CORELLATION REQUIREMENTS – FUNCTIONS – QUALITY CHARACTERISTICS FOR FIREFIGHTER SUITS

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REZUMAT. Costumul destinat pompierilor face parte din grupa echipamentelor de protecţie utilizate împotriva temperaturilor extreme. Având ca punct de plecare principalele cerinţe solicitate pentru aceste tipuri de echipamente (asigurarea temperaturii constante a organismului, asigurarea confortului şi a ergonomiei, păstrarea dispoziţiei şi a capacităţii de muncă, asigurarea disponibilităţii şi conservarea mediului), lucrarea prezintă funcţiile cu caracter prioritar, precum şi caracteristici de calitate reprezentative. Acestea pot influenţa semnificativ, modul în care echipamentele de protecţie pentru pompieri protejează viaţa utilizatorilor, permiţând în acelaşi timp conservarea mediului înconjurător.

Cuvinte cheie: pompieri, echipament, protecţie, cerinţe, caracteristici, calitate.

ABSTRACT. A fire fighter's suit is part of the group of protective equipment used against extreme temperatures. Starting from the main proprieties required for these types of equipment (ensuring a constant temperature of the body, ensuring comfort and ergonomics, maintaining the disposition and ability to work, ensuring the availability and preservation of the environment), the paper presents their primary functions, as well as representative quality features. These can significantly influence the way in which a fire-repellent equipment protects users' lives, while at the same time preserving the environment.

Keywords: firefighters, equipment, protection, requirements, characteristics, quality.

1. GENERAL CONSIDERATIONS

In the current stage, it has been noticed the development and extension of high-performance technical textiles with multifunctional destinations, those with special properties and products that "feel" and react to external stimuli of a mechanical, thermal, chemical or magnetic nature.

The differences between traditional textiles and those intended for technical use can be determined from the following points of view [1, 2, 3, 4, 5]:

- **Destination** - Technical textiles are used in industries or fields other than those specific to the textile industry;
- **Materials used in the production of technical textiles** - must have properties capable of ensuring the product performance under special stress conditions, specific to different fields;
- **The manufacturing process** - demands adapting the existing equipment or creating new machines, as well using new flexible and versatile technologies;
- **Testing the technical materials before their use** - involves computer simulations of the behaviour of the technical products in order to predict their performances and guarantee their optimal functioning;
- **Production costs** - the restrictions imposed by the raw material, manufacturing process, and beneficiaries' requirements of these technical textiles lead to a high production cost. However, this cost must be weighed against the benefits of these textile products, their long service life, as well as the significant reduction in maintenance and repair costs.

The textiles manufactured for their technical performance and their functional properties, meet the high technical – qualitative requirements (mechanical, thermal, electrical, durability, etc.) and can be adapted to a variety of purposes. According to Techtextil there are 12 different fields of activity of technical textiles (figure 1) [1].

2. PROTECH TYPE TECHNICAL TEXTILES AIMED FOR FIREFIGHTERS

Protech-type technical textiles are used in order to improve safety in workplaces, reducing the action

of risk factors that may be thermal, chemical, biological, mechanical, physical or electrical in nature. These factors have direct influence on both the health status and life of the person carrying out a certain type of activity [1, 6, 7, 8].

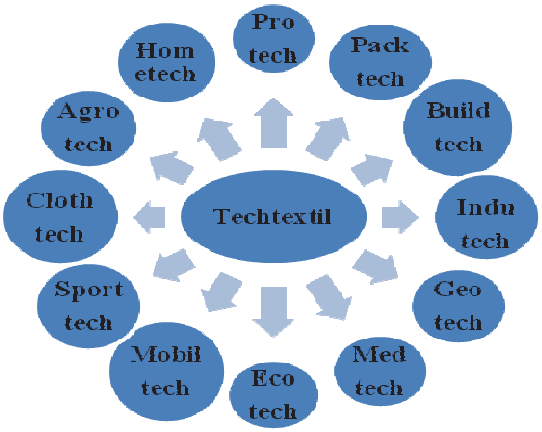

Fig. 1 Technical textiles applications

Protection of those carrying out certain activities in risky conditions can be done by using, depending on the case, the following protective equipment: clothing, footwear, gloves, helmets, glasses, visors, etc. The fire fighter suit is part of the group of **protective equipment used against extreme temperatures.** In the case of high temperatures, or the risk of ignition (fire, incandescent drops, sparks), the protective equipment is of a multilayer type, having a triple set construction:

- **The outer layer** constitutes a barrier against fire (being resistant, impermeable and non-flammable) – it is manufactured using fabric obtained from thermo-stable aramid yarns, such as NOMEX or KEVLAR;
- **The intermediate layer** represents a **barrier against caloric radiation**, as well as **moisture** (water or chemical agents used in extinguishing fire) – generally made out of FR non-woven materials coated with thermally resistant polyurethane membranes [8, 9, 10];
- **The inner layer** provides thermal protection (linings with high thermal insulation capacity).

