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Tibor Haraszti, Gergő Érces

APPLICATION OF PROTOCOL PROCEDURES IN CASE OF FIREFIGHTING

Abstract

New technologies and techniques are constantly appearing in our accelerated world. Safety and efficiency are important in all areas of life. There are expectations in the disaster management and in the firefighting. Different protocol procedures can help us to solve the problems with new technologies. Based on the information, they determine the real steps that can be taken to avoid the possible wrong decisions and the requirement of safety and efficiency is not compromised in addition to the speed.

Keywords: firefighter intervention, intervention protocol, fire prevention

PROTOKOLL ELJÁRÁSOK ALKALMAZÁSA A TŰZOLTÓI BEAVATKOZÁSOK SORÁN

Absztrakt

Felgyorsult világunkban folyamatosan jelennek meg az új technológiák, technikák. A biztonság és hatékonyság az élet minden területén felmerülő fogalom, illetve elvárás a katasztrófavédelem és természetesen a tűzoltói beavatkozások tekintetében is. Az új technológiák megjelenésével felmerülő problémák megoldásában, segítségünkre lehetnek különböző protokoll eljárások, amelyek összegzett információk alapján tényszerűen követendő lépéseket határoznak meg, melyek betartásával elkerülhetők az esetleges hibás döntések és a gyorsaság mellett nem sérül a biztonság és hatékonyság követelménye.

Kulcsszavak: tűzoltó beavatkozás, beavatkozási protokoll, tűzmegelőzés

1. INTRODUCTION

Examining the interventions of the firefighters from a technical point of view, we can see that keeping up with the technological development, the technical equipment of the rescue organizations is also developing [23]. New fire trucks, more developed technical tools and protective equipment appeared at the fire departments in case of firefighting and technical rescue [21]. Various protocol procedures can help us under such circumstances. Based on our professional experiences and observations we made during the research, the fire department does not currently use the possibilities of the protocols during the interventions. We would like to highlight the methodological advantages of using these protocols, the possibility of increasing the safety and the efficiency, through an evaluation of a building. A traffic tunnel is an excellent example for the possibilities of applying the protocol procedures.

1.1. International regulations

With the construction of the 4 tunnel systems on the highway M6 and the underground M4 in Budapest, new techniques, technologies and facilities have appeared at the fire departments. There have been several fires in the area of the underground, as well as vehicle fires in the M6 highway tunnels. The elimination of the incidents was successful in all cases, but the serious efforts of firefighters pointed to the difficulties of firefighting in tunnels. As a result of the serious and fatal tunnel fires and accidents of the recent decades, a lot of research has begun in the topic. These researches are primarily focused on equipment that increases the safety of tunnels and on the faster, more efficient elimination of the events. The European Parliament issued a directive in 2004 summarizing the shortcomings and research findings, which applies to all tunnels longer than 500 metres in the trans-European transport network. Directive 2004/54/EC provides a unified framework for the minimum fire protection and safety requirements for tunnels and in addition to the installation requirements, it also includes instructions and operation requirements [4].

1.2. Characteristics of fires in tunnels

In addition to the rapid heat generation, tunnel fires are also characterized by the formation of large amounts of smoke. Several previous tunnel disasters and experiments in the topic have shown that the temperature can exceed up to 1200 ^{o}C near the nest of fire. Due to the “closed” type of the tunnel, these fires are characterized by strong heat generation, rapid fire spread, longer escape time and large amounts of smoke. Intensive smoke generation in traffic tunnels is caused by the increasing amount of plastics and lubricants used in the production of vehicles from the fuel and tires of vehicles [1]. The heat and smoke cannot escape freely from the building. These flue gases are very toxic. The chances of survival of people decrease very quickly with the spread and accumulation of smoke [2].

1.3. Intervention techniques in case of road tunnels

With the increase of the traffic, accidents in tunnels have also become more frequent. Although the passive safety measures mitigated the consequences of the accidents and made the intervention safer in the tunnels, but the serious and fatal fires, necessitated the introduction of the active fire protection systems [3]. In Europe with the Directive 2004/54/EC of the European Parliament and of the Council of 29 April 2004 on minimum safety requirements for tunnels in the Trans-European Road Network [4] we have to count with the presence of certain technological systems and techniques.

If we study the “habits” of the tunnel construction and operation in countries with more road tunnels, we can see that these tunnels were made with completely different technologies at completely different times. However, by now, basically every tunnel has an escape route, mechanical ventilation, heat and smoke extraction in some form [5] [6] [7]. In addition, a variety of active and passive safety systems have been installed in each, which, due to their versatility, are coordinated and operated in each case by a complex surveillance system.

