

## **TRANSPORT RULES AND ASSESSMENT OF THREATS CONNECTED WITH TRANSPORT OF HAZARDOUS MATERIALS BY TRAIN**

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### **Abstract**

*Every year in Poland, approximately 22 million tons of dangerous materials is transported, which, apart from the German railway, places it on the second position in Europe. The most numerous group of dangerous materials include items of class 3 (liquid, flammable materials), especially liquid fuels. In order to prevent accidents and remove their effects, the European Union countries have developed an international code regulating transport of dangerous materials by railway, RID. Every year 110 billion ton kilometres of dangerous materials are transported on the territory of the EU. Materials carried by road transport account for 58%, by railway 25% and by water 17% of all the transported dangerous products. Transport of dangerous materials accounts for 8% of all freight transports in the European Union.*

*Having in view natural environment protection and safety of people, there are carried out works on one legal act to account for all the three transport branches. Railway transports of dangerous materials are performed in a safe*

way and rare, in terms of the transports number, accidents and failures do not cause harmful effects, neither on people nor the natural environment.

In the paper, there has been made an analysis of transport procedures and threats which occur while carrying dangerous materials. On the basis of carried out investigations an assessment of the risk factor in the studied process has been presented. General rules for transport of dangerous materials by railway and their classification have been presented, markings according to RDI regulations. An attempt of threats identification and analysis of the main causes of undesirable events occurrence during railway transport of dangerous materials has been made by the authors of this work.

**Keywords:** railway transport, hazardous materials, RID

## 1. Rules of hazardous load transport by railway

Transport of hazardous materials by railway carried out according to:

- Act from 28 March 2003 on railway transport
- Act from 31 March on hazardous materials railway transport
- The rules connected with transport of hazardous materials, including [1, 2, 3]:
- RID – ( regulations on international railway transport of dangerous materials)
- Annex 2 to SMGS – (regulations on transport of dangerous materials annex to the Agreement on International Railway Freight Transportation).

The rules connected with carrying hazardous materials are set by an adequate law which defines duties of the transport participants, principles for assessment of transport pressure devices consistence, powers of the transport safety consultants and organs and institutions of control and supervision [2]. This document also **defines** dangerous materials which authorized to international transport according to RID Regulations. Chapter 2 of the quoted document defines in detail duties of participants of hazardous material railway transport and requirements concerning packages, containers, and other devices used for transport of dangerous loads. Under this Act the railway carriers or other carriers dealing with loading, unloading, filling or reloading of such materials are obliged to hire, at their own cost, a consultant to assist them in handling those materials. Supervision and control over the safety of dangerous materials railway transport is the responsibility of the President of UTK (**Railway** Transport Office) on the basis of regulations from 28 March 2003 on railway transport (Official Journal No. 86. pos. 789, No. 170, pos. 1652 and No. 203, pos. 1966).

*Classes of hazardous load according to RID:*

- Class 1 Explosives and objects containing explosives,
- Class 2 Gases,
- Class 3 Liquid flammable materials,
- Class 4.1 Solid flammable materials, self-reactive materials, solid neutralized explosives,
- Class 4.2 Self-ignition materials,
- Class 4.3 Materials emitting flammable gases while in contact with water,
- Class 5.1 Oxidizing materials,
- Class 5.2 Organic peroxides,
- Class 6.1 Poisonous materials,
- Class 6.2 Infectious materials,
- Class 7 Radioactive materials,
- Class 8 Caustic materials,
- Class 9 Other dangerous materials and objects.

## 2. Transport of hazardous materials in Poland

In Poland approximately 20 million tones of dangerous materials are transported every year. Carrying such big amounts of hazardous materials with various, most often very harmful for the humans and environment, properties can pose a threat of fire and explosion which luckily has not been reflected by the number of accidents.

Statistics reveal that transport of dangerous loads by railway is considered to be the safest one. This has been confirmed by the number of environmental threats caused by railway transport while carrying those materials. This number is significantly lower as compared to road transport and from the beginning of the XXI century it has been constantly decreasing.

Additionally railway transport generates much lower external costs connected with the damage to the environment and effects of accidents – they account for merely 12.5% of similar costs, generated by car transport.

