, the samples were ironed according to the recommended maintenance symbols. The sample had a circular shape with a diameter of 140 mm. The essence of the test was the movement of a circular test specimen under a specified load on a friction surface formed by the same fabric, while the Lissajous pattern was observed. The test sample was also rotatable about its central axis perpendicular to the surface of the test specimen. The test specimens were mounted face up in the holders of the Martindale instrument. Category 2 was selected in the pilling test for fabrics. The abrasive was a face-to-face test fabric and a load weight of 415 ± 2 g used. The test run until evaluation stage 6 for 7000 revolutions was reached. At the indicated load, the test specimens moved along a friction surface formed by the same abrasive fabric material. The pilling was evaluated visually after the defined stages of the abrasion test. The determination of abrasion resistance of fabrics

by the Martindale method was performed according to the standard ČSN EN ISO 12947-2 (80 0846) [10]. One sample from each type of material was used before and after thirty washes. The method of washing the samples was described in the previous paragraph. The essence of the test was to abrade the circular sample clamped in the sample holder against the abrasive by a gradual movement that follows the Lissajous pattern. The abrasion resistance of the fabric was determined using a test speed interval until the samples damaged. For the abrasion load, a weight value of 595 g was determined for clothing and home textiles with a pressure of 9 kPa. On the sample-clamping holder, auxiliary materials placed under the sample in the order of foam material, felt and sample, which abraded by a defined abrasive fabric placed on the table. The dimension of the test specimen had a circular shape with a diameter of 35 mm. The test procedure was similar to the previous test, except that a wool abrasive fabric was used, which was attached to the holder of the Martindale instrument. The test specimen attached to the upper holder and abraded under the defined conditions specified until the first binding point ruptured or the fabric damaged. For each test specimen, a test interval was found in which the test specimen damaged or the first binding point of the fabric ruptured.

3 RESULTS AND DISCUSSION

A questionnaire was conducted to survey the satisfaction of soldiers using the current military uniform, and based on the results of the survey, the properties for measurement were identified. Tests for colorfastness to water dripping, pilling and abrasion resistance using the modified Martindale method were performed in the Laboratory of Physiological Comfort of the Technical University of Liberec.

3.1 Evaluation of the questionnaire of satisfaction survey

Although the maintenance symbols for trousers and the skirt of uniform 97 indicate a ban on washing in the washing machine, more than 60% of respondents said that they use this type of maintenance for these equipment components. The method of maintenance of the blouse 97 in the treatment plant is performed correctly by 129 respondents, which is 64.5%. As another method of maintenance, 6 respondents mentioned brushing. Based on the evaluation of the answers to questions No. 5, 7 and 16, it is possible to answer the 1st research question. In the case of trousers and skirts 97, the correct maintenance procedure is not followed. The components are washed in the washing machine. The blouse 97 is usually properly maintained in dry cleaners or the part is not maintained. Regarding the influence of the number of skirts on their maintenance, it can be said that the more pieces of equipment the user owns, the lower the frequency of its maintenance. Three respondents out of 40 women interviewed stated that they do not perform skirt maintenance. This is affected not only by the higher number of components they own, but also by the frequency of wearing. At least once every 14 days, 15 respondents perform maintenance. She wears the clothing component almost daily and each has two skirts available. Based on the evaluation of the answers to questions 2, 3, 4, 6, 8, 15 and 17, the 2nd research question can be answered. The frequency of maintenance of equipment components is affected not only by their number, which the user owns, but also by the frequency of wearing them.

When evaluating the questions, the statistical significance set to 5% confidence level between the frequencies of answers was divided into two parts, namely the group certainly yes, rather yes versus rather no and certainly no. In the case of satisfaction with the design of uniform 97, the result of 113 respondents satisfied (56.5%) versus 87 dissatisfied (43.5%) is not statistically significant and we cannot say with certainty that respondents are satisfied with the design of uniform 97. Satisfaction with the above-mentioned uniform in terms of the useful properties of the materials used expressed by 66 respondents (33%) and dissatisfaction by 134 respondents (67%). The above result is statistically significant and we can confirm that the respondents are not satisfied with the uniform in terms of useful properties of the materials used. The last question asked if the soldier felt comfortable in his/her uniform. The obtained result of 85 satisfied respondents (42.5%) versus 115 dissatisfied (57.5%) is statistically significant and it is possible to deduce that the respondents do not feel comfortable wearing a uniform 97. Based on the evaluation of the answers to questions 9, 10 and 11 answered to the third research question. Soldiers perceive comfort, which includes satisfaction with the design of the garment, useful properties and overall comfort when wearing the uniform 97, negatively. 82% of respondents would change the properties of the material used and almost half of those surveyed would change the design of the garment. Respondents would welcome the possibility of tailoring adjustments by the Dispensing Centres of Natural Clothing (VSNO) or sewing uniforms with a measuring system. Other preferred changes of respondents mentioned in the area of uniform 97 acquisition. 69.5% of respondents would increase the number of components to acquired, which are few when used almost daily. Soldiers would welcome the reintroduction of jacket shirts, perforated low shoes, winter boots and winter jackets. The soldiers emphasized their satisfaction

