

ROAD SAFETY OF THE TRANSPORT OF DANGEROUS GOODS - SOME ASPECTS

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Abstract

The subject of the research is the analysis of the impact of various factors on road safety of the transport of dangerous goods. The causes and circumstances of various types of road incidents involving vehicles transporting hazardous materials as well as technical states of vehicles has been analysed. The traffic incidents and their effects in period of 2014 - 2018 in Poland in three provinces have been analysed. Examinations on the technical conditions of vehicles adapted for the transport of dangerous goods in various age groups were carried out in the years 2007 - 2018. The results of road accidents usually depend on the types of vehicles and the collision geometry as well as the collision speed. Around 1,400 road incidents involving vehicles carrying dangerous goods have been recorded in Poland every year. Most of the accidents that have been analysed took place in the urban areas. Accidents involving vehicles carrying dangerous goods pose a risk not only for those participating in them, but also for the population and infrastructure of the neighbourhood. Most collisions were caused by errors of road users not related to the transport of dangerous goods. The analysis of traffic incidents in urban areas has shown that collisions occurred at road intersections of the same type. The results of the accidents depended mainly on the speed of crashing. Considering the threat arising from the type of cargo, due to speed limits resulting from traffic intensity, the results of accidents in urban areas were less severe compared to accidents in non-urban areas. The causes and effects of road collisions in non-urban areas were associated with the speed at which vehicles were moving and their technical conditions.

Keywords: Road transport, road safety, dangerous goods

1. INTRODUCTION

The road transport is important for economic and social development of each country. In addition to the undoubted benefits, the development of road transport creates new problems related to road safety and environmental protection. The traditional approach to the topic of transport safety includes: engineering, enforcement, and education. However, this issue cannot be analyzed without considering economics, emergency response and enablement [1]. The assurance of road safety as well as direct and indirect costs of removing the negative effects of road incidents constitutes a significant part of global transport costs. The costs are also generated by available data collecting necessary to conduct research on ensuring safety in transport. The enablement of research results in cultural and social environment supports activities aimed at improving road safety. The transport of dangerous goods requires special attention of the potential hazard that it can pose in road traffic and for the environment.

The prevention related to ensuring safety of the transport of dangerous goods can be classified into four groups: development of regulations and compliance to them, training of drivers and supervisory staff, proper maintenance and periodic examinations of vehicles and equipment, maintenance of traffic engineering including network of roads designed for transport of dangerous goods [2]. The requirements for the special technical equipment of vehicles, the qualifications of drivers and supervising personnel as well as classification of dangerous goods, the load methods, specific documentation to be provided in case of accidents are specified by national regulations and international agreements. In Europe the legal requirements for the

transport of materials posing a potential hazard due to their properties in both local and international road traffic are specified in the agreement concerning the international carriage of dangerous goods by road (ADR) [3]. Striving to minimize costs and reducing transport time require choosing the optimal route. However, these routes often connect and pass through major urban areas. The choice of route that minimizes both the risk to the public and the travel time is a major challenge. The route selection can be assisted by decision supporting systems. The main task of these computer systems is to extract a large amount of data and all necessary information to support the decision making process. The risk calculation includes geographical, demographics and meteorological data. The use of appropriate models can assist in risk analysis in emergency planning [4,5]. Systems supporting the organization of dangerous goods transport take into account local climate, geographical and road network conditions [6,7,8].

The location of vehicles transporting dangerous goods, especially in urban areas, is a separate issue. Controlling the movement of vehicles in real time allows to update the input data of supporting system and to respond to changes in traffic situations [9,10]. The effectiveness of the use of a vehicle movement control system depends on being applicable to all vehicles.

The safety of the transport of dangerous goods may depend on the technical conditions of vehicles, road infrastructure, route network, choice of routes as well as driver's skills and responsibility. The recognition of direct and indirect causes of road incidents may contribute to increasing road safety. Studies that have been carried out can provide data for analyzing the possibilities of limiting the number and the effects of road incidents involving vehicles which transport dangerous goods.

