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The Analysis of Threats Arising from the Relations of Dangerous Cargoes and the Rail-Road Infrastructure Illustrated by the Case of Selected Regions of Poland

Abstract. On the example of south-eastern region of Poland (Zamość district), the study characterized the transportation of dangerous cargoes via rail-road infrastructure in this area. It presented a general road and rail infrastructure in this region. In selected period of time, it shows the amount of transported dangerous cargoes. Moreover, it characterized type of transported loads and directions (relations) of these cargoes. It presents the amount of cargoes transported via road and rail means of transport. It indicated places of transshipment / unloading of dangerous goods, such workplaces as in the Zamość district with accumulated goods.

Keywords: Dangerous cargoes, Truck transport, Railway transport, Road infrastructure, Railway infrastructure.

Introduction

Transport of dangerous cargoes via land means of transport requires a very specific and detailed knowledge from participants of transport in order to realize the transport of materials in safe manner without endangering the environment, animals and people. Each dangerous cargo has individual properties [3]. Participants of dangerous cargoes transport via road means of transport are bound by the European agreement concerning the transport of dangerous loads called ADR (*Accord Dangereuses Route*). On the other hand, carriers of the railway transport use the RID provisions-regulations for the international railway transport of dangerous goods as Annex 2 to the regulations concerning the carriage of dangerous goods to the Agreement on International Goods Transport by Rail (SMGS). It should be also remembered about the CIM/COTIF agreement concerning the international carriage of goods by rail. A person, who undertakes to transport dangerous cargoes,

should not only know the regulations for the transportation of these goods, but above all to follow them and apply them properly in practice in order to prevent hazards against life, health and the environment. The carriage of dangerous cargos in large quantities via land means of transport poses a potential threat to both people, road users, animals and the environment. Humans employed in the production, storage, transportation or distribution are exposed to the harmful effects of chemicals. Transportation of dangerous cargos is determined by the provisions and restrictions and it is subject to specific restrictions that limit their release to the transport, packaging, marking along with requirements for the qualifications of the carrier, selection of the appropriate means of transport or the realization of transport in order to ensure the adequate level of security for people and the environment. The carriage of dangerous loads is subject to the special provisions concerning the admission of goods for transport, its packaging, marking, classification and requirements for means of transport, as well as realization of the transport process due to the need to ensure the safety of both people and the environment.

The fundamental act regulating the transportation of dangerous materials in the road transport in the European agreement concerning the International Carriage of Dangerous Goods by Road (ADR), which since the signing of 30 September 1957 in Geneva has been regularly amended. Poland acceded to the ADR agreement on 6 June 1975 [3]. Provisions concerning the carriage of dangerous cargos are applied to all transport participants from the sender and recipient to other persons participating in this process. It is prohibited to transport hazardous materials, which are determined in the ADR agreement as cargos not approved for the international carriage. Only the carriage of dangerous loads under the terms determined in the agreement is possible. There can be some derogations from the ADR agreement that allow the transport of dangerous cargos. These derogations include [1]:

- vehicles at the disposal of the Armed Forces of the Republic of Poland – under the terms and conditions of separate provisions, in conditions when the carriage is directed by aspects of the country's defense and the public order;
- realization or supervision of the transportation by certain emergency services, which are aimed at saving lives or human health, dealing with consequences of disasters, natural disaster or other cases specified in the agreement.

In Poland, the transportation of dangerous cargos via railway transport is based on the provisions of the *Transport Law Act of 15 November 1984*. Conditions concerning the adequate transport of materials by rail were described in the *Ordinance of the Minister of Communications of 6 October 1987 about the list of dangerous times excluded from the carriage by rail*, as well as special conditions for carriage of dangerous goods allowed to be carried. On the basis of this Ordinance, the provisions of the *Regulations for the International Carriage of Dangerous Goods by Rail (RID)* have been introduced. RID provisions are the legal basis both for transport in domestic and international communication. The provisions of the RID form an Annex I relating to the uniform rules on the Agreement for the International Carriage of Goods by Rail (CIM), forming an Annex B to the *Convention concerning the International Carriage by Rail (COTIF)*. During the carriage of dangerous goods by rail transport, provisions and internal instructions laid down by the Polish State Railways are also used. RID regulations concerns conditions of carriage of dangerous goods by rail between Member States of the COTIF Convention [3].