with the summer uniform of 2005, which unfortunately can no longer be obtained and is not suitable for winter weather. One respondent mentioned the unavailability of women's trousers 97 at a height of 189 cm. Based on the evaluation of the answers to questions 12 and 13; the fourth research question can be answered. Soldiers would like to change the use and acquisition of the uniform 97, in particular the properties of materials and increase the number of equipment components to purchase the uniform 97.

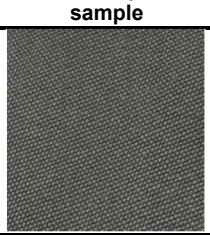
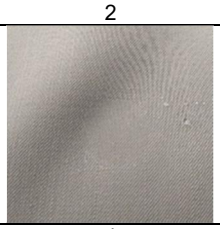
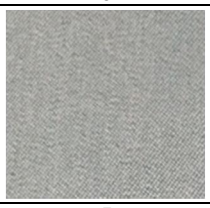
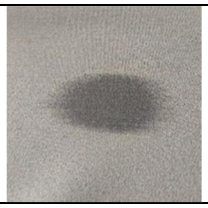
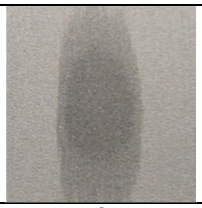
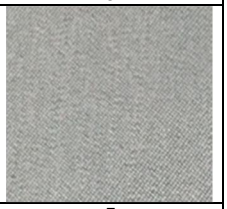
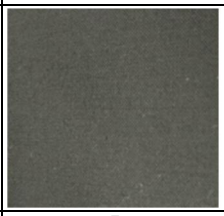
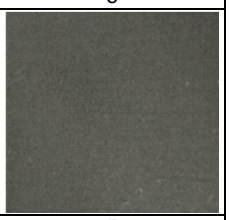
The results of the soldiers' satisfaction survey with the uniform 97 survey showed that most respondents are not well informed about the proper maintenance of service trousers and skirts. It turned out that the correct maintenance procedure not followed in this case. The components are normally machine washed, which can cause a change in the dimensions, colourfastness and useful properties of the materials. The soldiers also drew attention to the formation of permanent stains when dripping the uniform with water, such as rain. Improperly selected iron temperature during maintenance causes the material to flare up. According to the respondents, the material is biting, prone to dust and is very discomfort able in summer.

It has been show that the number of equipment components of the uniform 97 has an effect on the frequency of maintenance and on the frequency of wearing them. Soldiers are not satisfied in terms of comfort when using the uniform with useful features and overall wearing comfort. They perceive clothing comfort negatively. Only in the case of clothing design, 113 of respondents were satisfied, which is more than half. Regarding the opinions and attitudes of soldiers in what they would like to change to the use and purchase of uniforms, 134 respondents agree that they would like to change the useful properties of the materials used and increase the number of equipment components for their acquisition.

3.2 Evaluation of the colourfastness test when dripping with water

The evaluation was of the test performed based on a subjective evaluation of three experts in the laboratory. Subjects evaluated changes in colourfastness of samples by dripping with water after 2 minutes and after drying. All three persons agreed on the same test results, which shown in Table 2, together with photographic images of the test specimens. The images are illustrative.

