Nijole Batarliene[1], Aldona Jarasuniene[2]

ANALYSIS OF ACCIDENTS AND INCIDENTS OCCURRING DURING TRANSPORTATION OF DANGEROUS GOODS BY RAILWAY

The article analyzes accidents and incidents during dangerous goods transportation by railway. The research results indicate how the respondents estimate the main factors related to risks at rail transport. The annual losses incurred by enterprises due to accidents and losses incurred due to other factors are under analysis, the correlation is presented. Recommended measures on the reduction of accidents on rail transport while transporting dangerous goods are offered.
Keywords: *dangerous goods; railway; accidents; incidents; safety; transportation; risk.*

Нійолє Батарлієнє, Альдона Ярашунієнє

АНАЛІЗ АВАРІЙ ТА ІНЦИДЕНТІВ ПРИ ТРАНСПОРТУВАННІ НЕБЕЗПЕЧНИХ ВАНТАЖІВ ЗАЛІЗНИЦЕЮ

У статті проаналізовано аварії та інциденти при транспортуванні небезпечних вантажів залізницею. Представлено результати досліджень, що показують як респонденти оцінили чинники ризику на залізниці. Визначено щорічні збитки підприємств внаслідок нещасних випадків та втрат, пов'язаних з іншими причинами ризику, продемонстровано кореляційну залежність між цими чинниками. Запропоновано заходи зі зниження аварійності та скорочення кількості нещасних випадків на залізниці при транспортуванні небезпечних вантажів.
Ключові слова: *небезпечні вантажі; залізничний транспорт; аварії; інциденти; безпека; транспортування; ризик.*
Табл. 1. Рис. 6. Літ. 15.

Нийоле Батарлиене, Альдона Ярашуниене

АНАЛИЗ АВАРИЙ И ИНЦИДЕНТОВ ПРИ ПЕРЕВОЗКЕ ОПАСНЫХ ГРУЗОВ ЖЕЛЕЗНОДОРОЖНЫМ ТРАНСПОРТОМ

В статье проанализированы аварии и инциденты при перевозке опасных грузов железнодорожным транспортом. Представлены результаты исследований, показывающие как респонденты оценили основные факторы, связанные с риском на железнодорожном транспорте. Определены ежегодные убытки предприятий в результате несчастных случаев и потерь, возникающие из-за других факторов, представлена корреляционная зависимость данных факторов. Предложены меры по снижению аварийности и сокращению несчастных случаев на железнодорожном транспорте при перевозке опасных грузов.
Ключевые слова: *опасные грузы; железнодорожный транспорт; аварии; инциденты; безопасность; транспортировка; риск.*

1. Introduction

While carrying dangerous goods, there is a risk of incidents due to the fault of other traffic participants, climatic conditions, badly chosen packaging materials or the lack of marking. In dangerous goods transportation it is impossible to avoid risks; however, it is possible to manage and reduce them by minimizing the factors.

The goal of the article is to analyze incidents and accidents in rail transportation of dangerous goods, to identify key risks related to such transportation and to assess safety aiming at reduction of incident risks.

[1] Department of Transport Management, Vilnius Gediminas Technical University, Lithuania.
[2] Department of Transport Management, Vilnius Gediminas Technical University, Lithuania.

In Lithuania there are no announced prevention measures for transportation of dangerous goods. It is possible to distinguish the following problems, faced by Lithuania and the EU member states in transportation of goods: 1) danger posed to public, infrastructure objects and environment; 2) incidents, during which oil products and other hazardous substances get into environment.

This is a frequent phenomenon in the EU member states, but neither Statistics Lithuania nor "Eurostat" database provide exact data on how many and what incidents take place in dangerous goods transportation. Ghazinoory and Kheirkhah (2008) state that hazardous materials are continuously moving across countries all over the world. These movements are naturally dangerous as the release of hazardous substances as a result of any accident can lead to deaths and irreparable damages to environment.

In transportation of dangerous goods a greater responsibility lies on goods loading, packing, marking, documentation, acceptance and storage. Tomasoni, Garbolino, Rovatti, Sacile (2010) note that in order to ensure transportation safety in choosing vehicles, it is necessary to explore the factors making influence on transportation risks.

To ensure safety of the participants of the dangerous goods system, the following factors affecting the transportation process should be taken into consideration:

– selection of alternative transport types;
– evaluation of routes;
– evaluation of technological transportation process;
– assessment of transportation risk;
– reduction of accident risk to the minimum possible (Blanco, 2011).

