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Ageing Simulation of Fabrics Destined for Protective Clothing

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Abstract
The aim of the research was the elaboration of measurement methodology for establishing textile material resistance to atmospheric factors simulated by the Xenotest, specifically artificial weather or without rain. The ageing test was carried out on two groups of fabrics: the first - fabrics with a modified surface (resistant to chemicals) and modified structure (flame-retardant and electroconductive), and the second - fabrics used as the background of warning clothing. After the ageing simulation in the Xenotest, the following properties were examined: change in color, tensile and tearing strength, and electric resistance. For the second group of fabrics, photometric parameters were also measured. The results and their analysis are presented, some of which were compared with ageing in natural conditions.

Key words: *ageing, fabrics, protective clothing, atmospheric factors, warning clothing.*

Introduction

Textile materials destined for protective clothing belong to the group of textiles most exposed to the Sun's radiation and different atmospheric factors. The biggest influence on the degradation of textiles has the Sun's radiation, especially ultraviolet [1, 2]. Light waves are only a small part of the spectrum of electromagnetic waves. Visible light covers waves of a length ranging from 380 to 770 nm. In the light spectrum there are also non-visible waves, including short waves (below 380 nm), so-called ultraviolet waves, and long ones (above 770 nm) – infrared. The light spectrum contains high amounts of ultraviolet radiation.

Ultraviolet rays are, to a large extent, responsible for the ageing of textile materials because the majority of fibres are sensitive to this radiation. The Sun's radiation (ultraviolet radiation – below 380 nm) and humidity cause a change in the physical and chemical properties of fibre [3].

The condition necessary for the ageing polymer fibre structures exposed to light radiation is the absorption of Sun rays, occurring when quant and photon energy introduced to the fibre structure corresponds to the differentiated energy of its molecules. At the appropriate energy of absorbed radiation quants, a molecule reaction can take place and then the consequent breakage of cross-links of fibre polymeric chains [4, 5]. In the literature this process is called a photochemical reaction (photolysis).

In his theory, Egerton proved the existence of two different phenomena of photochemical fibre degradation – photolysis and photo-oxidation [3]. Photolysis appears when the energy absorbed by the fibre quants, h_V, is higher than the that of the molecule crosslinking E_c, causing the breakage of the main chemical crosslinks without the necessity of the simultaneous existence of additional means (for example oxidants). The energy necessary for this purpose is high and dependant on the cross-linking nature and reacting atoms. Therefore, the photolysis phenomenon can take place only in the presence of ultraviolet radiation.

The photolysis of silk or PA fibres causes the breakage of the following crosslinks: C – C and C – N. It was stated that to break a C – N crosslink, energy of 50 kcal/mol (21 kJ/mol) is necessary, whereas in the photolysis of cellulose fibres, the breakage of C – C or C – O cross-links requires energy of 80 – 90 kcal/mol (33.5 – 37.5 kJ/mol).

If the energy of absorbed quants, h_V, is smaller than that of molecule bonds, E_c, an impel state of the molecules occurs. The additional activity of the other means allows for the reaction of molecules and the degradation of molecular bonds. This process, due to the presence of oxygen, is named photo-oxidation.

Photo-oxidation takes place during fibre exposure to light rays of a length above 340 nm. The most common destruction factors are oxygen, dyestuffs, water and certain types of oxides. It was stated that they cause the creation of two-oxides of hydrogen, which, during the oxidation, can act even on fibres not exposed to light. Photochemical reactions decrease the degree of fibre polymerisation, and in consequence their mechanical and chemical resistance as well as their dullness drop [6].

The UV radiation falling on the textile is partially reflected by its surface, partially going through the fabric structure. Some of this radiation is absorbed by the fibres, as result of which some changes occur in them i.e. physical and physico-chemical properties and colour (fading). The following factors influence the velocity of the degradation process: the length of the radiation wave, the radiation intensity and time of exposure. With a decrease of wavelength, the effectiveness of photolysis as well as the fibre destruction and dyestuff degradation processes increase. A similar result is obtained when the intensity and time of light exposure increase.

For the purpose of the improving the time of clothing usefulness, manufacturers modify the surface or add UV absorbers and free radical stabilisers to polymers. Research carried out at the Institute of Textile Material Engineering concerning the basic utility parameters of fabrics exposed to light in laboratory conditions showed a significant decrease in these parameters [6]. The subjects of investigation were fabrics (woven and knitted) of different raw materials (PES-Cotton-PAN-PA-PES/viscose) designed for interior design.

At the Institute of Knitting Technique and Technology, research was carried out on the influence of light and artificial weather on knitted fabrics made of 100%

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Table 1. Characteristics of the fabrics chosen for investigation.

