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**Analysis of regulations regarding transport of dangerous goods by road
in Poland and in Europe**

Abstract: The subject of the article are regulations regarding transport of hazardous materials in road transportation. In Poland, as well as in most European countries, these regulations are mainly governed by the ADR Agreement, which is a supra-national legal act. The article contains an analysis of the mentioned legal act. Despite the fact that the ADR Agreement harmonizes regulations concerning the transport of hazardous materials, there are domestic standards that differ slightly from the provisions of this agreement. The article also describes parking facilities for vehicles carrying hazardous materials in Poland and presents statistical data regarding parking spaces for this type of vehicles.

Keywords: Road transport; Hazardous materials; ADR Agreement; Parking spaces; MOP

Introduction

Road transport is a mode of transport that is often used for the transport of dangerous goods.. These goods are more problematic when it comes to transporting them because such materials can pose risks to human health and safety and may be hazardous to the environment. The transport of hazardous materials is permitted only under the conditions specified in international agreements (including ADR) and the regulations and laws on road traffic of the respective country. Hazardous materials can take various forms, including solid, liquid, or gaseous substances [1, 2].

The transportation of hazardous goods constitutes approximately 10-15% of all shipments carried out in Poland. Over 70% of these transports involve the carriage of liquid goods, such as gasoline, solvents, acids, or paints [3]. Such a significant share of transports carried out by road transport is unfavorable in terms of safety, as road transport is considered one of the least safe modes of transportation.

Therefore, it is very important to strive for an increase in the safety of road transport of hazardous goods. To achieve this, the regulations from international agreements, such as ADR, should be as consistent as possible with the laws and regulations in force in a given country [4].

ADR Agreement

The primary legal act regulating the transport of hazardous materials by road in Europe is the ADR agreement (*French: L'Accord européen relatif au transport international des marchandises Dangereuses par Route*). This legal provision has a supra-national character. Currently, the "European Agreement concerning the International Carriage of Dangerous Goods by Road" is signed by all European countries.

The ADR Agreement was drawn up on September 30, 1957 in Geneva. Initially, it was signed by nine countries (Austria, Belgium, France, the Netherlands, Luxembourg, Germany, Switzerland, Great Britain, Italy), and later joined by other European countries. Since the inception of this Agreement, the authentic languages have been French and English (Article 17 of the ADR). The original document was deposited with the Secretary-General of the United Nations on December 15, 1957 (Article 17 of the ADR).

The agreement on the carriage of dangerous goods came into force in the founding countries in 1968, more than 10 years after its preparation. Poland ratified the ADR agreement on May 6, 1975, but the document did not immediately come into effect. It happened on February 1, 1983, when the Traffic Law was published, incorporating the first provisions consistent with the ADR agreement. Since then, continuous efforts have been made to ensure that internal regulations in Poland are as consistent as possible with the ADR [5].

The scope of the agreement on the transport of dangerous goods has been expanding year by year. In 2020, there was a very important change in the understanding of the ADR agreement. Until that year, it was considered a "European agreement," although several non-European countries were long-standing members of it. Therefore, it was decided to change the name to "international agreement" [6].

Currently, the ADR agreement is valid in 52 countries, including all European countries, Asian countries such as: Uzbekistan, Tajikistan, Azerbaijan and African countries: Morocco, Nigeria, Tunisia.



1. Countries that have signed the ADR Agreement

Source: own elaboration based on [7]

The ADR agreement consists of the Main Agreement and Appendices A and B. The Main Agreement describes the legal relations between the countries that have signed this agreement. It specifies supervisory and control authorities during the provision of transport services and outlines the requirements for those organizing transportation, drivers, and ADR

advisors. The Appendices, on the other hand, provide detailed regulations governing the conditions for the international transport of hazardous goods by road [3].

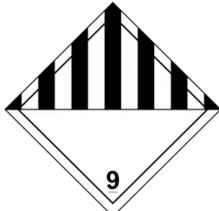
Classification of dangerous goods according to ADR

In Appendix A of the mentioned legal act, there is a categorization of all materials produced in the world into 13 hazard classes, indicating the types of hazards that these goods may cause. Each of these classes also has a characteristic warning sticker, thanks to which it is easy to recognize which class of dangerous goods we are dealing with [8].

