29. évfolyam (2019) 2. szám 5–20. • DOI: 10.32562/mkk.2019.2.1.

Urbán Anett[1]

The Characteristics of the Firefighter's Protective Equipment[2]

A tűzoltók védelmét szolgáló eszközök

During fire service interventions, firefighters have to perform a wide variety of tasks, but in many cases this diversity is accompanied by an increased hazard level. The protection and safety of the intervening staff of disaster management have always played a prominent role. Firefighters can only be expected to work the most efficiently if, during the interventions, they have every opportunity to preserve their own health. In order to process this topic, in addition to reviewing European and Hungarian standards, historical overviews, literature and related statistics, the author consulted with members of the intervening staff of disaster management, who regularly use personal protective equipment, to deepen her knowledge about the topic.

Keywords: *personal protective equipment, protective clothing, fireman, disaster management*

A tűzoltói beavatkozások alkalmával széles körű, változatos feladatokat kell ellátnia a tűzoltóknak, sok esetben azonban ez a változatosság a veszélyességi szint növekedésével is párosul. A katasztrófavédelem beavatkozó állományának védelme és biztonsága mindig kiemelten fontos szerepet játszott. A tűzoltóktól csak abban az esetben várható el, hogy a leghatékonyabban végezzék a munkájukat, ha a beavatkozások közben számukra minden lehetőség biztosítva van a saját egészségük megőrzésére is. A téma feldolgozásához az európai és magyar szabványok a történi áttekintések, szakirodalmi anyagok és a témakörhöz szorosan kapcsolódó statisztikák feldolgozásán túl a téma pontos megismeréséhez a szerző konzultációkat folytatott az egyéni védőeszközöket rendszeresen használó a katasztrófavédelem vonulós állományában szolgálatot ellátó személyekkel.

[1] National University of Public Service, Doctoral School of Military Sciences, PhD student, e-mail: urban.anett@uni-nke.hu, ORCID: 0000-0001-8934-0172

[2] The work was created in commission of the National University of Public Service under the priority project PACSDOP-2.1.2-CCHOP-15-2016-00001 entitled "Public Service Development Establishing Good Governance" in the Concha Győző Doctoral Program.

A szerző célja a katasztrófavédelem szervezete által használt és rendszeresített egyéni védőeszközök bemutatása, rendszerezése.

Kulcsszavak: *egyéni védőeszköz, tűzoltók, katasztrófavédelem*

Introduction

Every time firefighters answer a call, it is a race against time. Whether it is night or day, summer heat or winter cold, they have exactly 120 seconds to leave their station. Every work-type and workplace has their own unique traits; and in case of some professions, employees could meet threats to their health, safety or even life threatening situations. In order to minimise such risks strict guidelines, orders and even laws govern the steps of preforming such tasks. So it is in case of firefighters. The intervening staff has to perform mechanical safety and lifesaving actions at sites of fires, road and railroad accidents, accidents involving hazardous chemicals or manage the aftermath of natural disasters. There are no two similar cases, the circumstances of the work environment are determined by the work site.[3] Tasks during interventions often lie close to the upper limits of the capabilities of the human body and soul. Every intervention has its main factor of risk; however, these factors often surface with others, amplified by them, or coupled, or one after the other.

Such factors could be: high temperature, smoke, poisonous (chemical) gases, falling objects, collapsing buildings, slippery and/or jagged surfaces, adverse visual conditions, sudden and extreme change of temperature. We also need to consider unforeseen, but emerging events like explosions, or when working high above or underground (unexpected gusts of wind, landslides etc.). Moreover, the tiring firefighter's lapse of concentration can also lead to accidents.[4]

Workers in Hungary have a right to safe and healthy working conditions.[5] In order to reduce the above mentioned risks to the intervening staff, they are provided with modern protective equipment, which within reason, provide the maximum possible safety to the personnel. However, since safe and healthy working conditions cannot be provided to firefighters by collective measures (hence the diverse risks like mechanical damage, poison hazard, extreme heat load and unexpected events), it has to be achieved by individual protective equipment.

By the 39/2011. (XI. 15.) BM (Ministry of the Interior) directive, which details the general rules of firefighting and technical rescue, we can determine the tasks of firefighters which cover a wide range of events in Hungary.[6]

"Technical rescue is securing life and property in case of:

a) building damage, accidents at buildings
b) traffic accidents
c) accidents occurring on natural waters
d) accidents occurring in canals, wells and other reservoirs

[3] Dallos 2017.
[4] Kuti 2010, 1–7.
[5] Pántya 2017.
[6] Directive 39/2011. (XI. 15.) BM.

e) malfunction and accidents involving public utilities
f) accidents occurring in height or underground (caves and ravines included)
g) hazardous materials breaching containment, or nuclear accidents
h) natural disasters and any similar events."[7]

Besides the above, professional disaster management preforms radiological, biological or chemical reconnaissance and decontamination, if it proves necessary by indication with regards to the site or on-site scouting.