As the need for hazardous substances increases, the flows of dangerous goods also increase. Having estimated what threat is raised by hazardous substances to environment, individuals and the whole transport infrastructure, it is essential to guarantee safety of these processes. Diernhofer, Kohl, Horhan (2010) argue that most often incidents take place not due to features of hazardous substances but due to mistakes made by people during production and transportation processes.

According to Chakrabarti and Parikh (2011), in the transportation of hazardous substances, accidents depend on risks. The authors base risk calculations on the incident probability and the comprehensive analysis of consequences. In the article it is stated that risk assessment of hazardous substances depends on 3 factors:

– number of accidents;
– traffic intensity of one day and density of populated areas;
– length of a route.

Najib, Boukachour, Boukachour et al. (2009) distinguish the importance of information systems in dangerous goods transportation, as it is possible to quickly receive the required information on the state of goods, location of a vehicle and other required information at the right time to the right persons. The related works that deal with the evaluation of risks of transporting hazardous cargo is presented by Milazzo (2010), Fabiano (2005), Batarliene and Baublys (2007) etc.

Tomasoni, Garbolino et al. (2010) described the TIP system, which is used in Italy for dangerous goods transportation. In this system there is a number of functions, which help observe the transportation of hazardous substances on the road. The data

is collected real time, the sensors used "observe" not only the state of a vehicle but also the state of hazardous substances, changes in the amount, pressure and other physical features. The TIP system may also collect and analyse different data, transferred to emergency staff in the case of an accident while transporting hazardous substances.

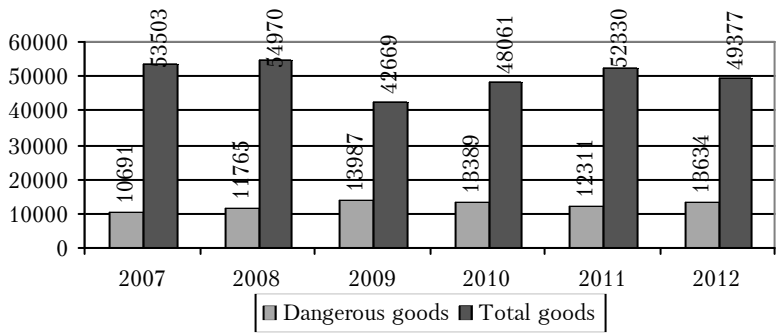
Bouissou, Ruffin, Dedert et al. (2010) described the QRA system, which is applied in France. The main goal of this system is risk assessment while transporting DC by roads, the system can simultaneously assess the consequences and different probabilities of incidents.

In everyday life, from the viewpoint of road safety, a vehicle that carries hazardous cargo is treated the same way as every other means of transport. Jarasuniene and Jakubauskas (2007) note that our aim must be noticeably develop and improve safety, security and effectiveness of transportation systems.

Tomasoni et al. (2010) described the importance of warning signs in transportation of hazardous substances. The authors state that it is very important to adequately mark the containers with hazardous substances by warning signs, as just in this way it is possible to provide the receiver with all the required information on hazardous substances.

2. Carriage of dangerous goods by the Lithuanian Railways

Prior to carrying out the analysis of accidents on rail transport, it should be found out what part is represented by dangerous goods in the total goods transported by rail in Lithuania (Figure 1).



Source: Official Statistics, 2013.

Figure 1. **Comparison of the number of dangerous goods with the total number of goods**

It is seen from the diagram dangerous goods make up about one third of the total goods transported by rail. Although the number of all goods fell insignificantly; however, the number of dangerous goods, except for the year 2011, was gradually increasing, and comparing 2012 to 2007, it increased by about 22%. The greatest part of dangerous goods is carried by transit.