Group of fabrics	Fabric	Raw material content, %	Mass per square meter, g/m²	Protective properties according to standards
Fabrics destined for protection clothing	Fabric 1	75%CO/24%PES/1% of electro-conductive fibres (net arrangement of carbon threads)	245(±4%)	PN-EN 470-1 Protection against small metal splashes during welding. PN-EN 531 Protection against flames and heat, PN-EN 1149-5 Antielectrostatic fabric.
	Fabric 2	100%CO	280(±5%)	PN-EN 470-1 Protection against small metal splashes during welding. PN-EN 531 Protection against the flame and heat.
	Fabric 3	97%CO/2.5%PES/0.5% of electro-conductive fibres (net arrangement of metal threads)	275(±4%)	PN-EN 531 Protection against flames and heat, PN-EN 1149-5 Antielectrostatic fabric.
	Fabric 4	99%CO/1% of electro-conductive fibres (net arrangement of metal threads)	270(±5%)	PN-EN 531 Protection against flames and heat, PN-EN 1149-5 Antielectrostatic fabric, PN-EN 13034 Protection against liquid chemicals.
	Fabric 5	100%PAN (coppered weft threads)	279(±5%)	PN-EN 1149-5 Antielectrostatic fabric, PN-EN 13034 Protection against liquid chemicals.
	Fabric 6	93%CO/7%PAN (coppered weft threads PAN)	255(±5%)	PN-EN 1149-5 Antielectrostatic fabric, PN-EN 13034 Protection against liquid chemicals, PN-P-82008 Oleofobic finishing.
Fluorescent fabrics – materials of the warning clothing backgrounds	Fabric 7 - orange. - yellow	80%PES/20%CO	285(±4%)	PN-EN 471 Materials of warning clothing backgrounds
	Fabric 8 - orange. - yellow	100%PES knitted	137(±3%)	PN-EN 471 Materials of warning clothing backgrounds

PES fibres dyed with dispersed dyestuffs. It was noted there was a significant decrease in dyeing resistance in artificial weather in comparison with that caused by the Sun's radiation. Of the 36 dyestuffs examined, the differences noted (in degrees of blue scale) were from 1 to 3, the biggest being for knits dyed with complex dyestuffs like P-4R violet, PRL orange and P-4PBL black [7, 8].

Natural ageing is a common phenomenon, and the degradation of textiles occurs by itself. Textiles are radiated to different degrees depending on the light intensity, air climatic conditions, and the way of exposing the textile to light. As a result, photochemical reactions take place at different intensities, causing no uniform changes in the properties of the same type of fibre, nor even of the same textiles.

For textiles destined for protective clothing, it is very important that destruction processes also concern finished fabrics which effects are not visible [9]. The destruction process can cause serious and dangerous situations at many work stations due to the decreasing resistance of textiles to harmful factors (for example, chemicals, flames and heat, UV radiation, electrical conduction and so on). The examination of textiles destined for protective clothing after natural or simulated ageing processes is of great significance because it can help in the determination of the range and degree of the decrease in the protective properties of clothing used in many types of work.

In the first stage of the research, all the fabrics chosen were exposed to daylight and atmospheric factors for 1200 hours. Next the mechanical properties of all the materials were examined, and depending on their application in protective clothing, other property characteristics were also established for the given material:
- flame propagation (flame retardant materials),
- surface resistance (anti-electrostatic materials),
- parameters of the hydrophobic properties and absorption of acids and alkali (materials applied in clothing protecting against liquid chemicals).

On the basis of these measurements, an initial assessment of the range and size of the initiated ageing effects of the materials examined was made i.e. changes in physical properties that have a direct influence on the level of protective properties and changes in the colour coordinates of materials applied in warning clothing. Based on the results of the analysis and conclusions drawn from the first stage of the research, which are described below, a plan of measurements was established. It covers only those materials for which changes were identified and quantitatively determined at the level which can have a significant influence on maintaining the protective clothing after the first exposure to atmospheric conditions.

Materials

Fabrics destined for protective clothing of different raw material dyed with different dyestuffs and with different finishings were tested in many aspects, which were divided into two groups:

I – fabrics most often used on the polish market, fabrics for flameretardant clothing, clothing for welders, and clothing against chemicals and antielectrostatic. They were manufactured using cotton or cotton/PES, with some percentage of electroconductive fibres (carbon metal and coppered).