As Tab. 1 shows, since 2002 the amount of transported hazardous material has systematically been increasing. Despite this, the share of PKP (Polish National Railway) Cargo S.A. is constantly decreasing as foreign and private transport companies have been taking over this kind of transport market.

Due to the character of the loads, the railway transport of dangerous materials is accompanied by risk of undesirable events occurrence whose effect is a threat to health and life of the people participating in the system and its environment. Failures during transport can also cause degradation of the natural environment or material goods.

*Tab. 1. Quantity of hazardous materials railway transport*

No.	Year	All transports	Polish National Railway Cargo S.A.		Other carriers	
		(in thousands tones)	(in thousand tons)	% share in market	In thousand tons	% share in market
1	2002	14.700	14.700	100		
2	2003	17.200	14.800	86	2.400	14
3	2004	20.000	12.500	62,5	7.500	37.5
4	2005	19.300	11.200	58	8.200	42
5	2006	19.675	11.265	57	8.410	43
6	2007	22.574	10.991	49	11.583	51
7	2008	20.102	8.015	40	12.087	60
8	2009	20.516	6.322	31	14.194	69

Due to the fact that railway transport of hazardous materials, like the road transport, comes under special and rigorous rules and regulations defining their authorization to be transported, choice of packaging, marking and requirements concerning qualifications of the staff, transport means and the transport procedures.

However, despite strict control and obedience of the rules regulating the operation and maintenance of the fleet and strict control of loading and unloading devices, tank wagons tests, there are still cases of leaks of dangerous substances outside into the environment posing a serious danger for the people and the environment. Most frequently they occur during loading. Inappropriately protected shipments are the most frequent cause of leaks, vapours, or emission of dangerous substances during carrying.

Due to the character of the loads, transport of hazardous materials is inseparably connected with the risk of the threat occurrence. Failures during carrying dangerous materials can result in life threat, damage to the environment, and material goods. Not surprisingly, the loads come under stringent rules concerning the choice of packaging, loading manner, marking and requirements concerning the staff qualifications, means of transport and transport procedure.

As Tab. 2 shows, the most often transported materials include:

- Liquid, flammable substances, class 3, mass app. 14.4 million tons, which accounts for 70.4%,
- gases, class 2, mass app. 2.7 million tons, which accounts for 13.%,
- caustic materials, class 8, mass app. 1.9 million tons, which accounts for 9.6%.

Tab. 2. Kinds of hazardous materials transported o the territory of Poland

Load class	Transport of dangerous materials [kg]					
	2004	2005	2006	2007	2008	2009
1	12127	27701	1431	23432	17955	10148
2	1960891	2094309	3016677	3216003	2661522	2672184
3	14543705	13055974	12953276	14778456	13328879	14435546
4.1	719483	744922	590335	900366	789575	504806
4.2	139798	129846	125882	109896	120973	148965
4.3	22658	16950	13240	12479	8636	7 141
5.1	204766	237313	332181	261586	190857	141637
5.2	112	67	979	307	143	121
6.1	294527	312627	261135	349431	291864	245000
7	157	314	268	300	323	505
8	1898280	245044	2086885	2831650	2244372	1973550
9	212326	243731	279804	87732	446865	376868
	20008830	19314238	19674972	22571638	20101964	20516474

