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TESTING OF FIREFIGHTER'S PROTECTIVE CLOTHING AND ITS SIGNIFICANCE IN TERMS OF RESPONSE TO DANGEROUS SUBSTANCE LEAKAGE IN ROAD TRANSPORT

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Abstract:

With the increasing number of traffic accidents, it is necessary for the responding members of the Fire and Rescue Service to have the most modern equipment, which can significantly speed up and facilitate the course of the intervention. Thanks to the constant development of new, more modern technologies by manufacturers, every year they manage to speed up the course of the intervention and also improve the comfort of using the tool. All responding firefighters must use designated personal protective equipment when responding to a traffic accident. Personal protective equipment is a means intended for use by individuals to protect against one or more hygiene, health and safety risks. Emergency suits are an integral part of the equipment of every emergency firefighter. The firefighter's body is thus protected from weather influences, mechanical dirt and especially from the fire itself. There are situations when an anti-chemical suit is needed for an intervention, but there you have to be careful about the time risk, as well as the way back and decontamination, because here the movement of the interventionist is limited.

Key words:

Protective clothing, a member of the fire and rescue service, risks, testing of protective clothing, traffic accident

1 INTRODUCTION

In the event of a traffic accident, in which a flammable liquid or liquefied gas leaks from the transport tank and its subsequent ignition, the intensity of its burning depends on the conditions of heat exchange between the flame and the surface of the liquid. The shell of the tank, as well as the exchange of heat inside the liquid, when there is a threat to firefighters in

the form of the FIRE JET effect and burning with intense radiant heat. Personal protective equipment designed to protect the respiratory tract and the surface of the body must therefore be used during interventions. Liquidation of such extraordinary events must be solved perpendicularly to the tanks from the direction of the wind and focus on the place of leakage or damage to the shell, pipe, or valve system.

In order to ensure the protection of the intervening members, it is necessary in particular:

- monitor the ground weather situation in the place of intervention, i.e. j. ensure measurement, direction and surface wind speed,
- monitor the concentration of vapors and gases of toxic substances, irritants and corrosive substances in the air,
- monitor the size and direction of contamination of the space with combustion products in the event of a fire in transported goods,
- use personal protective work equipment, especially for protection against radiant heat, chemical substances or biological materials,
- if the situation requires it, the presence of a specialist must be ensured in the intervention area, who will provide the commander with the necessary information on how to deal with the leaking substance or how to handle the damaged tank in order to avoid injury to the personnel involved (the so-called II. DINS level),
- ensure the presence of a special firefighting unit in the area of the intervention, performing the liquidation of chemical accidents (the so-called III. level DINS), if the situation requires it. (<https://elearnhazz-sk.webnode.sk/subory-na-stiahnutie/metodicke-listy/>)

In case of leakage of a flammable liquid or liquefied gas from a transport tank and its subsequent ignition, the intensity of its burning, depending on the conditions of heat exchange between the flame, the surface of the liquid and the surface of the tank shell, as well as the heat exchange inside the liquid, has an effect on the emergence of a threat to firefighters in the form FIRE JET effect and burns with intense radiant heat. Personal protective equipment (PPE) is any device or means intended for use by an individual to protect against one or more hygienic, health and safety risks (Vojta, Rucký, 2006). The purpose of PPE when working in a contaminated environment is to protect or isolate the user from risks in a contaminated environment (Szmytke, Brzezińska, Machnowski, Szymon, 2022). HAZZ personnel should be trained in the use, care and maintenance of protective clothing and should also be familiar with their limitations and the need to remove them as soon as possible after an intervention. Protective clothing for firefighters is one of the most important pieces of equipment to protect the personal safety of firefighters who work in the first firefighting line, against heat and fire. (<https://www.laboratuar.com/sk/testler/koruyucu-giysi-testleri/en-469-yangina-karsi-koruyucu-giyecekler-icin-test-standardi/>). Despite the different methods of wearing, all protective clothing used in firefighting must achieve properties such as a closure system, heat resistance, flame retardancy, tensile strength and resistance to the penetration of liquid chemicals. The main requirements for the performance of protective clothing for firefighting are flame spread, heat resistance, tensile strength, moisture barrier, resistance to penetration of liquid chemicals, visible material, metal accessories and e.g. closing system.