Table 1. Classification of hazardous goods according to ADR

Class 1	Explosive substances and articles	Liquid or solid materials that can emit gases as a result of a chemical reaction at a temperature and pressure such that they can pose a threat to the environment Examples: ammunition, dynamite	 2. Class 1 warning sticker Source [10]
Class 2	Gases	Pure gases, mixtures of gases (two or more) or mixtures of gases with other materials (one or more) Examples: acetylene, ammonia	 3. Class 2 warning sticker Source [10]
Class 3	Flammable liquids	Liquid materials with an ignition temperature below 60°C Examples: gasoline, ethanol	 4. Class 3 warning sticker Source [10]
Class 4.1	Flammable solids, self-reactive substances and solid desensitized explosives	Materials that can ignite due to friction, may spontaneously combust (even without oxygen), substances susceptible to spontaneous decomposition	 5. Class 4.1 warning sticker Source [10]

Class 4.2	Substances liable to spontaneous combustion	Pyrophoric materials (substances that ignite upon contact with air) and self-heating materials Examples: white phosphorus, damp cotton	 6. Class 4.2 warning sticker <i>Source [10]</i>
Class 4.3	Substances which, in contact with water, emit flammable gases	Materials that react with water and emit flammable gases that may form explosive mixtures with air Examples: aluminum hydride, calcium carbide	 7. Class 4.3 warning sticker <i>Source [10]</i>
Class 5.1	Oxidizing substances	Materials that may not themselves be flammable but may cause other materials to ignite due to the release of oxygen Examples: hydrogen peroxide, calcium hypochlorite	 8. Class 5.1 warning sticker <i>Source [10]</i>
Class 5.2	Organic peroxides	Materials that are susceptible to exothermic decomposition, where decomposition can be initiated by heat, impurities, acid or friction Examples: butanedioic acid	 9. Class 5.2 warning sticker <i>Source [10]</i>
Class 6.1	Toxic substances	Materials that may cause health damage or death if inhaled, swallowed or come into contact with skin	 10. Class 6.1 warning sticker <i>Source [10]</i>
Class 6.2	Infectious substances	Materials that contain pathogens, which are microorganisms that can cause diseases in humans or animals Examples: medical waste, medical samples	 11. Class 6.2 warning sticker <i>Source [10]</i>

Class 7	Radioactive substances	Materials containing radioactive isotopes Examples: fissile materials, surface contaminated objects	 <p>12. Class 7 warning sticker Source [10]</p>
Class 8	Corrosive substances	Materials causing irreversible damage to the skin. If leaked, they may also cause damage to other goods	 <p>13. Class 8 warning sticker Source [10]</p>
Class 9	Miscellaneous dangerous substances and articles	Materials that pose a hazard other than the above-mentioned classes Examples: asbestos, airbags	 <p>14. Class 9 warning sticker Source [10]</p>

Source: Own elaboration based on: [9]

Marking of vehicles carrying hazardous materials

To ensure safety during the transportation of hazardous materials by road, the ADR Agreement has prepared special stickers and markings that a vehicle transporting such materials should have. The type of markings used on vehicles varies depending on how the transportation of dangerous goods is carried out. According to the ADR agreement, such transportation can take place in three ways:

- transportation in pieces: this involves the transport of hazardous materials that have been placed in packaging. This category of goods also includes gases transported in cylinders or other containers. Transportation in pieces is carried out in closed, open, or covered vehicles or containers,
- bulk transportation: this involves the transport of goods that are loaded onto the vehicle without the use of packaging. It is crucial to check for tightness to ensure that hazardous materials do not escape during transportation,
- transport in tanks: this is the transport of goods such as liquids, gases or solid materials (tankers-silos).

The ADR agreement specifies the necessary equipment with warning boards and stickers for this type of dangerous goods [11, 12].

Marking a vehicle carrying goods in pieces

The marking of vehicles is the least complicated. A well-marked vehicle of this type should have [1]:

- orange boards: two smooth boards are required during transport. One of them must be placed at the front of the vehicle, the other is placed at the rear of the transport unit.