1.4. Road tunnel monitoring system

Even in the tunnel system installed on the highway M6 in Hungary, the same as in all European tunnels, the active and passive safety elements are coordinated and operated by a complex monitoring system. The monitoring system of the M6 tunnels is the so-called SCADA system (Supervisory Control and Data Acquisition). The task of the SCADA system is to establish the connection of the communication, to collect and display this data, and to establish the humanmachine connection in the control equipment. Using SCADA (for example in case of oil refinery technology or complex fire protection equipment), the entire system can be controlled by a single operator. Even with unlimited spatial extent, time-critical tasks are performed on local devices (intelligent devices) [8].

1.5. Techniques and equipment of M6 tunnels supporting the intervention

The full operation of the M6 tunnels is supervised by the SCADA system. The water supply of the tunnels is provided with water supply lines equipped with a pressure booster. Any of the boosters will start automatically when the hydrant is opened, they will also stop automatically when the water is no longer used. The water supply is kept frost-free by the electric heating. The energy supply of the tunnels (SCADA supervision and control) is double-sided and is via 20kV/0.4 kV own transformers. The second line of energy supply is provided by diesel-powered generators, which start automatically in case of a failure of the first side supply (SCADA system monitoring and control). Power centres also have uninterruptible power supplies that operate basic systems. The telecommunications facilities in the tunnels, as well as the event detection and telemetry systems, are also monitored by SCADA. The operational condition of the tunnel is detected by thermometers, traffic counters, vehicle class and speed detectors, smoke detectors, air flow speed and direction detectors, CO concentration detectors and cameras installed in the pavement and in the airspace and walls. The information is sent to the control centre under SCADA supervision.

1.6. Why are tunnel techniques needed?

Real fire test experiments carried out abroad (Austria, France, Japan) proved that it is necessary to keep the speed of the air flow in tunnels below 2 m/s. In case of artificial ventilation, smoke stratification does not occur due to turbulent mixing. In each of the experiments, a layer of breathable air remained for a very long time, up to a height of 1.5-2 metres with an air flow below 2 m/s. Occasionally during the entire duration of the fire. In case of natural ventilation with low airflow, a smoke plug may form at the opening of the tunnel due to transverse flow. This results in the re-layering of the smoke [17] [18] [19].

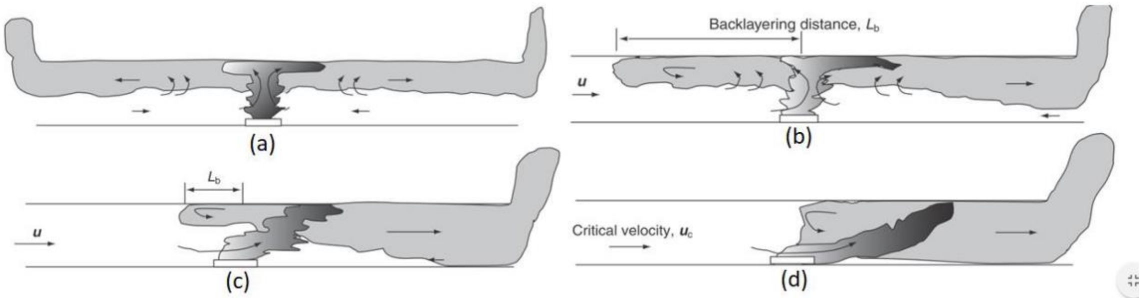

Figure 1- re-layering of the smoke (Source: Patricio Valdes: CFD Study on the Interaction between Water Sprays and Longitudinal Ventilation in Tunnel Fires page 7.)

To avoid this, in case of an emergency, the automation of the SCADA system controls the ventilators by switching them off in the fire section. The other ventilators are controlled by the airflow measurement to secure a continuous flow of 1-2 m/s. If the natural airflow is above 2 m/s, the ventilators will not turn on.

In case of a fire the SCADA system switches the ventilators in the same direction as the traffic direction of the tunnel pipe, regardless of the direction of the natural draft. At the same time, it starts in the parallel tunnel in the same direction [7].

It would not be a good solution to direct the smoke in both pipes in the same direction as the traffic. This is because the vacuum created at the “entrance” of the tunnel pipe from the direction of travel would suck the air coming out of the other tunnel. This would start circulating the smoke in the two tunnels, so we would create two tunnels full of smoke.