United Nations Committee of Experts grouped the dangerous goods into classes according to the type of created dominant risk. Typically, each dangerous material is characterized by two or even three different threats of different concentrations. At the beginning, this division was dependent on decreasing intensity and impact range of the material on the environment as a result of hazards occurring during the transportation. These included among others risk of fire, explosion, as well as oxidizing, toxic or corrosive action. In accordance with this division, classes were divided into subclasses of dangerous materials. Along with the development of land transport, subclasses have been transformed into classes (with the exception of subclasses belonging to the 1st class) and created 13 classes of dangerous materials [2] [4] [11]. Due to the fact that hazardous materials often

characterize by more than one risk, their division is made on the basis of the dominant risk. Such a classification of dangerous goods is designed to enable a precise choice of the conditions of carriage in order to guarantee a certain level of transport safety.

Road structure and railway structure of the Zamość district

Zamość district is located in the southern part of Lublin Voivodeship (Fig. 1) and covers 15 gminas (including 3 urban gminas) with the area of 872.27 km². It includes such geographical areas and the Lublin Upland (Zamojski Padół, Dział Grabowiecki, Zachodniowołyńska Upland (Grzędy Sokalskie) and Roztocze (Western and Central). Through the Zamość district, dangerous goods are transported by road and rail. Road Transport of hazardous goods is based on the provisions of the ADR, while the rail transport under the provisions of the SMGS and RID. Each class of cargos is characterized by individual properties and the structure of a substance. This district has two routes, which enable the transportation of dangerous goods. The first route is the national road No. 17 Hrebenne-Lublin and the rail road – Metallurgical Broad-Gauge Line (MBGL - in Polish LHS) [12] (fig.1).



1. Zamość district [14]

Zamość district is an important node of national importance for the Lublin Voivodeship. Two national roads run through this region:

1. National road No. 17 E372, Warsaw-Lublin-Zamość-Tomaszów Lubelski-Hrebenne (border crossing) to Lviv. This road is a part of the Via Intermare corridor running from Gdansk through Warsaw-Lviv to Odessa.
2. National road No. 74 Sulejów near Piotrków Trybunalski–Kielce–Kraśnik–Zamość–Hrubieszów – Zosin (border crossing), part of the former Royal Route from Prague and Krakow to Kiev.

The road infrastructure of the Zamość district also includes 3 provincial roads:

- 837 - Zamość-Żółkiewka-Piaski route;
- 843 - Zamość-Skierbieszów-Chełm route;
- 849 - Zamość-Józefów-Wola Obszańska route.

In Zamość, there are 10 bridges over the Łabuńka river and 1 bridge over the Topornica river. They connect banks of small rivers with quite narrow river-beds.

There are also 3 bigger viaducts in Zamość:

- viaduct on the Lubelska Street. The function of this overpass is to pass the MBGL/LHS line without collision;
- viaduct on the Wszyński Street. The aim of this overpass is to pass the normal gauge track No. 72 without collision;

- viaduct on the Powiatowa Street, which serves the same function as the viaduct located on the Lubelska Street.

The summary of engineering structures in the area of Zamość district is presented in Table 1.

Tab. 1. Transport and engineering structures in the area of Zamość district [13]

Zamość region		Bridges	Viaducts	Footbridges	Tunnels	Culverts	Total
	pieces	26	2	5	0	36	69
	Length [m]	472,7	158,64	48,73	0	584,12	1264,19
	Surface [m ²]	5855,71	1937,09	124,62	0	1373,61	9291,03

The city of Zamość has three ring roads:

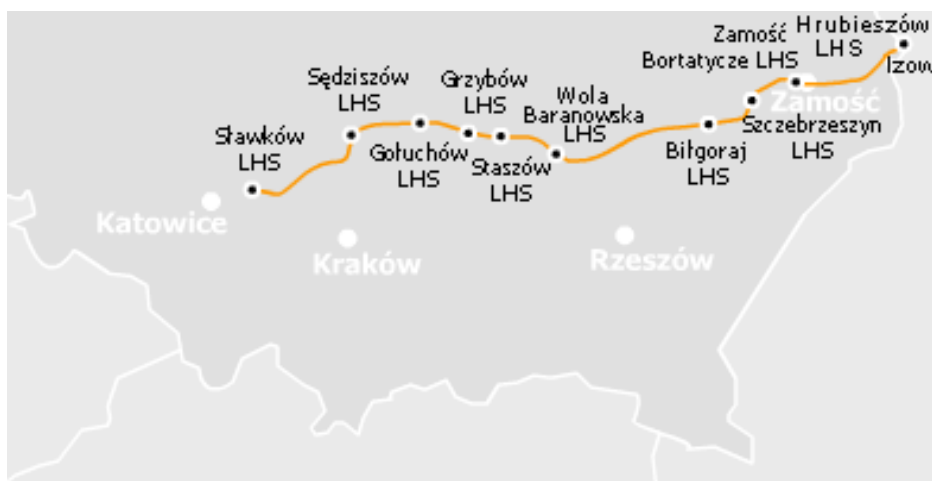
- Western Ring Road. This road is located in the western part of the city between buildings of the Orzeszkowej-Reymonta Housing Estate and buildings of the Karolówka Housing Estate;
- Hetmańska Ring Road. It is located on the north-eastern areas of the city. This ring road is the continuity of the national road No. 17 and partially the national road No. 74, so it is not necessary to drive through the city center;
- Śródmiejska Ring Road known as the Little Ring Road. It goes through the city center, but it bypasses the exact center of Zamość [8].

Two railways lines pass through the Zamość district:

- railway line No. 72 (normal gauge track) with a track gauge of 1435 mm on the route Zawada–Zamość–Hrubieszów (city). This line deals with passenger and freight traffic;
- railway line No. 65 (broad-gauge railway line) with a track gauge of 1520 mm known as the Metallurgical Broad-Gauge Line (MBGL - in Polish LHS) (Fig. 2). This line runs from the Polish-Ukrainian border crossing Izov/Hrubieszów to Sławków in the Dabrowa Basin, where it ends its course. The broad gauge line has national significance. It leads the freight traffic, bypassing city boundaries.

In Bortatycze (Zamość district), there are:

- reloading terminal, which has a track system “S” (1520 mm) and “N” (1435 mm) suitable for reloading liquid gases;
- lateral loading ramp located between two track gauges – 1435 mm and 1520 mm;
- electronic track scales on the track with a width of 1435 mm.



2. Metallurgical Broad-Gauge Line (in Polish LHS) [9]

Analysis of dangerous cargos' carriage on the example of the Zamość district

In the area of Zamość district, there are two freight stations: Zamość–Bortatycze MBGL/LHS station and Szczebrzeszyn MBGL/LHS station. There are ramps and freight yards, reloading terminals, bonded warehouses, storage halls and track scales. Zamość–Bortatycze MBGL/LHS station deals with the transshipment of bulk goods by means of scoops, palletized goods (in bundles, big bags, palletized), wood and liquid gases. In the area of Zamość district, there is also the second railway station – Szczebrzeszyn MBGL/LHS station, which has a reloading terminal allowing the transshipment of goods in the open air and in the storage hall. This terminal does not support the transshipment of dangerous goods [10].

Dangerous cargos are transported through the Zamość district via the national road No. 17. Summary of transported cargos, their type and amount is presented in Table 2.

Tab. 2. List of dangerous goods transported by the national road No. 17 (as of 31.12.2010) [6]

No.	Route	Type of goods	Annual number of transports [t]
1.	National road No. 17 Hrebenne-Lublin	Ammonia	8
		Chlorine	11
		Sulfuric acid	2,2
		Sodium hydroxide	4
		Nitric acid	3,5
		Petroleum products – motor and heating fuels	44 000
		Propane-butane	13 000
		Ammunition	4

In the area of Zamość district, the carriage of dangerous cargos by rail is realized through the broad gauge railway line with a spacing of rails 1520 mm. MBGL/LHS broad gauge line performs commercial transports of dangerous goods in accordance with the RID/SMGS regulations. List of dangerous goods carried by the rail transport is detailed in Table 3. Commercial transports of dangerous cargos by the LHS Ltd. is presented in detail in Table 4.