2. SCOPE OF RESEARCH

Examinations on the technical conditions of vehicles intended for transport of dangerous goods in various age groups and categories were carried out in the years 2007 - 2018. The tests were carried out during periodic examinations of vehicles at vehicle control stations in scope of road safety. Altogether, 63 vehicles were tested: 43 vehicles having a maximum mass exceeding 12 tons (category N3) and 19 trailers with maximum mass exceeding 10 tons (O4). Vehicles of all categories were tested applying devices used at vehicle inspection stations and road tests. The examinations included tests of the braking system on the roller device, road tests, measurements of braking deceleration during the road tests, examinations of ABS systems during road tests (only for trailers), testing the action of retarder during a road tests. The results of tests have been compared with the results of tests which were carried out for vehicles without dangerous goods licenses.

According to the World Health Organization road incidents have been analyzed in three categories: road traffic accident, road traffic crash and road incidents without serious financial consequences. The road traffic accident has been defined as a collision involving at least one vehicle in motion on a public or private road that results in at least one person being injured or killed. Road traffic crash has been defined as a collision or incident that may or may not lead to injury, occurring on public road and involving at least one moving vehicle. The third category has been introduced because some of incidents do not have serious consequences for vehicles or people but the transport process has been disturbed. This category is not included in the WHO glossary of terms.

Road incidents involving vehicles transporting dangerous goods in 2014-2018 were taken into account. The change of the number of road incidents has been assessed by determining the accident rate. Accident rate has been defined as a number of road incidents related to the total weight of transported goods. For the three areas with the highest number of road incidents, the causes of incidents have been analyzed taking into consideration direct perpetrators, technical conditions of vehicles, traffic situations and topography of the road network.

3. RESULTS OF THE RESEARCH

3.1. Technical conditions of vehicles

During control tests of vehicles intended for the transport of dangerous goods, defects that could affect road safety were found only in 5 vehicles (this is about 8 % of the vehicles that have been tested). The faults concerned the electrical system, indicators and lights. Faults related to the braking, steering or suspension systems which could have an impact on road safety were not identified. The faults found were not a direct threat to road traffic and were associated with typical damage occurring during the use of vehicles, not related to the quality of vehicle maintenance. However, it should be noted, that during the examination of vehicles the additional equipment of tanks for the transport of liquid fuels or gases were not checked.

For comparison, in the control group of vehicles the same categories (N3, O4) not intended for the transport of dangerous goods, serious defects were found in 26 % of vehicles.

3.2. Structure of road incidents

In 2018, 31,674 road incidents were reported in Poland. The number of road incidents has been decreased systematically. In 2018, 31,674 road incidents were reported. In relation to 2014, the number of road incidents were decreased by 10 % but in relation to 2009 28 % decrease can be noticed. The road incidents involving vehicles transporting dangerous goods represent about 0.05 % of the total number of road incidents and the number of these systematically grows. The number of traffic incidents and their effects have been shown in **Table 1**.

Table 1 Road incidents involving vehicle transporting dangerous goods

Year	Incidents	Fatalities	Seriously Injured	Slightly Injured
2014	1327	26	94	226
2015	1344	17	94	289
2016	1324	13	106	278
2017	1423	14	99	257
2018	1481	16	102	307
Total:	6899	86	495	1357

In 2018 the highest number of road incidents involving vehicles transporting dangerous goods was recorded in the Lower Silesian (246), Lodz (240), Silesian (200) provinces while the highest total number of road incidents was recorded in the Lodz (4600) and Lesser Poland (4003) provinces.

Within five years in Lodz province there were 1117 incidents involving vehicle transporting dangerous goods. The most incidents were recorded in Lodz city at three intersections with similar road layout. These are at-grade intersections with two-way streets. A similar situation can be observed in Wroclaw. The most road incidents were at the three intersections with the same type like in Lodz. In Silesian province the most road incidents were on straight sections of the road in city centres and districts with old buildings and road networks.

