

SAFETY OF THE ROAD TRANSPORT OF DANGEROUSGOODS

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ABSTRACT

The number of various kinds of dangerous goods, which require proper transport, is still growing. Their transport may present potential hazard to human life and health as well as to the environment. A degree of this danger tends to differ depending on what kind of substance is transported and what kind of consequences it has if it reaches the environment. The objective of this article is to depict safety rules related to transport of hazardous materials by road in Poland. A panel of Polish experts representing the ministry implements principles concerning carriage of dangerous goods in order to provide the highest level of safety possible. A plethora of legal documents include those recommendations. The author of this article intends to explain and evaluate measures that have been undertaken so as to analyze the risk, develop standards and safety regulations, provide surveillance and show guidelines for specialists with regard to risks in road transport with a view to increasing safety of dangerous goods transport. The reasons why not only implementation of guidelines is significant, but also monitoring and specifying safety demands will be pointed out.

KEY WORDS: road transport; road transportation safety; road transportation of dangerous goods

Introductions

Considering the total amount of the load, which is transported with the help of road transportation in Poland, the percentage of dangerous goods involved in it is estimated around 10% [1]. Transport of this kind implies the necessity to implement innovative technologies, whose fundamental task is to increase transport safety. Road transport, which is becoming more and more popular, plays a crucial role. The intensified increase of this branch of transport is primarily a result of new petrol stations that are built each year as well as specialized enterprises, which deal with their production, distribution, and trade.

Considerable amounts of liquid fuels, fuel gases in a liquid form, ammonia, chlorine, hydrocyanic and other toxic or explosive substances are transported on our roads every day [2]. Gases and liquids with low ignition temperature are listed as most hazardous materials. The aforementioned issues imply that carriage of dangerous goods entails potential danger to life and health of people as well as to the natural environment. A degree of this danger tends to differ depending on what kind of substance is transported and what kind of consequences it has if it reaches the environment. Such a danger poses a challenge to a number of entities, which constantly monitor and attempt to increase the safety level of road transport of dangerous goods.

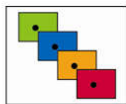
The objective of this article is to depict safety rules related to road transport of dangerous goods in Poland. It requires presenting brief characteristics of hazardous materials, specifying legal regulations pertaining to road transport of those materials (including the amendment of the European agreement concerning international carriage of dangerous goods), as well as showing ways of transport and vehicles labeling. The author intends to pinpoint the data illustrating the safety level of road transport of dangerous goods and possible changes focused on improving transport of dangerous goods by road.

Dangerous goods – general characteristics

In Poland regulations regarding transport of dangerous goods, demands imposed on drivers and other people engaged in such transport as well as appropriate institutions which monitor them are described in the act of 19th August 2011 *on transport of dangerous goods* (Journal of Laws of 2011, No. 227, item 1367, as amended).

According to Article 4 of this act, with regard to issues which are not regulated by act on road transport of dangerous goods, the basic international legislative act related to transport of dangerous goods is applied – the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR – *fr.L' Accord européen relatif au transport international des marchandises Dangereuses par Route*). The document is regularly modified and the latest version entered into force on 1st January 2015 (amendments enter into force every two years and new changes take effect on 1st January of an odd year – therefore the latest version will enter into force on 1st January 2017. Nevertheless, during first six months it is acceptable to conform to the previous version).

Dangerous goods are defined as *materials or items, which in accordance with ADR treaty, RID treaty or AND treaty are not permitted to be transported by road, by rail or by inland sailing or they are restricted under the conditions specified in those treaties* [3]. Dangerous goods include all items and commodities that present hazard to transport and have the UN number. The UN number is a four-digit number that identifies dangerous goods [4].



Dangerous goods are substances which due to the fact that they contain hazardous properties (chemical, physical or biological) may pose a danger to health, contribute to death, contaminate the natural environment or cause severe material losses if not properly handled in transport or storage. Those kinds of materials are commonly used and their transport present enormous hazard to people and the environment.

