MODELING OF THE EXTRAORDINARY EVENT CONSEQUENCES FOR THE TRANSPORT OF DANGEROUS SUBSTANCES

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Summary: Transport of dangerous substances by road tankers entails a lot of risks. In the event of a tank accident, apart from the possibility of explosion and fire, there is a possibility of extensive damage to the environment, human life or health. This article deals with the problems of dangerous substances (especially flammable liquid substances) transport. Purpose of this article is to model the consequences of traffic accident the tanker carrying petrol and determine the negative consequences on population.

Key words: road transport, safety factors, transport of dangerous substances, extraordinary even, modeling of consequences.

INTRODUCTION

Trends in the growth of product shipments between production, processing sites and consumption also affects the transport of products, which are called dangerous goods or dangerous substances. The transport of hazardous substances by means of automotive tanks brings many risks against road truck transport. Besides the possibility of explosion and fire of products in the case of a tanker accident, there is a great deal of damage to the environment, human life or health (1). Primary responsibility for safe transport is provided by the carrier through a trained driver of the vehicle. Transport routes are mostly driven by industrial agglomerations and storage and expense objects are situated in areas densely populated by the population; and therefore, there is a risk that the population will be threatened with dangerous substances in case of an extraordinary event. Every day we are informed by various media about accidents in the road transport and their various consequences, for example about the number of injured and killed persons, escaped quantities of hazardous substances, property damage, and pollution of the environment.

1. THE ROAD SAFETY

1.1 Factors affecting the road safety

The road safety is affected by many factors. The most important factors are demography, mobility pattern, regulations, clime and urbanization. In addition to these bases, there are number of factors that affect operating safety and, in most cases, affect each other (2). An example of such factors is illustrated in the following Figure 1.

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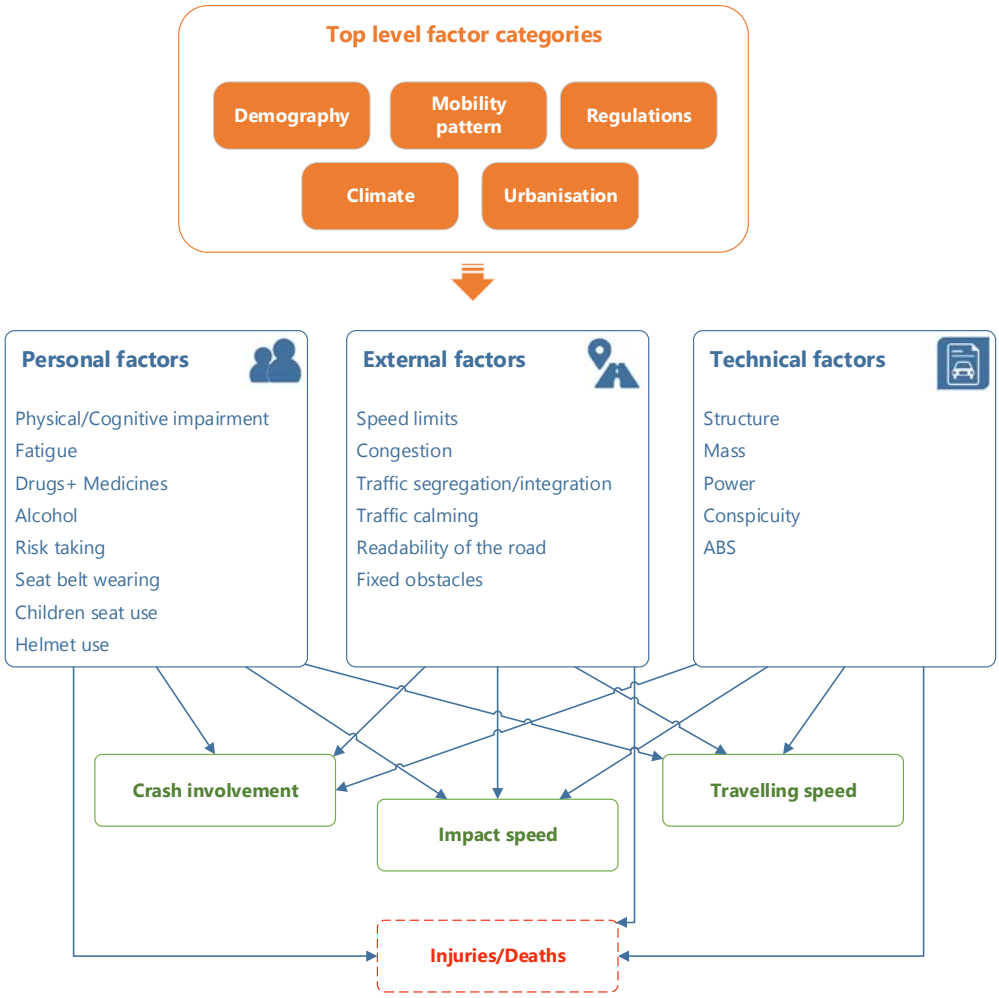

Source: Authors

Fig. 1 – Factors Affecting the road safety

Long-term statistical data from different countries coincide in that the most common cause of traffic accidents is man about in 85% of cases, traffic is the primary cause in 10% of cases and the means of transport is the source of accidents around 5% of cases. Often, several factors are involved in the occurrence of accidents.