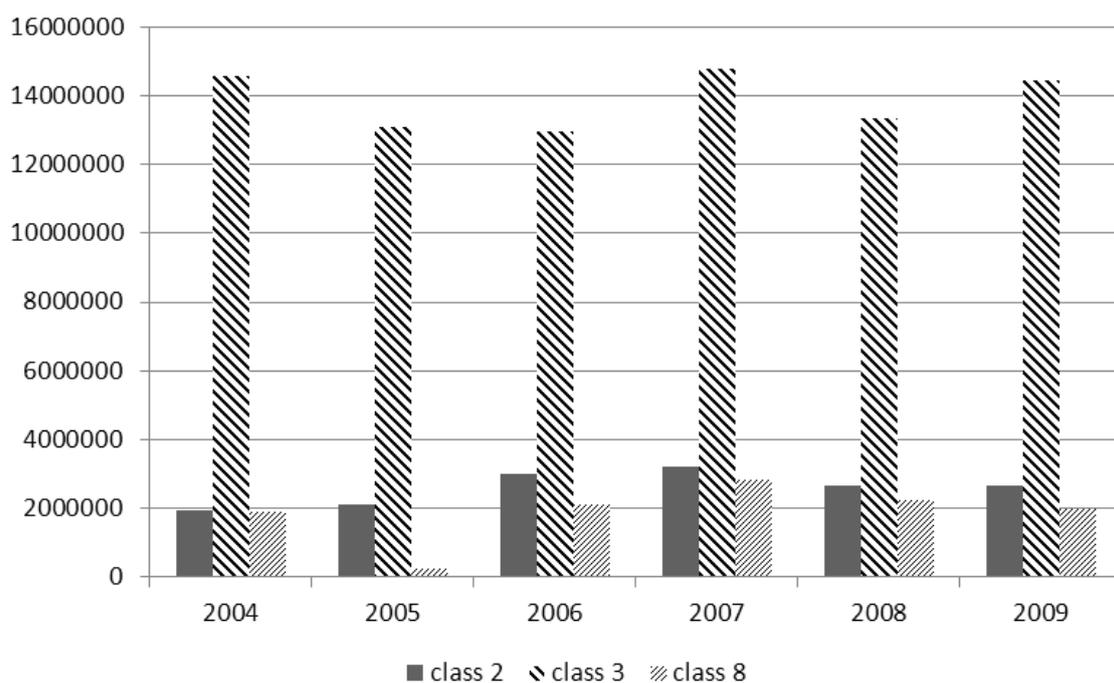


Fig. 1. Transport of hazardous substances of class 2, 3, 8

### **3. Examples of undesirable events occurred in the analyzed time interval**

- A. On the 24<sup>th</sup> of February, in Miały, 7 tank wagons derailed (4 tank wagons with diesel oil and one with carbon dioxide and hydroxide of sodium and one empty not cleaned after acrylonitrile) 3 tank wagons with diesel oil from a freight train on the route from Poznan to Szczecin depressurized which caused a leak of about 45 tons of the fuel and contamination of soil, which involved the necessity to take wide scale actions of land restoration. Also the energy track and rails were heavily damaged over a distance of 3 km. In the rescue action, 16 brigades of firefighters took part.
- B. On the 23rd May 2002, on the route from Szczygłowice Kopalnia – Knurów Szczygłowice, distance Rybnik-Gierłatowice, a train derailed (locomotive and 5 wagons). The first derailed wagon was a tank– wagon with octanol and the fifth was a cistern with ammonia. The tank wagon with alcohol was depressurized which caused a serious leak. Because of the location of the accident –a high railway embankment – the rescue action was very difficult. The train driver sustained injuries.
- C. 22 June 2002 in Chałupki Medyczne near Przemyśl, on a branch track, during reloading of a Ukrainian tank wagon with gas condensate there was an explosion and fire. A worker died and three people got burnt, the loading hall and 12 wagons were damaged. Estimated material loss amounted up to 3 million pln.
- D. 19 September, 2003 at the station Mleczewo, distance Hława Główna – Malbork, a tank wagon loaded with water solution of urea and ammonium nitrate derailed during leaving the station. The accident occurred when the last wagon was going through passage head. The tank wagon overturned and blocked the passage for many hours. 4 junctions were damaged.
- E. At night from 8. to 9. September 2003 a stationary train at the Cybie station tank consisting of wagons was hit by a locomotive moving at the speed of 50km/h. It bumped into an empty protection wagon which was tossed upward ramming a dished end plate of the cistern container of the connected tank wagon loaded with diesel oil UN 1202/30. Next, a coal car and 3 tank wagons were derailed. One of them depressurized at the container coat, in result of which a leak of 25 t of fuel followed. Contamination of the soil was another consequence. Actions of firefighters which lasted more than 38 hours were carried out with participation of 27 fire brigades including 4 groups of volunteer firefighters.
- F. 14 November 2004 at Twarda Góra station, two of the tank wagons derailed in result of twisting off a journal of the wheel set axel in one of the wagons while the train was leaving the station ( one was loaded with sulphuric acid the other was empty not cleaned after hydrochloric acid).
- G. 21 December 2005 after the train entrance to Chałupki station, a leak of benzol UN 3295/33 was found from a tank wagon which was detached from the train rake and towed to a branch track, where the leaking substance was collected to containers. Eventually, the leak was stopped by means of a pin, mass and tape, and the load was sent back to the sender The environment was slightly contaminated (560kg from which 310kg was retrieved). 11 brigades of firefighters took part in the action, apart from the army and the police.
- H. 22 March, 2006 at the station Zajączkowo Tczewskie, a tank cistern crashed with a train in result of which the wagon overturned on its left side and gasoline UN 1203/33 leaked from under a gland of the main switch valve. Loss of load - 1.5 tons.
- I. At 2:48, on the 28th of August, on the railway track from Koluszki to Łódź, in Gałków Mały, a locomotive derailed pulling a tank behind wagon filled with urea nitre. The cistern overturned on its left side and two cisterns behind with propylene fell out from the rail track. The electric over track was broken and rails were damaged. The loss was estimated to be 240 thousand pln. The rescue action was carried out by a rescue unit Koluszki, two groups of chemical rescuers, a rescue unit of Łódź and a special rescue train from Łódź.