Every intervention has risks. Therefore, we have to protect our firefighters by all active and passive means.

The intervention staff of the disaster management is the primary actor, after the alert, they are, in most cases, first on site to begin reconnaissance, rescue and damage management operations. Interventions are diverse and risky. It is not an exaggeration to say that there are no two similar ones. The goal of the author is to assess the individual protective equipment of firefighters and the possibilities of lowering the loads they are exposed to.

Individual Protective Equipment

The individual protective equipment used in Hungary is defined by the 1st appendix of the 6/2016. (VI. 24.) BM OKF directive: "Employed by fire stations, certified by BM OKF, issued to individuals, its function is to protect the wearer from one or more simultaneously affecting risk factors."[8]

Related to the directive, we need to mention the responsibilities of both employer and employee. It is the responsibility of the employer to provide the properly certified protective equipment to the employee and to train the employee for correct and safe use and maintenance of it. Twice a year it has to provide work safety training for the 24/48 shift personnel.[9] In case of new equipment, it is a must to have additional training above that is mandatory. Work safety trainings have to be properly documented adhering to the official guidelines.

It is the responsibility of the employee to inspect and maintain their issued personal equipment, to adhere to the work safety directives, and to wear and use the issued protective equipment. They have to know how to properly use the equipment, which of them provide protection against what risks, what are the limitations of each, as well as it is an employee obligation to report any limiting factor affecting the safety and usability of the issued equipment.[10]

The 18/2008. (XII. 3.) SZMM directive categorises individual protective equipment into three categories, based on the level of protection they are able to provide.

- 1st category: that protective equipment of which their manufacturer can assume that the user is able to correctly judge the level of protection provided by it with sufficient certainty, and judge the necessity of its use in the correct time and able to properly utilise it.

[7] Ibid.
[8] Directive 6/2016. (VI. 24.) BM OKF.
[9] KOK s. a.
[10] Protective equipment s. a.

The level of protection can be certified by the manufacturer via an EK sufficiency statement, providing a user manual is also available.

- 2nd category: all equipment not fitting into the 1st and 3rd categories.
- 3rd category: equipment that require complex design, which is used for protection against fatal accidents, severe, permanent injuries, of which the manufacturer may assume the user would not be able to judge direct effects in time.[11]

Which is the mandatory individual protective equipment in case of the intervention staff of disaster management? The mandatory protective equipment for the professional staff is defined by the 84/2011BM OKF directorial directive. In the appendix of the directive the following equipment is listed:[12]

- firefighter protective clothing (coat and pants)
- firefighter protective helmet (with faceplate and helmet): the faceplate is anatomically designed and can hinge downwards, the helmet is flame resistant and replaceable, hingeable protective glasses could be applied to it with a possibility of attachment of further protective equipment. They can be sourced from multiple manufacturers, they only differ in design and attachments. Suggested time of wear: 5–15 years.[13]
- protective hood: Can be sourced from various manufacturers, heat resistant protective hoods which also serve well in cold. An important feature to consider that they must not cause skin irritation. Suggested time of wear: 5 years.
- firefighter protective boots: It has to be comfortable to wear, needs to be breathable, to be quickly put on and taken off, it has to protect from cuts and punctures, provide traction and protection against chemicals. Suggested time of wear: 5 years.
- firefighter protective gloves: It can be said that firefighters dislike wearing protective gloves because of their bulkiness. But work safety regulations are mandatory and so are wearing gloves. They provide protection against mechanical and thermal injuries. Fortunately, chemical protection is rarely needed, but they offer no space for argument about wearing gloves either. Suggested time of wear: standard protective gloves 1 year, chemical protective gloves 3 years.[14]
- climbing harness with utilities (hand axe, hose holder rope): Provides security in heights by anchoring, but it can also be used to attach various pieces of equipment. Comes handy underground or entering closed spaces in smoke, but proves most useful when others or the firefighter needs saving from height. Loadbearing and ease of use are the most important attributes, they come in various sizes just like conventional belts. Suggested time of wear: 5 years.
- breathing mask: The mask itself is hardly separable from the complete breathing apparatus formed by the harness, the pressure vessel, pressure regulators and other systems (e.g. bodyguard system). The mask provides a steady flow of pressurised

[11] Directive 18/2008. (XII. 3.) SZMM.
[12] Directorial directive 84/2011BM OKF.
[13] Kövér s. a.
[14] MSZ EN 469:2014

air to the firefighter from the pressure vessel, guaranteeing proper pressure over the protected area regardless of external circumstances. Important features are good and distortionless view, proper fitting, decondensation, ease of vocal communication and easy but secure attachability. The overpressure within the mask provides safety in case of imperfect fit by rather venting some of the air than letting potentially dangerous external air in. An added benefit is that it makes breathing easier because of the relative pressure difference. Suggested time of wear: 5 years.[15]

- safety gloves (for technical rescue)
- ear protection: Is used mostly during technical rescues, when the sounds generated by applied machinery used on site can be harmful to hearing. It is a simple and cheap piece of equipment offering good protection.