The human factor thus has the largest share in the occurrence of traffic accidents. The cause these human failures can be multiple and may be interacting effect. These underlying causes can include fatigue in, inattention, violation of fundamental duties of the driver and wrong driving, lack of experience, lack of qualifications, non - compliance transport, storage and handling hazardous materials, underestimation risk. Infrastructure, resp. the road is the second major cause of traffic accidents. Conditions of communication, number of cars on communications, rising speed limits, insufficient resp. lack of traffic signage and poor conditions such as, for example, rain, snow, mud, poor visibility are all prerequisites for increasing the risk of a traffic accident. Underestimated the technical condition of the vehicle, such as insufficient functioning of brakes, tire wear considerably, mechanical and technical failures, failure of security systems, fatigue, and hidden bugs of construction materials also greatly contribute to increase the risk of traffic accidents. Currently, it is also necessary to mention unpredictable events such as recent terrorist attacks or landslides (falling roads), falling rocks on the road, sudden floods, and crossing the animal through the road.

When assessing the interrelationship between traffic conditions, technical condition of vehicles, climatic conditions, assessing the reliability of human factors and other factors, it can be noted that not all conditions for safe transport are improving even more. By complying with technical standards and the application of new research results are getting the technical state and the equipment of the means of transport improves, which corresponds to it the readiness of their crews mainly in international transport.

2. EXTRAORDINARY EVENTS IN THE TRANSPORT OF DANGEROUS SUBSTANCES IN ROAD TRANSPORT

Most accidents occur during transport, which is logical with regard to the mode of transport and the means of transport. Most accidents associated with leakage occur in the following activities (3):

- transport of substances 39.1%,
- processing of substances in technologies 24.5%,
- storage in large capacity units 17.4%,
- loading and unloading of substances 8.2%,
- use of substances and products in the home or for commercial purposes 5,8%,
- handling of substances in bulk storage 3.8%,
- storage of waste 1.2%.

Even though safety issues and adherence to established standards, rules and regulations for the transport of dangerous substances in road transport are a matter of great concern to the authorities, carriers and drivers, we are occasionally informed of accidents involving tankers transporting diesel, petrol or other dangerous substances. So far there have been accidents or crash in the transport of dangerous substances, which resulting in vehicle fire, environmental pollution by oil products or the contamination of groundwater. Luckily, none of these accidents have passed into a disaster of catastrophic proportions, which would endanger the lives and health of the population, infect large areas of land, water with toxic substances that act on the environment for a long period of time.

Tab. 1 – Number of Emergencies with Occurrence of Dangerous Substances for the Years 2013-2015

Extraordinary events	**2013**	**2014**	**2015**
Chemical liquid	446	631	604
Gaseous chemical	128	143	198
Chemical substance solid	7	1 3	7
Powder	43	2 2	25
Biological material	10	3	8
Radioactive material	0	1	1
Other	148	123	77
Together	**782**	**936**	**920**

Source: Pulcová, 2016

Based on the above, it can be stated that the transport of dangerous substances brings with it many risks. Any legal entity that operates in this area is trying to avoid these extraordinary events because in ultimately, besides the costs related to the occurrence of an

extraordinary event, is also damaged Its good s name, which may result in loss of trading partners and leading to liquidation of the company.

2.1 Fuel transportation by road

Safe transport of hazardous substances does not start at the road, but already in manufacturing plants and does not includes only the transfer process from one place to another, but also includes take over and storage the dangerous substance to designed location. In order to ensure the transport of the dangerous substance, it is necessary to bear in mind that it is not just about the protection of the health and safety of the vehicle crew, but also of security and security protection of all road users and residents of adjacent areas to roads.

Given the ever-increasing intensity of a road traffic density, an increase in other impacts on transport safety for example land and rock landslides, snow hazards, recklessness of road users, there is a significant increase in the risk of transporting hazardous substances which, in the event of non-compliance with the prescribed operating and transport conditions and in the event of a traffic accident, could endanger the life and health of people, the environment or cause material and financial damage. (4). An example may be a recent tragic accident on the D1 motorway in the Slovak Republic, where a 33-year-old driver died. The driver, for not identified reasons, went out of the way to the field, where he overturned the fully loaded tanker. Transport on the D1 motorway at the place where a tragic accident occurred was diverted for safety reasons because there was a risk of explosion.

The transport of fuels by road freight differs from other modes of transport, in particular technical, operational and safety requirements and conditions. Tankers transporting the fuel must comply with the strict criteria resulting from valid version of the ADR agreement and other regulations, meet the requirements of aspects of operator safety, environmental protection and security fire protection (5).

These vehicles, based on legal requirements, are equipped with various security electronic systems to prevent their switching, the release of a pair of products into the air, and product measurement systems. Fuel transport tanks are equipped with pneumatic valves to prevent spontaneous leakage of liquids. Compared to standard semi-trailer vehicles, fuel tanks use specially designed chassis due to the nature of the transported substances.

