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RISK ASSESSMENT AND MANAGEMENT DURING HAZARDOUS MATERIALS TRANSPORTATION

Nikola MIŠIĆ[1]
Aca BOŽILOV[2]
Jovan MIŠIĆ[3]
Bojan BIJELIĆ[4]

[1)] *assistant: Faculty of Occupational Safety in Niš, University of Niš, Serbia*
[2)] *assistant: Faculty of Occupational Safety in Niš, University of Niš, Serbia*

Abstract

Dangerous goods transport can occur huge problem in term of environment potential exposure, economic losses, injuries, etc. if an accident happens. In this paper was discussed about the possible risks from dangerous goods transport. For risk assessment it must take into account a few factors, such as physical characteristics of the terrain (tunnels, rail bridges, bend radii, slope, characteristics of neighborhood, etc.), then factors correlated to the traffic conditions (weather, traffic density, type of dangerous goods trucks, etc.), and about traffic accident evidence and transport output statistics. Based on this assessment it can be given an insight into the current state of safety for a given region. Scientific approach to this problem also allows the provision of the right information about the origin and development of the accident, and based on that it can be taken adequate measures of prevention and remediation.

Key words*: risk assessment, risk analysis, hazmat, emergency response, prevention.*

1 INTRODUCTION

With increasing environmental awareness of the population, also are growing requirements for reducing the risk in transporting hazardous materials (HAZMAT). Therefore, there is an increased need to set additional requirements related to reducing the risk and increasing safety during the transport of dangerous materials. The existence of high risk or consequences that may arise in case of accidents with these materials, it is required from all participants in the transport process, their maximum liability. Accidents with transport of dangerous materials may occur at the beginning or at the final destination (for loading and unloading) or on the road.

Transporting dangerous materials follows certain risk of unwanted, accidental events, and that may cause leaking dangerous content from the transport tank or package and creation of harmful consequences followed by explosions, fires, toxic evaporations, radiation, etc., and all this depending on the dangerous materials class, which they belong to [1].

Incidents that include the transport of hazmat may pose the greatest danger to people and property along the road. That risk is present due to their manner and conditions of storage, such as storage in containers under pressure or cryogenic containers courts. Such a manner of storage can lead to serious consequences in terms of deaths, injuries, evacuation, property damage and environmental degradation. Basic characteristics of these incidents are that it is not known the exact location and time when the accident will happen. The last characteristics is the known chemical composition of the transported material.

Table 1 represents the average cost (per event) of traffic accidents and accidents during transportation of hazmat by motor vehicle for a period of one year. Although the cost of possible accident during the transport of hazmat is not significantly higher than the cost for other traffic accidents, but the cost of accident followed by appearance of fire and explosion is much higher. This kind of accidents are seen as events of low probability and large consequences, and the data supports this claim.

Table 1 Comparison of the accident costs incurred during transporting of hazmat and accidents during in regular traffic [2]

Types of accidents	Average costs (in US$)	Average traffic delay (in hours)
Nonhazmat events	340 000	2
All hazmat events	414 000	-
Hazmat events with spill/release	536 000	5
Hazmat events with fire	1 200 000	8
Hazmat events with explosion	2 100 000	12

2 STATISTICAL REVIEW OF ACCIDENTS WITH TRANSPORT OF HAZMAT

1979 in Ontario, there was a leakage of chlorine from the slide down wagon train, and the city was forced to evacuate 200 000 people. In 1982, there was an explosion of gasoline tanks in Afghanistan, which caused the death of 2 700 [3]. In October 2007, a tank with 31,000 liters of oil overturned on the road Zlatibor - Nova Varoš due to inadequate vehicle speed. From the tank are part of the oil poured by road, nearby land and into the stream, which is downstream flows into a nearby lake. In Valjevo, July 2005, there was a leakage of 8.3 tons of gasoline at the gas station Lukoil-Beopetrol, due to the negligence of workers during its transferring from auto-tanks in underground reservoirs. Most accidents during

transportation of hazmat effects on a large number of people and represents a significant economic losses.
Erkut et al. (2007) notes that in spite of the fact that accidents during the transport of hazmat is very rare case, the potential impact of such accidents are very high [3]. Infamous disaster in Los Alfaques in Spain, traffic accident happened, where tank with liquid propylene (Class 2 by ADR) had exploded. The tank caught fire, which later resulted in a BLEVE effect. In this accident, 217 people were killed, and more than 200 are with severe burns [5]. Arturson (1981) states in the report, that after 2 months 102 people died due to the effects of the explosion. Table 2 shows the accidents in 2013 for each transport stage along with the costs.