3. Incidents on Lithuanian Railways

Incidents on rail are divided into 3 groups:

1. Derailment is an incident when due to collision of trains and rolling-stock or train and railway vehicle derailment, collision of trains and rolling-stock with road transport or other means of transport one or more persons lose their lives, or 5 or

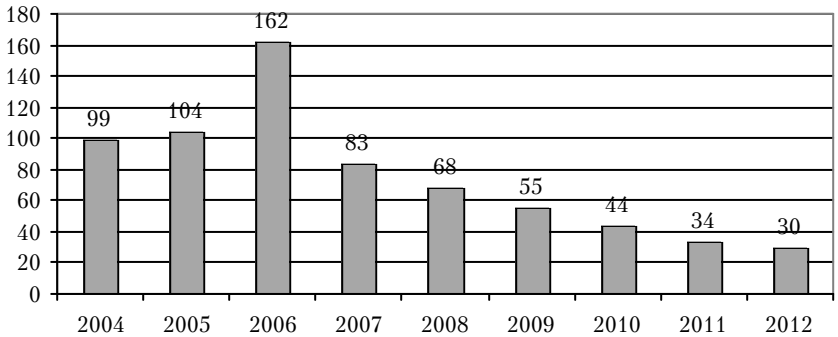
more persons are injured, or damage amounting to at least 2 mln EUR is done to railway infrastructure, rolling-stock, environment or property of legal persons, also any other similar incident due to which it is impossible to control or manage traffic safety on railways.

2. Accident is an incident of railway transport when trains, rolling-stock collide, trains collide with rolling-stock or buildings, installations, rolling-stock derails, railway transport accident occurs in crossing, due to moving rolling-stock more than 4 persons are injured and fire breaks out on railway transport.

2.1. Major accident is an accident when there is at least one moving rolling-stock and at least one person lost his life or was heavily injured or great damage was done to rolling-stock, railing, other installations or environment or traffic was cancelled for a long time. Great damage is considered to be EUR 150 ths or more. This definition does not include accidents in workshops, storehouses and depots.

3. Break is an incident, which occurred due to exploitation of rolling-stocks and trains, had negative impact on traffic safety control and management during exploitation, but did not cause derailment and accident consequences.

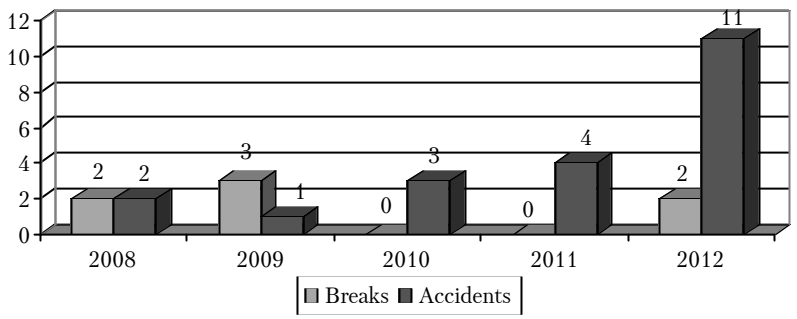
According to the data of Statistics Lithuania (Figure 2), the number of railway incidents has been decreasing every year since 2006. If to compared 2012 with 2004, the number of accidents decreased by about 33%.



Source: Freight transport, 2013.

Figure 2. **The number of incidents on rail transport**

The number of accidents and breaks in rail transport, where freight trains carrying dangerous goods participated, see Figure 3.



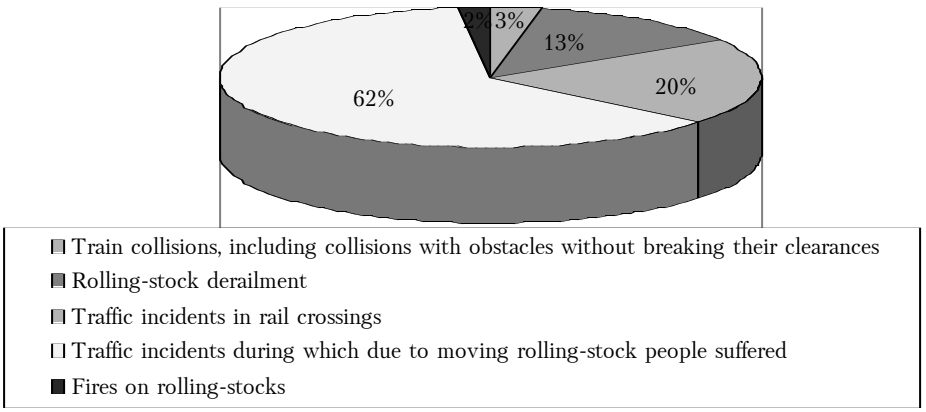
Source: Freight transport, 2013.