Table 2 Evaluation of the colourfastness test when dripping with water for all samples

Marking	Untried comparative sample	Tried sample at the beginning of the test	Tried sample after 2 min and after shaking the drop	Tried sample after drying
A				
Degree of grey scale	5	-	2	4
B				
Degree of grey scale	5	-	4	5
C				
Degree of grey scale	5	-	2	5
D				
Degree of grey scale	5	-	4	5

The Table 2 shows that according to the grey scale for evaluating the change of shade according to ISO 105-A02, samples of materials marked B and D have the best colourfastness when dripped with water. Drying of both materials had the same grade 5 as the untested comparative material. In the case of material samples A and C, the results are slightly different. For material C, immediately after dripping the liquid with a pipette, the drop soaked into the fabric and formed a gradually enlarging map, first with a circular diameter of 2 cm up to an oval shape of 4 x 5 cm. However, after drying, the colour change was at grade 5, which is a satisfactory result. The material obviously did not have a water-repellent or oleo phobic treatment that would prevent such rapid absorption of the droplet, and therefore would not be suitable for the production of a uniform in its current state. In the sample of material A, a part of the contents of the drop was soaked into the fabric more slowly than in the case of gabardine. Nevertheless, the change in hue to level 2 from the original colour was significant after 2 minutes. After the material has dried, the drop left a significant change in the shade of grade 4, which is the value that stated in the criteria of required values for colourfastness in the TS MPU uniform made of material A.

3.3 Evaluation of the determination of the inclination of fabrics for pilling by the Martindale method

The evaluation was of the test performed based on a subjective assessment of 3 experts in the laboratory with the help of standards and a visual appraisal, which shown in Table 3.

Table 3 Visual evaluation of the test [11]

Degree	Description
5	Without changes.
4	Slight pulping of the surface and / or onset of lint formation.
3	Slight pulping of the surface and / or slight pilling. The lumps of various sizes and densities partially cover the surface of the sample.
2	Significant surface pulping and / or significant pilling. The lumps of various sizes and densities cover a large part of the sample surface.
1	Dense surface pulping and / or heavy pilling. The lumps of different sizes and densities cover the entire surface of the sample.

Pulping and pilling were evaluated visually after defined stages of the test. Each test sample assigned the degree of pilling according to Table 3. If the evaluation fell between two degrees, an intermediate degree was marked, e.g. 3-4. The standards used to evaluate the pilling test are shown in Figures 2 and 3. The test result for each individual evaluator was the average of the pilling degrees given to the test sample. The result of the test for the laboratory sample was the average value of the degrees of pilling assigned by all evaluators.

Figures 4 and 5 show a comparison of the degrees of pilling according to the standard during the evaluation at speeds of 2000, 5000 and 7000 for the samples marked A and B, which showed differences in the evaluation in the individual stages. Arithmetic mean was 4.125 before and 4.5 after 30 washes. Reliability limit of the average value was 1.640 before and 0.919 after 30 washes.

Figure 2 Standards for the evaluation of the degree of pilling 3 to 5

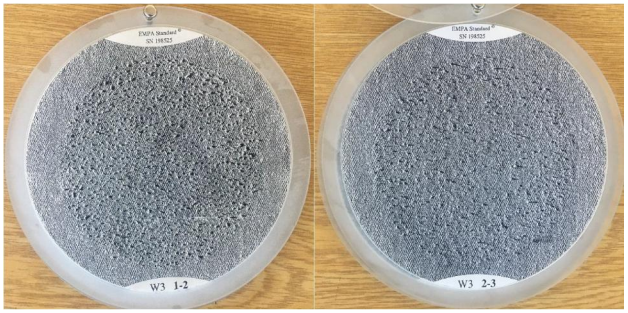


Figure 3 Standards for the evaluation of the degree of pilling 1 to 3

It can be seen from the graphs in Figures 4 and 5 that before washing, the degree of pilling is lower for both materials, so they have a greater tendency to pill than after 30 washes.