II - fluorescent woven and knitted fabrics used as the background of warning clothing [10 ÷ 12], most often made of PES and PES/CO yarns. PES knitted fabrics are often used for warning

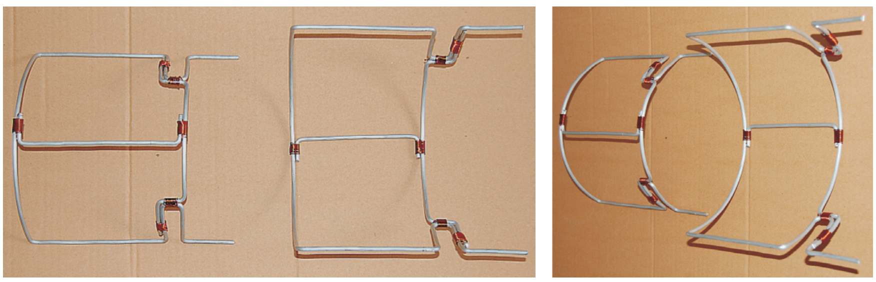

***Figure 1.** Clamps for textile specimen mounting.*

vests. Woven fabrics characterised by a higher strength and shape stability are used for the following warning clothing: overalls, jackets and trousers [14]. The characteristics of the fabrics chosen for investigation are given in ***Table 1***. All the fabrics were exposed to the Sun's radiation [13] and only some of them to ageing simulation in a Xenotest.

Scope of the research

The following tests were carried out:

- The mechanical properties of fabric 7 were established after the simulated and accelerated weathering process, i.e.
  - the tearing resistance according to PN-EN ISO 13937-2:2002,
  - the tensile resistance according to PN-EN ISO 13934-1:2002.
- The surface electric resistance of antielectrostatic fabrics was established according to PN-EN 1149-5:2008 (Fabric 5 and Fabric. 6) after the simulated and accelerated weathering process.
- Chromate coordinates and the coefficient of luminance of the fabrics after light exposure in the Xenotest were established without the artificial weather test in order to determine the influence of atmospheric conditions on the dynamics of colour change (for fluorescent fabrics).

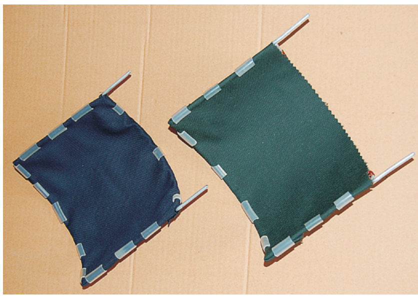

Figure 2. *Clamps with mounted textile specimens.*

Due to the fact that the standard methodology for establishing dyestuff resistance to light considers only fabric specimens of 28 × 100 mm. size, special clamps were constructed for these experiment. The new clamps, presented in ***Figure 1***, ensured a lack of contact between the samples and other surfaces (a requirement of Standard EN ISO 105-B04:1999). The new construction of clamps allow to mount specimens of 120 × 280 mm size - ***Figure 2***.

The Xenotest - type 150 S+, being part of the CIOP-PIB laboratory facility, was used for the artificial weather test. Four fabric samples underwent the artificial weather test. i.e., a repeated cycle of the following factors: rain time - 1 min., and drying time - 29 min with simultaneous light exposure. Only one side of the specimens underwent this cycle. During the rain, the samples were totally wetted in a uniform way.

Table 2. *Maximum force of the fabrics: Fabric 7 - orange and yellow – new and after the artificial weather test (the ratio of the maximum force Fz and mass per square meter g/cm2); standard deviations are given in brackets.*

Time of exposure, h	Maximum force, daN / and ratio of the breaking force, N and mass per square meter, g/m2							
	Fabric 7 orange				Fabric 7 yellow			
	- direction				- direction			
	Warp	Fz/mp	weft	Fz/mp	warp	Fz/mp	weft	Fz/mp
0	192.8 (3.79)	6.7	91.1 (2.92)	3.2	201.3 (3.87)	7.1	102.6 (3.93)	3.6
200	185.3 (3.87)	6.5	86.7 (3.98)	3.0	184.1 (3.66)	6.5	96.5 (4.11)	3.4
400	172.6 (4.21)	6.1	82.6 (4.41)	2.9	179.6 (4.05)	6.3	93.1 (3.78)	3.3
800	122.4 (3.83)	4.3	71.8 (3.26)	2.5	128.3 (4.12)	4.5	70.7 (4.17)	2.4