Figure 3. **The number of accidents and breaks while carrying dangerous goods**

As seen in Figure 3, the number of accidents is insignificantly increasing. In 2012 the number of accidents increased in particular and exceeded the total of the years 2008–2011. However, over these years there was no serious impact on environment or population, the majority of accidents happened due to violation of traffic rules by strangers. The last major accident took place in August 2006, when the train carried petrol from the company "Mazeikiu nafta" to the fuel terminal "Ave-Matrox" located in Gaiziunai, near to "Achema" factory. The train derailed, while petrol in containers exploded and a great fire started. There was no threat to human health; however, damage done to environment was great. According to specialists, the accident took place due to a breakdown in railing construction. Railings could break due to mounting mistakes, improper junction. The number of breaks was the largest in 2009, while in 2010 and 2011 they were completely avoided.

There were no derailments this year. In Lithuania just one major derailment happened on 4 April 1975 beside Zasliai railway station. During it 20 persons died and 80 were injured, damage was done to environment.

According to the statistical data the number of accidents is decreasing; however, it still remains large, what enhances the risk of major accidents. Having analysed the accident rate it is possible to make the conclusion that many of them happen in railway crossings and passages due to the fault of drivers and pedestrians who violated the requirements for road traffic regulations. Often the most important rule of safe traffic in crossings is forgotten – the train has the right-of-way in respect of other means of transport and pedestrians. According to the data by "Lietuvos gelezinkeliai" AB (Figure 4), 82% of the accidents happen due to that. While analysing the years 2008–2012 data, during any incident there was no threat to goods; however, the car which goes untimely might cause train derailment, while the consequences of that would be great. About 15% of accidents take place due to irresponsible work of staff and non-conformance with the rules.



Source: Freight transport, 2013.

Figure 4. **Traffic incidents in rail transport**

4. Research findings

To process the information received from expert surveys, a comparative research data analysis was used, while sizes are expressed in % to make the data be comparable. The averages of the data, the correlation of the factors were calculated.

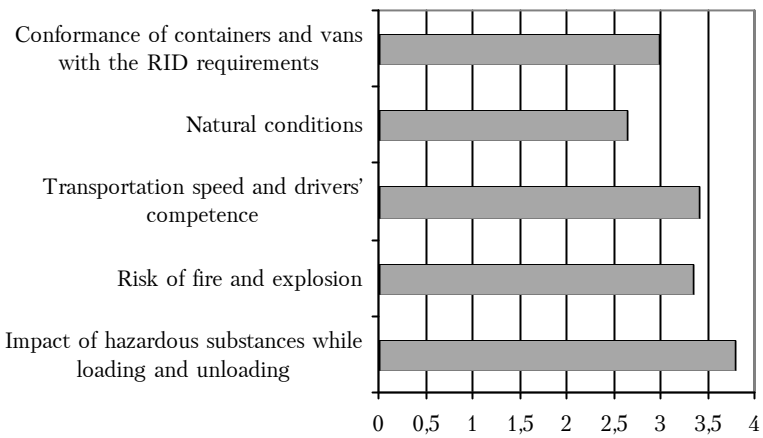
5 factors were provided for the survey, which had to be evaluated on the 5-point system by their importance. The summarised the respondents' answers, their evaluation averages and standard deviations of the answers are provided in Table 1.

Table 1. **Evaluation of the respondents' answers**

Evaluation / Factor	Very important	Important	Important on average	Unimportant	Completely unimportant	Evaluation average	Standard deviation
Impact of hazardous substances while loading and unloading	65	53	33	25	7	3,79	1,18
Risk of fire and explosion	39	57	44	25	18	3,40	1,24
Speed of transportation of dangerous goods and drivers' competence	37	28	84	26	11	3,33	1,09
Natural conditions	25	29	38	37	54	2,64	1,40
Conformance of containers and vans with the RID requirements	31	27	58	41	26	2,98	1,28

Source: Authors' calculations.

It was established that the greatest risks, in the respondents' opinion, are related to the features of hazardous substances, i.e. the impact on environment and human beings, in particular while loading and unloading (the average evaluation – 3.79), the risk of fire and explosion (3.4) as well as the speed of goods transportation and train drivers' competences (3.33). These 3 factors should be given the most attention. Whereas the evaluation of conformance of containers and vans with the RID requirements is less than 3 points, however, in order to ensure proper security of goods, these two factors must be also evaluated. The averages of all 5 factor evaluations are graphically shown in Figure 5.