Tab. 3. List of dangerous cargos transported by railway (as of 31.12.2010) [6]

No.	Route	Type of goods	Annual number of transports [t]	
1.	Metallurgical Line/LHS	Broad-Gauge	Propane-butane	282 006
			Propane	97 413
			Butane	56 772
			Pomace of oil plants	180 423
			Naphthalene	38
			Ferro-silicone	4 860
			Dinitrotoluene	58
			Aniline	1 829
			Flammable liquid	10
			Corrosive solid material	134
			Adhesives	92
			Pitch	3 373
			Methylamine	30
			Nitrotoluene	173
			Hydrogen peroxide	168
			Vinyl acetate	1 404
			Liquid cresol	28
			Trichlorosilane	244
			Diacetate toluene	1 417
			dimethylamine	130
Benzene	998			
Polyisobutylene	94			
Hydroxide	427			
Hexane	77			

Tab. 4. Commercial transports of dangerous cargos by the LHS Ltd. for the year 2010 [7]

Specification	Year 2010 (total)					
	total		Including international transport			
			export		import	
	[t]	[tkm]	[t]	[tkm]	[t]	[tkm]
Total	626 028	156 898 483	10 993	3 971 884	615 035	152 926 599
Explosive substances and articles	0	0	0	0	0	0
Gases	432 584	149 580 822	130	51 870	4 32 454	149 528 952
Flammable liquids	5 355	1 643 355	3 218	869 659	2 137	773 696
Flammable solids	38	15 162	0	0	38	15 162
Pyrophoric materials	176 040	879 341	0	0	176 040	879 341
Materials emitting flammable gases in contact with water	4281	1 695 533	0	0	4281	1 695 533
Oxidizing substances	1 623	647 577	1 623	647 577	0	0
Toxic materials	2 049	2 807 551	1 964	2 773 636	85	33 915
Infectious substances	0	0	0	0	0	0
Radioactive substances	0	0	0	0	0	0
Corrosive materials	591	235 809	591	235 809	0	0
Various dangerous materials and articles	3 467	1 383 333	3 467	1 383 333	0	0

List of dangerous cargos imported in 2010 by the LHS Ltd. to the Zamość–Bortatycze station is presented in Table 5.

There are many plants presenting a risk in the area of Zamość district. Two of them pose high and increased risk of serious industrial accident, i.e. STATOIL POLAND Ltd., warehouse LPG Zamość and LAMPOGAS.PI Ltd. (statement of threats – Table 6).

In addition to plants, where there is a significant or high degree of risk relating to the serious industrial failure, there are plants that pose a threat outside their facilities. Among these plants, we can distinguish among other things [6] :

- CHŁODNIA MORS (Zamość), wherein the ammonia is stored in fixed tanks. It is also used in the cooling installation;
- SPOMASZ Zamość – sulfuric acid and phosphoric acid are stored in fixed tanks;
- OSM Krasnystaw – a manufacturing facility, which has such hazardous substances as ammonia, nitric acid, sodium hydroxide, ammonia water. These substances are stored in the cooling installation, stationary tanks and portable tanks;
- PROFESIONAL P.W. – hazardous substance in the form of ammonia is stored in cooling installations and stationary tanks.

- oleochemical plants in Bodaczów – there is six hazardous substances: ammonia, hexane, sulfuric acid (95%), phosphoric acid (50%), ferrous sulfate. These substances are stored in stationary underground and terrestrial tanks, portable containers and technological installation.