Hazardous substances and items are chemical elements or effects of chemical reactions as well as mixtures consisting of chemical substances, which are classified based on their adverse impact on human health or natural environment. This impact has a lot to do with peculiarities of particular products (physicochemical, toxicological and eco-toxicological properties) [5].

Dangerous substances are chemical elements and their compounds in the states, in which they occur in nature or are obtained through production processes. At times substances can be mixtures, for example products of chemical reactions broken into separate compounds (e.g. isomers, alcohols, fractions of petroleum distillation). Dangerous substances are classified as one of danger categories stipulated in the act of 11th January 2001 *on substances and chemical products* (Journal of Laws of 2001, No.1, item 84, as amended). Whereas dangerous products are mixtures or solutions consisting of two or more substances, wherein one of them is a dangerous substance [6].

Another term which is of crucial importance while discussing this subject is dangerous waste, which is categorized as a dangerous item on the condition that it meets the conditions set out in the definition of dangerous goods provided by ADR. At the moment two different classifications are used [7]:

- Classification as per legal regulations stated in the ordinance by the minister of environmental protection, natural resources and forestry of 24th December 1997 *regarding waste classification* (Journal of Laws of 1997, No. 162, item 1135) the waste is classified taking into account its source, therefore it is divided into 20 groups. The first two digits signify a waste group that indicates its source. Marking a waste group together with next two digits identifies a subgroup, whereas a code consisting of six digits identifies a waste type.
- Classification for transport purposes in accordance with ADR agreement. The fundamental principle indicates carriage of waste that is considered hazardous according to regulations concerning the waste from places of its formation to recover facilities or places where the waste is incapacitated, taking into account current regulations applied to transport of dangerous goods.

Materials or items enumerated on the ADR list of hazardous materials or those classified in accordance with the aforementioned regulations are regarded as dangerous materials. Annex A of the ADR agreement includes the division of all hazardous materials produced in the world into 13 hazard classes as well as it shows a detailed classification of those materials in particular classes (depending on their properties and hazard that they cause). Particular groups are presented in table 1.

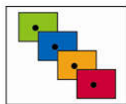
Class 1.	<i>Explosives.</i>
Class 2.	<i>Gases.</i>
Class 3.	<i>Flammable Liquids.</i>
Class 4.1.	<i>Flammable Solids.</i>
Class 4.2.	<i>Spontaneously Combustible Solids.</i>
Class 4.3.	<i>Dangerous when Wet..</i>
Class 5.1.	<i>Oxidizing Agent.</i>
Class 5.2.	<i>Organic Peroxide Oxidizing Agent.</i>
Class 6.1.	<i>Poison.</i>
Class 6.2.	<i>Biohazard.</i>
Class 7.	<i>Radioactive.</i>
Class 8.	<i>Corrosive.</i>
Class 9.	<i>Miscellaneous.</i>

Table 1. Classification of dangerous goods [8]

Detailed information pertaining to specific materials and items belonging to particular classes are given in special regulations related to particular classes, in chapter 2.2. of ADR.

Carriage of dangerous goods by road

One of the types of hazard in the road transport system is hazard stemming from relocating hazardous substances (table 2). Carriage of dangerous goods by road means *every transport of dangerous goods by vehicle on the public road or other common roads including stops required during transport and other activities related to this transport* [9].



<i>Scope of hazard</i>	<i>Type of hazard</i>
Reliability of cars	<ul style="list-style-type: none"> - hazard stemming from a car construction; - hazard stemming from technical condition of a car; - hazard stemming from technical equipment of a car;
Technical condition of roads	<ul style="list-style-type: none"> - hazard of obstacles on the road; - hazard of a collision of a vehicle at unguarded railroad crossing; - hazard stemming from extreme weather conditions; - hazard stemming from insufficient road markings; - hazard of obstacles on the road (ranging from left vehicles to damage of the transport route as a result of a natural disaster);
Transport Technology	<ul style="list-style-type: none"> - hazard stemming from non-compliance with transport regulations in the course of carriage; - hazard stemming from non-compliance with road traffic regulations; - hazard stemming from non-compliance with regulations in the process of loading and unloading;
Type of transported goods	<ul style="list-style-type: none"> - hazard stemming from carriage of dangerous substances; - hazard stemming from transport of load with a special mode of transport;
Others	<ul style="list-style-type: none"> - hazard of terrorist attacks; - hazard of a military conflict.