Table 2 Accidents during transportation of hazmat divided into the phases of transport in 2013

Transport phase	Total accidents	Total num. of hospitalized people	Total num. of non-hospitalized people	Total num. of deaths	Total damage (in US$)
In transport	4.184	11	37	9	67.056.517
Storage	483	8	0	0	562.306
Loading	3.350	3	22	1	2.836.118
Discharge	7.757	5	68	0	454.873
Total	**15.774**	**27**	**127**	**10**	**70.909.814**

Analyzing the data supplied by the Major Incidents Hazard Data Service, they are indicate that accidents which occur during the transportation of hazmat is considerably high (39%), then the accidents in the technological process (24.5%) and during the storage (17.4%). The analysis also indicates that accidents with flammable hazardous materials make up 69.4% of all accidents, then with the toxic substances 29.5% and corrosive with 10.4% [6].
According to the statistical data of US Hazardous Materials Information System, during the period from 1993-2004, the most common classes of hazardous materials, which have appeared in the accident during the transport of hazmat are materials of Class 2 (the flammable gases under pressure), class 3 (flammable liquids), class 8 (corrosive materials) and class 6 (toxic and infectious materials).

3 OBJECTIVE

The aim of the paper represent a response to the need for quality and accurate information about the possible consequences that can occur during transportation of hazmat.
The focus of the work will be aimed at analyzing approach for risk analysis during transportation of hazmat. Based on the risk analysis, consequences can be predicted and the accident development, and thereby raises the awareness of the risk which may be exposed to people, property and the environment.

4 RISK ANALYSIS OF ACCIDENTS DURING TRANSPORT OF HAZMAT

The release of hazardous materials on site can pose a significant threat to the health of the surrounding population. There are many risk factors for emergency response in the accident during transport of hazmat, and they include chemical, physical, and toxicological properties of materials, the ability of personnel, transport characteristics, weather conditions, traffic status, emergency plan, people distribution, and an overall security, etc. During the accident, it is necessary to determine the affected area that can be exposed to the harmful effects of the accident. Determination of endangered area is the main condition for the planning and organization of evacuation, and further formation of the protection zones, i.e. suppressing accident consequences (see Fig. 1) [7].

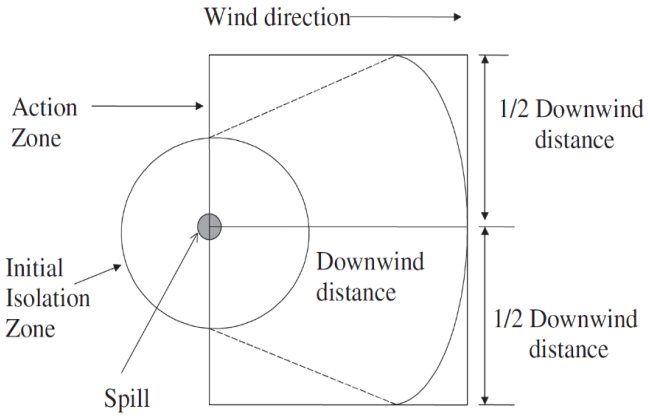

***Fig. 1** Determination of endangered area in the vicinity of the location where the accident happened [7]*

A comprehensive system framework for determination of accident response during the transportation of hazmat by road traffic is shown in Figure 2 [8].
First, it is necessary to identify the possible scenarios according to the types and amounts of transported hazardous materials, the characteristics of traffic information, weather conditions, transport vehicles, the driver skills, environmental sensitivity, density, zones of influence, etc.
Second, assessment the probability of an accident for the transport of hazmat is an essential step to determine the possibility for the occurrence of an accident, which refers to the flammable and explosive hazardous materials, which are manifested by the release and leakage into the environment and the possibility of ignition.

Third, determination the consequences of an accident during the transport of hazmat by road is a major step in order to assess the risk according to the amount and properties of the hazardous material, the state of traffic and environment, weather conditions and so on. Also, it is important to choose the appropriate fire and explosive models and scenarios, and then calculating the probability of mortality due to thermal radiation or explosion.
Fourth, the exposure of the population in affected region should be shown and described, according to the defined scenarios, and the result of analysis.
Fifth, based on the determination of population mortality due to accidents during transportation of hazmat, it should be calculated individual and social risk.
Finally, a risk assessment of an accident in the transportation of hazmat can be determined a proper manner of emergency response [8].

