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Problems and risk management options for the transport of dangerous goods

Summary

This article examines the advantages and disadvantages of rail and road transport as options for carrying dangerous goods. A procedure for managing the risk when transporting hazardous freight has been developed.

Keywords: risk management, risk assessment, transportation of dangerous goods

Introduction

The transport sector is an essential component of the global economy and is often used for its development. In every contemporary society the level of economic growth is directly proportional to the quantity and quality of the transport infrastructure. In order to fulfill the needs of the increasingly progressing world economy, both short and long distance transportation of dangerous goods is often required.

The carriage of goods by land is always accompanied by a certain risk of an accident but if these goods are hazardous there is also the possibility of spillage which in turn leads to risks of fire, explosions and environmental damage.

The main task in the transportation of dangerous freight is to ensure security by minimizing the risk when carrying it along the entire route. This primary goal can be achieved by guaranteeing the security of all safety aspects for trouble-free transport of hazardous goods under normal conditions /packages; filling and degree of filling; marking and labeling; mixed loading; technical equipment; special safety equipment; fixing transport; driver training; loading, overloading and unloading; documents/. All of the elements mentioned above have the same connection with the accident and this relationship depends on the intensity of their impact.

The aim of this paper is to examine the advantages and drawbacks of rail and road transport as alternatives for carrying dangerous goods as well as to develop a procedure to manage the risk of the transportation of such freight by ground transport.

1. Selection of the mode of transport for the carriage of dangerous goods

When analyzing the accidents related to the transport of hazardous freight, it is essential to determine the type of transport.

Rail is the most efficient way of transporting goods over long distances and long routes. However, in the case of an accident, it can cause a range of health related, physical, and environmental and other types of damages. Because of the additional risks posed by the large amount of cargo being carried, the degree of injury and damage can be very high.

Road transport provides fast and urgent delivery of goods and cargo and is characterized by high flexibility and maneuverability, the ability to determine the route and the delivery time, furthermore rail, air and sea transport normally require its use. This type of transport features the possibility of organizing the deliveries of small packages by simply using vehicles with smaller loading capacity in order to reduce the delivery time. Very often when the dangerous goods are

being delivered by road, they pass through urban routes with heavy traffic, large commercial and industrial sites, schools, residential and public buildings. Therefore the occurrence of an accident is a precondition for the appearance of significant damages and casualties.

The choice of mode of transport requires an analysis of the technical and economic characteristics of the different types of transport, focusing on the following points: features of the vehicles, specifics of the operation, economic efficiency and others. [3, pp. 80]

On this basis, it becomes necessary to solve the following dilemma – shipping a large amount of cargo in one course using rail transport or the same amount of cargo being transported in small consignments by road. [2]

The first option includes higher costs, and the second is accompanied by a higher probability of accidents - hence the occurrence of possible damages.

The amount of dangerous goods that are being transported and the likelihood of an accident are both influential and are risk factors (as well as the probability of an accident and the severity of the damage it can cause).

Possibilities to reduce the first risk factor include:

- Increasing the amount of a load, which will reduce the number of shipments and thus the probability of an accident;
- The proper selection of a route which is less populated, outside of any industrial sites and nature reserves and with good driving conditions;
- Full information on climate and season in order to avoid slippery roads in winter /when the likelihood of an accident is twice as high/ and to restrict travels considering the temperature on traffic routes provided that the hazardous cargo that is being transported is dependent on the temperature;
- Providing quality packaging and reliable attachment of dangerous goods, which will reduce potential harm to people and the environment.

Regarding the appearance of the second risk factor / the potential damage /, the risk can be reduced by:

- Reducing the amount of cargo in each shipment, since smaller quantities of dangerous goods will lead to a lower level of damage in the case of an accident. This in turn leads to an increase in the number of shipments which on the other hand is not an effective solution from an economic perspective /the result of reducing the risk in this possibility is practically equal to a reduction of the likelihood of reducing the risk of an accident /;
- Ensuring the quality of the packaging, the loading and the securing of the dangerous goods;
- Correctly selecting the route.