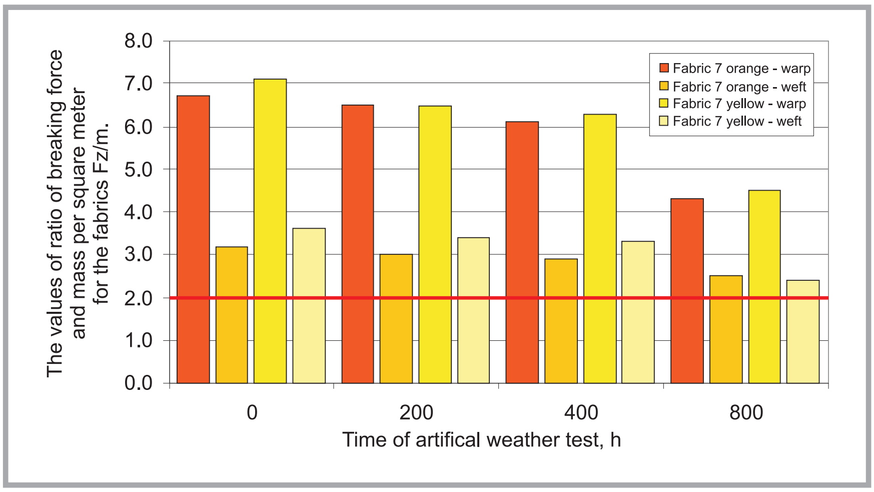

Figure. 3. *Values of the ratio of the maximum force and mass per square meter for the fabrics: Fabric 7 (orange and yellow) - new and after the simulated and accelerated weathering process.*

Results of measurements after the artificial weather test and their analysis

After the artificial weather test, the following properties were measured:

- mechanical fabric resistance (breaking force, tear resistance).
- surface fabric electric resistance.

Breaking force according to PN-EN ISO 13934-1:2002

Measurements of the new fabrics were carried out in the warp and weft directions, with five repetitions for each fabric. After the artificial weather test, measurements were performed in three cycles of exposure: 200, 400 & 800 h for three specimens in both directions (warp/weft). According to PN-EN 471+A1:2008 (p 5.5.1), the maximum force in the weft and warp directions should meet the following requirements:

- the absolute value of the ratio of the maximum force in N and mass per square meter in g/m2 should be ≥ 2 at the minimum of the maximum force - 400 N.

This is the only standard where the maximum force is combined with the mass per square meter. Such a requirement and its level are very useful for fabrics destined for protective clothing, because it reflects the minimum strength requirements for clothing, which is intensively used. ***Table 2*** and ***Figure 3*** present values of the maximum force and mass per square meter for Fabric 7 (new and after

__Table 3.__ Maximum force results of new materials and those after 1200 h of exposure to natural light; standard deviations are given in brackets.

Sample		New material		After 1200 h of exposure	
		Maximum force, daN	Ratio of maximum force and mass per square meter	Maximum force, daN	Ratio of maximum force and mass per square meter
Fabric 1 24%PES/ 75%CO/1%C	warp	118.5 (4.11)	4.83	102.3 (3.91)	4.17
	weft	50.2 (3.87)	2.04	42.2 (3.97)	1.72
Fabric 2 100% CO	warp	112.6 (4.27)	4.01	97.7 (4.09)	3.48
	weft	65.9 (4.31)	2.35	66.0 (4.12)	2.35
Fabric 3 2.5% PES/97%CO	warp	104.4 (3.91)	3.8	84.3 (4.03)	3.06
	weft	68.2 (4.07)	2.48	72.3 (3.87)	2.62
Fabric 4 99%CO/1%C	warp	132.2 (4.21)	4.90	104.0 (3.93)	3.85
	weft	52.9 (4.36)	1.96	46.8 (4.17)	1.73
Fabric 5 100% PAN	warp	128.5 (4.07)	4.60	137.5 (4.36)	4.92
	weft	89.3 (3.93)	3.23	92.9 (4.16)	3.32
Fabric 6 93%CO /7%PAN	warp	83.8 (3.97)	3.28	67.0 (4.23)	2.62
	weft	43.1 (4.16)	1.69	40.4 (3.81)	1.58
Fabric 7 yellow 80% PES/20%CO	warp	196.0 (4.23)	6.87	149.4 (4.11)	5.22
	weft	102.8 (4.31)	3.60	85.0 (3.93)	2.98
Fabric 7 orange 80% PES/20%CO	warp	193.0 (4.13)	6.77	134.8 (4.18)	4.72
	weft	91.9 (4.29)	3.22	76.9 (4.07)	2.69