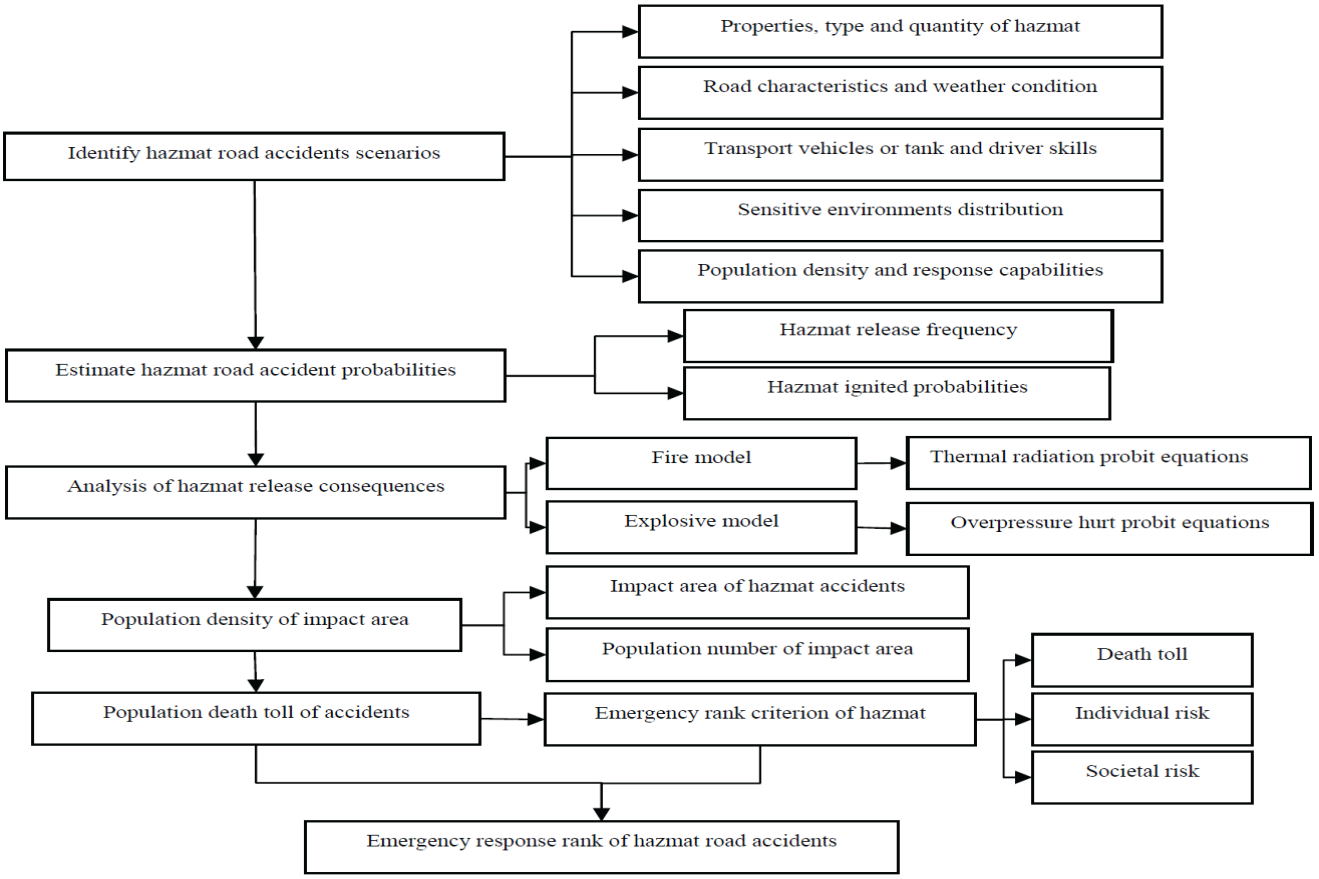

Fig. 2 *General framework of emergency response rank for hazmat road accidents*

4.1. Development of scenarios for possible accidental situations during transportation of hazmat

Scenarios for accidents during transportation of flammable and explosive hazmat are mainly associated with the type and quantity of hazardous materials. Figure 3 shows the possible outcomes for that type of accidents. In the case of flammable liquids, for the instantaneous and delayed ignition, the final outcome is a puddle fire with the potential effects of thermal radiation. Ignition of evaporable gases will result in several possible outcomes, as the vapor cloud explosion, fire balls, BLEVE effect, etc.