Often after an analysis it is established that the first ways to reduce the two risk factors are contradictory with each other, resulting in the price becoming a leading criterion when choosing the mode of transport.

There are hazardous materials /e.g. waste / that do not cost much, but exist in large quantities which makes it possible that the cost of the transport exceeds the price of the material. In this case, the sender often chooses the cheaper transport. Any mistake can bring great losses to the organization and for that reason the manager or the freight forwarder should have a good knowledge of logistics, economics and organization and management of transport.

When analyzing the problems associated with the use of combined transport, the importance of route planning is emphasized. There should be a minimum number of overloads, storages and stops during the transportation, which can be achieved with modern methods and ways of packaging – using containers for instance.

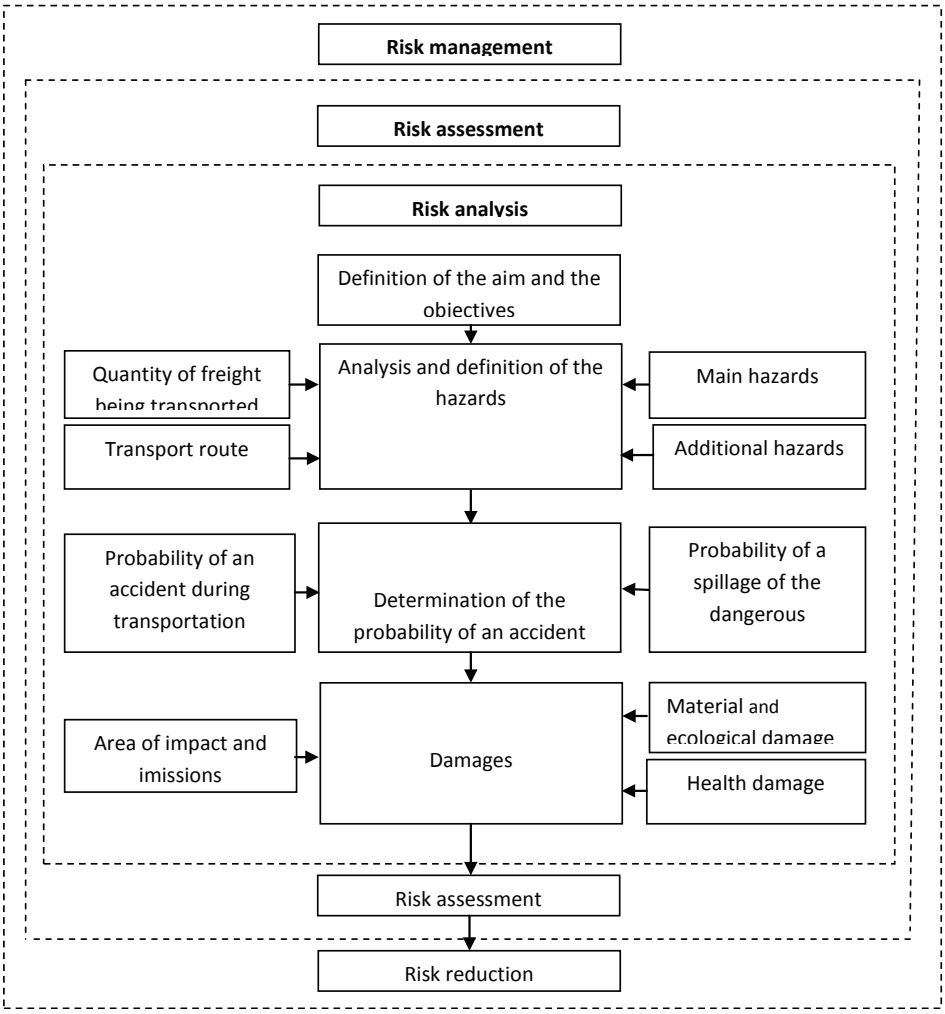
2. Risk management in the transportation of dangerous goods by road

Risk management in the transportation of dangerous goods is essential and a necessary condition for ensuring the security and safety during their carriage. In order to manage this risk successfully and accordingly reduce it to safe levels, it is necessary to analyze all types of hazards that may occur at various stages during the transport of dangerous goods.

