# APPLICATION OF KNITTED AND WOVEN PACKAGE IN THE ANTI-IMPACT VEST

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## EXTENDED ABSTRACT

**Key words**: spacer knitted fabric, woven fabric, impact, energy of absorption, anti-impact vest

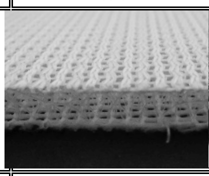
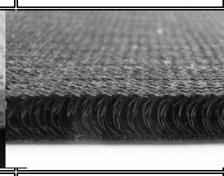
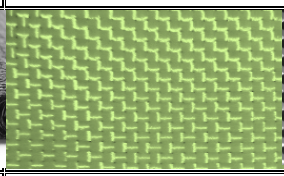
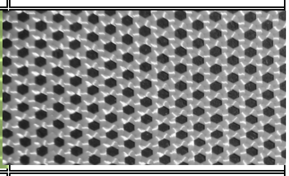
## 1. INTRODUCTION

Nowadays, protective clothing is widely used. Uniformed services, army, policemen, jockeys belong to the group which uses this type of clothing most often. The anti-impact vest must provide protection against impact at an appropriate level. Unfortunately, current vests available on the market don't provide comfort of use, through too high mass [1]. An alternative solution could be the usage of distance fabrics that are characterized by low surface mass, air permeability and high absorption of impact energy. Materials from Kevlar have also very good strength properties [2]. The main aim is to design a knitted and woven package that has the ability to protect against impact at Level 1 according to PN-EN 13158: 2010 [3], for use in anti-impact vests.

## 2. MATERIALS AND METHODS

Materials were obtained from „Baltex Gedeon"-textile company from Lodz. Among them can be distinguished two distance knitted fabrics (B and C) and two woven fabrics made of aramid fibres (E and F). Table 1 shows characteristics of these materials.

**Table 1**. Characteristics of tested materials [4]

| **Type of fabric** | **Spacer knittwear- B** | **Spacer knittwear- C** | **Two-axles fabric-linen weave- E** | **Three-axles fabric- F** |
|---|---|---|---|---|
| |  |  |  |  |
| **Raw material** | PES/PA | PES/PA | Kevlar 29 (1500 dtex) | Kevlar 29 (1500 dtex) |
| **Surface mass [g/m2]** | 889±20 | 895±12 | 200±10 | 198±10 |
| **Thickness [mm]** | 5,5 | 7 | 0,28±0,03 | 0,26±0,03 |

The materials described in Table 1 have been tested by the „Drop Tower". This device gives the possibility to do an impact analysis as defined by the standards *PN-EN 13158:2010* [3]. The measurement is carried out with two sensors located on the anvil and on the ram. The following parameters were chosen for the analysis: the force received under the anvil, the energy absorbed by the fabrics and the difference in deflection. Energy ($\Delta E$) which has been absorbed by the tested package was determined by the Formula 1. The value should be as high as possible.

$$\Delta \boldsymbol{E} = \frac{|E_p - E_k|}{E_p} \cdot \mathbf{100}\ [\%] \tag{1}$$

The force received under the anvil (F) depends on the course of the force value over time. Standards determine that this force should be lower than 4 kN. The created packages have different thicknesses, therefore the difference between the input thickness (h0) and the deflection value (h1) is an important parameter which is determined by Formula 2. This value should be optimal so that the package is not damaged and that the impact energy is not transferred to the human body.

$$\Delta \boldsymbol{h} = \frac{|h0 - h1|}{h0} \cdot \mathbf{100}\ [\%] \tag{2}$$

## 3. EXPERIMENTAL RESULTS AND DISCUSSION

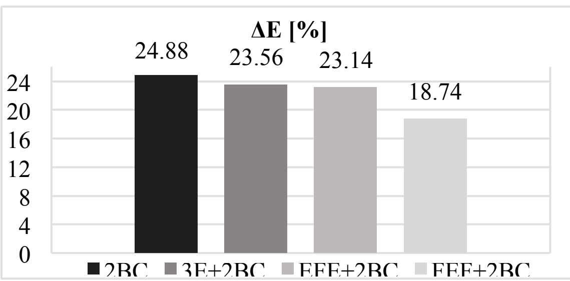
Based on the results of the preliminary tests, the materials were combined into four packages. The package name corresponds to the order in which the layers are laid. The following packages have been tested: **2BC**, **3E+2BC**, **EFE+2BC**, **FEF+2BC**. Each measurement was performed three times and then the average values and standard deviation were calculated from them.

### 3.1 Absorbed energy:

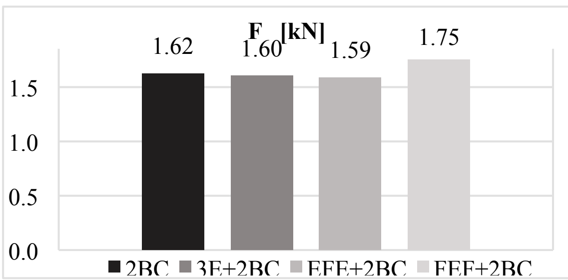
The results of the absorbed energy by the packages show that regardless of the order of the Kevlar layers, the samples absorb similar amount of impact energy as the sample without Kevlar (23-25%). The exception is the package containing Kevlar FEF layers, which consumed only 18,74% of the given energy. Therefore, the addition of Kevlar layers did not improve the energy absorption of the package. The results are presented in the Graph 1.

### 3.2 Force received under the anvil:

The next analysed value was the force which was recorded by the sensor on the anvil. None of the tested packages exceeded the limit value of 4kN. Compared to the 2BC package, the presence of Kevlar layers barely affected the reduction of the value. Therefore the use of Kevlar layers didn't improve its protective capability. The values of the force received under the anvil are shown in the Graph 2.



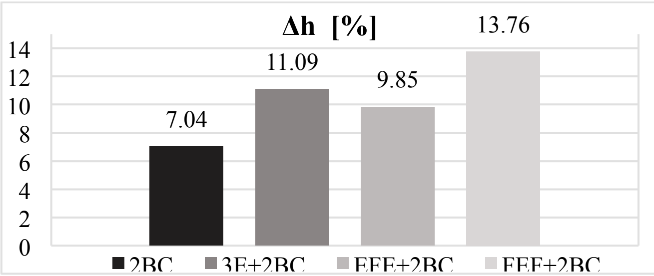

**Graph 1.** Percentage value of absorbed energy by the packages [%]




**Graph 2.** The force received under the anvil by the packages [kN]

### 3.3 Difference in deflection:

The results of deflection of the package show that the presence of Kevlar layers causes the increase of the difference in deflections (Δh). This means that a larger amount of the package remains intact during the impact. The measurements results are presented in the Graph 3.




**Graph 3.** The difference in deflection [%]

## 4. CONCLUSION

By using textiles such as spacer knitwear and woven fabric, it is possible to receive a protective package which provides both air circulation and protection against impact. Each of its layers have separate functions and are responsible for other parameters. The layers of distance knitted fabric absorb an impact energy and reduce received impact force. The layers of woven fabrics are responsible for reducing the deflection of the package during impact. Selected package 3E+2BC absorbed 23,56% of impact energy. For this package the force received under the anvil is only 1,60 kN. The addition of Kevlar layers doesn't improve the energy absorption of the package, but increases the difference in deflection (Δh) which affects the non-transmission of impact energy on the user's body. For this package, 11,09% of the input thickness haven't been damaged. The vest which could be made from the developed package, would be about 1,5 kg lighter than the typical current vests available on the market [5-7].

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