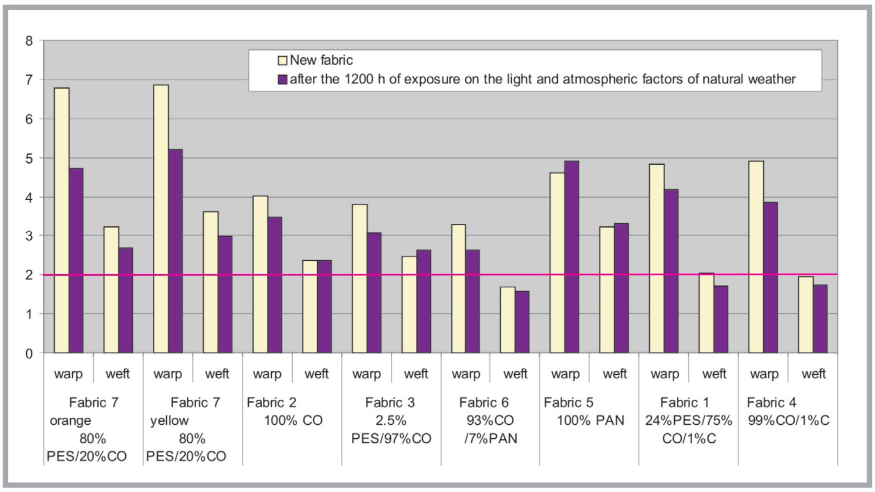

__Figure 4.__ Values of the ratio of the maximum force and mass per square meter for the new fabrics and of those after 1200 h of exposure to light and atmospheric factors of the natural weather test.

the simulated and accelerated weathering process).

In order to draw appropriate conclusions concerning ageing, ***Table 3*** and ***Figure 4*** present the strength results of all the materials after 1200 h of exposure to natural light (ratio of the maximum force and mass per square meter) to determine the minimum requirements for fabrics destined for protective clothing. This information seems to be of interest.

Based on the results presented in ***Figure 4***, we can see that the weft threads of Fabrics 4, 1, 6 & 2 measured in light, as required by PN-EN 471:2008, do not fulfill this requirement - $F_z/m_p \geq 2$ or are close to the minimum value. This is very important information because the appropriate mechanical strength of fabric destined for protective clothing is a necessary condition for ensuring its safe use.

Tear resistance according to PN-EN ISO 13937-2:2002

Ageing in natural conditions, which was carried out for 1200 h, showed big differences in mechanical parameters for fabrics 7. Therefore these fabrics (yellow and orange), destined for warning clothing, were taken into account in further tear resistance analysis after ageing. Tests of new fabrics were carried out on 5 specimens in two directions (warp and weft) for each fabric. After the artificial weather tests, measurements were carried out in 3 cycles: 200, 400, and 800 h of exposure on three specimens in both directions for each fabric. Mean values of the tear force are presented in ***Table 4*** and ***Figure 5***.

The tear resistance after the artificial weather test (200, 400 and 800 h) takes analogous values, as in ageing performed in natural conditions.

The simulation of ageing with the use of an artificial weather test was carried out for fabrics used in warning clothing - Fabric 7 – 80%PES/20%CO: yellow and orange. The results after 200, 400 and 800 h of exposure to artificial weather allow to draw the conclusion that they have an analogous character and size of changes as after exposure to natural conditions.

Surface electric resistance of anti-electrostatic fabrics according to PN-EN 1149-5:2008

Initial measurements of the surface electric resistance showed big differences for fabrics 5 and 6, which also underwent ageing lasting a further 1200 hours (total 2400 h). The surface resistance R of samples of fabrics 5 and 6 after exposure to natural conditions showed an increase above the level permitted by Standard PN-EN 1149-5:2009 ($R = 1 \times 10^{11}/10^{12}$ Ω). These fabrics also underwent the artificial weather test. Due to their structure (electro-conductive across the whole surface), measurements were performed according to PN-EN 1149-1:2008, the conditions of which are given in ***Table 5***, and the results - in ***Table 6***.

According to the requirements of Standard PN-EN 1149-5:2008 „Protective clothing – Electrostatic properties - Part 5: Material and construction requirements" - the fabric has anti-electrostatic properties if the surface resistance is $R \leq 2.5 \times 10^9$ Ω. No significant changes in anti-electrostatic properties were observed after the artificial weather test. However, a worsening of the anti-electrostatic properties was observed with an increase in the surface resistance of about 100 after 1 cycle of exposure and maintaining this value at a constant level after the remaining two cycles. Fabrics 5 and 6 meet the requirements described in Standard PN-EN 1149-5:2008.