The table containing the fire and disaster management equipment in service can be found on the website of the OKF. Firefighting and technical rescue guidelines for equipment to use is detailed by the 15/2010. (V. 12.) ÖM directive and 84/2011 directive of the Director of BM ÖKF.[16] The phrase in service is a criterion detailing which equipment can be used by professionals at disaster management. What is excluded from the table, is considered forbidden to use. In my opinion, this table had its importance before 2012 in the period of the local governmental firefighting; nowadays, procurement is centralised and supervised, so only equipment deemed fit can get to the members of the intervention staff. Regardless, we need to keep in mind to double check equipment from the pre-2012 period, to make sure they are certified and still fit for service today.

Such inspection obligations are contained in the 1st appendix of the 15/2010. (V. 12.) ÖM directive of "use of fire protection equipment during activities of firefighting and technical rescue", often citing articles of law and user manuals of manufacturers.[17]

In accordance with work safety regulations, the 29/2012 directorial directive contains all the equipment that needs to be provided for the intervention staff, which they are obliged to wear and use.

"Individual protective equipment is any sort of equipment which can be worn or carried by an individual person and which would protect the person from one or multiple dangers which would threaten the health or safety of the person. Individual protective equipment prevents or mitigates the effect of dangerous factors and its effect only protects the user."[18]

The use of individual protective equipment is justified when the work involves such dangers which cannot be countered by any other technical means.

[15] Protective equipment s. a.
[16] Directorial directive 84/2011BM OKF; Directive 15/2010. (V. 12.) ÖM.
[17] Directive 15/2010. (V. 12.) ÖM.
[18] Nagy s. a.

Dangerous and Harmful Factors

While doing work, the human body is exposed to such external stimuli, which can prove to be harmful to the worker's health. Such factors are classified into groups and subgroups. The main groups are numbered from 1 to 9. Subgroups contained in the main groups are also strictly numbered from 1 to 0.[19]

Main groups of harmful and dangerous factors:

- Mechanical
- Material
- Bad quality, contaminated air
- Radiations
- Cold and heat
- Noise
- Vibration
- Electrical phenomena
- Biological factors[20]

Classifying of protective equipment based on the direction of protection

The use of contemporary protective equipment is diverse, however their purpose and function are very similar. Their main purpose is the protection of personal safety and health, providing protection against external threats, mitigating the effects of threats and preventing them altogether. Protective equipment can also be classified by their function. Based on this, there are the following groups:

Main groups of protective equipment:

- Head protection
- Face protection
- Eye protection
- Respiratory protection
- Hearing protection
- Protective clothing
- Full body protection
- Hand protection
- Leg protection
- Other protective equipment

The staff has to be trained for their use. Firefighters have to inspect their equipment both upon starting their shifts and before use. In case of faults and malfunctions they are obliged to report it.

---

[19] Urbán 2017.
[20] Ibid.

Levels of individual protection:

- "A level" protection: fully closed, heavy type of protective clothing, closed cycle pressurised breathing apparatus, protective helmet, communication device.
- "B level" protection: insulating or filtering type of protective clothing, closed cycle pressurised breathing apparatus with full face mask, protective helmet, protective boots, protective gloves (dual layered), communication device.
- "C level" protection: insulating or filtering type of protective clothing, gas mask with appropriate filter, protective helmet, protective boots, protective gloves (dual layered), communication device.
- "D level" protection: light insulating or filtering type of protective clothing, gas mask with appropriate filter or half mask with protective googles, protective boots, protective gloves.[21]

The protection of the body of firefighters, as well as civilian workers, is of utmost importance. However, during some interventions it is unavoidable that the body surface of the intervention staff gets into contact with fire, red-hot and hot objects (occasionally with objects without any visual sign of heat) during repairs; while during technical rescues sharp and jagged objects can cause injuries. In order to mitigate or prevent this from happening, the intervention staff is obliged to wear protective clothing during intervention calls.