Fire-fighter equipment provides protection for:

- **Head and respiratory tract** (protect the body from UV radiation, infrared, sparks, inhalation of harmful substances, smoke, toxic gases, vapours) - examples: glasses, visors, headphones (figure 2);
- **Trunk and upper limbs** (protection against direct contact with substances, materials, hot liquids, as well as anti-slipping, falling) - examples: clothing, gloves (figures 3);
- **Lower body and limbs** (protection against direct contact with substances, materials, hot liquids, as well as against slipping, falling) - examples: clothing, footwear (figure 4).

Fig. 2 Equipment for head protection

Fig. 3 Protective equipment for the trunk and upper limbs

Fig. 4 Protective equipment for lower body and limbs

Fig. 5 Equipment for full protection

Fig. 6 Aluminized fire resistant suits

3. CORELLATION REQUIREMENTS – FUNCTIONS – QUALITY CHARACTERISTICS

Any endeavour in quality approach is based on the correlation between the requirements of the beneficiaries, the functions and the quality characteristics of the products [3]. The design and manufacture of protective products and equipment demands compliance with some **basic requirements**:

- ✓ **Ensuring constant body temperature** (avoiding hypothermia or hyperthermia). For this purpose, fire protection equipment consists of several layers that are resistant, impermeable and non-flammable.
- ✓ **Ensuring comfort and ergonomics**;
- ✓ **Maintaining the disposition and work capacity** (by avoiding states of stress and fatigue generated by the intense physical, mental and physiological demands);
- ✓ **Ensuring availability** (**durability and maintainability** must be in line with the extreme operating conditions);
- ✓ **Conservation of the users' health, but also of the environment.**

The interface between the users' requirements and quality characteristics is made up by the set of functions that a product has to perform (protection, constructive – ergonomic, comfort, availability, technological, ecological, knowledge, aesthetic and economic). The importance degree of these functions in quality assurance differs from one type of product to another, being determined by their end-use requirements. In regards to fire fighter suits, the primary functions are: protection (correlated with the constructive – ergonomic one), comfort, availability and ecological functions. The quality characteristics represent the levers through which the production process can be manipulated, in order to ensure the manufacture of high quality products that best meet the requirements demanded by the beneficiaries [3].

For fire fighting protection equipment, the main quality characteristics are presented in table 1.

Table 1 **Quality characteristics of fire-fighter equipment**

No.	Function	Main quality characteristics
1.	**Protection function**	Degree of body coverage; Finishing treatments applied (fireproofing, waterproofing); Ignition resistance; Flame propagation time; Burning time; Capacity of absorption and humidity transfer;
2.	**Constructive-ergonomic function**	Fibrous composition of the raw and auxiliary materials; Structure and structural parameters of the materials (thickness, compactness); Product structure (blueprint, piece components); Product dimension and admitted tolerance intervals; Type of access zones for the product (slits); Fastening system used (zippers, buttons, press buttons); Product extensibility in the access zones; Opening resistance of the access zones; Dressing – undressing time;
3.	**Comfort function**	Touch; Bulkiness; Flexibility Electrostatic charging capacity; Rigidity Hydrophilia and hydrophobia; Permeability to water, vapours, air; Airflow resistance; Thermic resistance; Thermic conductivity; Thermal insulation capacity;
4.	**Availability function (durability, maintenance)**	Breaking elongation and resistance; Resistance to tearing, piercing, hooking; Resistance to dynamic demands; Resistance to cyclical demands (resistance to aging); Friction resistance and piling forming capacity; Special treatment resistance (coating, waterproofing); Average number of defects; Dimensional stability to finishing operations; Dyeing resistance; Wrinkling capacity; Soil-resistance; Reconditioning capacity;

No.	Function	Main quality characteristics
		Ease of cleaning; Average remediation time; Remediation cost.
5.	**Ecologic function**	Product content of harmful substances; Flammability, ignition resistance; Resistance to biological factors; Decontamination capacity; Resistance to radioactive contamination; Biodegradability;
6.	**Technological function**	Processing capacity; Shaping capacity; Elasticity and extensibility; Assembly accuracy; Accuracy of the technological processing;
7.	**„Cognitive" function (informational)**	Identification data for the manufacturing or commercial company; Manufacturing/ commercial company brand; Product size; Fibrous composition; Parameters of the maintenance operations;
8.	**Ergonomic function**	Selling rate; Efficiency index;
9.	**Aesthetic function**	Degree of surface uniformity; Tightness degree; Tailoring line; Chromatic combination;

5. CONCLUSIONS

Protech – type technical textiles are used to improve safety in workplaces, reducing the action of risk factors whether they are thermal, chemical, biological, mechanical, physical or electrical in nature. These factors have direct influence on the health status and life of the person carrying out a certain type of activity.

The fire – fighter's suit is part of the group of protective requipment used against extreme temperatures (prevention against hypothermia or hyperthermia). The correlation between requirements – functions – quality characteristics (for any product group) is a tool that highlights representative requests (needs) for a particular type of product, the functions to which it must respond and the most important quality characteristics, as the levers through which the manufacturing process is directed, in order to obtain products of a high qualitative level. The paper presents systematically the main requirements expressed by the beneficiaries of protection equipment against extreme temperatures, the functions and the quality characteristics that significantly influence an efficient protection of both the user's life and the environment

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