

7. Sprawozdanie nr 12/2009 z porównań międzylaboratoryjnych organizowanych przez POLLAB
8. PN-P-04613:1997 „Tekstylija -- Dziańiny i przędziny -- Wyznaczanie masy liniowej i powierzchniowej”
9. PN-EN ISO 5084:1999 „Tekstylija -- Wyznaczanie grubości wyrobów włókienniczych”
10. PN-EN 29073-1:1994 „Tekstylija -- Metody badania włóknin -- Wyznaczanie masy powierzchniowej”
11. PN-EN 9073-2:2002 „Tekstylija -- Metody badania włóknin -- Część 2: Wyznaczanie grubości”
12. PN-90/P-04870 „Tekstylija -- Analiza statystyczna wyników pomiarów”

## PN-EN ISO 9073-5:2008 Standard versus PN-79/P-04738 Standard

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### INTRODUCTION

In November 2008 polish standard PN-79/P-04738 „Textiles -- Determination of bursting strength” [1], specified a method for determining bursting strength of the textile fabrics and ready-to-wear or use cloths and applied for determination of multi-directional strength, was withdrawn from catalogue of polish standards. This standard was very helpful in establishing the usefulness of textiles with the special regard of knitted fabrics and knitting products. Range (value) of the bursting strength mentioned above enables the potential manufacturer to the suitable selection of textiles, structure, content and finishing in the aim of keeping and fulfilling the requirements on the defined level.

PN-79/P-04738 standard was replaced by PN-EN ISO 9073-5:2008 „Textiles -- Test methods for nonwovens -- Part 5: Determination of resistance to mechanical penetration (ball burst procedure)” [2]. This standard specifies a method for determining the resistance to mechanical penetration of nonwoven fabrics.

Many standards [3, 4, 5] and specifications for example uniforms etc. for officers of The Ministry of the Interior and Administration created by the Institute of Security Technologies „MORATEX” staff including technical requirements of bursting strength need reviewing and updating because of the content-related changes introduced by 9073-5:2008.

Withdrawal of a commonly used PN-79/P-04738 polish standard leaves an unsolved major problem connected with lack of standardized test method of bursting strength for knitted fabrics and woven fabrics.

To be up to potential clients' expectations and the Institute needs as well in studies on new specifications it was advisable to create a new testing procedure. In this connection, withdrawn standard PN-79/P-04738 Metrology Laboratory of the Institute of Security Technologies „MORATEX” replaced by its own testing procedure PBM-31/ITB:2009 [6], which also expanded accreditation range No AB 154.

Moreover Metrology Laboratory of the Institute of Security Technologies „MORATEX” in 2009 expanded accreditation range of testing methods described in PN-EN ISO 9073-5:2008. Accreditation system demands from accredited laboratory taking part in Inter Laboratory Comparisons (ILC) which in this case were coordinated by Polish Testing Laboratories Club POLLAB. The aim of ILC is to assess laboratory technical competences in conducting tests in a specified range, measurements precision and accuracy of standardized test method. Comparisons testing were conducted on two different materials (the same as examined in this paper) and three different laboratories participated [7].

### AIM OF THIS WORK

The purpose of this work was to compare bursting strength results obtained by the means of two different test methods.

### DEFINITION

For the purposes of this paper, and according to definitions given in PN-79/P-04738 and PN-EN ISO

9073-5:2008 bursting strength means a force or pressure required to rupture a textile by distending it with a force, applied at right angles to the plane of the fabric, under specified conditions.

## RESEARCH MATERIAL

In presented work knitted fabric (polar fleece type) and electro-conductive nonwoven fabric were the subject of examination which previously were also reference materials in Inter-laboratory Comparisons (ILC) in the range of determination of resistance to mechanical penetration (ball burst procedure) according to PN-EN ISO 9073-5:2008.

Test results of basic parameters, characterized usage properties are shown in Tables no 1 and 2. Availability and compatibility with mentioned above standard were the main reason of executed choice.

Table no 1 - Knitted fabric characteristic (polar fleece type)

No	Parameters	Test results	Standard
1	Mass per unit [g/m <sup>2</sup> ]	366	PN-P-04613:1997 [8] Metoda: E
2	Thickness [mm]	4.49	PN-EN ISO 5084:1999 [9]

Table no 2 - Electro-conductive nonwoven fabric characteristic

No	Parameters	Test results	Standard
1	Mass per unit [g/m <sup>2</sup> ]	92	PN-EN 29073-1:1994 [10]
2	Thickness [mm]	0.68	PN-EN ISO 9073-2:2002 [11]

## TEST METHODS AND APPARATUS

Table no 3 presents comparison of technical and apparatus requirements of two methods PN-79/P-04738 and PN-EN ISO 9073-5:2008

Analysis of data presented in Table no 3 comes to the conclusion that the main differences in methods are:

- balls' diameters and internal diameters of ring clamps
- crosshead speeds
- shape and number of specimens.

Figures no 1 and 2 show apparatus placed in Metrology Laboratory of the Institute of Security Technologies „MORATEX” which enables to examine bursting strength using both methods.