Table 2. Kinds of the risk in the system of the road transport [10]

In order to cut back on hazard in road transport of dangerous goods, it is essential to strictly observe safety rules which are part of currently applicable regulations, that is among others proper marking of transport vehicles adequate to the type of transported goods.

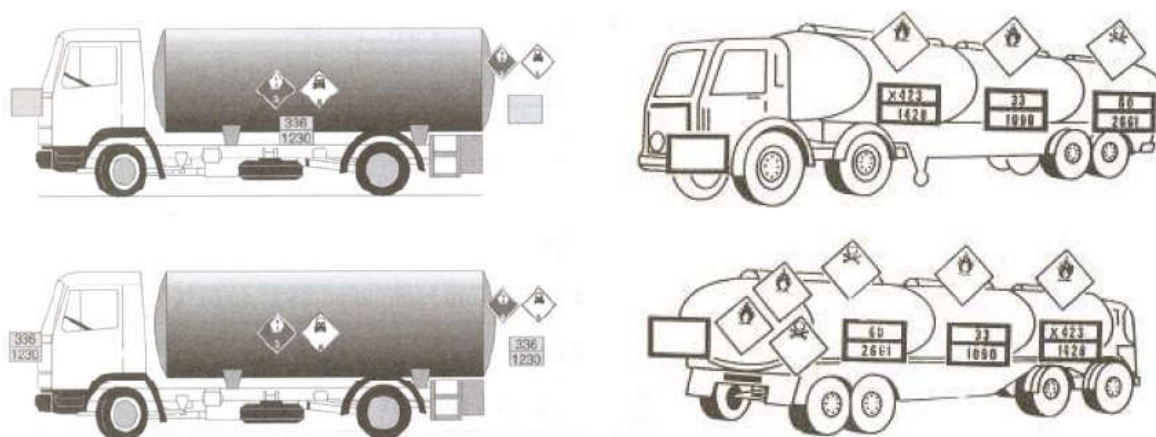


Fig. 1. Examples of labeling of vehicles carrying dangerous goods [11]

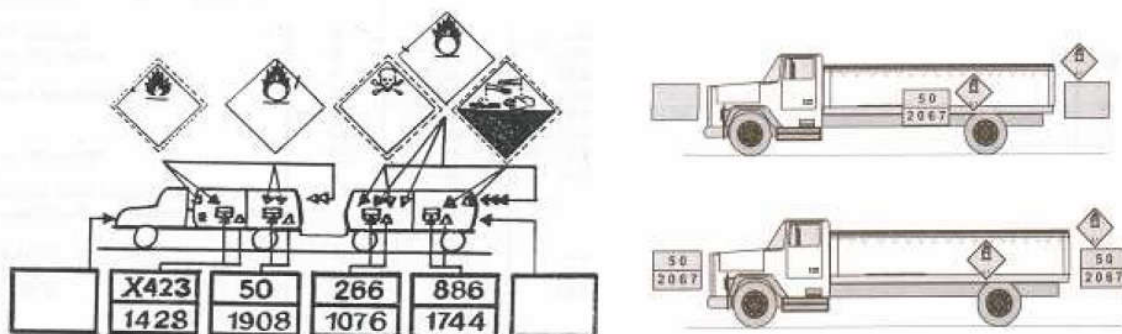
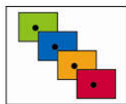


Fig. 2. Description marking tanks [12]

Each entrepreneur who is a sender or a carrier of dangerous materials and products is obliged to appropriately secure and label packages. Means of transport executing transport of dangerous goods are expected to be adapted, fitted and well-marked in accordance with ADR, except for vehicles belonging to armed forces that execute domestic transport of dangerous goods [13].

The ADR agreement governs regulations pertaining to appropriate marking of transport vehicles, which carry hazardous materials (e.g. tank trucks). Each of them should be marked with orange reflective warning plates of size 400x300 mm with danger identifying numbers (the upper part) and the UN code, that is an identifying number of hazardous materials (the bottom part). Plates should be placed on both lateral walls of a tank truck.



