Journal of International Trade, Logistics and Law, Vol. 3, Num. 2, 2017, 65-74

TRANSPORTATION OF DANGEROUS GOODS: TURKEY MODEL

Murat Şencan

Alışan Logistics, Turkey

Haki Yavuz
Alışan Logistics, Turkey

Received: Dec. 11, 2017 Accepted: Dec. 28, 2017 Published: Jan. 02, 2018

Abstract:
The shortcomings in the implementation of hazardous substances transport in the world and in our country lead to very serious hazards. These problems lead to life, property and very serious environmental disasters. This is not only a matter of transportation, but also of the chemistry, textile and fuel industries. This study provides information on the legislation on dangerous goods transport in Turkey. It also contains technical information on hazardous substances, following the search of the relevant literature for the province of hazardous goods.

Keywords:
Logistics, Transportation, Dangerous Goods Transportation

1. Introduction
Explosives, radioactive substances, such as chemical and/or physical characteristics that cause damage to the environment and the environment with qualities that are defined as "Hazardous Materials". Due to the nature of the contents of each of these items, each of which is classified by the United Nations Experts Committee, it is necessary to carry out transportation, and according to certain rules, unlike other materials. These special items, which require a separate sensitivity in all logistics processes, are often confronted frequently in our daily lives. The processes from the production of hazardous materials to the end-user are controlled by international legislation. With the developing technology, factory materials that are miles away from suppliers in different parts of the world are shipped, while products made in factories are shipped to customers in various parts of the world. In this process, dangerous substance transport is a real problem because of the risks involved.

The risks posed by accident possibilities in the transport of dangerous goods are diversified and various risk models are established in order to minimize these risks. There are two conflicting roles in the transport of dangerous goods. The first one is managers who aim to minimize the risks, and the second one is the ones that aim to minimize the costs. When the literature is examined, it is seen that besides the studies on which the risk is assessed, the optimization problems that deal with risk and cost are also examined.

Dangerous goods transport can be done by land route, railway, sea road, airway, inner waterway and pipe transportation. In Turkey, the most widely used type of transport is road transport. However, as the importance of green logistics is heightened, various studies are being done about railway transportation and these projects are aimed to increase the efficiency of railways.

2. Conceptual Framework
2.1. Identification, Movement and Legislation of Hazardous Materials
Hazardous goods are defined as explosives, radioactive substances, substances which have chemical and / or physical characteristics such as their physical and chemical properties that can cause harm to the environment. Dangerous materials; (explosive, poisonous) according to their chemical structures (flammable, pressurized), their

forms (solid, liquid, gas) and their hazards. Dangerous goods are defined by the United Nations Committee of Experts in nine classes.

- Explosive Materials,
- Gases,
- Flammable Liquids,
- Flammable Solids; Self-reactive substance , Substances which in contact with Water Emit Flammable Gases
- Oxidizing substances and organic peroxides,
- Toxic and Infections Substance ,
- Radioactive Material,
- Corrosive Substances,
- Miscellaneous Substances and Articles, Including Environmentally Hazardous Substances (IATA, 2013).

2.1.1. Dangerous Goods Classes

Class 1: Explosives

Sheltered storage should be provided from the staff area and away from the facilities. This class includes: Black powder, flares, fog bombs, ammunition, and dynamite.

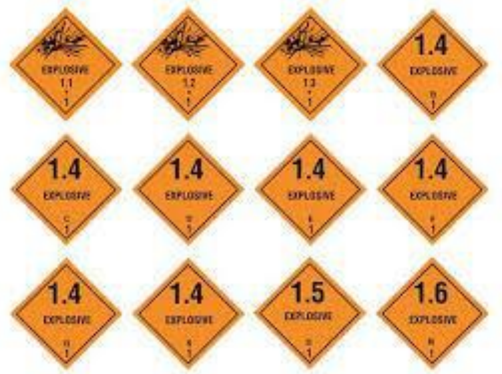

Figure 1. Label used for explosives according to IMDG code

Class 2: Gases

a) Class 2.1. Flammable Gas: They must be stacked away from any sources of heat and away from the personnel site. This class includes: Acetylene, ethane, ethylene, methane, hydrogen, lighter gas.

b) Class 2.2. Non Flammable Non Toxic Gases: They must be stacked away from any sources of heat, personnel, and food items. This class includes substances such as: ammonia, fluorine, prussic acid, chlorite, carbon monoxide.

c) Class 2.3. Toxic Gases: It should be stored in well-ventilated cool places. Tubes filled with these gases expand when they receive heat, which is very dangerous because it causes explosions. This class includes: Argon, helium, carbon dioxide, air gas, oxygen.