Tab. 5. List of transported dangerous materials by the year 2010; Arrival-Import: Zamość-Bortatycze station [7]

Name of goods	Class	UN No.	Cistern, in bulk, unit of shipment	Amount			Country of consignment
				Wagons Containers	Tons	TWR	
I quarter							
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	108	3 632	X	Kazakhstan
Gaseous hydrocarbons Condensed mixture	2	1978	Cistern	4	130	X	Kazakhstan
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	183	6 344	X	Russia
Butane	2	1011	Cistern	1	27	X	Russia
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	8	203	X	Belarus
II quarter							
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	284	251	X	Russia
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	128	4 271	X	Kazakhstan
III quarter							
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	4	101	X	Ukraine
Butane	2	1011	Cistern	15	431	X	Ukraine
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	267	8 787	X	Russia
Gaseous	2	1965	Cistern	13	327	X	Belarus

hydrocarbons Condensed mixture							
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	33	1 081	X	Kazakhstan
Gaseous hydrocarbons Condensed mixture	2	1978	Cistern	28	844	X	Kazakhstan
Butane	2	1011	C	26	861	X	Kazakhstan
IV quarter							
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	240	8 199	X	Russia
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	15	389	X	Belarus
Gaseous hydrocarbons Condensed mixture	2	1965	Cistern	3	3 177	X	Kazakhstan
Propane	2	1978	Cistern	26	825	X	Kazakhstan
Butane	2	1011	Cistern	21	550	X	Ukraine
Total	X	X	X	X	40 430	X	X

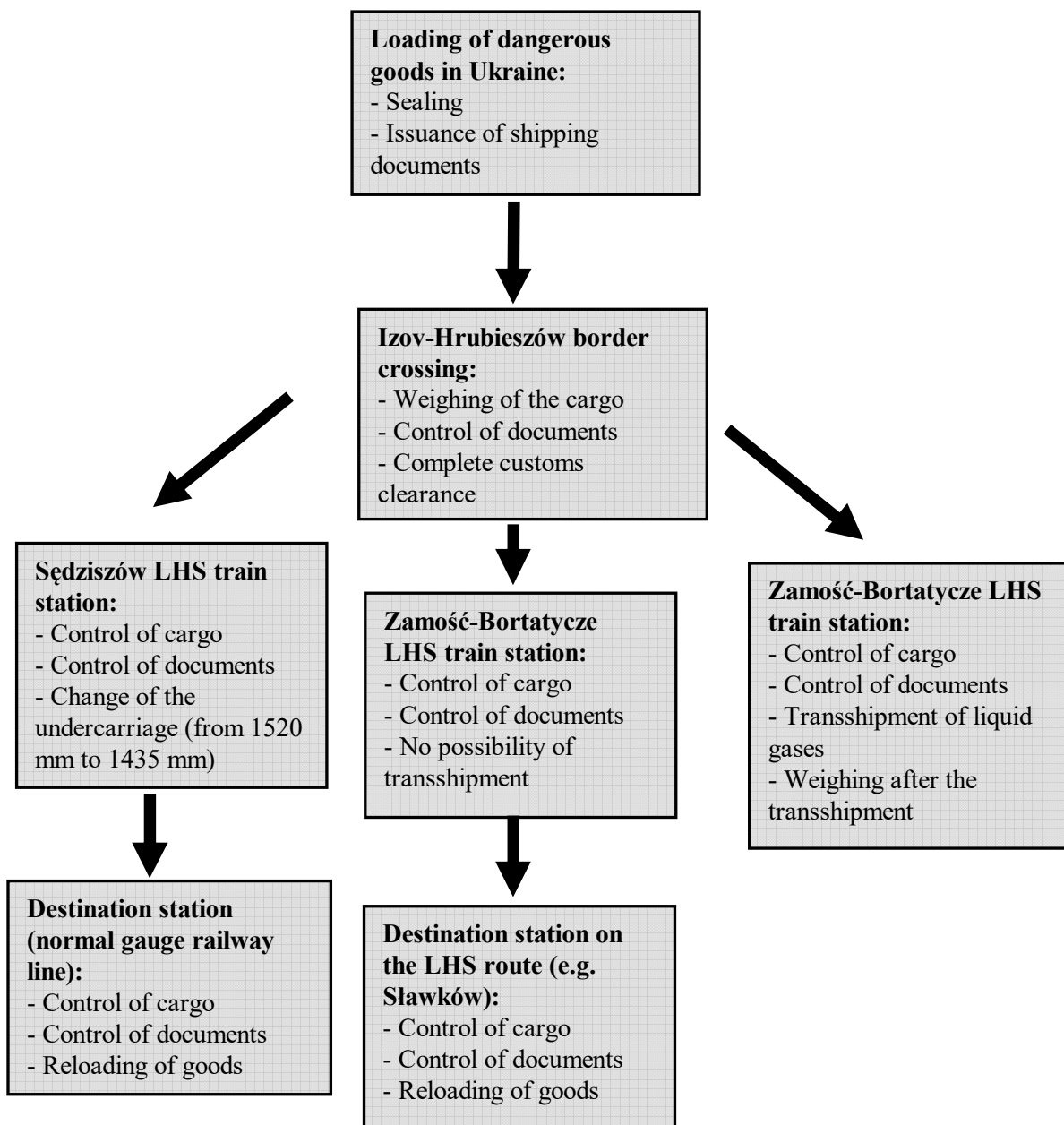
Tab. 6. List of plants with dangerous substances, which present high or increased risk of major industrial accident (as of 31.12.2010) [6]

