

## ANALYSIS OF EXTRAORDINARY EVENTS IN THE TRANSPORT OF DANGEROUS GOODS BY RAIL IN THE REPUBLIC OF SERBIA

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### Abstract

Transport of dangerous goods in the organizational and technical-technological sense, represents a constant threat to all who are indirectly or directly in contact with this type of goods. The paper presents transport of dangerous goods by rail on the territory of the Republic of Serbia in the period from 2008 to 2015. In this period there was an increase in the volume of transport of dangerous goods by rail. Extraordinary events are classified and specifically explained as extraordinary events in railway traffic and events in the transport of dangerous goods by rail as well. Extraordinary events in the transport of dangerous goods are thoroughly analyzed, i.e. analysis of the causes of these events, directions and stations where they occurred, as well as their dependence on the number of extraordinary events in railway traffic and the total amount of transported dangerous goods. The appearance of extraordinary events in the transport of dangerous goods by rail occur mostly due to the influence of the human factor; which is 47.8%. Based on the analysis carried out, the measures are proposed to prevent the occurrence of extraordinary events in the transport of dangerous goods by rail.

**Key words:** extraordinary events, railway traffic, dangerous goods

## 1 INTRODUCTION

Dangerous goods are substances that during manufacturing, packaging, storage, transport, handling and usage can be dangerous and harmful to human health and the environment or they can cause material damage if they are improperly handled [1]. Transport of dangerous goods in the organizational and technical-technological sense, is a

constant threat to all those who are directly or indirectly in contact with this type of goods. In the structure of total transport of goods, the transport of dangerous goods plays a significant role.

Transport of dangerous goods involves a change of the place, i.e. the movement of dangerous goods packed for transport or loaded into, especially for that purpose intended, means of transport. The railway transport itself includes intermittent stops and retentions of dangerous goods on railway wagons, which is determined by the specific conditions of this type of transport. In some cases, due to defects in means of transport, dangerous goods must be stored in the vehicle for relatively longer period or be reloaded. Transport, temporary storage and handling can be a source of critical moments with adverse consequences which, due to the nature of cargo, can be many times greater than the result caused by unwanted moments in transport all other goods [2].

Due to the stated negative impacts of dangerous goods, their transport must be organized according to certain rules in order to make the risk of accidents minimal, that is to minimize the consequences of accidents that have already occurred [3].

From the aspect of importance for the protection of the environment, people, and danger, and based on the recommendations of the United Nations, the regulations for the transport of dangerous goods by all modes of transport have been adopted. This contributed to regulation in this area when it comes to transportation safety, obligations and responsibilities of all participants in the transport of dangerous goods. The scheme of regulations for all modes of transport is shown in Figure 1.

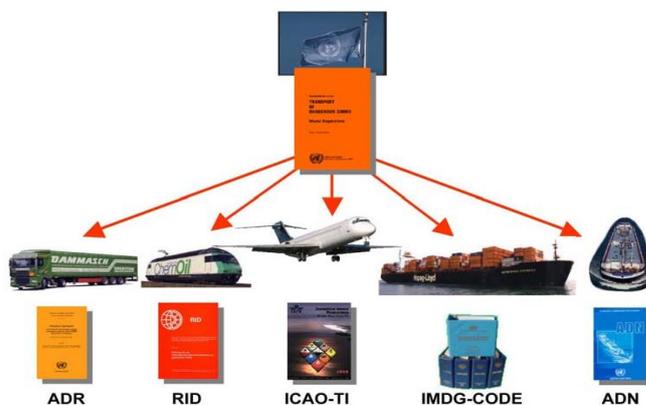


Fig. 1 International agreements concerning the transport of dangerous goods by means of transport [8]

The transport of dangerous goods in international rail traffic is completely legally regulated by the Regulation concerning the international carriage of dangerous goods by rail (RID) as Appendix "C" of the Convention concerning the International Carriage by Rail (COTIF). It regulates the general regulations for the transport of dangerous goods by rail, such as the classification of dangerous goods, the list of dangerous goods, regulations for manufacturing, testing, the use of packaging, transport means and regulations for loading, unloading, handling and shipment of packages with dangerous goods [4]. The issue of dangerous waste transport, in addition to being fully covered by RID Regulations, is regulated by the so-called "Basel Convention" on the control

of transboundary movements of dangerous wastes and their disposal.