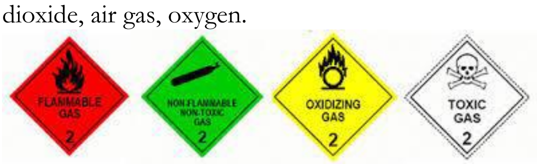

Figure 2. Label used for Flammable Gases according to IMDG code

Class 3: Flammable Liquid

The flammable liquids are separated into 3 groups according to the combustion point of the gas which evaporates in the form of heat.

a) Combustion point is lower than 18.0 C. It should always be stacked outdoors.

b) Combustion point is between 18.0 C and 23.0 C. Stacked in the open or in the building.

c) Burning point is between 23.0 C and 61.0 C. Stacked in the building.

Figure 3. Label used for Flammable Liquid according to IMDG code

Class 4: Solids

a) Class 4.1. Flammable Solid: They should be stacked outdoors or in the building. It should be kept away from life spots. This class includes: Aluminum powder, celluloid, naphthalene, red phosphorus, films, naphtha, dry fibers.

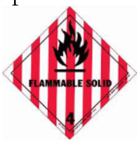

Figure 4. Label used for Flammable Solid according to IMDG code

b) Class 4.2. Spontaneously Combustible: Stacked in well-ventilated locations, stacks should be constructed to provide air circulation. These include: Dry grass, charcoal.

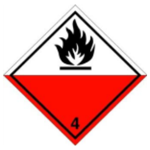

Figure 5. Label used for Spontaneously Combustible according to IMDG code

c) Class 4.3. Dangerous When Wet: They are burning properties when they come into contact with water or when they are wetted. It should be kept in well-ventilated dry places and avoid contact with water absolutely. This class includes: Alkaline alloys, such as barium, carbide, ferro silicon, natrium, magnesium.

Figure 6. Label used for Dangerous When Wet according to IMDG code

Class 5: Oxidizing Substances

a) Class 5.1. Oxidizing Agent: The materials entering this class bring oxygen to the environment by facilitating combustion. Because of these properties, they should not be stacked next to flammable materials. This class includes: Nitrates, artificial fertilizers, ammonium sulphate, barium chloride.

Figure 7. Label used for Oxidizing Agent according to IMDG code

b) Class 5.2. Organic Peroxide: The materials entering this class may be explosive, as well as being flammable. The open area should be covered with dry and cool places. This class includes: All peroxides are included in this class.

Figure 8. Label used for Organic Peroxide according to IMDG code

Class 6: Toxic

a) Class 6.1. Toxic: Poisonous substances can enter the human body by mouth and kill the human being. For this reason, food, beverages, living quarters and tobacco should be stacked away from substances such as moisture. This class includes: Arsenic, aniline, barium oxide, phenol, nicotine, lead, cyanide, mercury products.

Figure 9. Label used for Toxic according to IMDG code

b) Class 6.2. Infectious Substance: These substances cause diseases because they contain microbes. They must be stacked away from food, drink and life quarters. In the event of a hazard, the nearest health authority should be notified. This class includes: Bone, bone oil, compressed meat wastes, animal dander, blood soda, and so on.

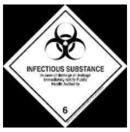

Figure 10. Label used for Infectious Substance according to IMDG code

Class 7: Radioactive

These materials are transported in special containers and without damage. They should be stacked outdoors in the open area, from the staff's area, from foodstuffs, unfiltered films, medicines and chemical substances.

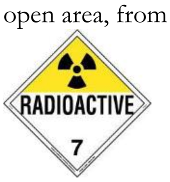

Figure 11. Label used for Radioactive according to IMDG code

Class 8: Corrosive

These substances are substances which are abrasive, thinning effect on human skin for a certain period of time. Materials with corrosive effects on steel and aluminum also fall into this category. Abrasive materials, organic tissue erosion, or some metals can cause corrosion. This class includes: Sulfuric acid, hydrochloric acid, potassium hydroxide, sodium hydroxide.

