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## SAFETY AND WAYS TO TRANSPORT OF GOODS IN LAND TRANSPORT ON THE EXAMPLE OF DIESEL FUEL

*This article presents issues related to the transportation of dangerous goods. It is focused on diesel oil carriage which represents the third class of hazardous materials. The transport of such commodities requires the use of specialized forms of transport, which equipment is strictly defined by the legislation. This article includes the requirements which carriers has to meet in order to transportation safety and regulations related to loading and unloading of the commodity. The paper discusses the dangers posed by the road transport of dangerous materials.*

### INTRODUCION









The transport of commodity is carried out using number of different forms of transportation selected especially on the basis of the conditions under which load has to be transported. Dangerous materials are a special type of commodity that requires not only specific transport conditions, but also specially prepared forms of transportation [8]. There is no doubt that inadequate adaptation of transport conditions can be a menace for both humans and animals, but also can be harmful for the environment. Anyone who undertakes to transport dangerous materials should make use of knowledge related to its transport, storage and dangers. Diverse substances which are considered as hazardous in their physicochemical properties require the choice of appropriate form of transport. It is also important to plan the route and take into consideration possible exclusions for vehicles carrying dangerous materials. Analyze of diesel oil transportation is an example of a substance transportation which is noticeable to the average person. Also the risks of improper forms of transport protection and drivers lack of knowledge about proper transportation of diesel oil can lead to many irreversible risks.

### 1. CHARACTERISTIC OF DANGEROUS

Within the meaning of art. 1 of ADR, "dangerous goods" indicate materials and objects which international road transport is prohibited or permitted under certain conditions which are set out in annexes A and B [10]. In order to properly interpret this term it should be distinguished what materials and objects are. According to this definition as a materials we will refer to all types of substances, mixtures and solutions as well as preparations and waste from dangerous commodities or things that as a side effect cause or may cause danger. The objects are products which contents are dangerous materials. Such objects are, for example, accumulators or commonly used aerosols.

Terms of carriage are also strictly defined in the ADR contract and can differ based on the characteristics of types of dangerous goods. The legislator has established the classification criteria based on the characteristics of the dangerous goods and how it is transported. On the grounds of the dangers which may be caused by dangerous materials, they are divided into 13 groups which legislator calls as classes. This classification is presented in Table 1.

**Tab. 1.** Characteristic of chosen dangerous goods classes [1]

Number and name of the class	Danger description	Cautionary labels
22 Gases	Flammable gases: fire explosion, suffocate act, low temperature	 
	Nonflammable gases: suffocate act, low temperature, explosion	 
	Poisonous gases: poisonous act, caustic, low temperature, explosion	
33 Flammable and liquid materials	Fire, explosion	 
99 Diversed dangerous materials and objects	High temperature, fire	

In this article will be considered the issue of diesel oil transportation which represents the 3rd class of dangerous materials.

By defining the concept of fuel in terms of technology, it is defined as any substance that has the capacity to oxidize with the intensity to recover the chemical energy contained in that substance.

In the legal aspect by fuel can be called any flammable solid, liquid or gaseous, except for waste. Biomass is also a fuel, considered as products consisting entirely or partly from plant substances derived from agriculture or forestry, used to regain their energy [6].

In summary, fuel is any derivative of petroleum, with or without additives, with a vapor pressure of at least 27.6 kPa, which is used as a fuel for motor vehicles, except for liquefied gas (LPG).

Analyzed diesel oil is a fuel designated for high-pressure engine with self-acting ignition. It consists of paraffin carbohydrate, naphthenic and aromatic hydrocarbons, which are separated by petroleum distillation. Diesel oils are also derived from the distillate fraction, but to have proper properties it must be subjected to catalytic decomposition processes such as catalytic cracking or hydrocracking. The carbohydrate proportions and diesel oil components are different due to the character of the processed oil and the technological processes used in their production.

**Tab. 2. Physicochemical properties [2]**

Matter of state	Liquid
Color	Light yellow
Scent	Characteristic
Coagulation temperature	-5°C gat. B (268 K) -20°C gat. D (253 K) -35°C gat. F (238 K) -40°C diesel oil Urban class 1 (233 K)
Temperature of boiling start	approx. 180°C (453 K)
Temperature of boiling finish	approx. 360°C (633 K)
Temperature of flammation	Not lower than 56°C (329 K)
Temperature of self - flammage	270°C (543 K)
Limit of explosion	3.11-approx. 15.0% volume
Density w temp. 15°C	820 - 845 kg/m <sup>3</sup>
Tenacity w temp. 40°C	2.00 - 4.50
Fog density in order to air	approx. 6
Dissolubility	It does not dissolve in water; it dissolves in hydrocarbons, alcohols, ethers, carbon disulphide, carbon tetrachloride, chloroform

The physicochemical properties that diesel oil undergoes are shown in Table 2. An important parameter is the ability to self-ignition under high temperature, measured by a cetane number.