Fig. 3. ADR board for the transport of petrol [14]

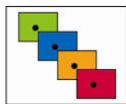
A two- or three-digit identifying number, which is placed on the upper part of a plate, specifies potential hazard of a transported item. Particular digits signify:

- 2 – gases;
- 3 – flammable liquids;
- 4 – flammable solids;
- 5 – oxidizing substances;
- 6 – toxic or infectious substances;
- 7 – radioactive material;
- 8 – corrosive substances;
- 9 – miscellaneous dangerous substances and articles;
- 0 – no hazard.

If the transported material is characterized by only one of potential dangers, there is “zero” following a digit assigned to it. In case of extraordinary intensity of particular hazard a digit is doubled (e.g. 33 stands for extremely flammable liquids). If hazard assigned to a particular item can be sufficiently signified with the use of one digit, there is “zero” following this digit. Furthermore, a hazard number can be preceded with the letter “X”, which means a total ban on contact of the material with water (in case of a fire water cannot be used for extinguishing). As explained above:

- 30 – flammable liquid (temperature of ignition 21-100°C);
- 33 – easily flammable liquid (temperature of ignition fewer than 21°C);
- X333 – spontaneously combustible liquid dangerously reactive with water.

A number provided in the bottom part of an orange plate is so called the UN code of the transported substance. It does not contain any information on potential hazard, but it specifies a type of transported goods.



As a consequence of assigning a UN code to the goods it is possible to recognize methods of most appropriate transport, suitable packaging as well as procedures that guarantee safety in usual conditions of road transport. In order to properly choose packaging of dangerous goods, some materials classified as hazardous according to ADR can be included in so called packing groups determining the degree of potential hazard that they entail. In the majority of cases the strength of hazard is estimated in the three-level scale. Packing groups are categorized in the following way [15]:

- packing group I – greatest danger;
- packing group II – medium danger;
- packing group III – least danger.

Moreover, vehicles marked with orange reflective plates should be marked with warning labels:

- carriage of dangerous goods in bulk on a trailer – both sides and the back of a vehicle;
- carriage of dangerous goods in bulk in containers – the front and the back as well as both sides of a container;
- carriage of dangerous goods in a single-chamber tank truck – both sides and the back of a tank truck;
- carriage of dangerous goods in a multi-chamber tank truck – labels on sides of each chamber suitable for the content of a container as well as the back of a tank truck;
- carriage of dangerous goods in a tank-container – both sides as well as the front and the back of a tank-container;
- carriage of explosive goods of Class 1 – both sides and the back of a vehicle;
- carriage of explosive goods of Class 7 – both sides and the back of a vehicle.

In 2010 Transport Technical Supervision issued approx. 15,5 thousand approval certificates for vehicles for transport of dangerous goods, including tractor units as well as tank trucks [16].

Regulations of ADR formulate clear rules as how to pack, mark and prepare for transport of dangerous goods, which will be devoid of any risk in usual transport conditions.

ADR contains guidelines related to appropriate preparation for carriage of dangerous goods by road which is also adequate to conditions. Taking into consideration the aforementioned issues, the emphasis is placed on regulations pertaining to technical conditions of packaging and means of transport, that is factors influencing safety of transport regardless of a place of its execution.

Apart from this regulation, there exists the Council Directive 94/55/EC of 21st November 1994 concerning the legislative alignment with regard to transport of dangerous goods by road, including the training of vehicles drivers responsible for carrying dangerous goods.

Annex B of ADR agreement specifies the following aspects:

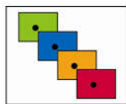
- requirements concerning the construction and approval of vehicles, including trailers, tank trucks, containers and tank-containers;
- additional equipment of transport units;
- requirements concerning vehicle crews;
- requirements to be complied with by the vehicle crew;
- documents to be carried on the transport unit;
- requirements concerning the supervision of vehicles and road tunnel restrictions.