No less important is the maintenance and cleaning - microemulsion decontamination technology for the maintenance of firefighter emergency clothing. It is a unique technology for professional cleaning and treatment of firefighter emergency clothing, textile equipment, as well as underwear, gloves, shoes, emergency hood and functional clothing, material equipment, etc. The principle is that it is possible to clean a wide range of extreme pollution,

which until now has been ineffective with conventional cleaning agents. The detergents intended for washing are suitable for professional freely adjustable washing machines, but also for classic washing machines intended for the home. For example, when exposed to flames, protective clothing must limit the spread of the flame, otherwise firefighters risk burns. According to EN ISO 469, all materials used to extinguish fires in protective clothing should not melt, ignite or collapse by more than 5 percent and all parts such as zippers should remain functional even when exposed to 180 degrees. In addition, the materials should have a maximum breaking strength of more than 450 N and the main seams of more than 225 N. The dimensional change of woven materials should not be more than 3 percent, and the size change of non-woven materials should not be more than 5 percent. However, according to this European standard, head and leg protective clothing can only provide sufficient protection when used together with basic PPE as specified in the relevant standards. The EN ISO 469 standard specifies reflective protective clothing that provides a higher level of protection against radiant heat compared to clothing without a reflective layer. This reflective garment can be used in certain special firefighting techniques. However, protective clothing according to the EN ISO 469 standard can also be used for various special extinguishing techniques. The type of protective clothing used must correspond to the relevant firefighting tactics. A risk assessment must be carried out to decide whether the garment specified by this European Standard is suitable for the intended purpose under the expected exposure. Specified laboratory - EUROLAB provides testing and compliance services within the EN ISO 469 standard. This standard specifies the minimum functional requirements for protective clothing intended to be worn during firefighting activities. It includes the overall design of the garment, the minimum performance levels of the material used, the test methods to be used to determine these performance levels, labeling and information provided by the manufacturer. Protective clothing for firefighters is one of the most important pieces of equipment to protect the personal safety of firefighters who work in the first firefighting line, against heat and fire. The aim of the post is to point out the importance of testing emergency clothing in the polygon, specifically - knowledge from testing the FireHorse emergency clothing from VOCHOC.

2 METHODS AND METHODOLOGY

When fighting a fire, firefighters must protect their bodies from flames and extreme temperatures. With the development of fire-causing agents, including chemicals, emergency suit fabrics have been gradually innovated to improve the physical barrier between the fire and emergency units. The most frequently used substances in the production of emergency suits are meta-aramid, para-aramid and Kevlar.

There are 2 types of emergency suits:

Light emergency suits - are single-layer emergency clothing designed to protect the body of firefighters when fighting fires in open terrain and during accompanying activities. We recommend that you also wear non-flammable underwear under those suits, which will guarantee additional protection against radiant heat.

Heavy emergency suits - are multi-layered emergency clothing intended for extinguishing fires in the interiors of buildings and also for fighting fires in the open space. They comply with EN ISO 469 standards in protection level 2, which is the maximum protection level (Xf2, Xr2, Y2, Z2). The layers of a heavy duty suit are as follows: top layer, moisture barrier and heat barrier.

The best impact suits in terms of quality and price:

OPTIMUS heavy hit set - with photoluminescent tapes. Visibility in complete darkness from a distance of up to 200 m. PATRIOT ELITE heavy hit suit - the most popular

heavy hit suit of DHZO hit units in Slovakia. Heavy duty ADRIAN set - high protection and many functional elements at a favorable price. New generation membrane. Protection against blood-forming pathogens, viruses, bacteria and HIV. This is illustrated in Fig. 1.



