TECHNICAL VEHICLES USED TO EVACUATE PEOPLE DURING RESCUE OPERATIONS AT HEIGHTS

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Abstract: The purpose of the paper is to present the technical equipment (vehicles) used to overcome height differences that are held by the Fire and Rescue Service in the Slovak Republic for the evacuation in the event of a threat to human life and health. The authors focus specifically on the division of categories of technical equipment and discuss the technical parameters of selected compositions as well as methods used by firefighters during operations. The risks associated with their use are also pointed out.

Keywords: evacuation, height, people, rescue, technical equipment, vehicles

INTRODUCTION

One of the basic tasks of members of firefighting units in emergencies is to rescue people who got stuck at heights. To ensure rescue and evacuation from endangered area various types of firefighting equipment are used. By firefighting equipment are meant various movable and immovable technical devices designed mainly to carry out tasks of fire brigades. Such a movable technical device is e.g. a hydraulic platform with aerial appliances. This vehicle is by its inclusion, external identification and internal equipment intended to perform tasks of fire-fighting units. Furthermore, various material assets, specifically technical means and equipment for climbing heights and going down to depths, are used for the rescue and evacuation of people. The paper discusses selected types of equipment and material assets used to evacuate people from endangered areas.

I. RESCUE AND EVACUATION OF PEOPLE

When the emergency situation occurs, the need to rescue people whose life and health are put in danger arises and it is necessary to ensure rescue and evacuation to safety areas. The terminological dictionary used by the Fire Rescue Services defines the evacuation of persons as leaving the danger area through escape route or any other possible way.
In case of an emergency situation, evacuation of people in terms of their rescue is carried out simultaneously with the exploration, immediately after the firefighting units arrive at the operation site. Rescue and evacuation of persons is managed by the incident commander, and he/she decides on the use of all available forces and means.

Rescue action is taken [8]:
- if persons are threatened by fire;
- if fire cuts off escape routes;
- if persons are in an area with high-density smoke;
- if there is a danger of explosion or collapse of structures;
- if escape routes cannot be used due to the high-density smoke, high temperature or flames;
- if people are unable to move independently;
- if there has been panic among the people.

Rescue work is carried out first in those places where people are most at risk, and where there are the greatest numbers of people. Usual ways of the rescue and evacuation of people include:
- leaving dangerous place by people on their own;
- leading out persons in danger;
- carrying persons in danger;
- rescue using high-rise technology;
- rescue using life-safety equipment (such as portable ladders, rescue tunnels, sheets and landing mattresses);
- rescue using air technology;
- artificially created open spaces in building constructions;
- rescue of persons from under debris, crashed cars and so on;
- transport of persons on board boats or using another technique from endangered sites.

To evacuate persons from endangered object (mostly endangered by fire or a leak of hazardous substances), structural components, construction elements and building equipment intended for the evacuation of persons or for intervention of fire fighting units (such as escape routes and access routes, fire lifts, evacuation lifts, fire ladders) are used. Escape routes from the building are used most. These routes should be open and clearly marked to allow safe and rapid evacuation of endangered persons.

The incident commander is in charge of rescue and evacuation of people. The most significant evacuations of people that were realized in the Slovak Republic include:
- evacuation of 12 people through windows using ladders from the burning block of flats in Revúca on February 6, 2008;
- residential house fire on March 6, 2011 in Šamorín. 17 people were evacuated, 6 of which with the use of a telescopic automobile ladder;
- evacuation of 130 people, 2 of which using the height-rise techniques at Hotel Junior Jasna in Demänovska Valley.

Outside Slovakia, the evacuation of 280 students (approximately 200 students by ladders), who were in a five-storey dormitory of the University of Friendship of Peoples in Moscow (Russian Federation), can be mentioned as one of the most
significant evacuation of people from fires by using construction elements and firefighting equipment. The fire occurred on November 24, 2003 on the third floor.

II. THE EVACUATION USING THE MOBILE HIGH-RISE TECHNOLOGY OR RESCUE DEVICES

People are evacuated using mobile high-rise vehicles or rescue equipment when any other ways of evacuation are inaccessible due to cutting off escape routes by fire, or they are used as secondary way of evacuation going on simultaneously. Each of firefighting units is equipped with predetermined technical means with appropriate parameters, which depend on different factors. Every firefighting unit is equipped with technical means with specific parameters, depending on their designation. These technical means are applied to overcome height differences. Amongst them, the following ones can be listed:

- high-rise firefighting apparatus,
- ladders,
- escape tunnels used for evacuation downwards, etc.