Drivers of vehicles carrying dangerous goods can hold a certificate, stating that they have participated in a training course, provided that they are eligible as specified in the act on transport of dangerous goods by road in Article 10, item 1-2. Furthermore, drivers are obliged to pass an examination after attending a basic training course. The ADR certificate is issued by the training course provider who leads a training for the period of 5 years, beginning from passing an examination in front of the three-person board of examiners, which is chosen by the training course provider. In the year preceding the expiry date of the ADR certificate, a vehicle driver is required to complete a specialization training course. Following the successful completion of this course, the training course provider prolongs the ADR certificate or issues a new ADR certificate for the period of 5 years.

The sender was obliged to provide the carrier with a written instruction for the crew of a vehicle. The document should be in a language that is well understood by the driver as well as in all official languages of issuing countries, transit countries and receiving countries.

The instruction should include the following information:

- actions to be taken in the event of an accident or a possibility of danger;
- characteristics of risks posed by dangerous goods of all classes;
- protective equipment, general and individual, which should be carried on a vehicle;
- actions related to first aid.



Entrepreneurs who take part in the process of dangerous goods carriage have been obliged to conduct internal supervision, which implies the necessity to appoint an expert in safety of transport of dangerous goods (so called DGSA advisor) at their own expense. The adviser has to have qualifications specified in the act *on transport of dangerous goods...* of 19th August 2011 in Article 42, items 1-4. On behalf of an entrepreneur he supervises activities related to transport, loading, and unloading of dangerous goods. On 15th November 2011, 1,237 people had of a valid adviser certificate for transport of dangerous goods by road [17].

Dangerous goods in road transport in Poland

In Poland around 100 million tones of dangerous goods are carried by car transport annually. Most often tank trucks are used for transport of liquid fuels (approx. 70%), followed by acids and hydroxides (10%), liquefied gases: propane-butane, ammonia and chlorine (9%) [18]. The main routes of transport of dangerous goods by road intersect highly urbanized areas. There is a considerable amount of flammable, explosive, and even radioactive materials that are transported on our roads each day, such as:

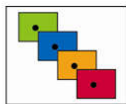
- aerosol;
- paint and solvent;
- chlorine to disinfect;
- technical gases for welding;
- plant protection products (pesticides);
- organic superoxide;
- pyrotechnical materials;
- radioactive materials used for radiotherapy;
- compressed air and oxygen for medical aid.

They are frequently transported in rush hours, close to public buildings and green areas. Breakdowns and accidents in the course of their carriage are noted more and more often. The number of breakdowns and accidents connected with carriage of such substances has risen from 220 in 2009 to 253 in the subsequent year [19].

Industrial plants are a chief recipient of dangerous chemical compounds transported primarily by tank trucks. Out of 300 plants, in which toxic agents are produced or used for production, nearly 60 of them are particularly hazardous. Consequently, hazard stemming from carriage of those items through cities appears to be grave and real. Around 40 truck loads with dangerous substances pass daily through Polish cities and their weight is 5 to 20 tons [20]. It is worth mentioning information provided by the Polish Organization of Oil Industry and Trade which indicates that the results of the official consumption of liquid fuels in Poland in the first half of 2015 showed growth (12,391 thousand m³) with respect to the same period in 2014 (11,846 thousand m³). The increase in demand for motor fuels alone amounted to 6% [21]. At the time being there are 8,863 petrol stations [22]. The largest amount of industrial toxic materials is transported near cities such as Łódź, Trójmiasto, Bydgoszcz, Kielce, Tarnów and Czechowice-Dziedzice [23]. Thus, in the vicinity of those cities special forces of the Road Transport Inspectorate are located in order to take care of safety as well as supervise and control the correct transport of dangerous goods. To illustrate the efficiency of the inspectors' work, it is worth recalling a specific event.

