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DETERMINATION OF THE CUTTING FORCE OF "MULTIRISK" MATERIALS USED IN MANUFACTURING OF THE PROTECTIVE CLOTHING

***Abstract**: In order to ensure adequate protection, the clothing used by workers in the work process must be designed and made of materials known to have a certain "resistance" both to the risks for which they are intended and to the factors present in the work environment. Currently, the protective characteristics of clothing used against clearly defined hazards, such as chemicals, fire, molten metal droplets, etc. are addressed in various technical specifications (standards). Also, the standards specific to protective clothing include some mechanical characteristics, such as puncture and tear resistance, without taking into consideration the cut strength of materials, although in some situations, the danger of workers coming in contact with various cutting surfaces is inevitable. Given that in certain fields (agriculture, chemical industry, food industry, etc.) the risk of cutting is ubiquitous, and the characteristics of the materials used to make clothing are defining to ensure adequate protection, the study aims to follow the cutting behavior of materials with specific uses.*

***Key words**: manufacturing, clothing, specifications.*

***Language**: English*

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Introduction

Regardless of of the activity which is performed, workers may be exposed to physical, mechanical, chemical dangers, actions which may cause harm as occupational disease or injury.

There are many jobs, where in addition to the predominant dangerous factors (presence of fire, heat, cold, chemicals, etc.) workers may be exposed to the risk of cutting, due to:

- handling various sharp objects (bottles, plates, containers, knives, etc.) or
- occasional contact with various sharp surfaces.

Most minor cutting incidents occur on hands and body, these being the normal parts of the human which are involved in most activities that imply risks and the cause is not using personal protective equipment (abbreviated PPE) or using an inappropriate PPE.

The obligation to provide PPE [1, p. 8] to ensure adequate protection [2, p.2] of workers has led to the development of a wide range of materials to meet specific needs. Currently, most textile manufacturers test and certify the materials they make, in relation to different standards of requirements which establish criteria and levels of performance for certain characteristics, considered defining in ensuring adequate protection.

For certain sectors of activity, as a result of the use of hand knives or the handling of various cutting objects, where the risk of cutting is foreseeable, standards of requirements have been developed in which certain performance limits are imposed to establish a certain level of protection. Thus, the standard SR EN ISO 13998: 2003 imposes for the protective clothing against cuts and blows of the hand knife with an average cutting force of at least 50 N [2, p.2], while for the protective gloves against mechanical risks, the standard EN 388: 2018 establishes 6 performance levels (A, B, C, D, E, F) classified according to cut force (2N, 5N, 10 N, 15 N, 22 N, 30 N) [4, p.7].

2. Purpose

In order to be placed on the market the protective clothing must meet, in addition to other essential health and safety requirements specific to certain risks, the following requirements in Regulation (EU) 2016/425 [5]:

- 1.3.2 on 'Light weight and solidity', which means that it must provide adequate protection against risks for which it is intended and be resistant to environmental factors under foreseeable conditions of use [5, p. 76] ;
- 3.3 on "Protection against mechanical injury", which means that the constituent materials of PPE must be chosen or designed to ensure sufficient resistance to abrasion, perforation and cutting under foreseeable conditions of use. [5, p.76; 6, p. 448]

Although the risk of cutting is pervasive in most workplaces, limited information is currently available on the cutting strength of different types of materials used to make protective clothing. The requirement in standard EN 13998 which refers to cutting strength is only considered for a high level of risk (such as that related to knife cutting), without taking into account that in certain situations, the danger of workers coming into contact with different sharp surfaces is inevitable [7, p. 107].

Thus, the study aimed to determine the cutting strength of different types of materials used to make protective clothing, in order to properly select them.

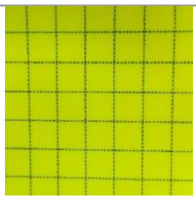
3. Criteria for selecting the test materials

To identify the elements that could influence the cutting force, were selected samples of materials frequently used in the production of chemical and "multi-risk" protective clothing , as they can be in a wide range: non-woven or woven, layered, with membranes, glued or laminated foils [8]. The criteria underlying the selection of materials used to perform the test series were the following:

- fibrous composition,
- specific mass [9, p. 17];
- thickness.

Considering the mentioned criteria, 6 types of materials were selected whose characteristics are presented in table 1.