Table no 3 - Methods' comparison

Requirements	PN-79/P-04738	PN-EN ISO 9073-5:2008
Apparatus	CRT <sup>*)</sup>	CRT
Size of balls (diameter)	10 [mm] <sup>**)</sup> 20 [mm] <sup>***)</sup>	25.4 [mm]
Ring clamp (internal diameter)	25 [mm]	44.5 [mm]
Crosshead speed	100 ± 5 [mm/min]	300 ± 10 [mm/min]
Number of specimens	10	5
Specimens shape	Circle Ø70 [mm]	Square 125 [mm] or Circle Ø125 [mm]
Unit	daN	N
Results precision	3 significant digits	to the nearest 5N

### Legend:

\*) CRT – Constant-rate-of-traverse tensile testing machine

\*\*) for technical fabrics (felts, nonwovens, textile fabrics)

\*\*\*) for remaining textile fabrics



Figure no 1 - Apparatus according to PN-79/P-04738 (PBM-31/ITB:2009)



Figure no 2 - Apparatus according to PN-EN ISO 9073-5:2008

Figure no 3 shows pins ended with balls used in measurements of bursting strength according to PN-79/P-04738 (PBM-31/ITB:2009) and PN-EN ISO 9073-5:2008.



Figure no 3 - Pins with balls, from the left diameters: Ø10, Ø20, Ø25.4 mm respectively

## RESULTS

In accordance with PN-79/P-04738 (PBM-31/ITB:2009) and PN-EN ISO 9073-5:2008 the bursting strength for both tested materials was examined. Measurement results of bursting strength are shown in Tables 2 and 3 respectively.

In this case repeatability tests results obtained under specified laboratory conditions required two series of measurements.

Table no 4 - Measurement results of bursting strength for knitted fabric (polar fleece type)

No	Parameters	Test results	Standard
1	Bursting strength [daN]	57.7	PN-79/P-04738 (PBM-31/ITB:2009)
		1 <sup>st</sup> series	
		55.6	
Additional information: Ball diameter: Ø20 mm			
2	Bursting strength [N]	665	PN-EN ISO 9073-5:2008
		1 <sup>st</sup> series	
		630	
Additional information: Ball diameter: Ø25.4 mm			

Substitution of ball diameter from 20 mm for 25.4 mm did not have any significant influence to bursting strength of knitted fabric (polar fleece type).

Table no 5 - Measurement results of bursting strength for electro-conductive nonwoven fabric

No	Parameters	Test results	Standard
1	Bursting strength [daN]	13.4	PN-79/P-04738 (PBM-31/ITB:2009)
		1 <sup>st</sup> series	
		14.5	
Additional information: Ball diameter: Ø10 mm			
2	Bursting strength [N]	330	PN-EN ISO 9073-5:2008
		1 <sup>st</sup> series	
		320	
Additional information: Ball diameter: Ø25.4 mm			

In contrast to above-mentioned it is logical that substitution of ball diameter from 10 mm for 25.4 mm did have significant influence to bursting strength of electro-conductive nonwoven fabric.

## STATISTICS

Statistical calculations of bursting strength obtained by means of two methods PN-79/P-04738 and PN-EN ISO 9073-5:2008 were used to compare standard deviations (variances) (F-test) and mean values (t-test) [12] (see Tables no 6 and 7).

F-test (Fishera-Snedecora) was used in comparing two independent samples of size  $n_1$  and  $n_2$ . The F-test provides a measure for the probability that they have the same variance. The estimators of the variance are  $S_1^2$  and  $S_2^2$  ( $S_1^2 > S_2^2$ ). Statistic F is defined by following formula:

$$F = \frac{S_1^2}{S_2^2} \text{ (Formula no 1)}$$

and F distribution with  $f_1 = n_1 - 1$  and  $f_2 = n_2 - 1$  degrees of freedom.

Modified Student's t-test (Welch's t test) was intended for use with two samples having possibly unequal variances. Statistic t is defined by following formula:

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad (\text{Formula no 2})$$

where,  $\bar{x}$ ,  $n$ ,  $S_n^2$  and  $n_n$  are the  $i^{\text{th}}$  sample mean, sample variance and sample size, respectively.

Table no 6 - Laboratory statistical results for PN-79/P-04738 (PBM-31/ITB:2009)

Parameters	Knitted fabric	Nonwoven fabric
1 <sup>st</sup> series		
Within-laboratory mean value [N]	57.7	13.4
SD <sup>*)</sup>	2.94	1.79
CV <sup>**)</sup> [%]	5.1	13.4
The 95% confidence limits [N]	<55.7;59.5>	<12.2;14.4>
The 99% confidence limits [N]	<55.3;60.1>	<11.9;14.8>
2 <sup>nd</sup> series		
Within-laboratory mean value [N]	55.6	14.4
SD <sup>*)</sup>	2.15	2.34
CV <sup>**)</sup> [%]	3.9	16.2
The 95% confidence limits [N]	<54.3;56.9>	<13.0;15.9>
The 99% confidence limits [N]	<53.8;57.4>	<12.6;16.4>
Test F ( $F_{95} = 3.18$ )	1.87	0.58
Test t ( $t_{95} = 2.10$ )	1.81	1.22

**Legend:**

\*) SD – Standard Deviation

\*\*\*) CV – Coefficient of Variation

On the basis of statistical analysis (tests F and t) following conclusion was drawn there was no significant difference between variances and mean values results of bursting strength measurements carried out

under the same conditions (the same: testing material, apparatus, procedure, observatory). Statistics F and t are in the 95% and 99% confidence limits.