On 15th October, while the inspectors from the Regional Road Transport Inspectorate in Gdańsk were conducting control activities in Stare Pole, they had to stop on the strategic road number 22 to control various vehicles belonging to the Russian carrier. During the verification it became clear that in the vehicle, which was on the way to Kaliningrad, there were dangerous goods and their transport violated certain regulations to a large extent. It turned out that in the trailer there were 18 barrels, 240 kilogram each, containing hazardous substances. A plethora of transgressions were revealed, for instance lack of marking, not to mention lack of proper equipment of the vehicles and the fact that the driver did not have the ADR certificate. In addition, the driver violated the applicable working hours, therefore he received a heavy fine. Whereas the Russian carrier was required to pay the deposit amounting to 3,650 PLN owing to reported violations concerning transport of hazardous materials. The further drive was prohibited because all faults had to be corrected. Moreover, measures were taken so as to penalize the loading company as it was also responsible for the defects [24].

It seems that the need for control and supervision of dangerous goods is crucial, considering possible consequences of an accident caused by such serious negligence of transport. During a road accident it is likely that dangerous substances may leak or spread, which brings about contamination of the natural environment (surface water and groundwater) as well as it presents hazard to human life and health. Properties of dangerous goods also may contribute to an explosion of high explosive power or to a high temperature fire. Illustrative scenarios of this kind: leakage of petroleum derivative substances from a tank truck causes contamination of the river over the length of several kilometers, an explosion of a container, heated by a fire, which contains liquid gas results in the destruction of the residential area (hundreds of casualties, damage, and destruction of a large part of buildings), a spreading pall of vapor toxic gas causes poisoning (which sometimes may lead to death) of people and animals as well as contamination of the environment. Leakage of hazardous materials brings tragic consequences. That is the rationale why *a participant of dangerous goods transport is obliged to undertake vital*



safety measures with the aim to prevent hazardous situations that can harm people, properties and the environment, and in case an accident occurs they should immediately inform endangered people about it as well as a rescue team or firefighters [25]. Incidents involving hazardous materials imply the necessity for tedious, difficult and long rescue actions oriented towards eliminating the consequences of the leak as well as they require sacrificing numerous forces and spending a considerable amount of money.

It is essential to specify rules related to conducting rescue operations when chemical and ecological threats emerge in a given area:

1. Safely get to the scene.
2. Attempt to carry out quick and safe evacuation.
3. Prior to proceeding to operations, thoroughly identify the chemical substance.
4. Use only functional metrological devices.
5. Use respiratory protective equipment and protective clothing.
6. Engage in the operation only those people who have an appropriate knowledge and have taken part in an adequate training.
7. Work only in pairs. The first pair is insured by the second pair which is ready for immediate entry into the action.
8. Apply the principle of absolute priority to rescue people.
9. Protect the place of the action against a fire (as long as there is a possibility of a fire or an explosion).
10. Pay attention to even minor leaks or chemical substances puddles.
11. Carry out decontamination and clean equipment after every action.

While taking part in operations caused by accidents related to transport of dangerous goods, it is of utmost importance to keep the minimum distance from the epicenter:

- for explosive substances – min. 100 meters;
- for other substances – min. 50 meters.

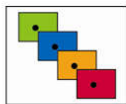
It is worth highlighting the necessity to rigorously comply with regulations included in the relevant, currently applicable legal documents. What cannot be omitted is the role of monitoring possible threats. Monitoring the situation on Polish roads allows for the systematic recording of instances of chemical and ecological threats, which are the result of non-compliance or ignorance concerning the rules of road transport of dangerous goods.

Supervision of the following aspects has an important meaning for ensuring safety of transport of dangerous goods [26]:

- classification of the goods;
- classification of the driver;
- ways of protection and placement of the goods;
- documents to be carried on a vehicle during transport of this type;
- the appropriate mode of transport and transport marking.