The SCADA system has three operating systems for safety. We prepared the technical detail and protocols concerning the M6 tunnels on the basis of the Emergency Action Plan (Hereinafter VIT)[1] of the Mecsek Autópálya company and of my personal consultations.

1.7. Remote automatic monitoring and control

The full control runs during SCADA, the system monitors everything. It can measure the temperature, the airflow, the carbon monoxide level, the air density, the gas concentration, and

[1] The VIT describes all technical parameters of tunnels and gives instructions to the operator about all malfunctions.

even the visibility. If it detects any abnormality, it immediately alerts the operator and starts the pre-programmed protocol for the event.

1.8. Remote manual mode

In this case, one device is removed from the SCADA supervision and management by the dispatcher (for example the control of ventilator or the control of signal lights). All other devices remain under the control of SCADA, but the certain device that is removed is placed under manual control to all intents and purposes. The associated protocols will not work automatically either. Like when we turn off the stability control in the car (ESP). From here, all components of the complete system removed from SCADA require manual adjustment

1.9. Local controller, local mode

A control centre was placed in one of the rooms connected to the tunnels and a so-called fire control panel at the entrance of the tunnels. By activating the mode (by turning a key), all control is transferred to the local control room or to the fire control panel. Dispatchers cannot take back control. By turning the key, all activity is in the hands of the person who turned the key. Emergency generators will not start either. This mode is only used by professionals for maintenance, as it results in a complete SCADA disallowance. This is ideal in case of a repair of the ventilators, because neither the automation will start the ventilator (e.g. due to the presence of increased exhaust gas) nor the dispatcher will do it accidentally [7].

To change the operation of the ventilation, the entire system must be removed from SCADA supervision. There is no braking mechanism on the ventilators and the technology's own protection only starts the ventilator in the other direction after it has stopped. The stopping time of the ventilator depends significantly on the speed of the air flow in the tunnel. The duration of the change in airflow direction is therefore disproportionately long. For the interference in the SCADA system requires a permission. In addition, the incident must be reported in accordance with the rules of the Highway Engineering.

With the permission of the Bátaszék Plant Engineering, I carried out some measurements. Switching the ventilators in the opposite direction is possible by a computer control with 4 clicks, which takes 20 seconds per ventilator, based on the calculated values and the consistent experience of the professionals. In case of operation of the "fire program" controlled by the SCADA system, the change of the air flow direction is at least 5 minutes. However, this can take an average of 7-8 minutes, and in some cases up to 10-12 minutes. In contrast, even in case of the longest tunnel, the penetration from the direction of travel is less than 2 minutes. Another important circumstance is that there are people in the tunnel and their direction of escape started with the given direction of air flow. The change of airflow direction during such an event can have serious consequences. The protocols recorded in the "fire program" will not happen either if the device is removed from computer monitoring. For example, in the parallel tunnels, the ventilators will not automatically start in the same direction. These have to be set manually one by one. This has already returned the possibility of the human mistakes into the processes. Computers were used to avoid this type of mistake. The situation can be even more serious if the fire chief decides to change the direction of ventilation and take control from the dispatch centre.

1.10. Regulation of road tunnel intervention

During my research, I was looking for an answer to that according to what kind of rules should a fire chief make his decisions for an intervention in case of road tunnels (even a tunnel installed on a highway) [22]. Based on the examined regulations, it can be stated that the regulations do not contain information specifically about the tunnels. The only point of reference that a fire chief can rely on is the so-called „TMMT[4]" data sheets" on the fire trucks and at the county operations management.

According to the National Fire Protection Regulations (hereinafter OTSZ[5]), road tunnels are special constructions[6] and facilities of high importance from the point of view of the fire protection. So TMMT will be mandatory for any road tunnel in the country that exceeds 800 metres [9] [10] [11] [12]. I analysed all the TMMTs of the fire departments belonging to the M6 tunnels (2 counties, 5 fire departments and 2 County TIK[7]). They contain relevant information and real data. However, if the incoming fire chief is not an expert in the technical equipment of the tunnels or has no knowledge of the subject, he is unlikely to be able to obtain meaningful information from the large amount of data in a short time [21]. The time will always

[4] TMMT: It is a support plan containing the manpower and equipment required for the firefighting and technical rescue.
[5] OTSZ: Hungarian Decree No 54/2014 of 5 December of the Ministry of Interior on the National Fire Protection Regulations.
[6] special construction: the special structure for fire protection is the road tunnel, the pedestrian underpass, the underground railway line, the lookout tower, the tarpaulin structure, the scaffolding structure.
[7] TIK: Tevékenység- irányítási központ (Activity Management Centre)

be short because international regulations require the distance of rescue units to be proportional to the tunnels [13][14][15][16].