RID fully regulates the transport of dangerous goods excluded from international transport and dangerous goods whose international transportation is allowed. Details on the implementation of certain provisions of RID are given in the Announcements (FISE) of European Railway Union (UIC), in the form of recommendations or executive (binding) provisions.

The competent authority for the implementation and enforcement of the Regulations and the Law on the Transport of Dangerous Goods (Official Gazette of RS, no. 104/2016), is the Department for the transport of dangerous goods in the Ministry of Construction, Transport and Infrastructure, as an external and the Advisor for safety in the transport of dangerous goods, as internal organ.

Organization of the transport of dangerous goods by rail on the territory of the Republic of Serbia is conducted by joint-stock company "Serbia Cargo".

## 2 THE DEFINITION OF AN EXTRAORDINARY EVENT IN THE TRANSPORT OF DANGEROUS GOODS

An extraordinary event in rail transport represents unpredicted and unexpected event which results in at least one of the following events: death of one or more persons, serious or minor injury of one or more persons, material damage, interruption of rail transport, endangerment or difficulty in the railway traffic [2].

If loading, filling, transport or unloading of dangerous goods result in a serious casualty or accident on the territory of a Contracting Party, the loader, filler, transporter or recipient must provide a report according to the prescribed form to the competent authority. The Contracting Party shall submit, if necessary, report to the Secretariat of the United Nations Economic Commission for Europe, in order to inform the other Contracting Parties.

An extraordinary event in the transport of dangerous goods has occurred in the case if there is a loss of product (if dangerous cargo leaked or there is imminent danger to leak), if there is a personal injury, material or environmental damage, or if the competent organs are engaged and, if one or more of the listed criteria are fulfilled [4].

Injury of the person is an event in which death or injury is directly related to the transport of dangerous goods and where the injury requires:

- intensive medical intervention,
- hospital stay of at least one day, or
- inability to work for at least three consecutive days.

Loss of products means the release of dangerous goods of:

- transport category 0 or 1 in an amount of 50 kilograms or 50 litres or more;
- transport category 2 in an amount of 333 kilograms or 333 litres or more; or
- transport category 3 or 4 in an amount of 1,000 kilograms or 1,000 litres or more.

The criteria for loss of product is applied even if there was an imminent risk of loss of product in the above amounts. As a rule, it is assumed that, if the vessel on the basis of structural damage is no longer suitable for further transport or for other reasons it cannot guarantee sufficient security (eg. due to

deformation of tanks or containers, overturning tank or fire in the immediate vicinity).

If dangerous goods of Class 6.2 are included, the reporting obligation exists without amounts limitation.

If there are some radioactive materials of Class 7 included in an extraordinary event, criteria set out in the RID are valid.

The material or environmental damage is if dangerous goods are released independently of load, wherein the estimated amount of damage exceeds 50,000 euros. The damage on the means of transport with dangerous goods, which have directly been involved as well as on the modal infrastructure shall not be taken into account.

It is sufficient to mention the following catastrophic accidents that were caused by dangerous goods, so that the perception of risk from dangerous goods gets a completely different vision. These are the following accidents in which only consequences for human life and health are outlined:

- accident in the port of Halifax, Canada, in 1917, over 2,000 dead and 9,000 injured,
- accident in Texas port warehouses, USA, in 1947, over 500 dead and about 3,500 injured,
- accident in the Salang Tunnel, Afghanistan, in 1982, over 3,000 dead,
- accident in the warehouse San Juan Ixauapetec, Mexico, in 1984, over 500 dead and about 3,500 injured,
- accident at the railway station Ufa, Chelyabinsk, USSR, 4th June 1989, about 2,200 dead and 3,000 injured and
- Explosion of railway tank wagons with dangerous goods in the Belgian city of Ghent in 2013 (Fig. 2).



Fig 2. Explosions of railway tank wagons with dangerous goods - Belgium, Gent 2013

The risk of the occurrence of the consequences in the transport of dangerous goods due to non-application of ratified international agreements, the Law on the Transport of Dangerous Goods and bylaws issued based on this law is classified into three categories [5]:

- Category I Risk is a danger to a person's life or pollution of the environment with the consequences whose elimination is long-termed and expensive;
- Category II Risk is the danger of causing serious body injury to a person, or considerable pollution of the environment, or environmental pollution on a larger area;
- Category III Risk is a risk of causing slight body injury to a person or low environmental pollution.