- J. 5 December 2006 on the track Poznań – Wągrowiec, distance Poznań Wschód – Czerwonak, at an unprotected railway crossing there was a collision of a train with fuel with truck carrying debris. In result of the crash the car was destroyed, the locomotive overturned and four first tank wagons derailed. A protection wagon (empty tank wagon) hit the head of the next tank wagon container damaging it with the bumpers to such a degree that an uncontrolled leak of light fuel oil UN 1202/30 followed. The environment was contaminated and railway traffic was stopped which involved a necessity of making a report in accordance with 1.8.5 of IRD.
- K. 15 March 2007 on the territory of OLPP Fuel Base No. 15 in Narewka, during reloading gas from a tank wagon to a car cistern, there was happened depressurization of a gasket on the cistern flange at the liquid phase. A leak of 1.630 l. of gas followed and the formed cloud of gas was ignited from contactors of the alarm system operating in a switching station located 110 m. from the place of the depressurization. The burning gas ignited rubber hoses connecting the wagon-cistern with a stable installation. A surface fire followed which changed into a stream fire of the cistern itself. Also the bedding of the nearby forest burst into flames. After putting out the fire and cooling the containers, the valve stopping the gas from further leaking was secured. Cause of the event- technical fault. One of the fuel base workers sustained burns while attempting to put out the fire.
- L. 8 December 2007, on the track Kędzierzyn Koźle – Stare Koźle, a freight train, consisting of tank wagons with ethanol UN 1174/33 standing before a semaphore was hit by another freight train consisting of 40 wagons with iron ore. In result of the crash, 47 tons of ethanol leaked out from one of the tank wagons. Soil was contaminated over a distance of 400 m. Two other tank cisterns were damaged but fortunately they were not depressurized.
- M. 28 June 2008, railway track No. 353 Poznan East – Skandawa, from Kobylnica to Biskupice. Train No. 28890 from Strzegomek to Police Chemia, in result of running down its bearing and damage to the axle bolt, there occurred a derailment of the 17-th wagon, and further ride of the train with a derailed wagon caused derailment of 4 more wagons (about 3 km over bolts and cross-sills). Two of them overturned and melted UN 2448/44 leaked out of one of them.
- N. 8 November 2010, at about 5.30, at a tunnel near a railway node at Hetmańska street in Białystok, two trains had a head on crash – one consisting of 32 cisterns containing diesel oil, gasoline and toluene and the other carrying gas propane-butane and junk. The event was followed by an explosion of a tank wagon and 2 hours later another one exploded. 30 units of firefighters fought with the fire. The burning trains contained almost 200 m<sup>3</sup> of liquid fuel 17 wagons and 2 locomotives burnt down and in switch tower 2 persons sustained injuries.

#### 4. Conclusion

In the paper there have been presented general guidelines concerning transport of hazardous materials by railway. As it can be seen, providing the transport with high safety level is a complex problem and requires an analysis of the system including identification of the causes of undesirable events occurrence as well as an assessment of the threats connected with improper identification of the influence of forcing factors. It can provide basis for elaboration of standards making it possible for the decision makers to take good and rational decisions connected with transport safety. It is necessary to do further research on identification of factors which contribute to occurrence of such events during carrying this type of materials and development of risk prevention methods.

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