Figure 12. Label used for Corrosive according to IMDG code

Class 9: Miscellaneous

They are dangerous substances that are harmful to human health, such as anesthetic or other harmful substances and temperature-graded substances, or dangerous substances that do not enter other categories from substances which are at risk of marine pollution. This class includes: Asbestos, air bag inflators, dry ice.

Figure 13. Label used for Miscellaneous according to IMDG code

2.1.2. Packing Groups of Dangerous Goods

Dangerous goods are generally divided into three groups. Packing group is determined according to the degree of risk of the material and sets forth the safety measures to be taken for the packages.

- High Dangerous
- Medium Dangerous
- Less dangerous.

First class explosives, second class gases, 5.2 organic peroxides and seventh grade radioactive substances are not allocated to the dangerous goods packaging group. Third grade flammable liquids, 4.2th grade self-extinguishing materials, substances that produce flammable gases when contacted with 4.3th grade water, substances with burning properties of 5.1th grade, toxic substances of 6.1th grade, corrosive substances of grade 8, acidic substances It is also reserved for the packaging group. 4.1 flammable solid materials and 9 other hazardous materials are divided into two groups as medium and less dangerous. Class 6.2 infectious substances enter the medium dangerous packaging group.

2.1.3. Legislation

In the case of hazardous materials transport, in case of accidents, the quality and quantity of the products transported may produce various physicochemical effects (thermal flux, overpressure, toxic radiological and corrosive effects, etc.) (Chollet et al., 2013). For this reason, the relocation of dangerous goods is regulated under the control of authorities and specialized agencies in an institutional framework determined by national and international laws. In the world, all modes of transport are harmonized with laws. The names of the specialized agencies and international regulations by type of transport are given in Table 1.

Table 1. Expert Institutions and International Agreements by Type of Transport

Type of Transport	Responsible Expert Institution	International Agreement
Roadway	UN Economic Commission for Europe (UNECE)	ADR
Seaway	International Maritime Organization (IMO)	IMDG-Code
Railway	Office Central Transport Internationaux (OCTI)	RID
Airway	International Civil Aviation Organization (ICAO)	ICAO-TI
Airway	International Air Transport Association (IATA)	DGR
Inland Seaway	Accord Européen relatif au Transport International des Marchandises Dangereuses par voie de Navigation du Rhin	ADNR-ADN

Turkey is a party of hazardous substances used in the transport of international treaties and agreements in our country is presented below hazardous materials used in transportation.
a. European Agreement on International Transport of Dangerous Goods by Roadway (ADR): The transport of dangerous goods must be regulated to prevent accidents that may harm people, neighborhoods, property and other property, and any damage that may occur because of the improper construction of the land. For this purpose, the United Nations, in 1957, signed the "European Agreement on International Carriage of Dangerous Goods by Land" (original name "Accord européen relative au transport international des marchandises dangereuses par route") in Geneva. As of now, 47 countries are ADR. Turkey became a party to the ADR agreement on 22 March 2010 (Aytekin, 2011). The objectives of the ADR are as follows:

- Increasing the safety of international transport by land,
- Based on the United Nations recommendations on the transport of dangerous goods, the provisions on the classification, packaging and labeling and testing of hazardous substances, including hazardous wastes, should be in accordance with other modes of transport (sea, air, rail)
- Determination of the conditions for the construction, equipment and operation of vehicles carrying dangerous goods by land.

The general characteristics of the ADR Convention are listed as follows:

- Rules for loading, transporting and discharging hazardous materials with flammable and explosive properties,
- The minimum duration of training the drivers must attend, the training curriculum and conditions for obtaining an ADR license,
- Signs and signs indicating that the vehicles used in the ADR carriage must be carried visibly,
- ADR must have the necessary technical characteristics of trucks, tractor trailers, semi-trailer vehicles, containers and similar freight containers,
- Regulations regarding ADR carriage and documents required to be kept during transport,
- The responsibilities of the vehicle owner, the driver and the driver within ADR,
- Accident and emergency measures and procedures to be taken,
- The equipment which is required to be kept on the vehicle and the additional equipment which it is obliged to keep and use the driver,
- An agreement that regulates the specification, marking, and registration of freight containers and containers with all details (M.E.B., web, 2011).