The executive authorities of tasks pertaining to organization, supervision and control over transport of dangerous goods are public administration entities, such as: the Managing Director of the Office of Rail Transport, province governors, marshals, the Chief Inspector of Road Transport, the State Fire Service. The province governor supervises carriage of hazardous materials by road. Whereas the marshal of the province supervises training courses for drivers who deal with transport of dangerous goods. Apart from that, the marshal serves as a governing body regarding the traffic on the roads, where transport of dangerous goods take place. The following entities control transport of dangerous goods by road as well requirements connected with it [27]:

1. inspectors of the Road Transport Inspection – on roads, parking lots as well as in the territory of an entrepreneur who possess dangerous goods;
2. officers of the State Fire Service – the territory of an entrepreneur who possess dangerous goods;
3. officials of the customs service;
4. policemen – on roads and parking lots;
5. soldiers of the Military Gendarmerie and of military law enforcement agencies – for vehicles of Armed Forces of the Republic of Poland;
6. Boarder Guard officers – in the territory covered by the territorial scope of the border and in the border area;
7. eligible employees of the State Atomic Agency – on parking lots as well as in the territory of an entrepreneur who possess dangerous goods;
8. eligible employees of the Transport Technical Supervision – on parking lots as well as in the territory of an entrepreneur who possess dangerous goods;



9. eligible employees of the Environmental Protection Inspectorate – on parking lots as well as in the territory of an entrepreneur who possess dangerous goods;
10. inspectors of the Labor Inspectorate – in the territory of an entrepreneur who possess dangerous goods;
11. eligible employees of roads management – places particular to their rights.

The Ministry of Environment also takes part in inspections initiated by various entities, which concern how means of transport that carry hazardous materials on public roads fulfill necessary conditions.

Conclusions and summary

Dangerous goods are defined as all items and substances that may present potential hazard to human health and safety, properties or the environment. Transport of hazardous materials entails posing a danger to health and life of people, animals as well as plants (as a result of an explosion, a fire, biological or chemical contamination, dustiness, noise or vibrations), contamination of air, water and soil (biological and chemical contamination, thermal changes), proliferation of pressure in the form of longitudinal and transversal waves, etc.

The objective of the author of this article was to indicate safety rules concerning transport of dangerous goods by road. It required alluding to their classification, taking into consideration currently applicable documents, ways of marking, packaging, and transmission, which enabled the quantification of potential dangers that can occur during transport. What is of crucial significance when it comes to safety of carriage of dangerous goods is appropriate marking of a vehicle, proper protection of transported substances as well as being in compliance with precaution rules and regulations regarding loading, transport and unloading. A lot of attention should be drawn to the quality of infrastructure since its condition has a profound impact on safe transport of dangerous goods. The fact that Poland became the member of the European Union is important given that it brought a plethora of profits related to transport of dangerous goods. Since Poland joined member countries of the European Union the number of accidents caused by carriage of hazardous materials has decreased. Numerous issues contributed to it, such as mandatory changes made in accordance with guidelines of abundant legal regulations, the appointment of entities that are responsible for supervision, introducing a position of an adviser regarding safety as well as financial support that facilitated modernization, purchase of innovative pieces of equipment, vehicles as well as improvement of road infrastructure.

The question arises whether transport of dangerous goods can be considered safe. Regulations connected with carriage of hazardous goods pointed out in the article indicate that knowledge, skills, and caution along with conforming to currently applicable legal regulations minimize the risk of accidents.

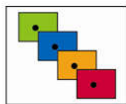
According to the latest NIK Report concerning "Performing tasks by public administration in the scope of safety of transport of dangerous goods", province governors and marshals of provinces are oblivious to potential threats, whereas people responsible for carriage of such materials are not well prepared to accomplish this task safely. Ensuring safe transport of dangerous goods should be treated as priority by entities that take care of proper functioning of road transport in areas where this type of transport is particularly dense.

Transport of dangerous goods is perceived as a complex problem, which calls for widely understood support and cooperation of various direct (senders, carriers and receivers) and intermediate (society, rescue teams, security forces and the media) participants of the road transport chain.

Potential hazard connected with carriage of hazardous materials evokes anxiety, which is justified, and therefore it requires providing adequate forces and safety measures. Obtaining information associated with: the implementation of transport technology, prevention, cooperation, rescue, training, supervision and other aspects which refer to road transport of dangerous goods helps to improve the analysis of the current condition of transport safety, and also it enables to show the way for future measures that will aim at improving this transport. It should be ensured that regulations, procedures, and standards are clear and rightly observed, because only on this account can undertaken measures provide safe transport of dangerous goods by road which is not harmful for people and the natural environment.

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