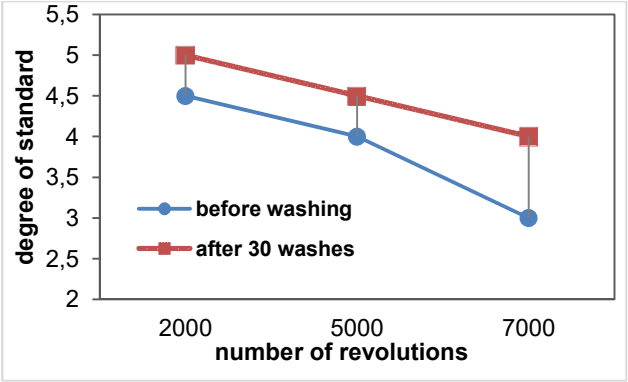


Figure 4 Comparison of average values of pilling for material A

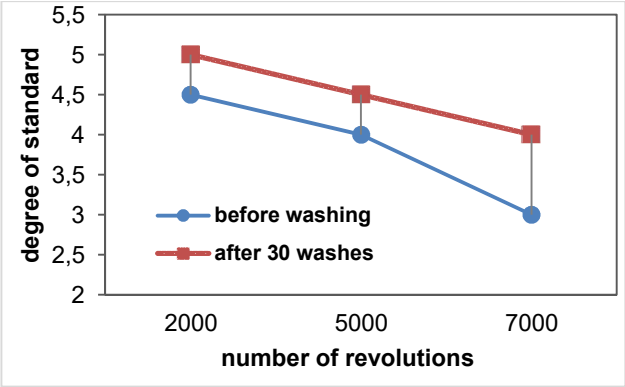


Figure 5 Comparison of average values of pilling for material C

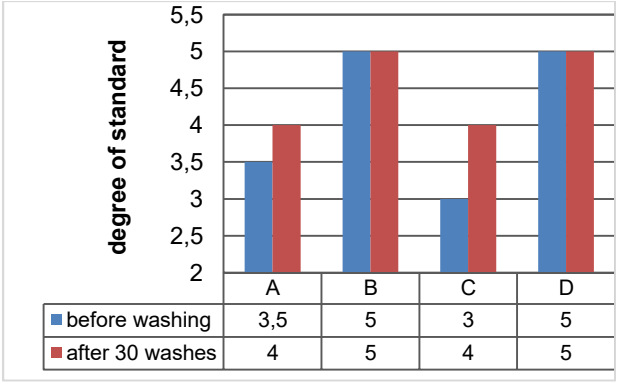


Figure 6 Comparison of average values of pilling for all samples

It follows from the above that, in the case of samples A and C, washing has a good effect on the pilling, since the degree of pilling after washing increases and thus the tendency to pill decreases. Washing releases the fibres, which probably worsened the pilling. Other test samples of other types of materials marked B and D showed no changes in surface pulping or the formation of lumps both before and after 30 washes. These samples evaluated at all times in grade 5, the evaluation of which is no change. Comparison of average values of pilling for all samples all samples is in Figure 6.

3.4 Evaluation of the determination of abrasion resistance of fabrics by the Martindale method

The evaluation was of the test performed based on the determined values of the number of revolutions at which the sample damaged or the first binding point of the fabric was torn. The graph in Figure 7 shows the resulting abrasion resistance values for damage to all samples.

Arithmetic mean was 35 000 number of revolutions before and 37125 after 30 washes. Reliability limit of the average value was 28642.01 before and 27471.65 after 30 washes. From the results of the abrasion resistance test, it can be stated that for the types of materials marked A and C, washing does not affect the abrasion resistance. Before and after 30 washes, the samples damaged at 50,000 revolutions per minute (rpm). For samples of material B, the first binding point ruptured at 26,000 rpm before washing and 9,000 rpm later for samples that washed 30 times. This means that in the case of B washing, it does not affect the abrasion resistance. For test specimens of material D, abrasion occurred after 30 washes 500 revolutions earlier. We can talk about a small, but still effect of washing, because washing can slightly loosen the bond, thin the material and thus reduce its strength. Comparison of abrasion resistance values for all samples can see in the graph in Figure 7.

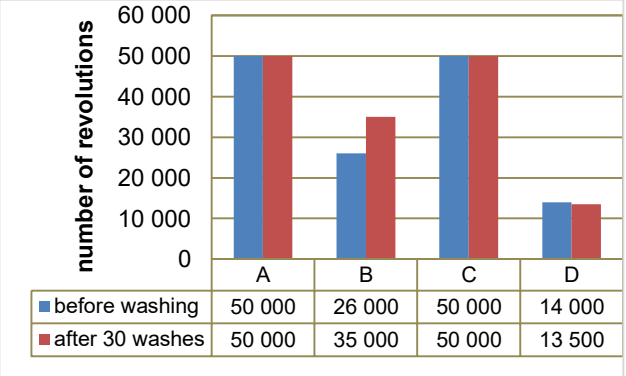


Figure 7 Comparison of abrasion resistance values for all samples

3.5 Proposal of possibilities of improvement properties of materials of military uniforms

In the evaluation of the survey, it considered that due to non-compliance with the proper maintenance of equipment components by washing, the useful properties of materials might deteriorate. The facts found above in the previous subchapter prove that the washing of materials B has no effect on the pilling and in the case of A material even has a favourable effect on the pilling resistance. This is an interesting finding, given that no type of material is allowed to be washed on the maintenance symbols and cleaning in the dry cleaner's is recommended, which will be significantly more expensive for soldiers. Washing these samples also does not affect the abrasion resistance. It follows from the above that in the case of skirts and trousers of materials A and B it is not necessary to maintain them in the dry cleaner's. For the sample of material A, which contains 45% wool and 55% polyester, it is recommended by the suit manufacturer to wash the clothes in a washing machine at 30°C, to gently spin them once, to dry without a dryer and to iron them up to 150°C. For trousers and skirts of material B, which contain 50% wool, 47% polyester and 3% elastane, it is sufficient to carry out maintenance by washing in a washing machine at 30°C, perform gentle single squeezing, dry without a dryer and iron to 110°C.