Table no 7 - Laboratory statistical results for PN-EN ISO 9073-5:2008

Parameters	Knitted fabric	Nonwoven fabric
1 <sup>st</sup> series		
Within-laboratory mean value [N]	665	330
SD <sup>*)</sup>	22.6	27.0
CV <sup>**)</sup> [%]	3.40	8.21
The 95% confidence limits [N]	<645;685>	<305;355>
The 99% confidence limits [N]	<640;690>	<300;360>
2 <sup>nd</sup> series		
Within-laboratory mean value [N]	630	320
SD <sup>*)</sup>	25.3	31.7
CV <sup>**)</sup> [%]	4.0	9.9
The 95% confidence limits [N]	<610;655>	<290;345>
The 99% confidence limits [N]	<600;660>	<280;354>
Test F ( $F_{95} = 6.39$ )	1.25	1.38
Test t ( $t_{95} = 2.31$ )	2.24	0.83

Moreover results of bursting strength obtained according to PN-EN ISO 9073-5:2008 are in good agreement with inter-laboratory results (see Table no 8).

**CONCLUSIONS**

1. Withdrawal of PN-79/P-04738 polish standard and replacement its by PN-EN ISO 9073-5:2008 leaves an unsolved major problem connected with lack of standardized test method of bursting strength for textile fabrics and technical fabrics as well.

Table no 8 - Comparison of ILC and Metrology Laboratory of ITB „MORATEX” statistical results according to PN-EN ISO 9073-5:2008

Parameters	Knitted fabric	Nonwoven fabric
Within-laboratory mean value [N]	665	330
	1 <sup>st</sup> series	1 <sup>st</sup> series
	630	320
	2 <sup>nd</sup> series	2 <sup>nd</sup> series
Inter-laboratory mean value [N]	605	310
The 95% confidence limits [N]	<505; 700>	<245; 370>

2. Substitution of PN-79/P-04738 for a new procedure PBM-31/ITB:2009 made by Metrology Laboratory of ITB „MORATEX” for own needs is only a provisional solution.
3. Many standards [3, 4, 5] including technical requirements of bursting strength obtained according to PN-79/P-04738 need revision and updating.
4. According to tests F and t the use of PN-79/P-04738 (PBM-31/ITB:2009) and PN-EN ISO 9073-5:2008 standards resulted in good within-laboratory precision for measured values of bursting strength two textile materials.
5. Results of bursting strength obtained for knitted fabric according to PN-79/P-04738 (ball diameter Ø20 mm) and PN-EN ISO 9073-5:2008 (ball diameter Ø25.4 mm) are in the same confidence level.
6. Results of bursting strength obtained for nonwoven fabric according to PN-79/P-04738 (ball diameter Ø10 mm) and PN-EN ISO 9073-5:2008 (ball diameter Ø25.4 mm) differ from each other.
7. The use of PN-EN ISO 9073-5:2008 test standard resulted in good agreement between three different laboratories for measured values of bursting strength for several textile materials.

8. There is a need and recommendation to conduct investigations for the wider assortment.

## References

1. PN-79/P-04738 „Textiles -- Determination of bursting strength” (in Polish)
2. PN-EN ISO 9073-5:2008 „Textiles -- Test methods for nonwovens -- Part 5: Determination of resistance to mechanical penetration (ball burst procedure)”
3. PN-P-84005:1996 „Textiles -- Knitted fabrics and knitting products -- Index values the resistance to puncture” (in Polish)
4. PN-P-84538:1996 „Transport packages from textiles -- Post and bank sacks” (in Polish)
5. PN-P-84252:1991 „Hosiery -- Indicators resistance to puncture” (in Polish)
6. PBM-31/ITB:2009 „Determination of bursting strength” (in Polish)
7. Report no 12/2009 from ILC organized by POL-LAB (in Polish)
8. PN-P-04613:1997 „Textiles -- Knitted and stitch bonded fabrics -- Determination of mass per unit length and mass per unit area” (in Polish)
9. PN-EN ISO 5084:1999 „Textiles -- Determination of thickness of textiles and textile products” (in Polish)
10. PN-EN 29073-1:1994 „Textiles -- Test methods for nonwovens -- Part 1: Determination of mass per unit area” (in Polish)
11. PN-EN 9073-2:2002 „Textiles -- Test methods for nonwovens -- Part 2: Determination of thickness” (in Polish)
12. PN-90/P-04870 „Textiles -- Statistical analysis of testing results” (in Polish)