Such boards should be placed in visible places and should be reflective. Their nominal dimensions are 40 cm wide and 30 cm high. The board should also have a black frame 15 mm wide. If there is not enough space on the vehicle, the dimensions of the plate may be reduced,



15. ADR smooth board

Source: [13]

- warning stickers: when transporting in pieces, stickers are not required, because warning stickers should be placed on each piece of transported cargo. Each package should have: material identification number, warning stickers and signs for environmentally hazardous materials.

Vehicle markings during bulk transport

The marking of this type of vehicle is more complicated than transportation in pieces. It looks like this [11, 15]:

- orange boards: when transporting hazardous materials in bulk, the boards can be placed in two ways. One way is to place two smooth boards, just as it was done in transporting goods in pieces. However in addition, during bulk transport, boards with hazard identification number and UN number must also be affixed. Two such boards must be affixed to the sides of the vehicle. The second method is to place boards with hazard identification number and UN number on the back and front of the vehicle, instead of smooth boards. In this case, boards on the sides of vehicle will not be needed,



16. ADR board with hazard identification number and UN number

Source: [14]

- warning stickers: when transporting in bulk, it is necessary to equip the vehicle with warning stickers on the sides and rear of the vehicle. Such stickers should be consistent with the class of the hazardous material being transported (drawings in Table 1),

- information signs: if the vehicle transports goods that pose a threat to the environment, it must be additionally equipped with appropriate information boards that should be placed on the sides and rear of the vehicle.



17. Sign for environmentally hazardous material

Source: [16]

Vehicle marking when transporting goods in tankers

The marking of vehicles of this type looks as follows [11, 15]:

- orange boards: if the vehicle transports only one type of dangerous goods, it may have only two orange boards, but these must be boards with hazard identification number and UN number,
- if more than one type of hazardous material is transported in a tank, a board with identification number and UN number must be placed on the sides of the vehicle in each compartment. Additionally, a smooth ADR board must be placed on the front and rear of the vehicle,
- warning stickers: during tanker transport, it is also necessary to equip the vehicle with warning stickers on the sides, on each compartment and at the rear of the vehicle. Such stickers should be consistent with the class of the hazardous material being transported (drawings in Table 1),
- information signs: if the vehicle transports goods that pose a threat to the environment, it must be additionally equipped with appropriate information boards that should be placed on the sides, on each compartment and at the rear of the vehicle.

Restrictions on the transport of goods through tunnels

In 2007, changes were introduced to the ADR Agreement which specified which tunnels may be passed through when transporting hazardous materials. All road tunnels located in the European Union are divided into 5 categories, which determine which vehicles can pass through a given tunnel while transporting hazardous materials.

Categorizing tunnels is based on three main types of hazards that can damage or destroy the tunnel or cause numerous casualties. Therefore, the threat may be caused by:

- explosion,
- release of poisonous gas or poisonous liquid,
- fire.

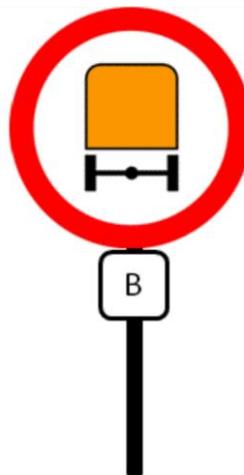
Categories of road tunnels according to the ADR Agreement:

- A. no restrictions on the transport of hazardous materials through the tunnel,
- B. the restriction concerns the transport of highly explosive hazardous goods with a very large radius,
- C. the restriction applies to the transport of dangerous goods with a risk of very long-range explosion, medium-range explosion or poisonous with a large range,

- D. the restriction applies to the transport of dangerous goods with a risk of large-scale explosion, large-scale explosion, large-scale toxic effect or large-scale fire,
- E. the restriction applies to all dangerous goods, except those with UN numbers: 2919, 3291, 3331, 3359, 3373. In the case of transporting dangerous goods in quantities exceeding 8 tons per transport unit, the restriction applies to all dangerous goods.

The tunnel can be classified into more than one tunnel category, depending on factors such as the day of the week or time of day.

Information about the category of tunnel in front of a vehicle transporting hazardous materials can be found on road signs that inform the driver about the tunnel category. On roads in Poland, there is a B-13a road sign, under which there is also a T-31 plate, which may contain one of five letters corresponding to the tunnel category (A-E) [17].