2. DECISION MAKING IN CASE OF AN INTERVENTION

The fire chief participates in and controls the intervention [20]. Fire chiefs are emergency decision-makers, who omitting the general decision-making matrix due to the time pressure. They make their decisions on the basis of so-called schemes [16]. Emergency decision-makers (such as police, ambulance, doctor, soldier, firefighter, etc.), based largely on their experience, they recognize a similar situation and select the most appropriate sample for which there has been a good solution before [16]. However, there are few road tunnels in Hungary, so the fire chiefs have little experience. In order to help to make a decision, it is important to summarize the information and to make a protocol out of it in advance.

2.1. Protocols in general

Today, the concept of protocol is very diverse. Nowadays, we mean different things in different areas of life by protocols. For example, an IT protocol means something completely different like the etiquette protocol. We also meet a lot of protocols in our everyday life, some of them are prescribed, others are used as a "habit". Protocols are used by doctors to care for patients, the ambulance also provide a step-by-step care to the patient, and even first aid BLS (Basic Life Support) steps are a protocol. There are very simple and very complex versions, but they have in common that they contain rules. This protects their user from the wrong decisions in a given situation or they prescribe the steps [20] [21] [22].

2.2. Protocol method for interventions in case of road tunnels

The protocol has been drawn up in accordance with the mandatory technical and design rules and harmonized with the rules of the intervention:

1. Interventions in case of road tunnels, all fire departments have to communicate on the common cooperation channel set up for this purpose.

The basis of a successful intervention is the good communication. Each unit includes a dispatcher service, county operations management, and all the fire chiefs on site. Communicating through the common cooperation channel, the information of the dispatcher service and the instructions of the fire chief are also immediately received by the county level TIK in real time. According to international regulations, every similar road tunnel will have a radio channel set up for this purpose. For similar tunnels, there will also be a tunnel specialist, who will be among the first to be involved in the fire management. These also help the safe intervention [23].

2. Closing, evacuation. Close of tunnels in both directions (via dispatch service with the help of the police). Steps must be taken to the dispatcher service to begin emptying the tunnels. Actions must be taken to divert and close the driveways.

One of the most important security protocols. People can escape from the tunnels, in case of a two-section tunnel, through the emergency passages to the opposite direction. During the detection, it may be necessary to stop in the tunnel, there may even be a set-up site at the emergency gateway. One of the most important actions is to stop the traffic in both directions of the tunnels as soon as possible. The dispatcher service has cameras, motion sensors and a loudspeaker system. Before the help arrives, they can most effectively begin to evacuate the tunnel. Operations like this require preparedness [24].

3. The approach, (direction of the migration) is possible only from the same direction as the direction of travel

Approaching can be a logistic problem [25]. Firefighters approaches the tunnels from the direction of travel. The duration of the change of direction in the tunnel areas does not justify driving on the highway in the opposite direction of the traffic. This must be prohibited in all cases.

4. Information, clarification: Which tunnel is affected? Number of people and their situation in the tunnel? In case of fire, the direction of air flow?

The primary task is to save human life. To do this, we need to know the number of people who need a rescue, their situation and the direction of the escape. In case of a fire, the direction of the airflow due to the automatic processes determines the location and approach of the intervention.

5. In case of fire, the intervention area is always approached from the direction of travel (in the same direction as the exit of heat and smoke) in accordance with the air movement. It is not recommended to change the airflow artificially!

The most optimal is if there is no question about changing the direction of heat and smoke. The tunnels can be traversed in a short time. In case of artificial heat and smoke removal, the change of direction is long. We are able to adapt to the stable environment provided by the techniques in less time than we can change them. In case of natural ventilation, it is not possible to change the direction of air flow. In case of tunnels shorter than 1000 metres, the mechanical ventilation is only recommended.

6. Life-saving and evacuation is realized primarily through the use of pressurized emergency passages and emergency exits. It is forbidden to support the doors of emergency exits and passageways, and it is also forbidden to lay fire hoses through them.

In case of road tunnels longer than 500 metres, there shall be an emergency exit or passageway to the not loaded tunnel in accordance with the installation rules. These exits and passages must be pressurized so that the draft cannot pass the smoke into the escape route in the tunnel. The overpressure is artificially created and secured by doors and windows. Due to the sluice design, fire hoses must not be placed on them or supported it in any way. So there is no question in connection with the direction of save. In the M6 tunnels, the longest road that needs to be taken to reach an emergency passage or exit is 300 meters.