General Requirements of On-Call Protective Clothing

The most important requirements of on-call protective clothing are defined by the MSZ EN 469 standard.[22]

The most important from these are:

- The protective clothing must provide protection for the firefighters' upper and lower body, including the neck and limbs, excluding the head, hands and feet.
- The clothing can consist of one or two pieces.
- The clothing has to be designed to fit other pieces of protective equipment (e.g. gloves) and to constrict the wearer's movement as little as possible.
- The clothing has to have visibility stripes in accordance with its use in the day (day and night).
- The protective clothing should be as light as possible while maintaining the required level of protection. Its design and material should ease cleaning and maintenance.
- The material of the protective clothing should prevent the spreading of fire. None of its materials should melt, drip, nor catch on fire and decrease in size more than 5%.
- The protective clothing should provide appropriate resistance to chemicals.

[21] Nagy s. a.
[22] MSZ EN 469:2014.

- It should be watertight while be breathable to water vapour and provide ventilation for the comfort of the wearer.[23]

Other Requirements for Protective Clothing

Requirements for chemical resistance: The innermost layer of the protective clothing must not be reached by 20°C sodium hydroxide (NaOH) at 40% density; hydrochloric acid (HCl) at 36% density; sulphuric acid (H_2SO_4) at 30% density and petroleum ether. These substances must be kept away from it by an additional or multiple layers.[24]

Requirements for radiative heat (conductive heat) protection: When examining resistance to radiating heat, the sample material is heated from the direction of its outermost layer. A sensor on the opposite side of the sample measures the heating and the time it takes for the temperature to raise to 24°C. If the time is found not within the pre-specified threshold, the material is deemed insufficient for use.

Requirements for flame resistance and flame spreading: Protective clothing for firemen with regards to flame resistance and flame spreading examined under standard heat stress has to fulfil the following requirements: The material of the clothing must not combust on any side or edge. It must not puncture, except for the outermost layer in case of multi-layered clothing. Flaming or melting parts cannot peel off of it. Average time of after flaming and afterglow cannot exceed 2 seconds.

The firefighter protective clothing has progressively changed through time. Both in protective and resistance capabilities, but their most important task was to protect the wearer. In the following, the author will describe in temporal order the standardised protective clothing of the past twenty years in Hungary.

Regulations of use for protective clothing:

- Fire approaching activities in protective clothing can only be performed by trained and medically fit personnel.
- Protective clothing can only be worn in conjunction with compressed air respiratory protection gear.
- Continuous use of protective clothing cannot exceed 20 minutes. After 20 minutes it must be taken off and the wearer must be provided 20 minutes of rest. During this time the clothing must be cooled (ventilated).
- For wearing underneath the protective clothing, natural or polypropylene-wool clothing is recommended.
- Damaged protective clothing is not to be repaired, further use is not allowed.[25]

[23] MSZ EN 469:2014.
[24] MSZ EN 469:2014.
[25] Protective equipment M-8 s. a.

Use of Protective Clothing

Protective clothing provides full body protection against 93°C environmental heat. For a short period, it is capable to withstand 1093°C radiative heat.

Based on measurements, protective clothing provides its protection in dry working conditions as shown in Table 1.

Table 1. Degrees of protection of protective clothing

Contact heat	100 °C	150 °C	200 °C	250 °C	300°C	350 °C	400 °C	500 °C
Time of use	226 sec	80 sec	51 sec	40 sec	29 sec	26 sec	23 sec	19 sec
Radiant heat	2 W/cm²			3 W/cm²		4.2 W/cm²		
Time of use	50 sec			20 sec		10 sec		

Source: Kanyó 2008

The use of various protective equipment hinders the work of the intervention staff as itself exerts their bodies. Even just wearing the protective clothing greatly reduces the heat regulatory (perspiratory) capability of the body. The protective clothing and its accessories can more easily snag in objects and structures. Respiratory protective equipment adds additional weight, restrict the range of motion and provide even more surface for snagging. When wearing a face mask, the wearer may experience a reduced hearing, visual acuity and a decreased field of view and intelligibility of speech.

However, despite all of the above, preforming firefighter duties is unimaginable without such protective equipment. As the on-site circumstances may exert extreme stress on the intervention staff from fires that can be put out in the matter of minutes, up until cases which can last several hours. Also, in some cases facing extreme heat may prove entirely unavoidable.

In light of the above, in the following section the author will discuss the effects of heat on the human body, the risk factors of firefighting and the possibilities of reduction of these risks and stresses.

The primary source of stress affecting working firefighters is external stress.

External stress is the summary of factors which affect the form of labour, its intensity, its duration and circumstances and trigger functional reactions of the human body.