The fabric destruction of material during ageing in natural conditions probably resulted from the complex chemi-

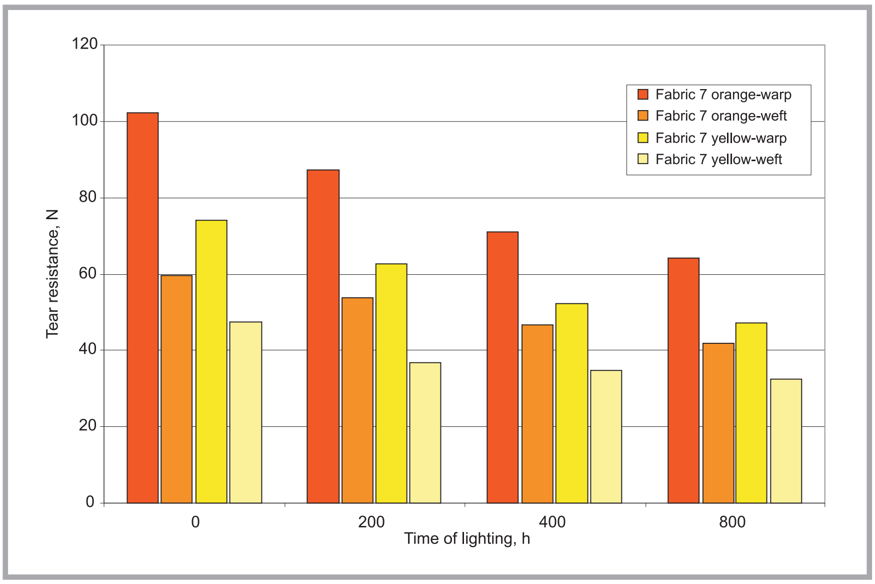

Figure 5. *Tear resistance of fabrics 7: orange and yellow – new and after simulated and accelerated weathering processes lasting 200, 400 and 800 h.*

Table 4. *Tear resistance of fabrics 7: orange and yellow – new and after simulated and accelerated weathering processes.*

Time of exposure, h	Tear force, daN			
	Fabric 7 orange - direction		Fabric 7 yellow - direction	
	warp	weft	Warp	weft
„0" new fabric	102.1	59.7	73.9	47.3
200	87.3	53.6	62.7	36.6
400	70.8	46.5	52.3	34.7
800	64.2	41.7	47.2	32.4

Table 5. *Measurement conditions of the surface resistance measurement.*

Symbol of fabric	Raw materials (conductive medium)	Time of exposure	Measurement method	Measurement conditions
Fabric 5	100% PAN (coppered weft threads)	- 100 h * - 300 h * - 500 h * */ 1 washing	PN- EN 1149-1:2008 Protective clothing – Electrostatic properties - Part 1: Method of surface resistance measurement	- air temp. 22.1 °C. - air RH 27%. - measurement voltage 10 V. - $T_{reading}$ 15 s. - for 2 specimens of each fabric
Fabric 6	93% CO / 7% PAN (coppered weft threads PAN)			

Table 6. *Results for surface resistance.*

Symbol of fabric	No of measurements/ Mean value	Surface resistance R × 10^{-6} , Ω			
		New fabric	Fabric after exposure:		
			100 h	300 h	500 h
Fabric 5	1	830	2.6	2.7	2.9
	2	15	2.3	2.7	2.9
	3	540	2.7	2.9	2.7
	4	720	2.5	2.6	2.9
	5	680	-	-	-
	$x_{śr}$	810	2.5	2.7	2.8
Fabric 6	1	350	0.4	0.8	0.9
	2	230	0.7	0.9	1.3
	3	520	0.7	0.7	1.4
	4	110	0.6	0.9	1.1
	5	410	-	-	-
	$x_{śr}$	320	0.6	0.8	1.2

cal activity of atmospheric rain and its concentration distribution on the copper covering the thread surface. Water in the Xenotest is a factor which causes much smaller changes in the way of metal corrosion (pH = 6 - 8, content of constant particles for silicium ≤ 1 ppm/cm^3) than atmospheric rain. A reaction close to neutral as well as a very low content of constant particles has a chemically insignificant influence on the material surface examined. The contamination of water arising from rain in city agglomeration conditions in the place of fabric exposure causes a pH value of about 4.3 – 5. The acidicity of atmospheric rain water can be the reason for damage to surfaces made of electro-conductive yarns covered by copper compound molecules.

Results of measurements after light exposure in the Xenotest (without the simulated and accelerated weathering process) and their analysis

Chromate coordinates and the luminance coefficient

The ageing carried out for 1200 h in natural conditions showed big differences in the colour coordinates and luminescence for fabrics 7. Therefore, these fabrics (yellow and orange), destined for warning clothing, underwent further tear resistance analysis after ageing in the Xenotest. In order to determine the changes in the optical properties (dye intensity) of the fabrics chosen, used as the background of warning clothing, photometric parameters were measured. The chromate coordinates and luminescence coefficient of fabric 7 (orange and yellow) after the artificial light test in the Xenotest were determined according to PN-EN ISO 105-B02:2006. Five specimens of each color were measured. Light exposure was carried out until the observation of changes in the chromate coordinates (outside the area determined in ***Table 2*** of PN-EN 471+A1:2008) or to the moment when the values of luminescence were lower than the minimum value permitted.