Firefighting trucks that are equipped with turn-table ladders or lifting working platforms belong to high-rise rescue automotive technology. The first mobile pivot ladder placed on a horse-drawn carriage was constructed in 1808 by a German locksmith from Lienzingen, Andreas Scheck. Another German, a master carpenter Kohler from Magdeburg made a five-part retractable 18 m long ladder harnessed by horses for the Berlin fire department in 1848. Currently, the German company MAGIRUS, which started its production in 1872, is among the leading ladders manufacturers. [5]

High-rise rescue automotive technology, which can be used for rescue and evacuation of persons from heights consists of [11]:

- a rotating automotive ladder (AL) - a car with a hardtop with stabilized rotating retractable ladder kit with a platform (basket) attached, which can be erected and folded down from 5° to 75° and rotated continuously by 360° in all positive angles limited to the driver's cab. A rotary ladder is illuminated when working during reduced visibility or at night (Figure 1);
- a high-rise automotive work platform (AP) - a car with a hardtop with stabilized high-rise rotary joints or a telescopic multi-arm. A part of the last arm is a work platform (basket), which can be erected and folded down from 5° to 75° and rotated continuously by 360° in all positive angles limited to the driver's cab (Figure 2).
Fig. 1 Automotive ladder AL 39 Mercedes Benz Atego 1529 F 4x2

Fig. 2. Automotive work platform AP 44 Bronto Skylift MAN TGS 26.440 BB 6x4
The main characteristics of the displayed high-rise vehicle equipment are shown in Table 1.

Table 1. Technical data on automotive ladder or automotive work platform [6]

<table>
<thead>
<tr>
<th>Basic vehicle data</th>
<th>Characteristics of automotive ladder and automotive work platform</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AP 44 MAN / AL 39 MB Atego 1529</td>
</tr>
<tr>
<td>Chassis</td>
<td>MAN TGS / Mercedes Benz 1529 F 4x2</td>
</tr>
<tr>
<td>Top</td>
<td>Bronto F44RLX / AR L39 Metz</td>
</tr>
<tr>
<td>Squad</td>
<td>1 + 1 / 1 + 2</td>
</tr>
<tr>
<td>Longitude</td>
<td>10,01 m / 10,90 m</td>
</tr>
<tr>
<td>Width</td>
<td>2,55 m / 2,50 m</td>
</tr>
<tr>
<td>Height</td>
<td>3,75 m / 3,65 m</td>
</tr>
<tr>
<td>Weight</td>
<td>22 560 kg / 15 300 kg</td>
</tr>
<tr>
<td>Maximum high-rise</td>
<td>44 m / 40 m</td>
</tr>
<tr>
<td>Maximum outreach</td>
<td>22,6 m / 19,2 m</td>
</tr>
<tr>
<td>Basket carrying capacity</td>
<td>5 persons / 3 persons</td>
</tr>
</tbody>
</table>


### III. EVACUATION PERSON USING A LADDER AND A RESCUE TUNNEL SLEEVE

Although the use of ladders was known from the past, the history of special ladders for firefighters started in the year 1761, when a German locksmith Birner from Munich projected probably the first extension ladder in the world. Later, in 1792 he resolved its latching mechanism, which prevented spontaneous retraction. French inventor Regnier was likely the first who invented the rotary ladder in 1802 [5].

Currently firefighters use portable fire ladders to work at heights, which are divided in terms of their:

**Usage:**
- an intervention access ladder that allows only access to the site of action, but not the rescue of people;
- an intervention rescue ladder that allows the rescue of persons by carrying them down or up.

**Construction:**
- a hook ladder (one or two hooks made of light metal, natural or composite material) is used to climb up or down using window frames and balconies;
- a multi-piece ladder (made up of four parts connected to each other) can be used also as a double ladder (equal-arm and unequal-arm), the length of one piece is 2 700 mm, a composed ladder reaches the length of 8 400 mm;
- a slider ladder (consisting of fixed and moving parts) for which the ejection is solved with a rope and the entrance height is 9200 mm at 15° inclination;
- a folding ladder (joint attachment rungs and side-rails that can be folded down with a simple movement) has good maneuverability despite the little available height of 3 000 mm;
- a rope ladder is used most frequently for overcoming depths in the rugged terrain, it is produced in lengths of 5-30 m, its rungs are made of polyamide and are reinforced. They are set on two 9 mm ropes with a braided core and secured with a 4 mm synthetic cord.

Evacuation using ladders is carried on by individuals capable of independent movement and it is appropriate to use at lower elevations (under 20 meters). In case of a higher elevation it is necessary to choose another way for evacuation. It is required to coordinate numbers of people climbing down according to the ladder carrying capacity.