The two main types of external stress are:

- Related to human activity:
  - physical stress (dynamic and static muscle work or combination of the two)
  - mental stress (stress caused by information processing)

- Related to the site:
  - heat stress
  - chemical stress caused by poisonous or corrosive materials, coupled by emerging mental stress due to improper pre-assessment of the situation[26]

The requisite of effective use of human resources challenges greatly the fire departments of several countries. It is very important that the personal strength of fire departments should consist of people in appropriate number, who are ready and able to do their jobs, so they are well-trained, specially skilled and motivated professionals. At the scene of the damage the intervention – which can be a 1–2-minute long fire up to a many-hours-long duty – sets the firefighters' organism to an inordinate physical pressure. Human organism – depending on age, physical and toughness level – adapts differently to the pressure on it. In case of firefighters, we have to pay attention to extreme heat effects, spasms and circular problems caused by liquid- and salt deficiency. As a result of these, even death might occur.[27]

The Effect of Heat on the Human Organism

Humans are one of the most tolerant creatures on Earth, so we can hustle for longer periods even between –30 and 45°C.[28] Despite the extremes, the sustainability of operability of our organism is possible between certain temperature boundaries. The organism can only partly compensate the changes with its body temperature level keeping mechanism. Under circumstances warmer than our body temperature (36.3–36.8°C), the body has to increase heat egress, while during colder circumstances, it has to decrease it. Further temperature increase or decrease without adequate defence might lead to death. In case of overheating, the body tolerates by heat egress. This time the veins of the skin expanse, more warm blood gets on the surface of the body, sweating starts, which is a cooling mechanism. During this process, our body distracts blood and liquid from other parts of the body, which worsens the performance.[29]

If the environmental temperature rises above the neutral zone, besides the oxygen consumption, the heat production rises as well. This fact obviously is not ideal from the heat conditioning point of view, because the sustainment of constant body temperature really charges the organism. The reason for this phenomenon is said to be found in the so called Van't Hoff (empirical) rule, which says that by the increase of temperature by 10°C, the speed of reaction grows up by 2–4 times.[30]

In case of firefighters, this is really important, as during an operation a bad decision might result in the death of their own or their partners or the civilians.

[26] Detre s. a.
[27] Lits s. a.
[28] Fejes–Kóródi 2014.
[29] Cohen 1912.
[30] NFPA s. a.

Contingencies while Firefighting

Basically there are two sorts of heat dangers threatening the firefighters: burnings and heat load. Outer heat effects and work load do not influence body temperature equally. Outer heat first has to get through clothes and skin, before influencing the body temperature, while work load first increases the inner temperature of the body before leaving through the skin. If the environmental temperature is higher than the body temperature, the heat surplus can only be egressed by sweating. The evaporation should take care of the compensation of outer temperature. According to American statistics, only 10% of accidents during firefighting are burns. During firefighting, the number of deaths is very high, 48%. More than 50% of the victims die because of heart attack, and only 12% because of burning. By estimations, with 80–90% the cause of accidents is false positioning, as you could see with the Van't Hoff-rule. So it is assumable that most of the accidents are caused directly or indirectly by the overheating of the body.[31]

Circumstances during Firefighting

It is an essential rule that warmer body egress heat to colder ones, with which its own body temperature decreases, and the colder one's increases. Organisms produce heat during their functioning: approximately 80 W while sleeping, and more than 1000 W during intensive work. The bodies of firefighters produce 300–500 W heat during work, and they can egress it by breathing, by dry heat conveyance and by evaporation. At room temperature and 50% relative moisture (RH) the egress leaves 20% by evaporation, 25% by conveyance, 45% by heat radiation and 10% by breathing. If the environmental temperature reaches 35°C, the only way of cooling the body is evaporation. Evaporation is a very effective method, because one litre evaporated sweat takes 672 W out of the body. The amount of evaporated sweat decreases as time goes by. If the body is affected by heat charge, sweat becomes stronger at the trunk.[32] The higher the body temperature is, the lower skin temperature is needed to start sweating. During firefighting, the protective clothes strongly insulate, so the body is not in a heat balance with the environment and a part of the produced heat piles up in the body. In addition to observing the burn injuries, it has also been observed how much heat charge does the firefighter equipment cause to the firefighters' organism. The results strongly differ from each other depending on outer conditions of the measurements (temperature, moisture) and the quality – and vapour permeability of the clothes. The quantity of the clothes also has to be taken into consideration (a 24 kg heavy equipment reduces the person's performance by 25%), as well as the fact that moving in such equipment how much more heat production it causes in the organism. By knowing the allowed maximum body temperature, in principle, it can be counted to each equipment that after how much work should the person stop to prevent any dangerous situation. We also have to take into consideration that body temperature keeps rising for minutes even after stopping work. But the fact that circumstances during the

[31] Fahy et al. 2018; Lorenz et al. 2007; Fábián et al. 1989.
[32] Fahy et al. 2018.

firefighters' work change very quickly and the evaporation speed depends on age, physical state etc. make calculation very difficult or almost impossible.[33]

Developments in the field of firefighter safety equipment are continuous throughout the world. Despite this, the interventional staffs have to suffer a great amount of heat charge during a long-lasting intervention, or during wearing heavy gas protective equipment at the presence of dangerous materials. The goal of the author is to present the possibilities that can decrease temperature during firefighter interventions.