18. Road sign B-13a with board T-31

Source: [18]

Sign B-13a means that vehicles transporting hazardous materials are prohibited on the road where this sign is placed. However, when such a sign is positioned before the entrance to a tunnel and is equipped with plate T-31 with the letter "B," its meaning is different.

The above-presented sign indicates that a vehicle transporting highly explosive hazardous materials with a very large range is not allowed to enter the tunnel in front of which this sign is placed.

Parking lots for vehicles carrying hazardous materials in Poland

Service Area for Travelers (in Polish: „Miejsce Obsługi Podróżnych” - MOP) is a very important element of road infrastructure that serves to meet the needs of travelers. In Poland, MOPs are located along highways and expressways (Class A and S roads). These facilities should also ensure the safety of vehicles and drivers, which is particularly important during the transport of hazardous materials. However, not all Service Areas for Travelers are adapted to handle this type of vehicles [19].

While traveling on roads with limited access, such as expressways and highways, drivers are only allowed to stop at designated and equipped locations, namely Service Areas for Travelers (MOPs). These are designated areas on the roadside beyond the road crown, equipped with parking spaces for various types of vehicles and facilities to meet the needs of the drivers present there [19]. MOPs differ in terms of their functional features, which is why they are divided into three types [20]:

- MOP I → an object of this type serves only a recreational function. It includes: parking spaces for vehicles, maneuvering roads, lighting, sanitary and recreation

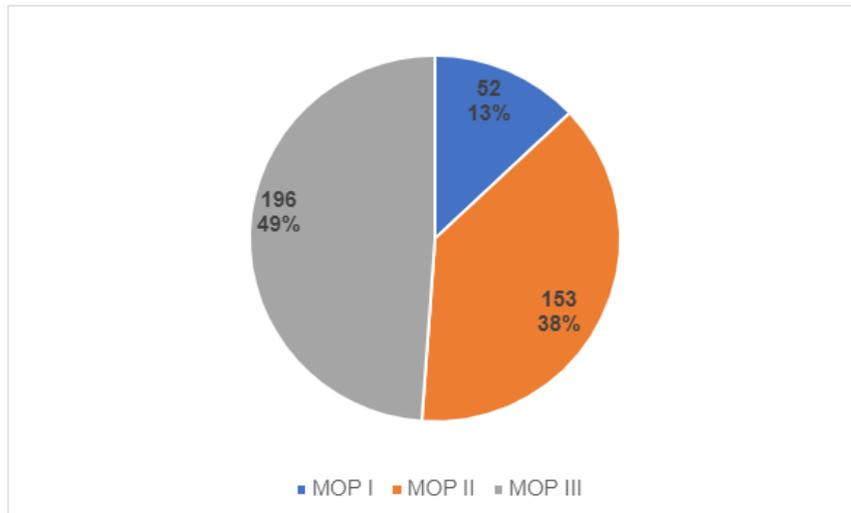
facilities. It is permissible for such a facility to be equipped with small catering facilities (usually fast-food),

- MOP II → an object of this type serves a recreational-service function. It is equipped with the same facilities as MOP I and additionally should include a gas station, vehicle service station, tourist information points, as well as gastronomic and commercial establishments,
- MOP III → an object of this type serves both recreational and service functions. The facility is equipped with the same elements as MOP I and MOP II, and additionally includes accommodation facilities (motels, hotels). Depending on the needs, one can also find establishments such as post offices, banks, tourist offices, or insurance offices.

Drivers of passenger cars can stop at any MOP. However, truck drivers transporting hazardous materials do not have the same degree of freedom. Stopping such a vehicle is possible at the Service Area for Travelers where there are no prohibition signs for vehicles carrying dangerous goods. However, according to the Regulation of the Minister of Infrastructure regarding technical and construction regulations for public roads, the number of parking spaces for vehicles transporting hazardous materials on Service Area for Travelers should be no less than 10% of the total number of parking spaces available for trucks, but at the same time, this number cannot be less than 2 parking spaces. The location of such parking spaces is also precisely defined. The distance between these parking spaces and those designated for other vehicles or infrastructure facilities, such as rest areas for drivers, must be at least 30 meters. This is not the only requirement for parking spaces for vehicles with hazardous loads. Such spaces must also be equipped with a separate, sealed drainage system, equipped with devices to neutralize any potential leaks from the transport unit carrying hazardous goods. It is not permissible for a parking space for such a vehicle to be located within a distance of less than 10 meters from ditches or manholes, and it cannot be located in a wet area, but should be located in area that is hardened and non-absorbent [19, 21].

