Technical requirements for the materials from which clothes for firefighters are made. Types of tests

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Abstract: *The report examined the technical requirements for materials from which firefighters' clothing is made and the types of testing of the materials from which the specialized protective equipment for the protection of firefighters, for neutralizing and eliminating threats and their follow-up to incidents at critical infrastructure sites are made.*

Keywords: *CRITICAL INFRASTRUCTURE SITES, FIREFIGHTERS' REMEDIES*

1. Introduction

The modern development of technology predetermines the use of heterogeneous substances and materials in the production of clothing for firefighters.. Many of them, according to their physico-chemical properties, are combustible, explosive and toxic. The requirements for specialized protective equipment for the protection of firefighters involved in accidents and their neutralization of their consequences are determined by the physico-chemical properties of the material from which they are made. The purposes of the garments are to protect the body of the firefighter to the maximum extent possible, to have minimal movement restrictions and to be of minimal weight.

Although there are no universal protections to protect, the research is aimed at universalising them in terms of activities in which to use them. Modern protective garments are designed and made, identifying the areas of application. . [1,2,3,4,5,6]

Clothes for firefighters are made of multi-layer fabrics or one-layer fabrics. In the first option, where they are multi-layered, the surface layer is in direct contact with the environment in which it is used and therefore has the greatest requirements, such as:

- be in combustible;
- be antistatic;
- do not leak water and air/gases;
- be dielectric;
- to resistant to chemicals;
- be mechanically durable and not change its characteristics over time.
- have a minimum weight;

2. Technical requirements for materials for surface layer textiles from which garments for firefighters are made

Protective clothing for firefighters is a specialized personal protective equipment, providing protection of the torso, neck, hands and feet of the firefighter. [7]

The type of clothing of the firefighter is determined depending on the specific incident in which it will be worn. For this, the top layer of clothing must have technical parameters that must protect the remaining layers of clothing and body from the harmful environment.

In all cases of use, two are the main characteristics that are basic and mandatory, in the case of different types of clothing for firefighters, respectively, and to the surface layer of clothing: to be non-combustible (its combustion behavior) and to be mechanically durable (to withstand mechanical wear and not to change its characteristics).

2.1 Surface layer of textile combustion behaviour

To determine the heat and behaviour of the fiery impact of the surface layer of textiles and, where appropriate, to be tested.

The purpose is to determine the moment of ignition by means of tests, the samples being placed vertically, due to their faster ignition and spread of combustion.

Using a test, the properties of textile fabrics in contact with fire shall be assessed, to what extent they are retained and for how long [8,9].

The test shall be carried out at a defined minimum ignition time and a well-formed flame from a burner which can be adjusted in the range of 10 mm to 60 mm. For combustion, liquefied gas or butane/propane mixtures are used in the burner.

The working position of the burner shall be at the front, below the test specimen, so that it is in a plane through the vertical centreline of the specimen and perpendicular to its own surface with its longitudinal axis inclined below 30o towards the vertical lower edge of the test specimen. The distance between the tip of the burner stabilizer and the lower end of the test image is required to be 20 mm ±1 mm.

Adjust the flame after ignition and heat for two minutes. The height of the flame shall be 40 mm ± 2 mm and the measurement shall be from the top of the burner stabilizer to the extreme point of the yellow part of the flame, looking against a dark background. The height of the flame shall be tested before the samples are tested.

To measure the combustion time, a relay device is used to control and measure the flame application time with the possibility of adjusting 1 second with an accuracy of 0,2 seconds. In order to measure the time after ignition, three relays with readings up to 0,2 seconds are required.

A device starts automatically at the moment the flame is sharpened or stopped, stopping manually.

Figure 1 - Apparatus for conducting tissue combustibility tests

The apparatus for conducting the combustibility test of tissues is shown in Fig.1. It consists of a performance reporting computer, a textile sample frame, a burner, ignition time reporting relays and burner reading markers in the vertical. The listed deer are placed in an isolated environment after their preliminary conditioning and tempering.

For textile testing, 12 samples/samples are taken.

The samples are tested in a vertical direction, with the outer layer directed to the flame source.

The samples shall be the dimensions (200 mm ± 2 mm) x (80 mm ±2 mm) which are tempered in advance at a temperature of 20 ^{0}C ± 2 ^{0}C and a humidity of 65 % ±5 % for 24 hours. If testing is

not carried out immediately after conditioning, the samples shall be placed in a sealed container and testing must be initiated within 2 minutes of being removed from the conditioning atmosphere.