Adaptable Temperature Decreasing Clothing

Heat egress solutions by evaporation

At evaporation from the surface of the liquid molecules leave, which increase the steam-capacity of the room above the liquid. So evaporation is quite similar to boiling, because in both cases liquid turns into steam. The difference is that during evaporation molecules can leave only from the surface of the liquid, while at boiling steam-bubbles can appear throughout the whole volume of the liquid which leads to the intense movement of the whole liquid.[34]

The reason of the evaporation is that the molecules on the surface of the liquid move inordinately. Because of their anomalous impacts, they sometimes have such big kinetic energy that they can defeat their neighbour's magnetic interference and split from the surface of the liquid.[35] Only those particles can do it, that have the greatest kinetic energy, so they take energy away from the liquid. In other words, the average amount of energy of the rest of the particles decreases if those with the greatest level leave. Its consequence is that during evaporation the energy of the liquid decreases which is shown by the decrease of its temperature.[36]

The evaporation, the transformation of liquid into gas draws away a lot of energy. There are certain clothes that are made from special material and use this evaporation as cooling. Their material takes in a certain quantity of water, while thanks to their water resistant tarnish, the dress stays dry after wiping. Due to the evaporation of the water, the dress becomes 5–7°C cooler than its environment, and it can hold up to it for 5–10 hours long; we can achieve this only by dipping it into water for 1–3 minutes.[37]

Setting heat-capacitors that draw away much heat on cryogenic surface

We need significant heat quantity for dissolving the crystal state of crystallisable materials, in other words for melting. They have another feature that until melting utterly happens, their temperature remains constant. By using this knowledge Kovox Ltd. developed such a cooled piece of clothing that contains small cryogenic blocks. These cryogenic bags melt at 14°C,

[33] Lorenz et al. 2007.
[34] Pavlik 2013, 32–35.
[35] Kóródi 2013.
[36] Kanyó 2014, 84–88.
[37] Gribovszky 2010.

at a lower temperature than this, they ensure a 14°C temperature for three hours long during their melting. The producer offers his clothes having appropriate aggregate changer cooling solutions for steel factories and firefighter interventions. According to this, among the developed variations of clothes, you can find the flameproof cooled vest, as well.[38]

The circulation of liquid that is cooler than the environment in tubing built into clothes

Though clothes heated by electricity have been produced for a long time, a few years ago a Hungarian developer team came up with an entirely new solution. In the dress, designed by the Hungarian inventors, liquid circulates through narrow silicon tubes and its temperature can be set between 35 and 55°C by the user.[39]

The 'liquid circulated clothes' can be used in a wider field than the electronic ones, because with this invention its wearer cannot only be heated, but cooled, as well. The Thermoflash electronics system controls that with the help of small pumps circulating a special liquid in the tubing of the dress. This liquid is absolutely harmless to health, it is a monopropylene-glycol based, environmentally sound and not poisonous bio freezing-mixture. In the dress, the tubes are placed in a way to cover all the most significant parts of the body, and the designers also paid great attention to the fact that the whole surface of the body should be reached by the generated cold or warm properties.

During hot weather – more or less according to the individual makings – every person's stamina decreases. Even above 20°C we can sense such body reactions that not only obstruct the performance, but increase the intensive strain. At interventions, firefighters have to do hard physical work under extreme circumstances. This is especially true for firefighters because a badly judged decision might cost his own or his partner's or the to-be-rescued civilians' lives.

Each firefighting intervention is risky. That is why our firefighters have to pay great attention to both their active and passive defence. With the use of the clothes presented by the author, we can increase the effectiveness of the interventions and the protection of our staff.

Summary

As we could see, firefighters face diverse dangers while on duty. During preforming their tasks, not only the recognition of risks factors but protection against them are not just important, but indispensable. During such tasks, these risks have to be mitigated to acceptable levels by utilising personal protective equipment at hand. It is the firefighters' own interest and duty to use such equipment properly, and to report any damages to them since damaged equipment cannot fulfil its function. Since external risks can never be fully avoided, personal protective equipment has to provide the relative safety to firefighters so that they can perform their

[38] Kovox Kft. s. a.
[39] Hollenberger–Szállás 2010, 19–20.

duties. Every intervention has its risks, hence we need to protect our firefighters by all active and passive means.

This safety rests on three pillars:

- firstly, they need appropriate equipment (tools and protective clothing)
- secondly, well-defined tasks and appropriate work management are required to tackle on-site damage cases
- thirdly, the intervention staff must be trained and prepared for handling expected and unexpected on-site events

If we keep these in mind and take safety measures, spend the time and effort on the theoretical and practical training of the staff, then we could raise the effectiveness of interventions, as well as the safety of the personnel.