Table 1. Characteristics of the materials selected for testing

Material code	Composition	Mass, g/m^2	Thickness, mm	Weave structure
 n	100% polypropylene laminated with polyethylene film	53	0,23	Nonwoven
 e1	98% polyester + 2% antistatic fibers + PU membrane	250	0,25	Plain 1/1
 e2	96% polyester + 4% antistatic fibers + PU membrane + knit	250	0,46	Twill 2/1

Material code	Composition	Mass, g/m^2	Thickness, mm	Weave structure
 e3	49% PPAN-fr + 42% cotton + 5% Para-aramid + 3% polyamide + 1% antistatic fibers	250	0,39	Twill 2/1
 e4	99% cotton + 1% antistatic fibers	220	0,48	Twill 2/1
 e5	65% Cotton + 33% polyester + 2% antistatic fibers	340	0,53	Twill 2/1
 e6	26% Cotton + 41% polyester + 32% modacrylic fibers + 1% antistatic fibers	330	0,80	compound bond

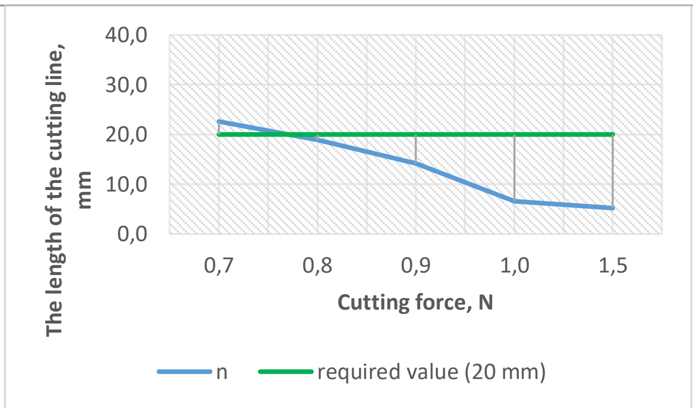
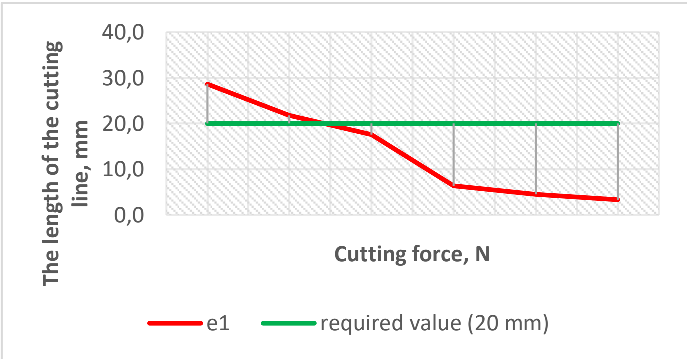
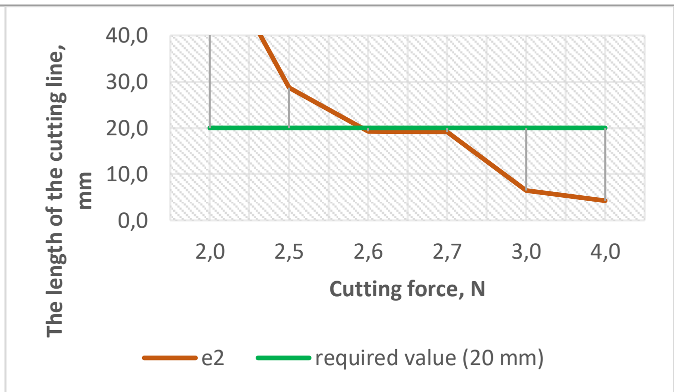
4. Tests and results