Measurements of photometric parameters were made at three points of each specimen for the following time periods: 24, 48, 96, 168, 264, 336, 408, 480 & 552 h. A reflectometer - Mini Scan XE was used for this purpose. Mean values of the above-mentioned parameters for fabrics of both colours are presented in ***Figures 6 & 7. Table 7*** presents values for the time of light exposure in the Xenotest and in natural conditions, after which the values of the photometric parameters exceed the limit allowed.

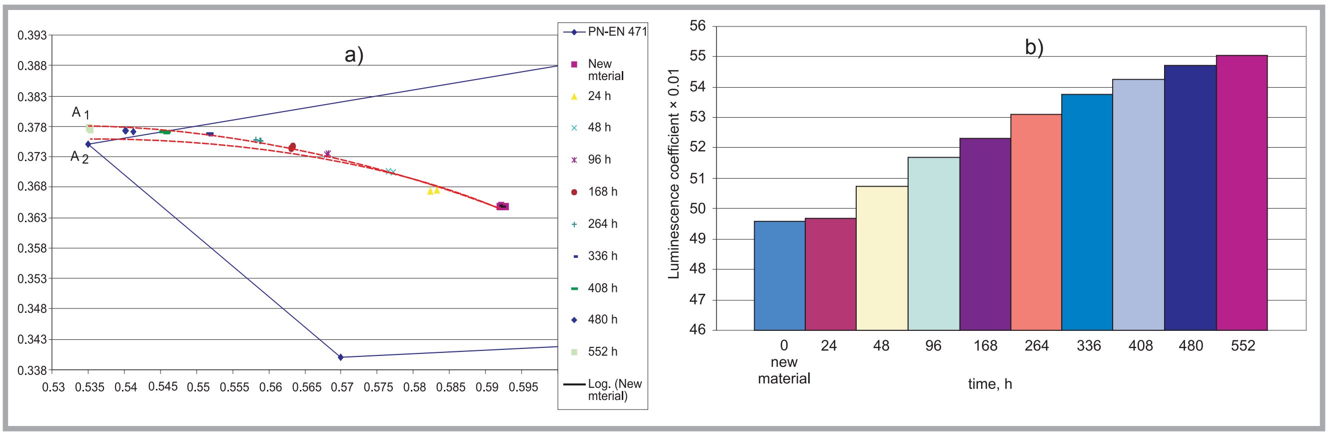

Figure 6. Values of chromate coordinates (a), and the luminescence coefficient (b) for orange Fabric 7.

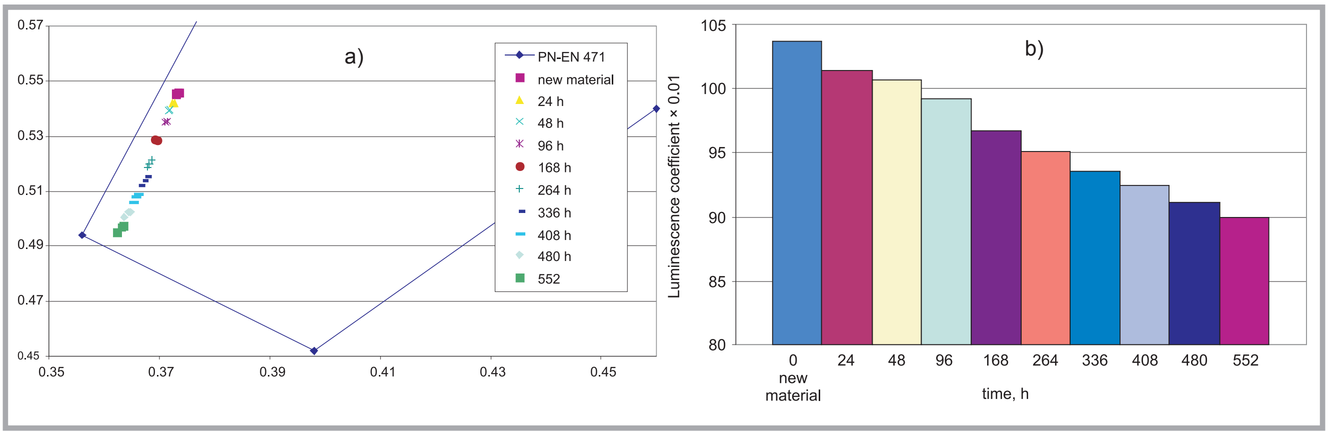

Figure 7. Values of chromate coordinates (a), and the luminescence coefficient (b) for yellow Fabric 7.