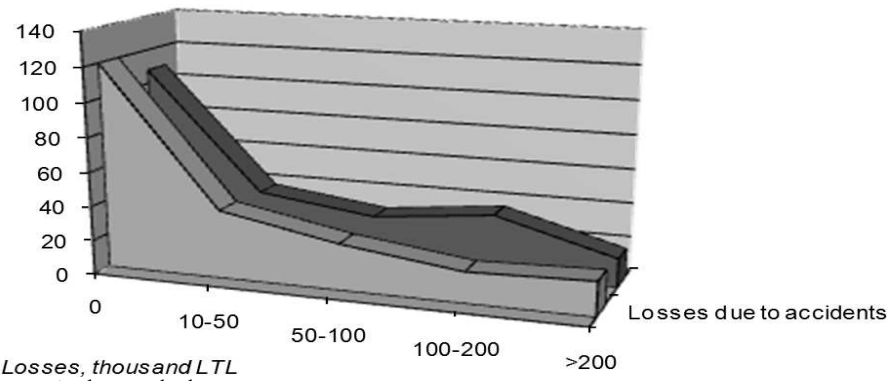


Source: Authors' calculations.

Figure 5. **The averages of risk factor evaluations**

The analysis of losses incurred by enterprises is based on the respondents' answers to the questions about the losses incurred by enterprises due to accidents during transporting of dangerous goods and due to other factors.

The analysis data is presented in Figure 6.



Source: Authors' calculations.

Figure 6. **Annual losses incurred by enterprises, ths LTL**

Having analysed the data presented in Figure 10, it is obvious that the losses incurred due to accidents and losses due to other factors distribute in a very similar way. Smaller than LTL 10 ths losses due to accidents and not due to other reasons are incurred by 10% more respondents. The frequency of losses of 10–50 ths and LTL 50–100 ths due to accidents and losses due to other factors is practically the same. Larger than LTL 200 ths due to accidents because of other reasons are incurred by 4% less respondents, LTL 100–200 ths due to accidents are incurred by 9% less respondents.

On the basis of these responses, it is possible to state that in order to reduce the losses incurred by enterprises, attention to accident prevention and reduction of losses should be distributed proportionally to attention to other circumstances (proper planning, containers and vans meeting the requirements, proper packaging).

Having analysed accidents during dangerous goods transportation it is seen that accidents or incidents in transportation of dangerous goods cause more problems than the transportation of usual goods. The problems in dangerous goods transportation are important not only to enterprises engaged in transportation of dangerous goods, but also to all the institutions responsible for control of dangerous goods. In dangerous goods transportation, risk and possible danger to public safety and environment are inevitable.

In order to ensure safe transportation of dangerous goods, different controlling institutions, which would be responsible for safe transportation of dangerous goods, should be combined. Necessary measures, which must be taken to ensure as safe transportation process as possible are the following: control on roads; speed limits; traffic flow control mechanism; safety measures in crossings; improved infrastructure.

5. Recommendations on reducing the accident rate

European safety and health policy covers risk assessment and implementation of prevention measures by giving priority to risk elimination in its occurrence source. These principles should be applied also in the implementation of the safety plan, covering rail vehicles and equipment, activity planning and personnel. The recommendation is to make a record of accidents. Accidents should be analysed as an integral part of risk assessment, contributing to identification of what actions should be best taken.

The number of accidents in rail transport must be reduced, this may be done via:

– reducing the amount of dangerous goods per one transportation unit, as smaller amount reduces the risk of threat to public and environment;

– ensuring the quality of loading, container, mounting, transporting and unloading;

– giving attention to climatic conditions, to avoid bad weather conditions, when there is poor visibility;

– ensuring preparation, experience and knowledge of train drivers and other participants related to transportation of dangerous goods;

– to implement prevention measures, at the moment of which attention would be paid to technical state of vans, ensuring tightness of containers, marking;

– to implement preventive actions in rail crossings, where drivers and pedestrians would be informed on the accident rates in railway crossings, would be encouraged to follow the provisions of road traffic rules;

– taking into consideration the incidents that already took place, to take all measures to avoid similar situations;

– installation of new technologies.

6. Conclusions

1. Transportation of dangerous goods is one of the most complex and most safety requiring transportation technologies. Because of peculiarities and risks, transportation must be precisely controlled, regulated and handled.