References

Cohen, Stuart (1912): A study of temperature-coefficients and Van't Hoff's rule. *KNAW Proceedings,* Vol. 14, No. 2. 1159–1173.

Dallos Tamás (2017): *Védőeszközök.* Available: www.langlovagok.hu/azs/46_vedoeszkozok (Downloaded: 16.08.2018.)

Detre Zoltán (s. a.): *A megszokottól eltérő környezet hatása az emberi szervezetre, különös tekintettel a hőmérséklet változásaira.* Available: http://docplayer.hu/2447819-A-megszokottol-elteri-ko-rnyezet-hatasa-az-emberi-szervezetre-kulonos-tekintettel-a-himerseklet-valtozasaira.html (Downloaded: 09.09.2018.)

Fahy, Rita F. – LeBlanc, Paul R. – Molis, Joseph L. (2018): *Firefighter deaths by cause and nature of injury, NFPA.* Available: www.nfpa.org/News-and-Research/Data-research-and-tools/Emergen-cy-Responders/Firefighter-fatalities-in-the-United-States/Firefighter-deaths-by-cause-and-na-ture-of-injury (Downloaded: 03.12.2018.)

Fábián Gyula – Nádori László – Derzsi Béla – Ozsváth Károly – Rigler Endre – Zsidegh Miklós (1989): *Sportképességek mérése.* Budapest, Sport. 300–312.

Fejes Zsolt – Kóródi Gyula (2014): Analysis of upper respiratory tract infections in mission circum-stances. *AARMS,* Vol. 13, No. 1. 47–52. Available: www.uni-nke.hu/document/uni-nke-hu/aarms-vol-13_-issue-1_-2014.original.pdf (Downloaded: 06.04.2018.)

Gribovszky Zoltán (2010): *A vízrendezés, mint a komplex vízgazdálkodás része: Hidrológiai és hidraulikai alapok.* Available: www.tankonyvtar.hu/hu/tartalom/tamop425/0027_MGIN7/ch01s04.htm (Downloaded: 12.11.2016.)

Hollenberger Melinda – Szállás György (2010): Hazai védőruha sikere Lipcsében. *Védelem,* Vol. 12, No. 4. 19–20. Available: www.vedelem.hu/letoltes/ujsag/v201004.pdf?13 (Downloaded: 16.07.2018.)

Kanyó Ferenc (2008): *A tűzoltók fizikai alkalmasságának felmérése az új évezredben: Laboratóriumi és pályavizsgáló teljesítménydiagnosztikai eljárások alkalmazási lehetőségei a tűzoltók teljesít-ménymérésében.* Available: http://m.ludita.uni-nke.hu/repozitorium/bitstream/handle/11410/9911/Teljes%20sz%C3%B6veg%21?sequence=1&isAllowed=y (Downloaded: 04.09.2018.)

Kanyó Ferenc (2014): *A beavatkozó tűzoltók élettani paramétereit monitorozó telemetriás rendszer alkal-mazási lehetőségei veszélyes anyag jelenlétében történő beavatkozásoknál.* Budapest, Konferencia-kiadvány: Katasztrófavédelmi Díj Tudományos konferencia 2014. 84–88.

KOK (s. a.): *Védőeszközök.* Katasztrófavédelmi Oktatási Központ. Available: http://fejer.katasztrofave-delem.hu/letoltes/document/fejer/document_73.pdf (Downloaded: 02.03.2017.)