According to the location, causes of occurrence and consequences that have caused or could cause, extraordinary events in rail transport are divided into [6]:

- casualties and
- accidents.

## 2.1 The term of casualty in rail transport

Casualty in rail transport is an extraordinary event that has resulted in death or serious injury of one or more persons, significant material damage to the means of production or greater disruption of rail transport.

From the standpoint of the degree of endangerment of the safety of the railway traffic, the method and place of occurrence, casualties can be divided into [6]:

- casualties in the performance of rail transport,
  - casualties at level crossings and
  - casualties outside the level crossings at railway area.
- Casualties in the performance of rail transport are:
- train collision - when a train hits the front, side, or rear end of the other train, wherein both of them are moving, or just one of them is moving, irrespectively of the direction of movement,
  - rear-end collision - when a train hits the front, side, or rear end of the maneuvering composition, a group or an individual vehicle or rail vehicle, and which is also moving or standing on a track,
  - derailment - when one or more vehicles, or towing vehicle, runs off the rails,
  - fire or explosion - when they have at least one of the consequences typical for the accident, regardless of whether they occurred on a train, line, or facilities, if at the same time they endanger rail transport,
  - derailment and rear-end collision at maneuvering - when one or more vehicles run off the rails when maneuvering or if there is an impact on maneuvering composition - the towing vehicle on the front, side, or rear end of the other maneuvering composition, individual or groups of vehicles, when maneuvering or derailling the vehicle,
  - collision, rear-end collision and derailment of railway vehicles - when rail vehicles hit the front, side or rear end of the other rail vehicle or crash into other vehicles or when the railway car derail,
  - other casualties - casualties that are not classified into the above-mentioned groups having at least one of the consequences typical for the casualty.

Casualties at level crossings are extraordinary events caused by illicit and careless movement of persons, road vehicles and the herd, which caused the death or serious injury of one or more persons, substantial material damage or greater disruption of rail transport. They are divided into:

- Casualties at level crossings for road vehicles secured by gates, half-gates and light signals,
- Casualties at level crossings for road vehicles secured by traffic signs for road vehicles and
- Casualties at level crossings for pedestrians and cyclists.

Casualties outside level crossings in the railway area are extraordinary events caused by unauthorized and careless movement of persons in the railway area, falling, jumping out or on the train, falling of objects or road vehicles on the track, which caused the death or serious injury of one or

more persons, considerable material damage or greater disruption of train traffic. They are divided into:

- Casualties on the open line,
- Casualties at official places,
- Casualties caused by falling out of a train and
- Casualties caused by jumping onto or out of a train.

## 2.2 The term of accident in railway traffic

The accident in railway traffic is an extraordinary event which results in a minor injury of one or more persons, the minor material damage, less disruption or difficulty in the rail transport [6].

From the standpoint of the degree of endangerment of the safety of rail transport, manner and place of occurrence, accidents are divided into:

- accident at the performance of rail transport,
- accidents at level crossings
- accident outside the level crossings in the railway area.

Accidents at the performance of rail transport are:

- avoided collision of trains - when the illicit trains movement could have caused a collision,
- avoided rear-end collision of a train or a rail vehicle - when the illicit movement of a train or a rail vehicle could lead to rear-end collision,
- the passage of a train or a rail vehicle by the signal indicating the prohibited driving - when the train or a rail vehicle passes by the main or the other signal which prohibits further driving and when the train passes through the office place on the line in which according to the timetable or order should stop,
- derailment or rear-end collision of the vehicle when maneuvering - when it derails or collides into one or more vehicles when maneuvering or when a vehicle derails.
- fire or explosion - with the consequences typical for the accident,
- collision or a rear-end collision of railway vehicles - with the consequences typical for the accident,
- other accidents - accidents that are not classified into the above-mentioned groups but have consequences typical for the accident.

Accidents at level crossings are extraordinary events caused by careless and illicit movement of persons, road vehicles and the herd, which resulted in a minor violation of one or more persons, minor damage, minor disruption or difficulty in rail transport. They are divided into:

- accidents at level crossings for road vehicles that are secured by gates, half-gates and light signals,
- accidents at level crossings for road vehicles which are secured by traffic signs for road vehicles,
- accidents at level crossings for pedestrians and cyclists.