Test procedures:

– if a specimen ignites within 1 second, cary not burning '0' is recorded and the test is repeated by 1 second in the duration of application of the flame;

-if there is no ignition within 20 seconds, repeat the test again with 20 seconds of ignition time. Testing continues until 5 examples of combustion and 5 examples of non-combustion appear.

The maximum time of application of the flame is 20 seconds.

The samples shall be tested by ignition and at the lower end.

The results obtained from the test from all the ignition and ineeding times recorded shall be calculated the average time at which the specimen is ignited. The purpose of these tests is to determine the average combustion time of the test specimen, which is the minimum flame application time, in order to reproduce continuous combustion under certain test conditions calculated to the nearest second. (An example of an average time of 4.2 seconds is taken from all circumcised time of 4.2 seconds).

The average time is the limit between burning and burning the specimen. Both types of behavior can be observed by tiping the pattern the flame is applied just as long as the average time. Testing of non-combustible materials is not appropriate, as is the use of materials that have only limited combustion. The results obtained are in the column "un ignited at 20 seconds application of flame- "lightness of ignition".

After determining the mean ignition time, another important indicator is the 'flame propagation time' – the time it takes for the flame on the burning material to travel a certain distance under certain test conditions [10]. Three devices (relays) are used to read the time. Relays reading to within 0.2 seconds. Measure the flame propagation times, starting the devices simultaneously when applying a flame and stopping automatically when the individual marker threads are damaged/destroyed.

The method is designed to test flammable materials that support the flame when ignited. In this type of material, this method is accurate to the nearest second.

The precision of the results depends to a large extent on the type of material to be tested. When testing system materials, ignition and combustion of the specimen shall be reported.

The procedures described with regard to the determination of the average ignition time and the time of spread of the flame are used in tests of textile fabrics for clothing, a procedure for determining combustion behaviour [11,12,13].

Tests of samples have been carried out in an accredited test laboratory - "TEX CONTROL" Ltd- Bulgaria, Gabrovo.

The apparatus on which the tests were carried out in the accredited laboratory is SHIRLEY FLAMMABILITY TESTER mode; M233B - Fig. 1. The results of the tests carried out on five samples of different materials with different technical characteristics are shown in Table No1 and Fig. 2.

Table № 1

Type of material	Mass per unit area [g/m^2]	Mean ignition time of vertical-female samples [s]	Quantitative analysis	Weave
META ARAMID FLAME- PRO, after anticomar apreture and after sanfor	251,98	0/0/0	49/49 /(2 -4) viscose/aramid/antistatic	keper
KORDURA 5 color print with non-combustible smear, TL 8305-0278/from TMN - Austria/	249	>20		keper
REGATTA,T.P.304, after sanfor	330	0,4	100% cotton	satin
FRESCO after softening and sanfor	163	0/0/0	((49/49 /(2 -m4)± 2 viscose/aramid/antistatic	
SAMPLE	261	0/0/0	93% Nomex, 5% Kevlar, 2% antistatic	

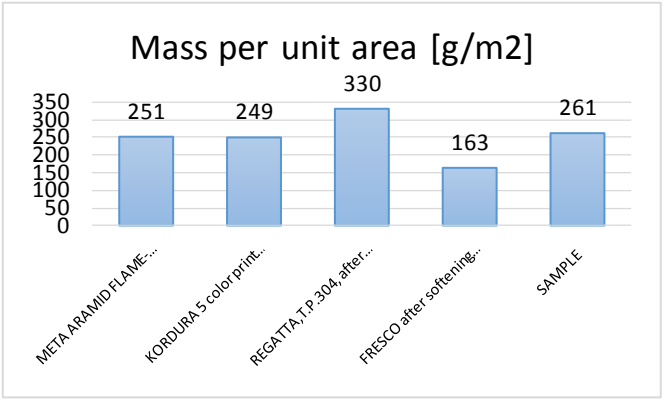

Fig.2 Mass of test samples

Table №2

Type of material	Flame propagation time of vertically located samples when igniting: ground -in length (first, second and third marker threads) [s]		Weave
META ARAMID FLAME-PRO, after anticomar apreture and after sanfor	first marker thread:0 second marker thread:0 third marker thread:0		keper
KORDURA 5 color print with non-combustible smear, TL 8305-0278/from TMN - Austria/	first marker thread:0 second marker thread:0 third marker thread:0		keper
REGATTA,T.P.304, after sanfor	first marker thread:0 second marker thread:0 third marker thread:0		satin
FRESCO after softening and sanfor	at 5 s burning:≤1 smoldering:≤5	at 15 s burning:≤0 smoldering:≤5	
SAMPLE	at 5 s burning:≤4 smoldering:≤5	at 15 s burning:≤0 smoldering:≤5	