Fig. 1 RED FOX FIT Blue/Red Heavy Duty Suit (left), STEFAN II heavy hit suit (right)

2.1 Firehorse impact clothing - "fire" test

FireHorse emergency clothing from VOCHOC was tested in the Czech Republic. They tested at the Zbirožský polygon. Good PRO FR3 FireHorse - is a professional three-layer emergency clothing for firefighters designed for interventions and extinguishing fires in difficult conditions, especially in closed spaces. This is illustrated in Fig. 2.

Example of a figure:



Fig. 2 Polygon in Zbiroh

The training ground in Zbiroh is a relatively unique training ground that serves not only professional, but also volunteer firefighters in the future. The training equipment includes a flashover container for solid and gaseous fuels, simulations of an intervention in an underground garage. In the outdoor area, firefighters can then practice extinguishing the gas tank, product pipeline, bulk material tank and hydrogen management. Firefighters from the Pilsen region are testing this suit for a long time. The advantage was that, based on the

requirements of the firefighters and their comments, the suit was modified several times by the manufacturer. During the production and conception of the Fire Horse suit, it focuses on the places of increased mechanical stress or heat, i.e. on the shoulders, thighs, back and hands. The firefighter said that he feels very good about the suit after about four months of use. He felt safe in the polygon. The suit feels and is a few grams heavier than the competition, but still does not hinder movement. (<https://www.rednod.sk/viacvrstvove-zasahove-obleky/zasahovy-oblek-firehorse-fr3/>). This is illustrated in Fig. 3,4.



Fig. 3 FireHorse FR3 Response Suit material specifications



Fig. 4 Firehorse emergency clothing test (Six months of independent testing directly by firefighters)

3 RESULTS

The intervention suit was tested in the Zbiroh fire range. The suit was also tested independently by several firefighters throughout the Czech Republic. It was tested by firefighters in Olomouc, Brno, Karlovy Vary, Hradec Králové, Kladno, Prague and Pilsen.

3.1 Testing of emergency suit by firefighters

Ostrava is currently testing clothing. The firefighters of the HZS Pilsen region were the first to get to know the FireHorse suit. The company VOCHOC sewed a sample of 6 sets for the instructors of the training ground. Later, 13 more suits were delivered. Today, all instructors who work in the polygon have an FR3. Thus, the continuous development of this intervention suit is ensured. This is illustrated in Fig. 5.



Fig. 5 *GoodPRO FR3 FireHorse Innovative Response Garment*

The company VOCHOC pointed to the experiences of the firefighters themselves, who go through difficult conditions every day. It is in the fire range that the adjustment of the places of increased heat action, in the area of the shoulders, thighs and chest, has proven itself. Currently, these exposed places are supplemented with a serial fourth protective layer made of a special fabric with a 3D profile. The training facilities in Zbiroh inspired the manufacturers to develop double removable knee pads with the option of inserting a non-flammable cushioning insert. This is illustrated in Fig. 6.



Fig. 6 *Neck area - critical place for heat penetration*

The collar itself is about 8 centimeters high, on the right side there is a pair of Velcro fasteners for easier attachment of the extended part, which then covers the front of the neck.

In the front part, there is a thorough covering of the neck in the part where the bite is, that is one of the critical places for heat penetration. Shoulders and elbows are reinforced with special fabric for high mechanical load. As standard, the sleeves are equipped from the inside against heat penetration and against shrinking of the sleeve. As for the pants, firefighters are worried about whether they will fit and how they will behave when bent. The tested pants have increased protection of the bottom hem of the pants, they have sufficiently large pockets on the sides on the side. Double knee protection is an advantage. The braces are removable and are attached with plastic Velcro fasteners. They especially appreciate that the initial setting holds. No changing position when dressing, no readjustment. Yellow-silver-yellow 3M Scotchlite reflective tapes with a width of 75 mm (optionally 50 mm) are placed on the coat and trousers. The inscription FIREFIGHTERS is placed on the back. Emergency clothing certified according to relevant standards, e.g. EN ISO 469 and also meets the requirements of the Decree in the Czech Republic.