The results of measurements of the photometric parameters of fabrics destined for the background of warning clothing after light exposure in the Xenotest and in natural conditions allow to state that:

- The direction of changes in chromate coordinates for a fabric of given color is identical in the case of light exposure in natural conditions to the test of artificial weather or light exposure in the Xenotest (without rain).
- The radiation spectrum of the xenon lamp (in the total range of 310 nm to 750 nm. 90% of the filter permeability is in the range 380 - 750 nm) combined with cyclic rain causes the quality displacement of the given color to be identical in the case of solar light and atmospheric conditions (curves of trend A_2 in ***Figures 6*** and *7*).

After light exposure without rain for the same time intervals, the points of colour changes deviated on the right side of the fabric (trend curves A_1, ***Figures 6*** and *7*). The direction of changes in luminescence coefficient values during light exposure in the Xenotest for the given fabric and colour is similar to that after solar light exposure.

During light exposure without rain in the Xenotest, the angle of the trend of curve changes is characteristic for the given colour (A_1 and A_2):

- for the orange fabric - the critical time of light exposure and action of the atmospherical factors are determined by exceeding the values of chromate coordinates permitted;
- for the yellow fabric - the critical time of light exposure and action of atmospherical factors are determined by exceeding the values of the luminescence coefficient, $ß_{min,\ permitted}$;
- the yellow fabric does not fulfill the requirements of Standard PN-EN 471+A1:2008 in the range of the minimum luminescence value required after about 552 h of light exposure with rain and after about 420 h of exposure without rain;
- the chromaticity coordinates of the orange fabric exceed the area permitted by PN-EN 471+A1:2008 after about 408 h of light exposure with rain and after about 360 h without rain.

The conclusions above confirm the different dynamics of colour changes in fluorescent fabrics depending on the ageing conditions. In light exposure without rain (in natural conditions as well in the

Table 7. Border values for the time of exposure in the simulated and accelerated weathering process for fabric 7.

Fabric symbol and colour		Time of light exposure in the artificial weather test, h	Time of light exposure in the Xenotest, h
Fabric 7	orange	408 (exceeding the values of chromate coordinates permitted)	360 (exceeding the values of chromate coordinates permitted)
	yellow	552 (exceeding the values of the luminance coefficient permitted)	420 (exceeding the values of the luminance coefficient permitted)

Xenotest), for a given fabric of known finishing, the changes in photometric parameters received appear to be 17% faster in the case of orange fabric and 24% faster for yellow fabric comparing to the light exposure with the rain acting.

Conclusions

1. The tear resistance of the new fabrics after 1200 h of light exposure in natural conditions and 800 h of the artificial weather test showed a decrease in resistance varying depending on the raw material. The highest drop in the tear resistance (about 35%) was noted in the case of Fabric 7 – 80% PES/20% CO, and the lowest for cotton Fabric 2 – (100% CO) after ageing in natural conditions.

2. The results of strength parameters obtained for Fabric 7 after 200, 400 and 800 h of the artificial weather test show the analogous character and size of changes after ageing in laboratory conditions, similar to those in natural ones.

3. As shown in ***Figure 4***, the weft threads of fabrics 4, 1, 6 & 2 in sunlight do not fulfill the requirements of PN-EN 471+A1:2008 concerning the value of the ratio of the maximum force and mass per square meter (minimum $F_z/m_p \geq 2$).

4. The measurement of anti-electrostatic properties after light exposure in natural conditions did not show the significant influence of fabrics with a net arrangement of carbon conductive thread. For fabrics with a content of coppered thread, an increase in the surface resistance value, R_p, of up to $10^{11}/10^{12}$ Ω was noted (above the value admitted for this parameter according to PN-EN 1149-5:2008). After the laboratory ageing of the fabrics, changes in the electrostatic properties of this type of fabric were not observed. The destruction of material during ageing in natural conditions probably resulted from the complex chemical activity of atmospheric rain as well as from the concentration distribution of the copper on the surface of the thread.

5. It was noted that the different dynamics of colour changes (photometric parameters) in fluorescent fabrics destined for warning clothing depended on the ageing conditions (in laboratory conditions with rain and without, as well as in natural ones), the raw material of fabric and the kind of finishing. The conditions of the ageing simulation of PES fabrics should take into consideration, namely the energy aspect of radiation and associated humidity changes, which is important from the point of view of colour and mechanical properties.

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