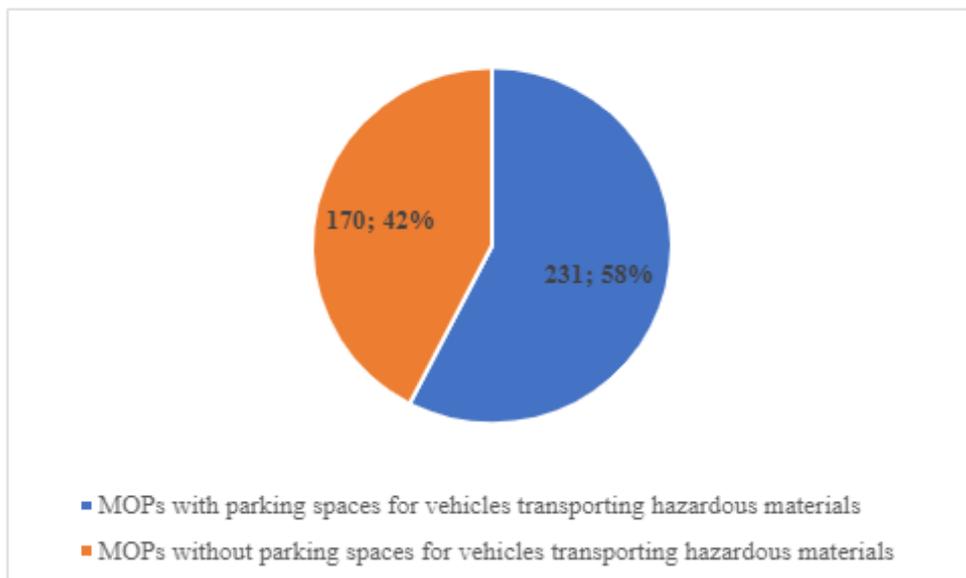
MOPs on expressways and highways in Poland

The network of expressways and highways in Poland is constantly expanding. Therefore, with the development of the road network, the number of MOPs is also increasing. According to data from the General Directorate for National Roads and Motorways (in Polish: GDDKiA), in the middle of 2023 the number of MOPs in Poland was 401. For comparison, in 2015 the number of objects of this type was 257. Regarding the division between MOPs located along expressways and highways, there are 236 objects along expressways and 165 along highways. When it comes to the division of these objects according to their class, in Poland in 2023 there are 52 class I MOPs, 153 class II objects and 196 class III objects [22]. This is illustrated in the Fig. 19.



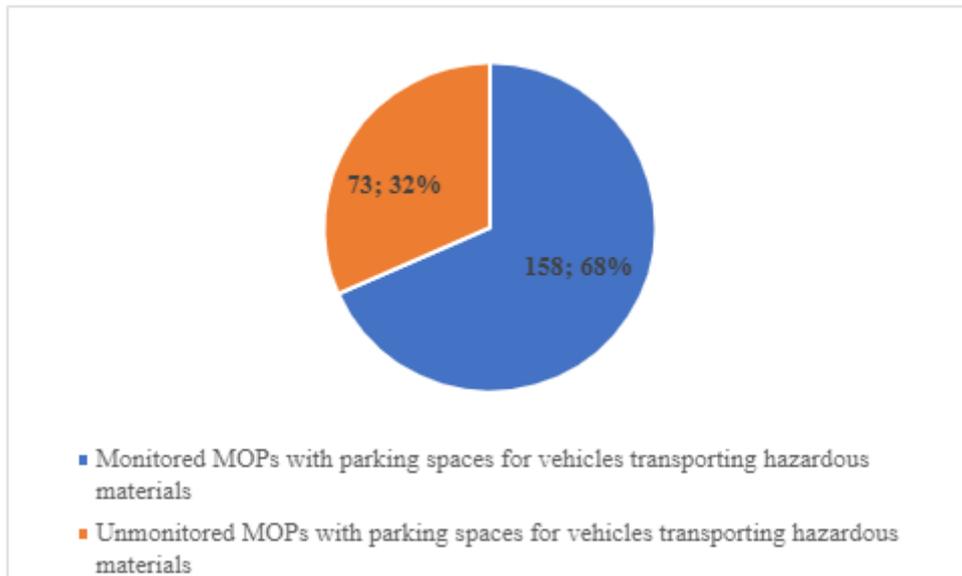
19. The percentage share of Service Areas for Passengers of a given class
Source: Own elaboration