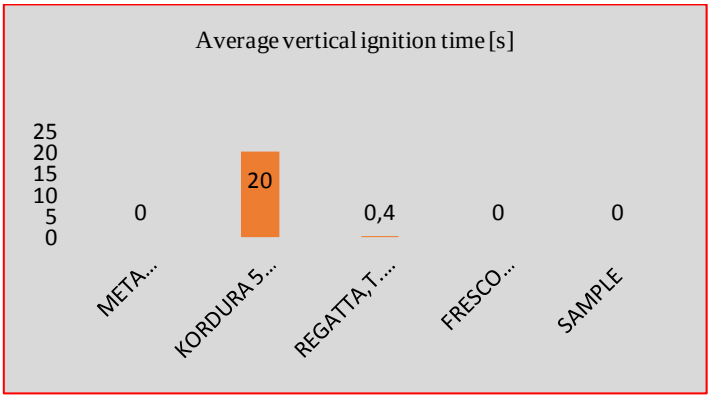

Fig. 3 Average ignition time of samples

2.2. Determination of the rupture of the surface layer.

To determine the strength of the raking, the surface layer of textiles shall be tested. No change in size should be observed after testing, use and cleaning of the material for a surface layer for protective clothing.

Permissible changes of a surface layer shall not exceed ±3 % for fabrics and ±5 % for knitted material and non-woven fabrics.

The method by which the study is carried out [14] - STRIP refers to the determination of the maximum breaking force of fabrics when the force is located on the tested pattern of textiles, both on the basis and in wee. The method is not applicable to fabrics of elastic fabrics, geotextiles, non-woven fabrics, coated fabrics, woven fabrics of glass fiber and carbon fiber fabrics.

In tests, a constant rate of extension machine is used. The tensile test machine shall be fitted with one gripping jaw which is stationary and another which is moving at constant speed during the test.

Tests of samples have been carried out in an accredited test laboratory - "TEX CONTROL" Ltd - Bulgaria. Gabrovo.

The apparatus for which the tests were carried out in an accredited laboratory is Zweigle F 427, shown in Fig.№ 4,

Fig. 4 tensile testing equipment

The results of the tests carried out on five samples of different materials have different technical characteristics are shown in Table № 3

Таблица №3

Type of material	Power of rationing basis [N]		Power of rationing Weft [N]		Quantitative analysis
	test	norm	test	norm	
META ARAMID FLAME- PRO, after anticomar apreture and after sanfor	31,9	35	35,2	35	49/49 /(2 -4) viscose/aramid/ antistatic
KORDURA 5 color print with non-combustible smear, TL 8305-0278/from TMN - Austria/	273,3		252,3		
REGATTA,T.P.304, after sanfor	116,8	110	82,8	80	100% cotton
FRESCO after softening and sanfor	27,9	12	25,2	23	(49/49 /(2 -m4)± 2 viscose/aramid/ antistatic
SAMPLE					93% Nomex, 5% Kevlar, 2% antistatic