Accidents outside the level crossings in the railway area are extraordinary events arising from unauthorized and careless movement of persons in the railway field, falling, jumping out of or on the train, objects or road vehicles falling on the track, which resulted in a minor injury of one or more persons, minor damage, minor disruption or difficulty in rail transport. They are divided into:

- accidents on the open line,
- accidents in official places,
- accidents caused by falling out of a train and
- accidents caused by jumping on or out of the train.

### 3 EXTRAORDINARY EVENTS IN THE TRANSPORT OF DANGEROUS GOODS BY TRAIN IN THE REPUBLIC OF SERBIA

The paper presents analysis of extraordinary events in the transport of dangerous goods by rail on the territory of the Republic of Serbia in the period from 2008 to 2015. During this period there was an increase in the volume of transport of dangerous goods by rail. Based on the unified data [4] on the volume of the transport of dangerous goods by class, it is observed that most transporting substances were of the Class 2 (gases), Class 3 (flammable liquids), Class 5 (oxidizing substances), Class 8 (corrosive substances) and Class 9 (miscellaneous dangerous substances). The remaining quantities are negligible: Class 1 (explosives), Class 4 (flammable solids) and Class 6 (toxic substances), while Class 7 (radioactive materials) was not transported. Figure 3 graphically shows the amount of transported dangerous goods by classes (2, 3, 5, 8 and 9) in the period from 2007 to 2015.

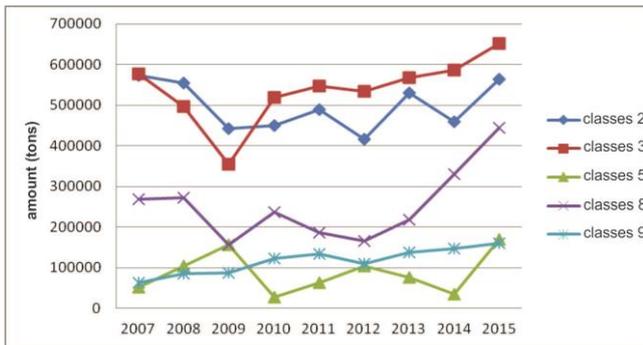


Fig. 3 Transported amounts of Classes 2, 3, 5, 8 and 9 in the period from 2008 to 2015 [7]

Figure 3 shows that, starting from 2009, there is a steady increase of transported quantities when Classes 3, 8 and 9 are concerned. At Class 2, we have the standard quantities ranging between 400 and 550 thousand tons per year, and at the Class 5 up to 150 thousand tons annually.

Table 1 provides an overview of extraordinary events in the rail transport, as well as the percentage of extraordinary events with dangerous goods in relation to the total number of extraordinary events in the period from 2008 to 2015.

Table 1 The overview of extraordinary events in rail transport from 2007 to 2015 [8]

Year	Extraordinary events	Extraordinary events with dangerous goods	Percentage (%)
2008	541	20	3.7
2009	528	14	2.6
2010	574	8	1.4
2011	495	15	3.0
2012	503	14	2.8
2013	482	8	1.6
2014	562	12	2.1
2015	497	20	4.0
Σ	4182	111	2.65

The number of extraordinary events with dangerous goods in relation to the total number of extraordinary events ranges from 1.4% in 2010, when it was the lowest, to 4% in 2015 when it was the highest. It can be concluded that in 2015 the total number of extraordinary events was decreased by 11.6%, while there was an increase of extraordinary events in the transport of dangerous goods by 66.7%, which is an alarming fact. On average, for that period, the number of extraordinary events with dangerous goods makes 2.65% of the total number of extraordinary events during the period.

In order to adequately determine the causes of the occurrence of accidents in the transport of dangerous goods, extraordinary events are thoroughly analyzed [7]. To carry out the analysis it is primarily necessary to divide the causes of extraordinary events in the groups, in order to obtain a clear image.

Figure 4 shows the percentage of certain causes in the total number of extraordinary events in the transport of dangerous goods by rail in the period from 2008 to 2015. [8]

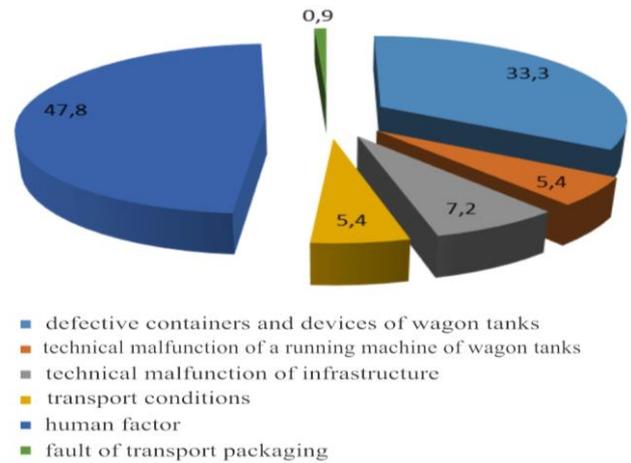


Fig. 4 The causes of extraordinary events in transport of dangerous goods by rail [8]