b. International Maritime Dangerous Goods Code (IMDG): The International Maritime Dangerous Goods Code (IMDG) is a detailed publication prepared and regularly updated by a subcommittee of the International Maritime Organization (IMO), the body of the United Nations Dangerous International Marine. Turkey is also a party to this code 1974. The code is intended; to provide safety and environmental and safety of life and property at sea and coastal facilities by having the infrastructure to provide safe, undamaged and shortest access to the places of consumption of the loads from the coastal facilities handling dangerous cargo ships and such items. The code covers the packaging and packaging of packaged dangerous goods to be transported by sea, the loading and unloading of ships, the loading and unloading of ships, the handling and storage of dangerous goods in port areas and logistics centers and the measures to be taken against dangerous situations and first aid procedures it is determined.

c. International Civil Aviation Transport Organization (ICAO): Objective of the International Civil Aviation Transport Organization (ICAO); in order to ensure that international civil aviation can be developed safely and regularly and that civil aviation services can be operated in a robust and economical manner by registering on the basis of equal opportunities. Turkey became a party to the agreements referred to Law No. 4749 and June 5, 1945 date.

d. International Air Transport Association (IATA): The International Air Transport Association (IATA) is an international trade organization, where only airline companies can become members. IATA has DGR rules (Dangerous Good Regulations). All freight forwarding cargo companies must comply with these rules regarding the transport of dangerous goods. These rules require; responsibility for the transport of dangerous goods by air belongs to all parties involved in the transmission and transport system.

2.2. The Importance of Transportation of Dangerous Goods

Dangerous items are items that can be found in every area of life, as can be understood from their definitions. Today, materials transported by rail, road, sea and pipelines are dangerous and play an important role in international trade. The logistics process, especially transport and storage, increases the size of the hazardous materials dangerous to people, animals, the environment and the assets of the property. The obligation to eliminate the deficiencies in the EU candidacy process rapidly became clear after the 2000s in our country. Accelerating efforts to establish a system that can reduce the risks of dangerous substances the most, to train and develop personnel and to create more professional working environments.

3. Literature Review

The literature review on the transport of dangerous goods is under investigation under three headings and consists of thirty-five articles and a thesis study. In the first part, fourteen papers on roads, in the second part eleven papers and in the last part ten papers on multimodal transport and a thesis work are summarized in chronological order.

Erkut and Verter (1998) emphasize that different risks can be defined in different ways using traditional risk. The risk associated with the transport of dangerous goods is expressed not only by the substance itself, but also by features such as road network and road network along the selected route. Four different risk model comparisons are made by developing a conventional risk model for hazardous substance transport, starting with the generated unit path segment risk and edge risk. In the traditional approach, the probability of an accident is 10-6 per mile.

Erkut and Ingolfsson (2000) introduce three different disaster-avoidance models. In the first model, disaster avoidance is achieved by minimizing the maximum population impact. In the second model, variance decision is included as route result. In the third model, an explicit malignancy function is used. All three models aim to minimize in a standard shortest path problem. The transport network in every mode is preventing high population areas. In this study, similarities and differences between models are discussed with examples.

Mills and Neuhauser (2000) present simple methods for statistical significance of differences in roots, histograms, and methods for comparing populations and racial / ethnic compositions using chi-square tests. These methods are presented in two examples: Two routes are compared and a route is compared with the environment. First, a compact area (Silicon Valley) is compared with two alternative roads, and secondly, a route without sudden alternatives is made. In this case, a close population (eg population within a certain band width on the road) is compared with the population of the population to which it passes. A quantitative method based on the new GIS-effective capability and the chikare test for the improvement of adaptation of the two distributions is being developed in order to create distribution of population data on the way of transportation.

Fabiano et al. (2002) develop a unique site-focused framework that is generally applicable at the local level in route selection, according to the risks involved in transporting hazardous materials. Field data are obtained from systematic research and road data reporting. The developed technique is implemented in a pilot region, taking into consideration the individual risk and social risk, when the atifft is provided to flammable and explosive substances scenarios. Risk assessment of sensitive route features and population exposure is recommended, thus reducing general uncertainties in risk analysis.

Kara and Verter (2004) develop a two-level programming formulation for the network design problem. In the delivery of dangerous goods, all people are exposed to the risk of evacuation at the relevant distances of the roads used by the trucks. For this reason, using the GIS based model, the exposure areas are determined around each link for 800 meters and 1600 meters of evacuation distances. The populations in the impact area are estimated by the GIS-based model, and the values of each road connection (number of affected people) and (linkin length) are estimated. In the study Western Ontario, an application of the method developed with Canada data is presented.