For both uniforms, the maintenance of the blouse would be left to the dry cleaner's, as the blouse is not maintained as often and it is sufficient and affordable to have the blouse treated professionally once a year.

The soldiers also drew attention to the formation of permanent stains when dripping the uniform with water, for example during the rain on a sample of material A. Yes, this happens, for example, during the ceremonial parades of professional soldiers in uniforms, when it starts to rain and an umbrella can used. The results of the experiment proved that the degree of colourfastness resistance when dripping with water agrees with the value required in TS MPU and is sufficient [12]. Here it is appropriate to think about whether the value determined in the TS MPU is correct and whether further mechanical action on the surface of the dripped fabric does not cause permanent stains. In a test carried out in accordance with the standard by dripping on a fabric that is no longer mechanically subject, there may be no permanent staining. The drop dries eventually. It is also important to consider the choice of determining the appropriate mechanism by the commander for the occasion. A field uniform can also be used for the winter. For the summer period, it would be more appropriate to use a uniform of material B, which shows excellent colourfastness values. However, the problem is insufficient equipment and little or no garments at present. It not known whether it will still be possible to purchase the said summer uniform 2005, which is in all respects a quality and functional equipment component.

To achieve the comfort of the soldier, it would be appropriate to ensure that each soldier has a service and walking uniform available for both the cold season and the summer season. Soldiers who wear uniforms daily in the office would especially welcome the restauration of the availability of uniforms made of B material for summer. The existing uniform made of material A calls for a change, which means both the properties and the design. Especially for women's blouses, there is no inner chest pocket and for trousers, the lining in the front part is missing. For possible innovation of military uniforms, two materials C and D selected, which could replace the materials of current uniforms.

The C type of material selected as a replacement for the material for the service uniform 97. A different variant of the material composition chosen than that of A, with a composition of 62% polyester, 32% viscose and 6% elastane. It is a woven, softly flowing, bi-elastic fabric suitable for business clothes, comfortable suits, trousers, skirts and blazers. Despite the fact that it does not contain wool, the material is pleasantly soft to the touch, as if woolly. The basis weight of the material is 264 g/m^2 at a width of 145 cm. The price of the footage is 279 CZK for 1 m incl. VAT.

From the results of the utility measurement experiment, the following was found. The tested material would be suitable in terms of research results only for abrasion resistance, where, as with material A, the final value was 50,000 revolutions before and after 30 washes. In terms of the pilling resistance, the substitute material ended up as the worst of all. It has a great tendency to pill. In the water drip test, the material reached grade 4 as well as A. The time of drop infiltration was different, when C immediately absorbed the drop and formed visible maps. This fact would eliminated by oleo phobic or waterproof treatment of the fabric. To replace the material of the uniform, I would recommend performing tests on three other suitable materials and increasing the number of tested properties by tests of dimensional changes during washing and ironing.

As an innovative material suitable for the summer variant of the military uniform, the D type of material selected. It has a composition of 53% polyester, 43% wool and 4% elastane. It is a woven, softly flowing, light, elastic fabric suitable for casual clothes, blazers, jackets, trousers and skirts. The material is soft to the touch. The basis weight of the material is 273 g/m^2 at a width of 150 cm. The price of the footage is 449 CZK for 1 m incl. VAT. Based on the results of the utility measurement experiment, it was found that, compared to material B, the substitute material has the same values of colourfastness to dripping water and resistance to pilling. The abrasion resistance of the innovative material is 22,000 revolutions before washing and 21,500 revolutions after 30 washes. For this reason, the material is not suitable for summer uniform innovation. According to the results of experimental measurements of colourfastness, pilling and abrasion resistance, the B material of the summer uniform ended up as the best of all. It meets all the requirements for sufficient comfort of the soldier when worn, and therefore there is no need to innovate it.