2. Having carried out the accident analysis on the rail transport, it is possible to make a conclusion that although the number of all the accidents decreases; however, dangerous goods often occur in accidents. The main reason is the non-conformance of road traffic rules by strangers and other vehicles, which pose great risks not only to them but also to people around. Within the year under research, great accidents were avoided, however, there is no guarantee that in the future they would be still avoided.

3. According to the authors' research, losses due to accidents and losses due to other factors distribute in a very similar way. Enterprises should pay equal attention to mounting of goods (prevention of losses incurred during accidents) and measures on preventing accidents as well as measures contributing to accidents consequences reduction.

4. The losses incurred could be reduced just by the complex use of different measures, as individual actions reduce only the probability of specific risks, while the set of adequately chosen measures allows reduction of risks to a tolerable level.

5. Having carried the research, it was established that there is a need to apply prevention measures and inform all traffic participants about the danger of dangerous goods transported. Persons being aware of that would try to keep safer distance and adequately assess risks. This could reduce the number of accidents.

References:

Basic figures on the EU. Summer 2013 edition. EUROSTAT. [cited 15 July 2013]. Available from Internet: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-GL-13-002/EN/KS-GL-13-002-EN.PDF.

Batarliene, N., Baublys, A. (2007). Mobile solutions in road transport. Transport, 22(1): 55–60.

Blanco, M.A. (2011). Safety adviser for the transport of dangerous goods by road, Seguridad sy medio ambiente Nr.123, [cited 15 July 2013]. Available from Internet: http://www.mapfre.com/fundacion/html/revistas/seguridad/n123/docs/Articulo4en.pdf.

Bouissou, Ch., Ruffin, E., Defert, R. et al. (2011). A new QRA model for rail transportation of hazardous goods [cited 15 July 2013]. Available from Internet: http://otif.org/otif/_defpdf/04_04_QRA-Model-F_E.pdf.

Chakrabarti, K.U., Parikh, K.J. (2011). Route evaluation for hazmat transportation based on total risk – a case of Indian state highways. Journal of Loss Preventation in the Process Industries, 24: 524–530. DOI 10.1016/j.jlp.2011.03.002.

Diernhofer, F., Kohl, B., Horhan, R. (2010). New Austrian guideline for the transport of dangerous goods through roads tunnels, in 5th International Conference "Tunnel Safety and Ventilation". 44–51, [cited 15 July 2013]. Available from Internet: http://ilf.com/fileadmin/user_upload/publikationen/51_New_Austrian_Guideline_Transport_Dangerous_Goods_Road_Tunnels.pdf.

Fabiano, B., Curro, F., Reverberi, A.P., Pastorino, R. (2005). Dangerous good transportation by road: from risk analysis to emergency planning. Journal of Loss Prevention in the Process Industries, 18(4–6): 403–413.

Freight transport AB "Lietuvos Gelezinkeliai" [cited 1 June 2013]. Available from Internet: http://www.litrail.lt/wps/portal.

Ghazinoory, S., Kheirkhah, A.S. (2008). Transportation of hazardous material in Iran: a strategic approach for decreasing accidents. Transport, 23(2): 104–111.

Jarasuniene, A., Jakubauskas, G. (2007). Improvement of road safety using passive and active intelligent vehicle safety systems. Transport, 22(4): 284–289.

Milazzo, M.F., Lisi, R., Maschio, G., Antonioni, G., Sadoni, G. (2010). A study of land transport of dangerous substances in Eastern Sicily. Journal of Loss Prevention in the Process Industries, 23(3): 393–403.

Najib, M., Boukachour, H., Boukachour, J. et al. (2009). Multi-agent framework for hazardous goods transport risk management, [cited 25 June 2013]. Available from Internet: http://www.srlst.com/ijist/special%20issue/ijism-special-issue2010-2_files/Special-Issue2010_2_27.pdf.

Official Statistics Portal. Statistics Lithuania, [cited 8 July 2013]. Available from Internet: http://www.stat.gov.lt/.

Thomson, J.B. (1999). International cooperation in hazardous materials accident prevention. Journal of Loss Prevention in the Process Industries, 12: 217–225.

Tomasoni, M.A., Garbolino, E. et al. (2010). Risk evaluation of real-time accident scenarios in the transport of hazardous material on road. Management and Environmental, 21(5): 695–711. DOI 10.1108/14777831011067962.

Стаття надійшла до редакції 14.09.2013.