Material composition:

Upper layer: 53% KERMEL®, 39% Lenzing FR®, 6% Technora, 2% carbon fibers, RipStop binding, grammage 230 g/m², FC treatment against water and chemical liquids, Inner layer: TOPAZ PU membrane laminated to Interlock knit, grammage 145 g/m², Bottom insulating layer with lining: 50% Aramid, 50% Lenzing FR®, stitched, grammage 270 g/m². This is illustrated in Fig. 7.



Fig. 7 Innovative natural material LENZING FR

4 CONCLUSIONS

Unique polygon - for professional firefighters, in the future also for volunteer firefighters. The training equipment includes a flashover container for solid and gaseous fuels, simulation of an intervention in an underground garage. They tested the specially modified GoodPRO FR3 FireHorse emergency clothing (assignment was: emergency clothing for a fire horse instructor). Improvement of the suit (internal structure of the garment). Knees suffer in the polygon - thanks to the perimeter velcro, they doubled the outer worn part that can be replaced, inserted foamed silicone inside to protect the knees. Sewn-in rubber in the raised waist of the trousers, instead of a regulation tape. The covering part, which is widened in the upper part and goes all the way to the collar. This is illustrated in Fig. 8,9.



Fig. 8 Knee protection



Fig. 9 Protective part on the collar

Protective clothing for firefighters according to (National Institute of Safety, Health and Wellbeing at Work (INSSBT)-(EN 469:2005). This is illustrated in Fig. 10.

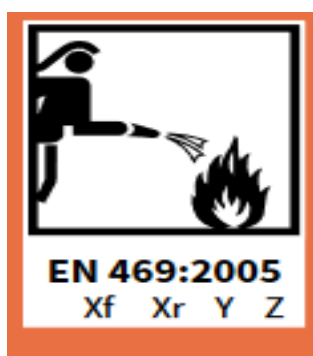


Fig. 10 Pictogram and 4 performance levels of clothing resistance

This clothing is designed to fight fires commonly referred to as "structure fires". Level 1 can be selected for outdoor firefighting and support activities, while Level 2 is applicable for firefighting and fire rescue in structures where a higher fire risk is expected.

The response activity of fire brigades is diverse. Starting with fires, which in the past were also the reason for the first fire brigade creation, via crashes to the most common events, traffic accidents. When fighting a fire, firefighters must protect their bodies from flames and extreme temperatures. With the development of fire-causing agents, including chemicals, emergency suit fabrics have been gradually optimized to improve the physical barrier between

the fire and emergency responders. When fighting a fire, firefighters must protect their bodies from flames and extreme temperatures. With the development of fire-causing agents, including chemicals, emergency suit fabrics have been gradually optimized to improve the physical barrier between the fire and emergency responders.

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REFERENCES

National Institute of Safety, *Health and Wellbeing at Work (INSSBT)-(EN 469:2006)*.

Szmytke, E, Brzezińska, D., Machnowski, W. and Szymon Kokot, A., 2022. Firefighters' Clothing Contamination in Fires of Electric Vehicle Batteries and Photovoltaic Modules—Literature Review and Pilot Tests Results, *Int. J. Environ. Res. Public Health*, 19(19), 15 pages.

Vojta, Z., Rucký, E., 2006, *Personal protective work equipment*. (original in Czech), SPBI, 211 pages.

<https://elearnhazz-sk.webnode.sk/subory-na-stiahnutie/metodicke-listy/>

<https://www.laboratuar.com/sk/testler/koruyucu-giysi-testleri/en-469-yangina-karsi-koruyucu-giyecekler-icin-test-standardi/>

<https://www.tophasici.sk/>

<https://www.rednod.sk/viacvrstvove-zasahove-obleky/zasahovy-oblek-firehorse-fr3/>