4 CONCLUSIONS

The paper dealt with the materials of the CAF military uniforms and its possible innovations. Based on the need to improve the performance and design of the existing uniform, it was necessary to verify the functionality and suitability of the maintenance of current military uniforms by measuring selected properties of materials.

A survey of soldiers' satisfaction with the use of uniforms 97 conducted. The aim of the survey was to find out the experience, opinions and attitudes of the CAF soldiers to use and quality of uniforms 97. The survey showed that most respondents not well informed about proper maintenance of service trousers and skirts. The correct maintenance procedure was not followed.

The components are normally machine washed, which can cause a change in the dimensions, colourfastness and useful properties of the materials. The soldiers also drew attention to the formation of permanent stains when dripping the uniform with water, such as rain. Based on the evaluation of the survey, the properties of colourfastness to water dripping, resistance to pilling and abrasion selected for the measurement experiment so that the above could objectively confirmed or refuted. Based on the results of the survey and experimental measurements, a proposal made to improve the performance and innovation of equipment material. The proposal evaluated the suitability or unsuitability of selected innovative materials C and D for Uniform 97 (A) and Summer Uniform 2005 (B) and recommended other possible procedures to improve the performance of the equipment. It has been proved that washing the equipment parts of the uniform 97 and the uniform 2005 does not affect the colourfastness and resistance to pilling and abrasion. According to the results of the experiment, the material of the summer uniform 2005 ended up as the best of all, it meets all the requirements for sufficient comfort of the soldier when wearing it, and therefore there is no need to innovate the material. The question remains whether it will be possible to restore the option of its acquisition and replenishment of the equipment by soldiers in VSNO, which currently stopped due to the termination of the contract with the manufacturer. All selected utility properties greatly affect the function of equipment components, as they are crucial for the durability of the product and its aesthetic properties, which are key in the case of military uniforms. The appropriate design of the garment is also important. It affects not only the function of the garment, but also the clothing comfort of the soldier who wears the uniform. Selected utility properties of equipment components affect their function in terms of durability of clothing, aesthetic properties, clothing design and the soldier's clothing comfort. The obtained research results and the proposal of possibilities to improve the useful properties of equipment components are a source of important information not only for the design and innovation in the introduction of new equipment components, but also lead to the improvement of military equipment.

5 REFERENCES

1. Kozlovska H, Bohanesova B.: Clothing materials II, 2nd edition, Praha: Informatorium, 1998, ISBN 80-86073-29-7 (in Czech)
2. Mračkova I.: Clothing materials for vocational schools, Praha: Septima, 2000, ISBN 80-7216-140-7 (in Czech)
3. Švecova J.: Innovations specifically functional clothing for the troops, Diploma thesis, Liberec: Technical University of Liberec, 2014 (in Czech)
4. Kovačič V.: Chapters from textile testing. Liberec: Technical University of Liberec, 2004, ISBN 80-7083-823-X (in Czech)
5. Ragab M., Darwish H.: Evaluation of end use properties of knitted scarves in the Egyptian market, Vlakna a Textil (Fibres and Textiles) 27(1), 2020, pp. 55-61
6. Textor T., Derksen L., Bahners T., Gutman J. S., Mayer-Gall T.: Abrasion resistance of textiles: Gaining insight into the damaging mechanisms of different test, Journal of Engineered Fibers and Fabrics 14, 2019, pp. 1-7, https://doi.org/10.1177/1558925019829481
7. ČSN EN ISO 105-E07 (80 0145) Textiles - Tests for color fastness - Part E07: Color fastness to dripping: water. Prague: Office for Technical Standardization, Metrology and State Testing, 2010 (in Czech)
8. ČSN EN ISO 12945-2 (80 0837) Textiles - Determination of the inclination of fabrics for surface pulping and pilling - Part 2: Modified Martindale method Prague: Czech Standards Institute, 2001 (in Czech)
9. CSN EN ISO 6330 (800821) Textiles - Domestic washing and drying procedures for textile testing. Prague: Office for Technical Standardization, Metrology and State Testing, 2012 (in Czech)
10. ČSN EN ISO 12947-2 (80 0846) Textiles - Determination of abrasion resistance of fabrics by the Martindale method - Part 2: Determination of sample damage Prague: Office for Technical Standardization, Metrology and State Testing, 2017 (in Czech)
11. ISO 105-A02 ISO Textiles - Tests for colourfastness - Part A02: Grey scale for assessing change in colour - Technical Corrigendum 2, 2005
12. CZMTýlSl: The Technical Specifications for Material for Personal Use of Soldiers - Uniform 97, 2014 (in Czech)