## 2. RECOMMENDATIONS REGARDING TO THE TRANSPORT OF DANGEROUS MATERIALS

The ADR Agreement is an act regulating the transport of dangerous materials in road transport, which is an international convention drawn up in Geneva on 30 September 1957. It has been in force in Poland since 1975. ADR legal rules are amended every two years and refer to transport in 46 countries.

- The ADR Agreement contains information on actions aimed at:
- minimization the risk of an accident and the extent of possible damage,
  - maximum safety measures during the carriage of dangerous goods,
  - safety of people involved in carriage of goods and as well safety of other road users, the environment ect.

Analyzed diesel oil is, under the ADR contract, liquid and flammable material. The identification number is 1202. The hazard identification number is 30 though, meaning a flammable liquid with a flash point of 294 K to 373 K. The board showing what type of load is transported should be orange color which is shown on the graph number one [9].



**Fig. 1. Diesel oil safety tag [9].**

This board is placed at the front and the back of a vehicle to the left side of it at a height of no more than 2 meters and not less than 0.5 meters measured from the ground. The size of these tables is strictly defined and it is 40 centimeters wide and 30 centimeters high. Surrounded by a black border of 15 millimeters wide, a horizontal black line of the same width should run through the center. This line separates the fields containing the identification number of the commodity and the danger it may cause [9].



**Fig. 2. Safety sticker - liquid and flammable material [9].**

In addition, vehicles carrying dangerous materials must also be marked with warning labels with a minimum dimension of 250 x 250 millimeters what fig. 2 [9].

At the time of unloading the materials from a vehicle, the information stickers should be completely removed or temporarily covered. In the case that the load is not 100% unloaded or the vehicle has not been cleaned and disinfected yet, the warning sticker cannot be removed [7].

Table 3 shows road signs referring to the carriage of dangerous commodity. Responsibility for the transport of dangerous materials (in this case diesel oil) takes the sender, the carrier (the driver) and the receiver as well as the person who fills in the tank car. Activities and manner of work of these people directly affect the safety of liquid fuels transport.

**Tab. 3. Road signs [11].**

	Prohibition of vehicles transport that are carrying dangerous materials according to legal rules - classes: 1, 3, 4.1, 4.2, 4.3, 5.1, 5.2 or flammable gases 2nd class in quantity that requires orange safety boards marking.
	This sign signify direction of motion on junctions effective for vehicles carrying dangerous materials, what indicates road signs number C-2, C-4, C-5, C-6, C-7 or C-8.
	Prohibition of vehicles transport that are carrying dangerous materials according to legal rules - classes 3, 4.3, 6.1, 6.2, 8, poisonous or caustic gases 2nd class or materials endangering environment 9th class in quantity that requires orange safety boards marking.
	Prohibition of vehicles transport, specified in the regulations on the carriage of dangerous goods (goods), dangerous goods in quantities for which vehicle marking is required with orange warning signs; A sign with the appropriate inscription placed under the sign indicates that the ban applies only to certain classes or groups of hazardous materials or to the way they are transported.

### 3. ANALYSIS OF AN EXAMPLE TRANSPORT ROUTE

The fuel carrying route is between Plock and Grudziądz which is shown on the graph number 3 [4]:

- Start: PKN Orlen Fuel Base, ul. Chemików 7, 09–411 Plock
- End: Orlen Fuel Station, ul. Chełmińska 173, 86–302 Grudziądz
- 1. Access to Voivodeship Road No. 559 – 6.6 km
- 2. By provincial road no. 559 towards Lipno – 41 km
- 3. Drive DK No. 67 – 1.1 km
- 4. Drive DK 10 towards Toruń – 40 km
- 5. Take the A1 motorway to Grudziądz (paid) – 44.2 km
- 6. Drive DK95 and DK55 – 4.4 km
- 7. Downhill at ul. Chełmińska and access to the petrol station – 1.7 km
- Total: 139 km.

On the route that has been chosen, there are no traffic bans for dangerous material carriage such as diesel oil. The ride by this route is possible throughout the whole day regardless of the season of the year.