However, it should be noted that not all MOPs are adapted to serve vehicles transporting hazardous materials. Out of the total of 401 such infrastructure facilities, only 58% of them are equipped to handle such vehicles. Therefore, vehicles transporting dangerous goods can stop at 231 MOPs in Poland.



20. Percentage of MOPs with and without parking lots for vehicles with dangerous goods
Source: Own elaboration

According to the provisions of the ADR Agreement, drivers transporting hazardous materials should organize stops at supervised parking areas, meaning those that are monitored. According to GDDKiA data, out of the 231 MOPs equipped to handle vehicles with hazardous goods, 158 are monitored, accounting for 68%.



21. Percentage of MOPs with monitored parking spaces for ADR vehicles and without monitoring

Source: Own elaboration

Service Areas for Travelers in Poland are not evenly distributed across the entire country. There are significant disparities in the number of MOPs between voivodeships. The highest number of these facilities is in the Łódź Voivodeship, where there are 59. Meanwhile, the fewest Service Areas for Travelers are in the Pomeranian and Silesian Voivodeships, with significantly fewer MOPs than in the Łódź Voivodeship, specifically only 8 [22].



22. Map of Poland with the number of MOPs in individual voivodeships

Source: Own elaboration

The Fig. 22 shows the location of all MOPs in Poland, including those that cannot be entered by a vehicle carrying hazardous materials. The largest number of such facilities that can be entered by this type of vehicles is located in the Greater Poland Voivodeship. There are 25 facilities there with special places for vehicles with dangerous goods. The fewest of

these MOPs are located in the Opole Voivodeship. There are only three facilities of this type located there [22].



23. Map of Poland with the number of MOPs with parking spaces for vehicles transporting hazardous materials in individual voivodeships

Source: Own elaboration

The Łódź Voivodeship, where the largest number of MOPs are located, has the lowest percentage of the number of MOPs with parking spaces for vehicles with dangerous goods in the total number of such facilities. It is only 37%. The Lublin Voivodeship is the best in this respect. All Service Areas for Travelers located there are adapted to handle vehicles with dangerous goods [22].

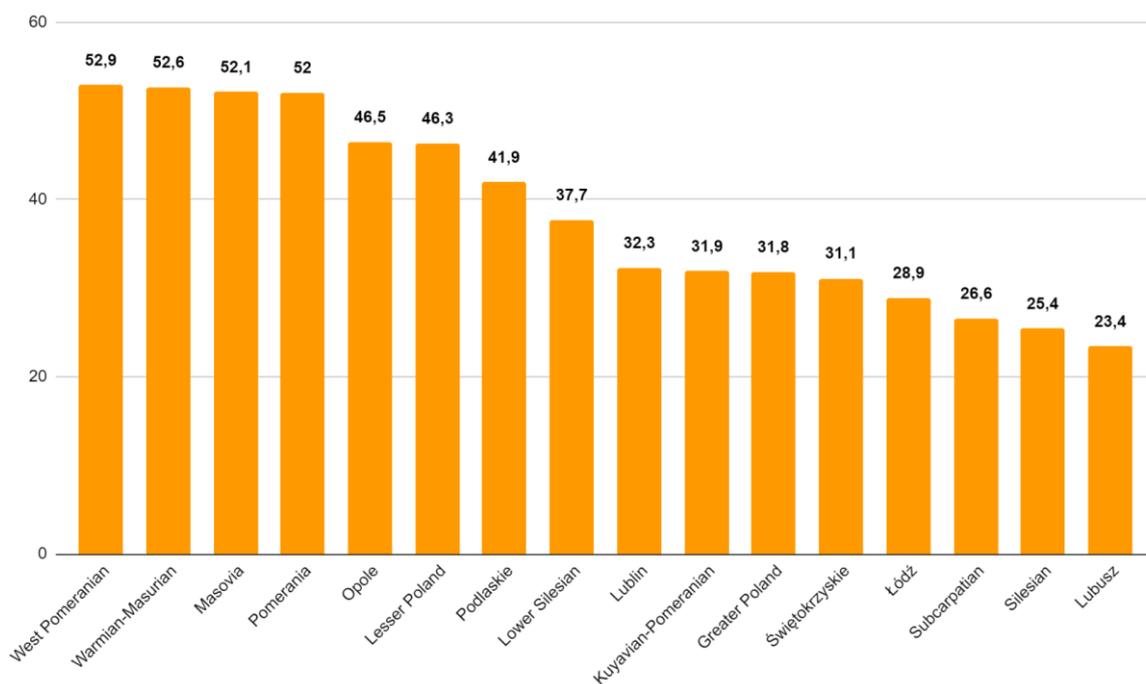
The diverse number of Service Areas for Travelers in different voivodeships results from the fact that such facilities are located in Poland only along expressways and highways. These road classes are also not evenly distributed across the surface of Poland, which may explain the variation in the number of MOPs in different voivodeships. To accurately compare which voivodeship has the largest gaps in the number of these facilities, it is necessary to calculate how many kilometers of expressways and highways correspond to one MOP.