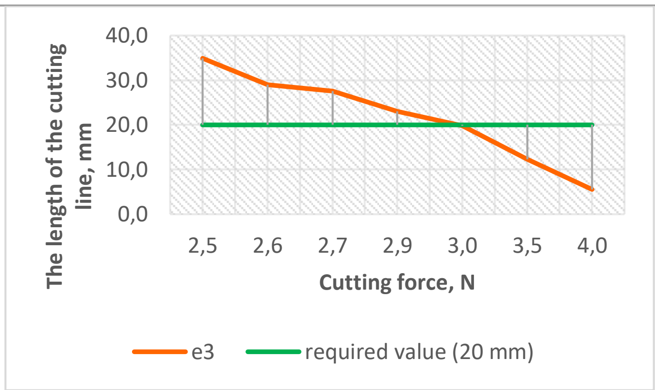
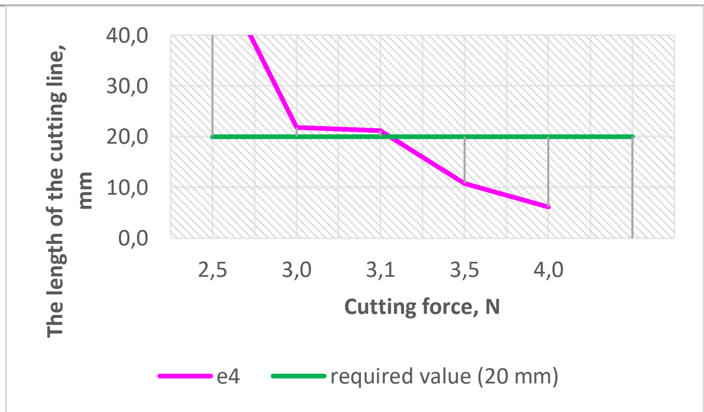
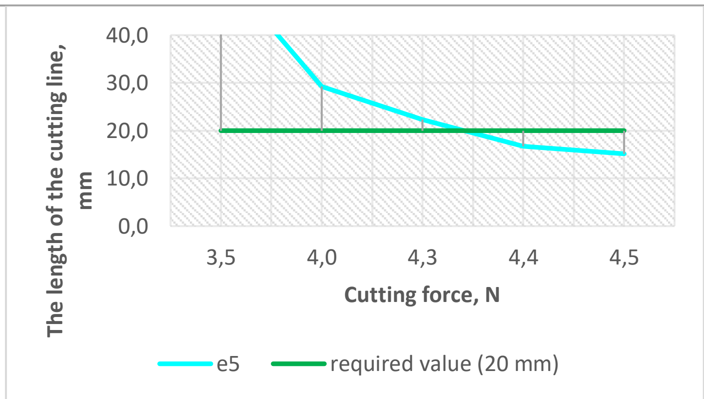
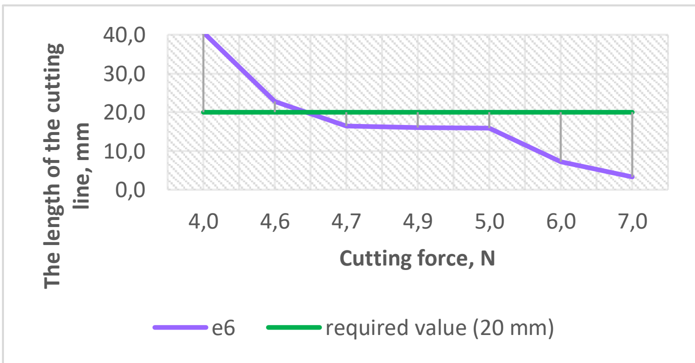
The determination of cut strength was based on compliance with the test method described in standard EN ISO 13997. In order to determine the force required to break through a material to a length of 20 mm, [10, p. 9] the specimens were taken at an angle of 45 degrees to the warp thread and were subjected to the cutting test with a stainless steel blade, on which different forces were applied (see figure 1).

Figure 1- Device for determining the cut strength

The results of the series of tests were summarized in Table 2.

Table 2. The results of the test series

Composition	Mass, g/m^2	Graph of determining the cutting force	Cutting force, N
100% polypropylene laminated with polyethylene film	53		0,77
98% polyester + 2% antistatic fibers + PU membrane	250		2,14
96% polyester + 4% antistatic fibers + PU membrane + knit	250		2,58

<table>
<tr><th>Composition</th><th>Mass, g/m²</th><th>Graph of determining the cutting force</th><th>Cutting force, N</th></tr>
<tr><td>49% PPAN-fr + 42% cotton + 5% Para-aramid + 3% polyamide + 1% antistatic fibers</td><td>250</td><td>
</td><td>2,99</td></tr>
<tr><td>99% cotton + 1% antistatic fibers</td><td>220</td><td>
</td><td>3,12</td></tr>
<tr><td>65% Cotton + 33% polyester + 2% antistatic fibers</td><td>340</td><td>
</td><td>4,34</td></tr>
<tr><td>26% Cotton + 41% polyester + 32% modacrylic fibers + 1% antistatic fibers</td><td>330</td><td>
</td><td>4,64</td></tr>
</table>

Although it is known that the mechanical strength of the plain fabrics is higher than that of the twill fabrics, the comparative analysis of the results obtained for „e2” and „e3” specimens shows that although they have a similar composition, the cutting strength is higher in the case of the twill material.