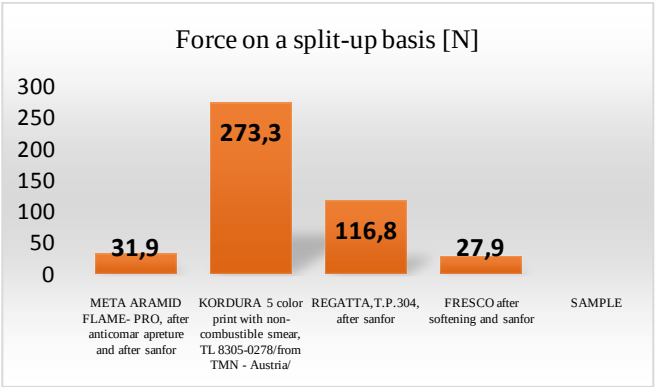

Fig.4 Sampling force

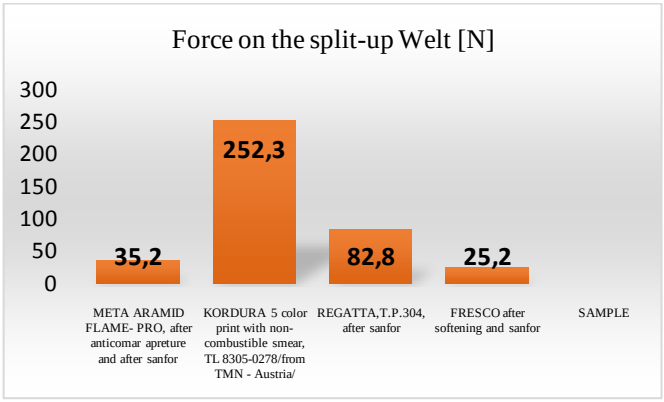

Fig.5 Sampling strength

When testing the external material after pre-treatment, its base and weath strands must withstand a rupture force of ≥ 30 N to meet the requirements for use in clothing for firefighters. [1]

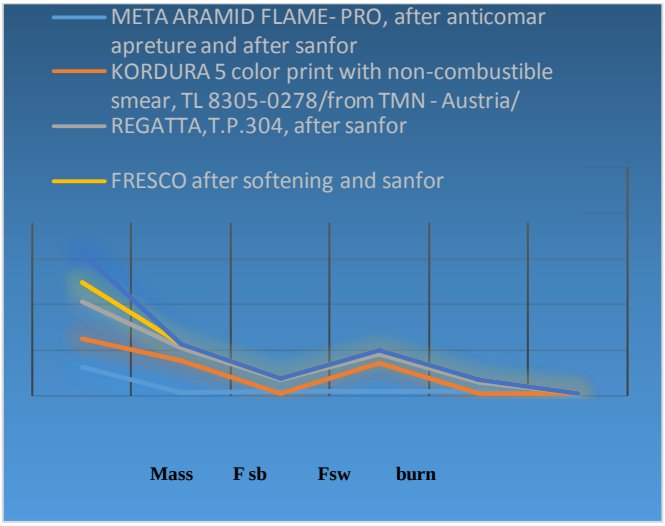

Fig.6 The comparative results of the test specimens are

From the results obtained described in table No 2, with average test data of five counts, the following conclusions may be drawn:

-Further treated textiles in order to improve its fire resistance to fire, greater resistance to fire and non-flammability is established by not igniting for 20 seconds:

-With the additional treatment, sample screed № 2 (Cordura 5) has a mass of a single area of 249 g/m^2, is almost as raw samples of material № 1 (meta aramid) with a mass of 251 g/m2 (Fig. 2)

- Samples of synthetic composition are ignited immediately while organic materials are recorded at a time of 0,4 s (Fig. 3)

- Some synthetic materials have higher indicators of mechanical resistance than organic materials.

- the type of material has importance - its chemical composition, the goal is to achieve a combustion-resistant textile, non-growing combustion with a low heat transfer coefficient and a reduced mass of edenic area;

-The type of textile braid in the tested robes is relevant, the results show that the tper weave is more resistant to flame spread than an satin braid.

- It is apparent from the tested samples that melt-resistant textiles are made of natural materials, but are more unstable to spread fire than synthetic products with additional processing smear.

- Cordura-branded sample tested sample has the highest performance in terms of base and weaning strength, which shows its mechanized durability and strength.

3. Conclusions

Following the tests carried out on five samples of textiles of different types, the following conclusion may be drawn:

- there is a tendency to achieve material that can withstand a longer fire time and temporarily reduce the mass of a single area.

Depending on the material, a type of textile design for a surface layer is more appropriate to use only in certain activities, examining combinations of new materials in a different weave and further processing until the goal of making a fabric resistant to a wide range of harmfulness, with minimal weight and without creating movement restrictions, with a sufficient degree of mechanical durability.

The results are aimed at the implementation of Work Package 2 "Intelligent Security Systems" of project BG05M2OP001-1.002-0006 "Construction and development of the Competence Center "Quantum Communication, Intelligent Security Systems and Risk Management (Quasar)", which has received funding from the European Regional Development Fund through the Operational Program "Science and Education for Smart Growth" 2014-2020.

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14. Number of threads per unit length - base - weak - BDS END 1049-2:2002, method A .