Table 2. Table describing the number of MOPs in individual voivodeships compared to the length of expressways and highways

Voivodeship	total number of MOPs	the number of MOPs that can handle vehicles with dangerous goods	percentage	length of expressways and highways	kilometers of expressways and highways per one MOP handling vehicles with hazardous materials
Masovia	50	24	48,0%	1250,7	52,1
Silesian	36	20	55,6%	507,9	25,4
Greater Poland	45	25	55,6%	795,5	31,8
Lesser Poland	13	8	61,5%	370,3	46,3

Lower Silesian	32	17	53,1%	640,1	37,7
Łódź	59	22	37,3%	635,0	28,9
Pomerania	8	6	75,0%	312,2	52,0
Subcarpathian	24	14	58,3%	371,9	26,6
Lublin	18	18	100,0%	581,7	32,3
Kuyavian-Pomeranian	27	16	59,3%	510,1	31,9
West Pomeranian	19	13	68,4%	687,3	52,9
Warmian-Masurian	18	101	55,6%	526,2	52,6
Świętokrzyskie	9	8	88,9%	248,6	31,1
Podlaskie	17	13	76,5%	544,3	41,9
Lubusz	18	14	77,8%	328,0	23,4
Opole	8	3	37,5%	139,6	46,5

Source: Own elaboration based on: [22, 27]



24. Kilometers of expressways and highways per one MOP handling vehicles with hazardous materials

Source: Own elaboration

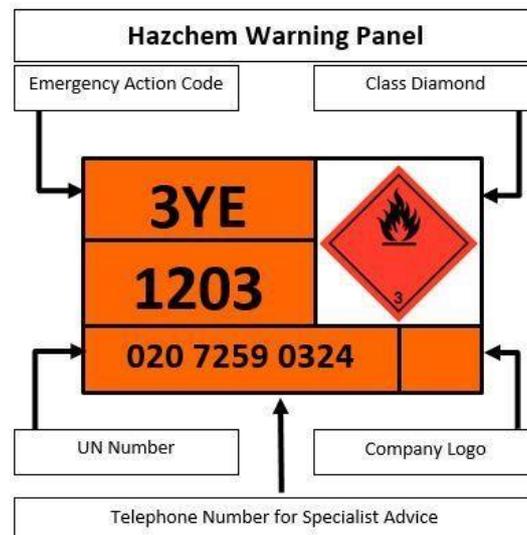
Differences in regulations regarding the transport of dangerous goods between ADR member countries

Legal regulations concerning the transportation of hazardous materials by road are uniform in all countries that have signed the ADR Agreement. However, it should be noted that they are not completely standardized because the ADR Agreement allows member states to introduce

their own domestic regulations in certain matters. An example of such a separate legal provision can be found in the law on the carriage of dangerous goods in Poland. This law clearly specifies that the consignor, consignee, and owner of the hazardous material must be indicated on the shipping document during the transport of dangerous goods. While the ADR Agreement only requires the identification of the consignor and consignee of the dangerous goods. It is important to note that this Polish requirement applies only when transporting such cargo within the borders of Poland. For transportation beyond the borders of Poland, it is sufficient to specify the consignor and consignee, as required by the ADR Agreement [6].

