

DOI: 10.34658/9788366741751.37

THE EFFECT OF 3D WEFT-KNITTED FABRIC COMPOSITION ON PUNCTURE, TEAR, AND AIR PERMEABILITY

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ABSTRACT

This study investigates the influence of 3D weft-knitted fabric fibre composition on the risk of puncture and tear and evaluates the air permeability of these protective knits. For this purpose, different 3D weft-knitted fabrics, consisting of outer (protective), binding, and inner (suitable for contact with skin) layers, were produced on an E20 circular weft-knitting machine using different quantities of high molecular weight polyethylene (HMWPE) (from 49% to 24%) and inorganic yarns (from 0% to 23%) in the outer layer while the quantity of polyester in the inner layer and polyamide in the binding layer was kept the same. The puncture and tear resistance tests were conducted to determine the resistance of the 3D weft-knitted fabrics to mechanical risks. The air permeability test was performed to assess the comfort properties of the protective 3D weft-knitted fabrics. According to the puncture and tear resistance testing results, it was determined that the highest HMWPE percentage content in the outer layer of 3D weft-knitted fabric provided the highest resistance to these mechanical risks. Based on the air permeability test results, it was found that knit with the highest inorganic yarns content in the outer layer achieved the highest air permeability value.

KEYWORDS

3D weft-knitted fabric, puncture resistance, tear resistance, mechanical risk, air permeability.

INTRODUCTION

Every year, many workplace injuries occur in the world that can be prevented by using appropriate protective clothing/personal protective equipment [1]. Puncture and tear resistance are among the mechanical properties required in protective clothing in order to avoid serious injuries in the workplace [2]. Textile materials are complex therefore investigations of puncture also tear resistance are highly demanded to determine the effect of different parameters of knitted fabrics on such mechanical risk [3,4]. Also, comfort properties such as air permeability is an important characteristic that should be evaluated as well because the wearer can perform well only if feels comfortable when wearing personal protective equipment [5,6].

This study aimed to determine the influence of 3D weft-knitted fabric fibre composition on the puncture, tear risk and to evaluate the air permeability of these protective knitted fabrics.



MATERIALS AND METHODS

For this study, different 3D weft-knitted fabrics, consisting of outer, binding, and inner layers, were produced on a E20 circular weft-knitting machine using different quantity of high molecular weight polyethylene (HMWPE) (from 49% to 24%) and inorganic yarns (from 0% to 23%) in the outer layer while the quantity of polyester yarns in the inner layer (46%) and polyamide yarns in the binding layer (6%) were kept the same.

Prior to the test procedures all specimens were conditioned for 24 h under standard conditions according to standard EN ISO 139:2005 [7]. The puncture and tear resistance tests were performed to determine the resistance of 3D weft-knitted fabrics to mechanical risks in accordance with EN 388:2016 [8]. A SATRA STM 566 Tensile testing machine was used for the puncture resistance testing to determine the force required to cause a standard puncture needle to break through a knitted fabric. The test was performed at a test speed of 100 mm/min on four different specimens for each knitted fabric. A SATRA STM 566 Tensile tester was used to determine the maximum force necessary to propagate a tear in a rectangular specimen of the 3D knitted fabric slit halfway along its length. Trouser-type samples (100x50 mm) with an incision in the longitudinal direction of the sample were investigated, i.e., four specimens were cut both in the course direction and the wale direction. The test was performed at a test speed of 100 mm/min.

The air permeability of 3D weft-knitted fabrics was investigated in accordance with EN ISO 9237:1995 [9] using a pressure of 200 Pa. Ten tests were conducted for each 3D weft-knitted fabric.

RESULTS AND CONCLUSION

Based on the analysis of the results, it was determined that the puncture and tear resistance of 3D weft-knitted fabrics is significantly affected by the HMWPE content in the knitted structure: the highest resistance to these mechanical risks was determined of the knitted fabric with the highest percentage of HMWPE in its structure. All the investigated 3D weft-knitted fabrics comply with the highest levels of puncture and tear resistance, i.e. level 4 (Puncture resistance ≥ 150 N, Tear resistance ≥ 75 N) in accordance with EN 388:2016. Thus, it can be concluded that all the investigated 3D weft-knitted fabrics provide high levels of protection against puncture and tear risk. The results of air permeability showed that the air permeability of 3D weft-knitted fabrics enlarges by increasing inorganic fibre in the structure: the highest air permeability value was achieved in the knitted structure with the highest inorganic yarns content.

ACKNOWLEDGMENT

The authors would like to acknowledge company Granberg AS for the cooperation of the investigation.

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