7. Fire hydrants are available for the firefighting in every 250 (M6-100m) metres. 2 "C" jets can be operated without a fire truck.

According to the European Union regulations, the minimum requirement is that there must be a hydrant in every 250 metres in the traffic tunnels. The hydrants should be able to perform 600 l/min in 6 bar pressure, and provide two simultaneous operations. This is enough to operate the jet.

8. Additional information, instructions: (the most necessary additional information for the tunnels).

It is also necessary to include specific important information. In case of M6 tunnels: Landing place of the rescue helicopter between tunnels „B" and „C". To give the injured people to the ambulance, preferably in a protected tunnel. Additional fire trucks should be outside the tunnel etc.

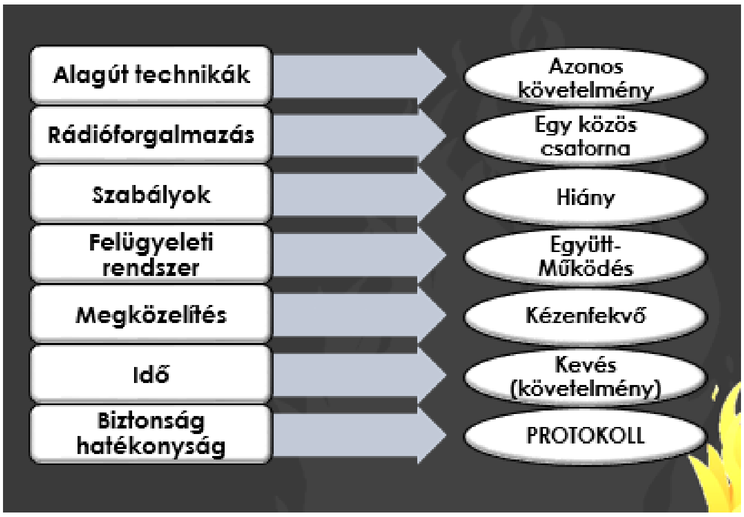

Figure 2- Aspects of preparation of the intervention protocol (Created by the authors)

Table 1- Summary of protocol procedures (Created by the author)

Number of protocols	**Name of protocol**	**Content of the protocol**
1.	**Communication protocol**	Interventions in case of road tunnels, all fire departments have to communicate on the common cooperation channel set up for this purpose.
2.	**Closing and evacuation protocol**	Closing, evacuation. Close of tunnels in both directions (via dispatch service with the help of the police). Steps must be taken to the dispatcher service to begin emptying the tunnels. Actions must be taken to divert and close the driveways.
3.	**The approach protocol**	The approach, (direction of the migration) is possible only from the same direction as the direction of travel.

4.	**Information protocol**	Information, clarification: Which tunnel is affected? Number of people and their situation in the tunnel? In case of fire, the direction of air flow?
5.	**Heat and smoke extraction protocol**	In case of fire, the intervention area is always approached from the direction of travel (in the same direction as the exit of heat and smoke) in accordance with the air movement. It is not recommended to change the airflow artificially!
6.	**Rescue protocol**	Life-saving and evacuation is realized primarily through the use of pressurized emergency passages and emergency exits. It is forbidden to support the doors of emergency exits and passageways, and it is also forbidden to lay fire hoses through them.
7.	**Firefighting protocol**	Fire hydrants are available for the firefighting in every 250 (M6-100m) metres. 2 "C" jets can be operated without a fire truck.
8.	**Additional information and instruction protocol**	Additional information, instructions: (the most necessary additional information for the tunnels).

3. SUMMARY

Techniques and design features in case of road tunnels are an excellent example for technological challenges. Nowadays it can be stated that for any complex facility, a fire chief has to process a huge amount of information. It is also proven that there is a short time for this decision in case of a special institution. A summary protocol system helps in the decision making, thus reducing the possibility of the wrong decisions. It follows that the intervention becomes safer and more effective. By developing the intervention protocol procedures for each facility that has TMMT and we place these protocols in the TMMT documentation, we can be more successful in the field of security challenges. The topic is approachable in the future

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Tibor Haraszti
Student, University of Public Service, Institute of Disaster Management
E-mail: haritibor@gmail.com
ORCID: 0000-0002-5545-2325

Maj. Gergő Érces, PhD
assistant lecturer, University of Public Service, Institute of Disaster Management,
Department of Fire Protection and Rescue Operations Management
E-mail: erces.gergo@uni-nke.hu
ORCID: 0000-0002-4464-4604