The most extraordinary events in a given period (47.8%) happened due to the influence of the human factor, and 33.3% of extraordinary events happened due to defective containers and devices of wagon tanks, which transported the dangerous goods. The technical malfunction of infrastructure follows with 7.2%. The next is a technical malfunction of a running machine of wagon tanks and transport conditions with 5.4%. At the end there is the fault of transport packaging with 0.9%.

### 4 PROPOSED MEASURES FOR PREVENTION OF EXTRAORDINARY EVENTS

Based on the analysis carried out [8], the measures are proposed to prevent the occurrence of extraordinary events in the transport of dangerous goods by rail. In order to prevent the occurrence of extraordinary events, it is necessary to define a wider range of measures that would contribute to it. Based on the results of the analysis carried out for the period from 2008 to 2015, it can be seen that the human factor largely contributed to the occurrence of extraordinary events. It is necessary to define the measures with the aim of action according to participants in the transport of dangerous goods in order to avoid the environmental degradation. Safety

advisers for the transport of dangerous goods shall provide their contribution in such situations.

Based on the results and goals they want to achieve, measures for preventing the occurrence of extraordinary events in rail transport can be divided into [8]:

- organizational,
- investment and
- educational.

One of the biggest challenges is reflected in the organization of the transport of dangerous goods. In order to eliminate the risk of the occurrence of extraordinary events it is necessary to implement measures to prevent extraordinary events from the very receipt of the consignment, then the transport of the shipment with increased security, to the establishment of appropriate organizational structure for more efficient management.

The support of the good and quality transport organization depends on railway infrastructure that sets various restrictions. Limits itself solely depend on the quality of the railway, its maintenance, longitudinal inclination, and besides that to the selection of locomotives. In order to ensure the arrival of the goods in marshalling yard, it is necessary that the management invest in the rail infrastructure, locomotives and wagons in order to modernize and provide better monitoring of the composition of dangerous goods.

The educational measures, that relates to the transport of dangerous goods, refer to the knowledge and training of workers involved in the transport process in order to increase security for people and their environment. When you examine the damage that can be caused by dangerous goods during accidents, it is sure that educational measures relating to people who handle dangerous goods have a distinct significance.

Knowledge, training and readiness of workers who participate in the organization of transport of dangerous goods significantly contributes to raising of the safety requirements to a higher level, which can reduce costs in eliminating potential accidents [9]. The training of participants in the transport of dangerous goods by rail is the basis for safe transportation. One of the main links in this chain of education is the advisor for security in the transport of dangerous goods, who must possess adequate knowledge in a given field, in order to safely organize the transport process and participants who will be involved in the implementation of these processes.

## 5 CONCLUSION

The safety of rail transport is one of the main indicators of the quality of transport services. Greater safety of rail transport, taking into account other relevant parameters, allows the service to be of higher quality and at a higher level. In the analyzed period from 2008 to 2015 there were 4182 extraordinary events, where 111, or 2.65% with dangerous goods.

According to the results of the analysis [8] carried out in the period from 2008 to 2015, the most extraordinary events were caused by the human factor (47.8%). This result leads to the conclusion that it is necessary to work more to educate participants in the implementation of process of transport of dangerous goods.

Measures that would contribute to prevent the extraordinary events with dangerous goods in rail transport can be divided into: organizational, investment and educational. The security adviser in the transport of dangerous goods is of special importance in education which should contribute to increasing the security of the realization of the transport process. The work of the security adviser is reflected in monitoring regulations, strategic decision-making, training of the workers, rehabilitation of the consequences and monitoring transport. The importance of security advisers in the transport of dangerous goods is recognized by the government, which defined their role, tasks and responsibilities through the legal framework. Obligations of advisers are regulated by the RID Regulation and the Law on the Transport of Dangerous Goods, as well as bylaw acts, passed on the basis of laws, which are harmonized with international regulations.

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