4.2. Determination affected zone near accidents during transport of hazmat

According to NFPA 471, control zones of hazmat incidents are divided and established based on criticality and risk level at all hazardous materials incidents [9]. The committee has used the terms cold, warm, and hot to describe these zones because the words are easily understood and clearly suggest the nature of the situation one would expect to encounter within the zones. The relationship between these zones at the incident site is shown in Fig.4. This diagram of control zones

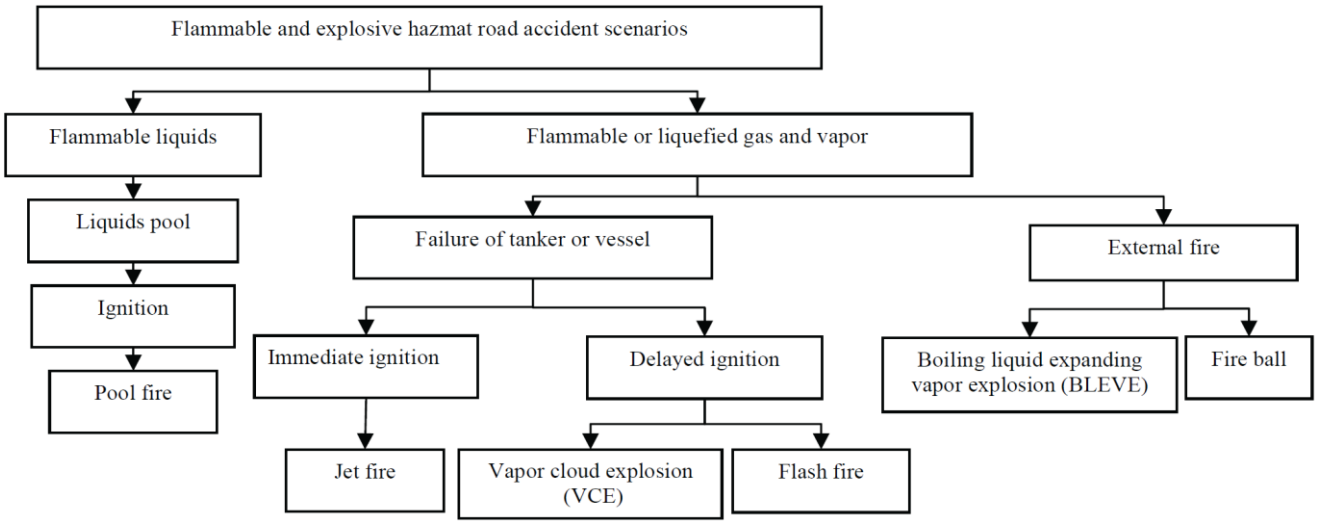

Fig. 3 *Accident scenarios of flammable and explosive hazmat by road*

show the cold zone contains the command post and such other support functions as are deemed necessary to control the incident.

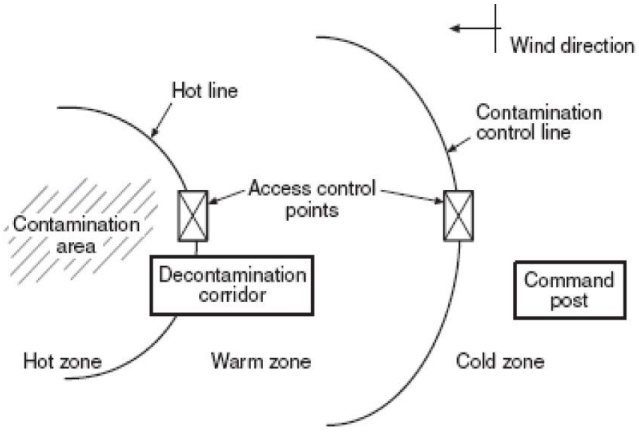

Fig. 4. *Control zones shown in relation to the incident site from NFPA471 [9]*

5 CONCLUSION

Government and industry alike, see a need for safety and policy analysis to plan the minimum risk movement of these dangerous materials over the world's network of highways, railroads, waterways, and other ways of transportation.

In case of hazmat road accidents, hazmat release consequences always are catastrophic, and a great lot people have to be evacuated and protected. Therefore, it is very important to firstly determine emergency area and response rank of hazmat road accidents, which helps optimize emergency resource and carry out some reasonable emergency action.

In order to transport hazmat, we must take into account and estimate the following main aspects:

- the technical base of type of transport;
- length of the road;
- the cost of the shipment;
- the preparedness and knowledge base of the staff;
- route;
- climate conditions;
- the level of probable damage.

The vital point of accident prevention and emergency rescue is to study and analyze the transportation risk involved.

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Contact address:
Nikola Mišić,
Faculty of Occupational Safety in Niš
18000 NIŠ
Čarnojevićeva 10a
E-mail: nikola.misic@znrfak.ni.ac.rs