1. *Differences in vehicle markings*

One of the differences that can be noticed in the regulations regarding the transport of hazardous materials in countries that have signed the ADR Agreement is that not everywhere uses the same warning boards and markings that were presented earlier. Different warning signs are used in the UK. The markings there are based on the Hazchem Code, the so-called Emergency Action Code (EAC). This code is applied to warning boards on vehicles transporting hazardous materials in the United Kingdom. In addition to this, the sign contains information identical to those on warning signs used in other ADR Agreement member countries, including the UN number and a label indicating the class of dangerous goods according to the ADR classification. Additional information contained in the board in the United Kingdom is the manufacturer's or dispatcher's number and the manufacturer's logo. As seen, such signs are much more detailed than those used in most ADR Agreement member states, including Poland [4].



25. Warning board used in Great Britain

Source: [23]

2. *Driver training*

Further differences can arise during training for drivers intending to transport hazardous materials. The ADR Agreement does not specify how the training process should be conducted. Most countries that have signed the ADR Agreement conduct training by having candidates instructed and taught by a suitably trained person, an instructor. After completing the required number of lectures, candidates must pass exams that authorize them to transport hazardous materials by road. The situation is somewhat different in Italy. Driver training in Italy combines traditional classroom lectures (similar to most ADR Agreement member countries) with online sessions,

where candidates have the opportunity for self-learning, and their progress is monitored by authorized instructors and stored in a database. The platform for independent learning is called TIP – Transport Integrated Platform. This platform is part of an integrated teaching model, where self-paced remote learning is combined with traditional classroom teaching methods. The course concludes similarly to other ADR Agreement countries, with final exams, passing which authorizes the driver to transport hazardous materials [24, 25].

3. *Passage of vehicles with dangerous goods through tunnels*

Another difference observed in ADR member countries is the regulations regarding the transit of vehicles transporting hazardous materials through tunnels. Austria has introduced a slight deviation from the generally accepted ADR Agreement provisions. In this country, it is required that a vehicle transporting dangerous cargo in a tunnel be equipped with at least one flashing warning lamp in orange. It should be activated shortly before entering the tunnel and can be turned off after completely exiting it. Additionally, regulations in Austria differ in another aspect. During the transportation of high-risk goods (goods that potentially could be used in terrorist attacks) through certain tunnels, the vehicle must be accompanied by an escort vehicle, which also must have an orange warning lamp and must have information about the transported hazardous cargo [26].

4. *Other differences*

In the regulations concerning the transportation of hazardous goods by road in the ADR member countries, one could certainly find more differences among individual countries. However, these are not regulations that deviate significantly from the international legal act that is the ADR Agreement. As previously described, this agreement allows member states the flexibility to introduce their own legal regulations, and many countries take advantage of this provision.

Summary

Hazardous materials require specialized knowledge regarding their properties and behaviors, and demand familiarity from every participant in the transportation process with handling such goods, whether it be loading, unloading, or the transportation itself. The transport of such cargo must be carried out by properly trained drivers, using specialized packaging and adequately equipped road transport vehicles. Regulations concerning the transport of hazardous materials are applicable at the international level. They are precisely defined in a legal document that applies to virtually all European countries, as well as some African and Asian countries, namely the ADR Agreement. Member countries of this agreement commit to harmonizing its regulations with domestic regulations. This is a significant facilitation for drivers transporting goods where loading and unloading occur in different countries that are members of the ADR Agreement. Such a driver does not need to be familiar with separate regulations for transporting hazardous goods in each country they pass through because, thanks to the ADR Agreement, the regulations in all these countries are harmonized in the most important aspects. However, the legal act allows each member country to introduce its own regulations that may slightly deviate from the agreement. Nevertheless, in many cases, these are regulations that apply only when the entire transportation process takes place within one country [5].

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