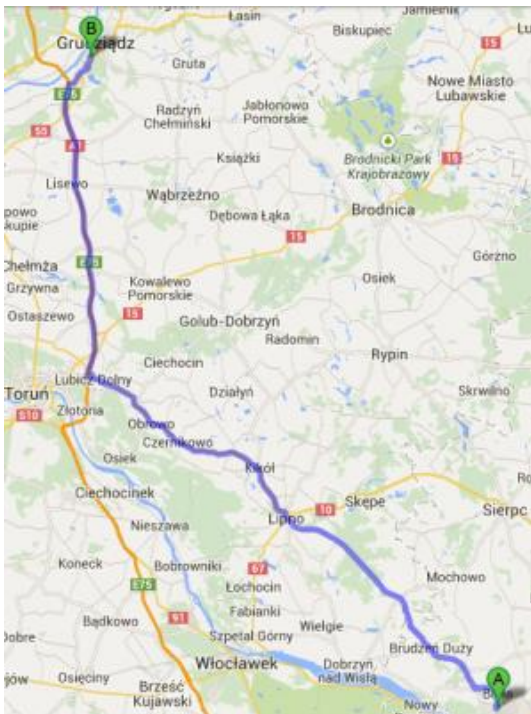


Fig. 3. Route map [4].

### 4. CHOICE OF FORMS OF TRANSPORT

The transport of dangerous materials in road transport is carried out in the form of packages, loose material or in tanks based on the choice of the load sender. Duties that the sender is obliged to do are to secure the vehicle and get it equipped with appropriate load-dependent components. The carrier (driver) should check whether these conditions are met and should direct a suitably adapted vehicle for the carriage of a particular load classified under the UN code.

Tank equipment includes [9]:

- ADR case with equipment 1 piece,
- ABC Powder Extinguisher – 2 kg 1 piece,
- ABC Powder Extinguisher – 6 kg 2 pieces,
- extinguisher container 6 kg 2 pcs – option,
- warning triangle 2 pcs,
- 2 signaling lights – option,
- wedge under wheels 2 pcs,
- ADR Numeric Tables 2 pcs,

- warning stickers.

The equipment of the vehicle from 3.5 t to 7.5 t includes [9]:

- ADR case with equipment 1 piece,
- ABC Powder Extinguisher – 2 kg 1 piece,
- ABC Powder Extinguisher – 6 kg 1 piece,
- extinguisher container 6kg 2 pcs – option,
- warning triangle 2 pcs,
- 2 signaling lights – option,
- wedge under wheels 2 pcs,
- ADR Tables 2 pcs.

Tank transportation is permitted on the basis of the vehicle's design requirements and authorization to use in roads. For each dangerous material, the ADR Act lists what requirements tank car must meet. Among the requirements are for example: vehicle design requirements, permissible container filling level, required vehicle marking and other additional detailed safety requirements.

For the transportation of diesel oil in greater quantities there is tank car used.

Chamber equipment in tank:

- scuttle with filler, pneumatically operated breathing valve, fire protection fuse,
- terminal of closed fumes installation circulation,
- optoelectric overfilling sensor (10 – pin),
- pneumatically operated bottom valve.

Method of loading / unloading the tank [9]:

- top Loading – through fillers in scuttles,
- bottom Loading - independently of each chamber through MAPI connections on the right,
- unloading through the MAPI connection and bottom filling, installation of closed vapor circuit connecting all chambers and entered by the left side of the truck to the closed line vapor circuit DN80.

### 5. DOCUMENTATION OF THE DANGEROUS MATERIALS CARRIAGE

Documents that should be instanced when transporting dangerous goods are [9]:

- the transport document,
- written instruction for the driver,
- certificate attesting drivers training,
- identity document of all crew members containing photographs,
- ADR admission certificate.

Informations contained in transport document:

- UN number,
- correct shipping name,
- the number and definition of packages,
- the total quantity of each of the dangerous goods having a separate un number,
- sender name and address,
- consignee name and address,
- records required under a special agreement,
- tunnel carriage restriction code, if assigned to the particular commodity.

Written instruction for the drivers provide information on the type of commodity, dangers connected to it and emergency behavior in case of danger. Sender prepares it and delivers it to the driver no later than in the moment of loading the commodity on the vehicle. The driver should keep this instruction in the vehicle's cab in an easily accessible place.

The Driver's Certificate of Completion is issued in Polish and English language and it is acknowledged in all countries covered by the ADR Agreement. Bearing in mind the constantly changing regulations and the characteristics of trucking, the driver should retake the



course and required examinations every five years. When the exam is passed successfully, a new ADR certificate is issued for a further 5 years [10].

For vehicles intended for the trucking of first class explosive materials and objects of 1st class and vehicles intended for the carriage of dangerous materials in solid tanks, demountable tank containers, portable tanks or MEGC, an additional "approval certificate" is required. The certificate is valid for one year. The certificate is issued for vehicles of the following type:

- EX / II, EX / III, MENU,
- FL, OX, AT.

## 6. THREAT OF DANGEROUS MATERIALS TRANSPORTATION

The dangers of diesel oil transportation as well as other dangerous materials are extremely important because of the threat to the environment it may cause. They can appear in every stage of transportation – on loading, trucking and unloading [5].

The consequence of improper behavior may be:

- environmental degradation,
- contamination of air, water and soil,
- the need for immediate evacuation of people from endangered areas,
- loss of health or life of large numbers of people in the danger zone,
- serious material losses.