3.3. Causes of road incidents

The causes of road incidents has been analyzed of the example of Katowice. The cause of most traffic incidents was the failure to yield right of way, almost 32 % (**Table 2**). All incidents were not caused by drivers of vehicles transporting dangerous goods. All vehicles transporting dangerous goods were in good technical conditions.

Table 2 Main causes of road incidents involving vehicles transporting dangerous goods in Katowice (2014-2018)

Causes of road incidents	Number of incidents
Failure to yield right of way	55
Improper following distance	27
Incorrect passing	13
Improper overtaking	6
Improper changing of lanes	6

In 20 cases, minor technical failures of vehicles not transporting dangerous good were found. Incorrect pedestrian behavior caused 25 road incidents.

4. DISCUSSION

In 2014-2018 in the countries of The European Union (EU) 397,711,000 tons of dangerous goods were transported. About 80,000,000 tons of goods are transported every year. Germany and Spain are leaders in the transport of dangerous goods. In Poland the transported mass of this type of cargo is comparable to Great Britain, France and Italy. In terms of type of load, the largest percentage of transported mass are flammable liquids (54 %) and gases (18 %). About 85 % of cargo is transported by tank trucks. In Poland, in 2014-2018 42,567 tons of dangerous goods were carried which is about 10 % of the mass of transport in the EU.

Road incidents involving vehicles transporting dangerous goods represent a small percentage of total number of accidents. However, this type of road incidents can be very dangerous due to potential threats to the people and the environment. The trends in changes of the number of accidents can be characterized by the accident rate (Table 3).

Table 3 Accident rate - the number of road incidents related to the weight of transported dangerous goods

Year	Weigh of transported dangerous goods (t)	Number of road incidents	Accident rate
2014	8778	1327	0.151
2015	9174	1344	0.146
2016	8444	1324	0.156
2017	8785	1423	0.161
2018	7386	1481	0.201

Examples from Lodz and Wroclaw of the places where collisions often occur indicate that apart from direct reasons caused by traffic participants, the type of road network and intersection layout are important.

Intentions aimed at improving road safety should concentrate on reversing the unfavorable trend of increasing the accident rate. If it is not possible to limit the movement of vehicles transporting dangerous goods, the solution to improve road traffic safety may be the adaptation or use new traffic control systems with permanent controlling of vehicles with hazardous cargo. This seems to be the only way to reduce the number of collisions.

In the analyzed cases of road incidents, except for cases of unpredictable damage of special equipment of vehicles, there were no deficiencies related to the technical conditions of vehicles and their equipment. Most of the vehicles that were examined were in good technical conditions. Also, the analysis of the causes of collisions has not shown that the technical conditions of the vehicles were the causes of road incidents.

Observance of the correct methodology of performing tests and extending the scope of tests allowed to detect inefficiencies in vehicles that could be considered as efficient during routine, periodic inspections. Apart from road tests related to testing ABS systems and retarders in trucks, the tests were carried out at vehicle inspection stations using measuring devices that are the standard equipment. However, in the case of damages of ABS systems or retarders, defects may not be detected due to the lack of an appropriate testing methodology. The change in the criteria was important for the assessment of the technical conditions of vehicles.

5. CONCLUSION

In the analyzed cases of road incidents, except for cases of unpredictable damages of special equipment of vehicles, there were no deficiencies related to the technical conditions of vehicles and their equipment. The increase of the number of road incidents involving vehicles transporting dangerous goods is a problem that should be resolved in the nearest future. The increasing number of collisions is not related to the amount of transported freight but rather to the overall increase of traffic. In the analyzed cases of road incidents, the causes of the collisions were not related to the level of drivers' training or the technical conditions of vehicles transporting dangerous goods. One can observe a lack of awareness among other road users that causing a collision with a vehicle with a hazardous cargo can have much more serious consequences. Special marking of vehicles with hazardous freight should be properly interpreted by both the drivers and the pedestrians.

Despite the relatively small number of collisions involving vehicles carrying dangerous goods, increasing tendency should not be underestimated. It should be kept in mind that the effects an accident in an urban area can be catastrophic.

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