Name of the company	District	Degree of hazard	Type of dangerous substance	Max. amount [t]	Method of storage
STATOIL POLAND Ltd.; LPG Zamość	Zamość	large	Propane-butane	1 360	Railway cisterns
LAMPOGAS.PI Ltd.; Gas Bottling Plant	Zamość	increased	Propane-butane	164,3	Terrestrial static tanks, railway cisterns

Example of the carriage of dangerous goods realized through the broad-gauge railway line

PKP Broad Gauge Metallurgical Railway Line Limited Liability Company performs tasks of the carrier and the railway manager. Dangerous cargo is sent in the initial station in Ukraine. Subsequently, there is a technical and commercial briefing. The sealed goods are placed in an appropriate wagon along with transport documents. Then the goods are transported on a wide track to Poland crossing the border crossing in Izov-Hrubieszów (Ukraine-Poland). At the Hrubieszów LHS (railway border crossing), the goods are taken over from the representatives of Ukrainian railways.

The charge is thoroughly checked, weighed on electronic wagon scales SCHENECK in order to determine the exact weight of the goods. This procedure is finished by the complete customs clearance. Then, the train with cargo moves on the destination station – e.g. to the Zamość-Bortatycze LHS station. At the destination station (Zamość-Bortatycze LHS STATOIL) there is a possibility to transship liquid gases in railway or car cisterns. Reloading of bulk materials with the use of scoops or piece goods (in bundles, big bags, palletized) is made on the Zamość-Bortatycze LHS station or Szczebrzeszyn LHS station. After this transshipment, the carriage of goods through the LHS is finished. If, however, it is not possible to overload the cargo, the goods are sent to other destination stations located on the broad-gauge line to the Wola Baranowska LHS, where bulk materials are transshipped or the Gołuchowa LHS, where the transshipment of liquid gases is realized or the Sędziszów LHS, where there is a possibility to change the running gear from 1520 mm to 1435 mm.



3. Transport of dangerous goods via rail transport by the LHS Company

Consequently, the goods are sent to the destination station on a standard gauge railway line. After reaching the destination station, the cargo is subjected to final operations, as well as technical and commercial briefing [7].

The process of carriage the dangerous goods by the LHS Company is presented in Fig. 3.

Final remarks

The analysis of the dangerous goods' transportation via land means of transport on the example of Zamość district was intended to illustrate land corridors, which enable the carriage of goods. Performed analysis has shown the importance of Zamość district in the region and in the Lublin Voivodeship. Moreover, it presented an example of transportation by railway rolling stock between neighboring countries with the use of Broad Gauge Metallurgy Line (LHS), which is based on the provisions of the RID and SMGS agreement. It should be noted that the safety of dangerous goods' transport significantly depends on the road and railway infrastructure, on which the cargo is transported. In reloading places, technical quality of reloading equipment, which is not always a part

of the transport infrastructure, has a large importance. Another issue (beyond the subject matter of this elaboration) is the problem of loading and unloading of dangerous cargos in the place of their production and reception.

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