Another means that can be used to evacuate persons from heights (upper floor) are as follows [3, 7]:
- rescue tunnels that can be used to rescue people by slip down sideways;
- rescue sleeves that can be used for rescue and evacuation of people by slip straight down (Figure 3).

![Fig. 3. Evacuation sleeve](source)


Rescue tunnels and rescue sleeves are the means of emergency rescuing of people. Their advantage is:
- quick installation (sleeves can be installed in windows and balconies as well as on a basket on the automotive ladder, etc. Such a basket is installed on the place of the rescue operation that is accessible for high-rise technique. In places where there is no access for high-rise technology
a sleeve is installed in windows. In this case, such a sleeve can be installed with a hook ladder, climbing from the roof, etc.);

- security for the rescued person;
- possibility of saving large numbers of people (including children and disabled people) in a short time;
- removing the evacuee’s fear of heights to a certain extent.

The purpose of using a sleeve can be also to lead rescued people to several floors below to a place with no active danger, similarly to the use of an escape route. As a result, the rescue and evacuation of people is significantly faster. To prevent free-fall, evacuation sleeves are fitted with coils (Rescue Tunnel PNJ 95-80-70 used with the automotive work platform PP 27 on the T 148 and T 815 chassis) or the inner platform. Three-layered sleeves, which utilize the elasticity of the materials used, can be considered the most modern systems.

When using a sleeve to evacuate persons, stability must be ensured and overloading or any other damage (by heat or flames) must be avoided.

IV. FIRE BRIGADE TRAINING FOCUSING ON THE EVACUATION OF PEOPLE

To plan and to perform evacuation, drills are of crucial importance for quality of activities of fire brigades. Training and exercises focusing on the evacuation of people allow for shortening of the total time of the fire units’ operation.

Evacuation of people from a multi-storey building is one of the critical routines of fire brigades. Therefore, preparation of firefighters for this activity plays an important role. It is necessary that the members of fire brigades are familiarized with such areas, and that they exercise properly with the height technology. Tactical exercises must take into account the real state of access roads, boarding places, real objects changes, alterations and other important events that may influence the options and timescales of evacuation of people.

The aim of tactical exercise must be practicing the methods of deployment and management of forces and means of fire brigades as well as mutual cooperation with holders of a high-rise building in addressing safe and rapid evacuation of people and liquidation of an incident.

The objective of the mentioned exercises is to be the verification of:

- skills and professional readiness of the management staff;
- readiness of members of firefighting units, operational capability of technology and technical resources;
- actuality of processed evacuation documentation in comparison with a real state;
- the procedure of evacuation of people in case of an incident (Figure 5 and 6);
- the time needed for arrival of fire-fighters and equipment;
- access of roads and assembly areas;
- the capacity of immobile patients’ evacuation using the height technology [2].
Based on practice and training of fire brigades with the height technology, it can be stated that during any such exercise it is very difficult to comply with all security measures.

Fig. 4 Museum evacuation
Source: Author

Fig. 5 Evacuation of the injured person
Source: Author
CONCLUSION

Rescue and evacuation of people is one of the crucial tasks in which firefighting units participate. These units carry out evacuation of vulnerable people in different ways and using different technical means. The method and deployment of various technical resources in rescue and evacuation of people is influenced by a number of factors. The most important factors include the type of incident, the type and height of an object, time necessary to save people, etc. The high-rise rescue automotive technology, ladders, rescue tunnels and rescue sleeves are amongst the decisive means for rescue and evacuation of persons. The prerequisite for safe and fast rescue of endangered persons by firefighting units is their proper training and improvement of evacuation procedures, the use of technology, etc. The best ways to ensure this are theme drills of various evacuation operations and practicing in objects at different heights.

REFERENCES

TECHNICZNE POJAZDY WYKORZYSTYWANE DO EWAKUACJI LUDZI PODCZAS OPERACJI RATOWNICZYCH NA WYSOKOŚCI

Streszczenie: Celem artykułu jest przedstawienie wyposażenia technicznego (pojazdów) wykorzystywanego do pokonania różnic wysokości, które są utrzymywane przez straż pożarną w celu ewakuacji w przypadku zagrożenia życia i zdrowia ludzi w Republice Słowackiej. Autorzy koncentrują się przede wszystkim na podziale kategorii urządzeń technicznych i omawiają parametry techniczne wybranych kompozycji oraz metody stosowane przez strażaków podczas pracy. W artykule ukazano również zagrożenia związane z ich użyciem.

Słowa kluczowe: ewakuacja, wzrost, ludzie, ratunek, wyposażenie techniczne, pojazdy