The main difference is in that the tank is self-supporting and at the rear is attached to the chassis or frame of the axle unit. The axles are the same as the ones classic trailers, but they are always pneumatically spring-loaded. The material from which the container is made is resistant to scratches and abrasion on the asphalt surface in the event of an accident. To make it happen leakage of fuel, the container of the tank should be damaged. Tank is made of aluminum or steel sheets which are formed into cylindrical shapes and connected with welding. The quality of the tank depends on the quality of the welds. The welds are defectoscopically controlled already in production.

After welding and the assembly passes the tanks of the tank vehicles under a pressure test under the prescribed pressure. The size of the tank is given by the permitted vehicle weight limit the specific weight of the transported product. For the transport of fuels with a density of around 800 kg/m3, for weighing 48 tons produce tanks up to size 43 000 to 46 000 liters. The payloads of tanker tractors range from 10 010 kg to 28 900 kg. The usable volume of each tanks comprised between 4 700 liters and 10 600 liters of fuel.

In the light of these figures, we will model the phenomenon of traffic accident of a gasoline tanker within this article. A simulated traffic accident was caused by the transport of gasoline along a motorway leading across the city which resulted in a tank crash, leakage of

the entire quantity transported, and a subsequent gasoline escape. The first step in determining the negative consequences of an extraordinary event is to determine the sources of danger. The source of the danger in this case is a 46 m^3 tanker which transports the dangerous substance 36 800 kg of petrol.

2.2 Modeling the consequences of traffic accident the tanker carrying petrol

Determination of explosion, thermal and of the toxic effects of the emergency scenario was carried out by ALOHA, EFFECTSGIS and TerEx. By using selected programs, it was first necessary to determine the current meteorological situation in site of the accident. Due to the high complexity of the modeling of six representative weather classes, a situation characterized by very stable conditions only the 1st class = F, the wind velocity was low 1.7 m. s^{-1} (the worst scattering, the largest area hit - the worst scenario) was modeling.

Tab. 2 – The results of the accident scenario modeling model

Emergency scenario	Consequences	Aloha	EFFECT	TerEX	Deviation max.
POOL FIRE petrol	1st degree burns [m]	-	88	134	46 m
	Second degree burns [m]	-	65	-	-
	Death threat [m]	45	50	66	21 m

Source: Authors

The results obtained using ALOHA are shown in both text and graphical (cloud footprint with the concentration, the dose and the yield of the source). From the practical experience of using this software indicates that the affected areas are conservative and are the worst possible accident scenarios.

The EFFECTSGIS program determines the consequences of an accident, mortality of people, burns first and second degree, lung damage and ear bands. The advantage of this program is complex calculations from initial physical effects to the consequences of an accident.

The consequences of the emergency scenarios of the TerEx modeling program provide information on the threat zone and the distance of the evacuation of the persons, so the program is suitable for operational use by the integrated rescue system units to intervene in the rapid determination of the extent of the threat and implementation of the subsequent measures for the protection of the population.

2.2.1 Estimation of the presence of the population in the vicinity of a traffic accident

The presence of the population changes over a 24-hour period, it is different in day and night. A daily time is considered for the need for a modeling emergency scenario. When evaluating the presence of the population, it is assumed that part of the population is located within buildings, so the Purple Book methodology determines the shares of the population located inside and around out buildings. Values are valid for residential and industrial areas unless other information is available.

The modeling of leakage scenarios and demonstration of the emergency scenario showed that in the case of air stability class F, the impact of the fatal consequences on the population in the event of a fire in the vicinity of 66 m from the point of escape, which represents an area of 1.4 ha. At an estimated population density of 80 people / ha (according

to the Decree of the Ministry of the Environment No. 489/2002 as amended), the number of people on the affected area is about 112 people (1, 4 ha x 80 people / ha).

Pursuant to the procedures specified in the Purple Book, the shares of residents located inside and around the buildings were calculated. In case of fire of crashed tank with petrol was found that this number is 103 people and 9 people are located in the open air. The death threat is assumed in the neighborhood 66 meters from the fire site, which is the number of people outside the building, in the open air. This count based on calculations tells about 9 fatally injured people during the day when a spilled petrol fired.

It is clear that the analysis of the consequences of a petrol tanker accident is inevitably linked to certain uncertainties that arise from input data used, selected exposure factors, by estimating the presence of the population and his behavior during the occurrence of an extraordinary event. (6). Therefore, it is important to consider uncertainties and extrapolation inaccuracies that are associated with calculations made and estimated estimates.

CONCLUSION

The aim of this article was to highlight the significance of the consequences of incorrectly selected transport routes which many times at the expense of residential areas are elected in view of the economic benefits. From one party is necessary to devise a careful selection of routes for the transport of dangerous substances. This selection can be supported and different to model costs and the benefits of individual roads. On the other hand, it is necessary to thoroughly analyze human failure is causes of these failures and then create tools to reduce them. Particular attention should be given to the role of the human factor in the prevention of accidents involving the transport of dangerous substances and responsiveness during extraordinary events.

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