Since the only differences between the two materials are the number of layers and the thickness, a first conclusion that can be drawn is that the cutting strength is not influenced by the type of weaving but by the thickness of the material.

Furthermore, the fact from above is also supported by the analysis of the „e5" and „e6" specimens. Even if there is often a tendency to say that a material with a higher specific mass is thicker or has a higher cutting strength, this is contradicted by comparing the results obtained for the „e5" and „e6" specimens. It should be noted that although the material from which the „e6" specimen was taken is „lighter" than the material from which the „e5" specimen was taken, in this case the cutting strength is higher. This may be the result to both the thickness, determined by the weaving mode, and the content of modacrylic fibers, which are in proportion of 1/3 of the fibrous composition.

In addition, by comparing the results obtained for the „n" and „e1" test pieces, it was observed that although the two materials have approximately equal thickness, they have different cutting forces. As expected, nonwovens have much lower cutting strength than woven materials, even if both types of material have the same chemical protection characteristics.

Overall, it can be said that the cutting strength:

- is very small in the case of nonwovens compared to woven materials;
- it is not significantly influenced by the specific mass of the material;
- it is higher in the case of thicker materials;
- it is larger if the fabric has aramid and modacrylic fibers in its composition.

By analysing the results obtained for all types of selected materials, it can be said that even if the material has been certified for a certain risk considered major, knowing the cutting strength of materials is really important for selecting appropriate protective clothing, considering the fact that each job is unique in the risks it may have.

5. Conclusions

As the characteristics of the materials used to make clothing worn by workers at work are defined to ensure adequate protection, the results of the study can be used to develop a set of guidelines for their rapid selection by PPE producers when:

- the basic risk is cutting;
- the risk, although hazardous to the worker, can significantly affect the protective characteristics of PPE against other risks that may seriously affect health.

References:

1. (2006). Legea 319 din 2006 - Legea privind securitatea și sănătatea în muncă; Retrieved from https://www.iprotectiamuncii.ro/legi/legea-319-2006.pdf
2. (2006). HOTĂRÂRE Nr. 1048 din 9 august 2006 privind cerinţele minime de securitate şi sănătate pentru utilizarea de către lucrători a echipamentelor individuale de protecţie la locul de muncă, Retrieved from http://www.mmuncii.ro/pub/imagemanager/images/file/Legislatie/HOTARARI-DE-GUVERN/hg1048_2006.pdf
3. (2003). EN ISO 13998:2003, Protective clothing - Aprons, trousers and vests protecting against cuts and stabs by hand knives (ISO 13998:2003)
4. (2018). EN 388:2016+A1:2018, Protective gloves against mechanical risks
5. (2016). REGULATION (EU) 2016/425 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0425&from=EN
6. Priscilla Reiners, Yordan Kyosev, Laurence Schacher, Dominique Adolphe (n.d.). About the cutting resistance measurement of textiles, Hochschule NIederrhein – University of Applied Sciences, Textile and Clothing Technology, Mönchengladbach (Germany).
7. Emilia Irzmańska, Agnieszka Stefko (n.d.). Comparative Evaluation of Test Methods for Cut Resistance of Protective Gloves According to Polish Standards, National Research Institute (CIOP-PIB). ul. Czerniakowska 16, 00-701 Warsaw, Poland Department of Personal Protective Equipment. ul. Wierzbowa 48, 90-133 Łódź, Poland. Retrieved from https://www.researchgate.net/publication/298553949_Resistance_of_protective_gloves_to_cut_according_to_the_European_standard_EN_388 2003
8. (n.d.). A SHAW, Steps in the selection of protective clothing materials, University of Maryland Eastern Shore, USA, Retrieved from

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7171460/

9. (n.d.). Retrieved from https://sp1cahul.md/files/bib/190221083237.pdf
10. (1999). EN ISO 13997:1999, Protective clothing — Mechanical properties — Determination of resistance to cutting by sharp objects.