The main stages of the procedure for managing the risk (Figure 1) are:

- Risk analysis;
- Risk assessment;
- Risk reduction.

Fig. 1. Procedure for risk management



Analysis and assessment of the risk require considerable amount of information. Basic information should include data on:

- The amount and type of dangerous goods;
- Characteristics of the designated transport route /hazardous areas, residential areas , weather and climate/;
- Alternative traffic routes;
- The number of incidents on the route for a certain period of time;
- The location and composition of the rescue services on the route.

The route has to be divided into individual road segments (these are separate road sections of the route with approximately the same characteristics) in order to make a precise assessment of the risk.

Identification of the hazards requires identifying all hazards, hazardous situations and hazardous events associated with the transport of the amount of dangerous freight with the selected type of land transport. For this purpose data for the types of hazards that may occur in case of a spill of the transported dangerous goods is required, as well as secondary hazards that can be activated depending on the location of the accident and the presence of hazardous sites in the impact area.

The probability of an accident is determined by the probability of a road accident, the probability of a spillage of the dangerous goods and the possibility of an explosion or fire with the following formula: [4]

$$P_i(I) = P_i(A).P(B|A) \quad (1)$$

where : I – random event accident;
A – random event road accident (RA);
C – random event spillage;
i – number of the road segment on the selected route.

The probability of road accidents on the route is defined as:

$$P_i(A) = \frac{N_i}{tr_i} \quad (2)$$

where: N_i – number of RA in the i-th road segment;
tr_i – traffic in the i-th road segment,
for a specific time interval.

It can be interpreted as the number of collisions to the total number of vehicles that have passed.

Spillages after the occurrence of a road accident are random events that are a realization of a random variable that has a Poisson distribution [1, pp. 14–22]

$$P(n) = \frac{(V.L)^n}{n!} e^{-VL} \quad (3)$$

where: n – number of spillages;
V – coefficient, which is determined by statistics /average number of spills per unit of length per unit of time /;
L – length of the route, m.

Formula (3) shows that for determining this probability, the presence of statistics on spillages that occurred under these conditions is necessary.

In order to determine the amount of damages, it is necessary to determine the impact zone of the accident, as well as the objects of infrastructure and people caught in this area. The shape and size of the area of impact depend not only on the substance which is being transported, but also on other factors

such as topographic relief, infrastructure, time, speed and direction of wind and others.

Various geometric shapes are used to describe this area. Traditionally, the area of impact is expected to be a circle centered at the scene of the accident and is accepted to be called "Dangerous Circle". [5, pp. 1–5] The estimated radius [6] of hazard is an important assessment, which determines the material and environmental damage, and the number of vulnerable people in the use of a specific route. The radius depends on the type of dangerous goods being transported, their amount and the time of impact on people and objects found in the "Dangerous Circle".

The risk assessment for each road segment of the route is calculated by the formula:

$$R_i = P_i(A).V_i(A) \quad (4)$$

where: $P(A)$ is the probability of damage A in the i-th road segment;

$V(A)$ – severity of the damage A in the i-th road segment.

The risk assessment for the entire route is calculated by the formula:

$$R = \sum_{i=1}^{n} Ri \quad (5)$$

where: Ri – total risk in the i-th segment,

n – number of segments.

Risk reduction is a lowering of the risk, which involves the application of methods and means for prevention and limitation of the damages. In this case this is achieved mainly by changing the route and time for transportation.

Based on this study, we can conclude that risk management in the transportation of dangerous goods by road should primarily focus on its reduction within the normal range, which can be achieved on the basis of:

1. The right choice of land transport depending on the type and the amount of dangerous goods being transported and the length of the route for their transportation ;
2. The correct choice of the optimal traffic route, taking into account the density, type and characteristics of the existing transport network. The optimal route for traffic on the one hand should be with minimal risk - satisfying the public, on the other hand – at minimal cost – satisfying the business;
3. The choice of the time of the day for the transportation of the dangerous goods, taking into account the traffic flow and the population density on the selected route at different times of the day.

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