If, during the transport of dangerous materials, such an event occurs, it is defined as a serious failure by the environmental protection law. The authority responsible for carrying out the rescue operation is obliged to inform the Chief Inspector of Environmental Protection about it, through the Voivodeship Environmental Protection Inspector.

In the case of an accident or danger, crew members of particular vehicle should do the following actions, if it is possible and safe:

- brake the vehicle, switch off the engine and disconnect the battery by starting the main battery cut – out, if available,
- avoid sources of ignition, in particular do not smoke or operate any electrical equipment,
- notify the appropriate emergency services by giving them all available information about the accident or threat,
- wear a warning vest and place adequate warning signs,
- provide rescuers with easy access to transport documents,
- do not step on effused materials, do not touch them, prevent inhalation of vapors, smoke, dust and vapor by staying on the windward side,
- if appropriate and safe, use fire extinguishers to extinguish a small or starting fire, including tires, brakes or engine compartments,
- crew members should not extinguish a fire covering the cargo compartment,
- move away from the scene of the accident or danger, inform others about the need to move away from this place.

Carriage through road tunnels is a specific form of threat that transportation of dangerous materials pose. There are no tunnels on the route we choose earlier, but for other routes danger has to be kept in mind and the safety features of the tunnels has to be known (see graph 4).

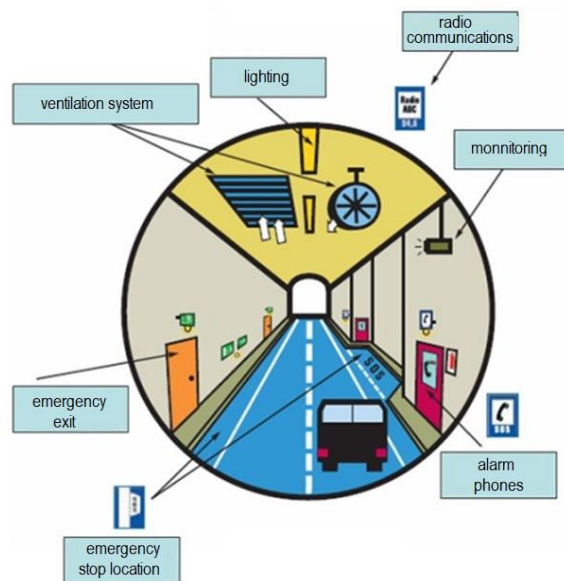


Fig. 4. Safety elements in road tunnels [3].

## SUMMARY

The manner of carrying the fuels and other dangerous materials has a significant impact on road safety. The liquid fuel carrier must comply with the safety rules for the carriage of dangerous goods covered by a contract commonly referred to as ADR ("European Agreement for the International Carriage of Dangerous Goods by Road").

An important element in the transportation of liquid fuels is the correct labeling of the vehicle, which is an information for all of the road users - due to the marking of the vehicle, other road users know that they should be very careful.

Proper education, and hence the acquired eligibility and health condition of the driver, are essential for the safe passage of dangerous commodity. Equally important is proper work preparation of the driver. Failure to comply with these guidelines drastically increases the risk of an accident, collision or accident, leading to leakage of commodity. The prevention of such cases can be gained by organizing trainings, research and rigorous roadside inspections.

Failure to select the right tank for the material that is carried can lead to serious consequences such as accident, leakage or explosion. Considering the risks associated with tanks it is important to mention other such as not maintaining adequate pressure and temperature in it, not cleaning it after previous transport or exceeding permissible payload. All the above – mentioned cases can endanger life.

Other deviations occurring in the use of tank, such as unmarked vehicles, lack of additional equipment and documentation of the vehicle, present a significantly lower risk. The risk associated with transport is higher but results in fines or tickets.

Unacceptable risk during the transport of hazardous materials is the failure of the driver to use vertical signs and take into consideration all of the road conditions. This situation can lead to accidents, tank leakage, threat to life and contamination of the environment.

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## Bezpieczeństwo i sposoby przewozu towarów w transporcie lądowym na przykładzie oleju napędowego

*W artykule omówione zostały zagadnienia dotyczące transportu towarów niebezpiecznych drogowymi środkami transportu. Uwaga została skupiona na przewozie oleju napędowego reprezentującego trzecią klasę towarów niebezpiecznych. Przewóz tego typu towarów wymaga zastosowanie specjalistycznych środków transportu, których wyposażenie zostało ściśle określone w ustawodawstwie. Artykuł zawiera stosowanie się przewoźnika do zasad bezpieczeństwa transportu oraz obsługi załadunku i wyładunku towaru. W referacie podjęto temat zagrożeń występujących w trakcie transportu drogowego materiałów niebezpiecznych.*

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