Kóródi Gyula (2013): Health screening examinations in cardiovascular risk estimation. *AARMS,* Vol. 12, No. 1. 39–44. Available: https://folyoiratok.uni-nke.hu/document/uni-nke-hu/aarms-20131-korodi.original.pdf (Downloaded: 14.09.2018.)
Kovox Kft. (s. a.). Available: www.kovox.hu/html/huto.futo.ruhazat.html#hutott (Downloaded: 12.10.2016.)
Kövér Tamás (s. a.): *Munka és tűzvédelmi oktatás.* Available: http://fox.klte.hu/~beneg/oraianyagok/1.,%20Munkavedelemrol%20altalaban,%20Kornyezetvedelem.pdf (Downloaded: 04.03.2017.)
Kuti Rajmund (2010): *Komplex műszaki mentések tervezésének lehetőségei.* Védelem Online: Tűz-és Katasztrófavédelmi Szakkönyvtár. 1–7. Available: www.vedelem.hu/letoltes/anyagok/233-komplex-muszaki-mentesek-tervezesenek-lehetosegei.pdf (Downloaded: 02.07.2018.)
Lits Gábor (s. a.): A szélsőséges időjárási körülmények hatása az emberi szervezetre. *Folyóiratszemle.* Available: http://epa.oszk.hu/02700/02735/00064/pdf/EPA02735_katonai_logisztika_2007_4_223-244.pdf (Downloaded: 09.09.2018.)
Lorenz, R. – Franz, K. – Krieger, S. – Zeilberger, K. – Jeschke, D. (2007): Dynamische Leistungsfähigkeit bei reduzierter Wärmeabgabe in Feuerwehrschutzanzügen. *Deutsche Zeitschrift für Sportmedizin,* Vol. 58, No. 5. 132–137.
Nagy Zsolt (s. a.): *Egyéni ABV védelem és mentesítés katasztrófa helyzetekben.* Available: http://www.vedelem.hu/letoltes/anyagok/537-egyeni-abv-vedelem-es-mentesites-katasztrofa-helyzetekben.pdf (Downloaded: 16.04.2017.)
NFPA (s. a.): National Fire Protection Association: *Firefighter activities, injuries, and deaths.* Available: www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/osffinjuries.pdf (Downloaded: 03.06.2018.)
Pavlik Gábor (2013): Élettan – *Sportélettan.* Budapest, Medicina Könyvkiadó Zrt. 32–35.
Pántya Péter (2017): A katasztrófavédelem és a tűzoltóságok hazai és nemzetközi tevékenysége, a beavatkozások keretei, a biztonság és hatékonyság megjelenése. *Hadmérnök,* Vol. 12, No. 2. 201–213. Available: http://hadmernok.hu/172_16_pantya.pdf (Downloaded: 02.08.2018.)
Protective equipment (s. a.): *A tűzvédelem és veszélyelhárítás védőeszközei.* Available: www.fajltube.com/gazdasag/gepeszet/A-TUZVEDELEM-ES-VESZELYELHARIT65255.php (Downloaded: 02.04.2017.)
Protective equipment M-8 (s. a.): Védőeszközök M-8. Available: https://tuzoltotudas.hu/wpcontent/uploads/2016/02/Védőeszközök.doc (Downloaded: 03.09.2018.)
Urbán Anett (2017): A katasztrófavédelem tűzoltó egységeinél rendszeresített védőruházatok vizsgálata. *Műszaki Katonai Közlöny,* Vol. 27, No. 4. 103–122.

Legal References

18/2008. (XII. 3.) SZMM rendelet az egyéni védőeszközök követelményeiről és megfelelőségének tanúsításáról. Available: https://net.jogtar.hu/jogszabaly?docid=A0800018.SMM&timeshift=20170101&txtreferer=00000003.TXT (Downloaded: 04.03.2017.)
15/2010. (V. 12.) ÖM rendelet a tűzoltási, műszaki mentési tevékenységhez kapcsolódó tűzvédelmi technika alkalmazhatóságáról. Available: https://net.jogtar.hu/jr/gen/hjegy_doc.cgi?docid=a1000015.onm (Downloaded: 02.03.2017.)
39/2011. (XI. 15.) BM rendelet a tűzoltóság tűzoltási és műszaki mentési tevékenységének általános szabályairól. [BM Regulation. General rules of the fire extinguishing and technical rescue operation activity of the fire department service.] Available: https://net.jogtar.hu/jogszabaly?docid=a1100039.bm (Downloaded: 03.05.2018.)
84/2011. számú BM OKF Főigazgatói Intézkedés a személyi állomány egyéni védőeszközzel történő ellátásáról. Available: https://docplayer.hu/18726585-A-bm-orszagos-katasztrofavedelmi-foigazgatosag-foigazgatojanak-84-2011-szamu-intezkedese.html (Downloaded: 02.03.2017.)

6/2016. (VI. 24.) BM OKF utasítás a Tűzoltás-taktikai Szabályzat és a Műszaki Mentési Szabályzat kiadásáról. [BM OKF Regulation of the Rules of the Firefighting-tactics and Technical Rescue Operations.] Available: https://net.jogtar.hu/jogszabaly?docid=A16U0006.OKF&txtreferer=00000001.TXT (Downloaded: 18.07.2018.)

MSZ EN 469:2014: *Védőruházat tűzoltók részére. Tűzoltók védőruházatának teljesítménykövetelményei.* Magyar Szabványügyi Testület. Available: www.mszt.hu/web/guest/webaruhaz;jsessionid=F3C50719BBFE9F6CE2296461FD4D740D?p_p_id=msztwebshop_WAR_MsztWAportlet&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=1&_msztwebshop_WAR_MsztWAportlet_ref=158768&_msztwebshop_WAR_MsztWAportlet_javax.portlet.action=search (Downloaded: 15.04.2017.)