Huang et al. (2004) develop a new approach integrated with GIS and Genetic Algorithms (GA) to assess the risk of transportation of dangerous goods. In this study, a set of evaluation criteria are used to identify and identify vehicles

carrying hazardous materials. Accepted criterion is; safety, cost, and more importantly, security. GIS is used to measure factors on each link in the network. GA is used to determine the weights of the factors. For this reason, a general cost function is created which is comparable to the hazardous substance transport suitability of each road. The proposed route evaluation method is shown in a typical part of the Singapore road network.
Fabiano et al. (2005) form a risk model for road transport and present a theoretical approach to emergency planning and settlement based on graph theory. The model focuses on evaluating the expected frequency of accidents and is aimed at finding the expected number of deaths for the arc between the two nodes. In this study, Djikstra algorithm is used as the shortest path algorithm.

Erkut and Alp (2007) formulate the tree design problem as an integer programming problem with the aim of reducing the total transport risk due to hazardous material flows on the network. Although the risks are slightly increased by developing intuition to expand the solution of the tree design problem by adding road segments, there are options to guide the vehicle to reduce costs. Thus, a method can be used to describe the ways in which dangerous goods are transported in large population centers, and a formulation for OCST (Optimum Communication Spanning Tree Problem) is presented. Milazzo et al. (2009) focuses on the emergency management of a terrorist attack in the transport of hazardous materials in urban areas. A high-security urban area is a potential target for terrorist attacks. Since it is not possible to predict where and when an attack will occur, the risk associated with terrorism is complex. It is possible to determine critical points for the potential actions that this counter-measure should be applied to. The use of dynamic geoevents gives the possibility of having a dynamic evolution of the instantaneous location of the event on the georeferenced map and the number of scenarios and related contacts. In this study, dynamic scenario-ending simulation code output (ALOHA and EFFECTS-GIS) and a GIS software are used.

Guo and Verma (2010) investigate the traditional riskie effect of trucks carrying flammable materials such as gasoline or explosives on a given route and with different capacities. A US-based problem case is solved in order to gain managerial insights by creating three scenarios to improve the preference conditions for a particular vehicle size under two assumptions of neutral risk and one avoiding risk. Yang et al. (2010) assess 322 accidents and their consequences in China during the transportation of dangerous goods by road between 2000 and 2008. According to these results, an increase in accident frequency occurred between 2000-2007. The most common types of accidents are in the form of spills (84.5%), gas clouds (13.0%), fires (10.2%), dangerous hazards (9.9%) and explosions (5.9%) due to timely measures. In the study, the spatial distribution of the accidents, the causes and the results related to the population (for example, the number of people who were killed, injured, evacuated or poisoned) and environmental elements were analyzed. Approximately 16.9 accidents lead to an explosion, 9.8 accidents lead to a fire, and 40.2 accidents result in a fire and explosion. The driver error-road accident (46.6%) is followed by the driver error-the false emergency response (13.7%) and the management failure-overload (9.0%), in the total of 322 accidents. It is stated that a good database is needed to develop specific security measures in land transport of dangerous goods in China.

Changing and others (2012) establish dynamic equations for deviations of vertical, horizontal, rolling, pitch and vibration modes for vehicle loading based on China's technical standards in rail transport. The relationship between the height of the center of gravity of the loaded vehicle and some operated safety indices is also investigated by making calculations for the loaded vehicle body. To provide a suitable method for railway transport, the loaded vehicle is built on the basis of body dynamics equations, multi-body system dynamics and vehicle-component dynamics. In dynamic equations, the loaded vehicle-body is regarded as the position of the center of gravity. Safety indices are estimated to have the same tendency as the rising center of gravity of the loaded vehicles.
Samanlıoğlu (2013) develops a multipurpose location and punctuation model for managing hazardous waste and waste residues. The model which aims at risk and cost optimization is applied in the Marmara region. Minimizing the total cost, including the total fixed costs and total transportation costs, resulting from the establishment of production, treatment, disposal and recycling centers of hazardous waste and waste residues; minimizing the risk of total exposure associated with the exposure of the population present along the access roads of hazardous waste and waste residues; and to minimize the total risk for the population around treatment and destruction centers (site risk). A lexicographic weighted tchebycheff formulation is developed and CPLEX software is used for the solutions. The

data for the Marmara region are obtained using Arcview 9.3 GIS software and the Marmara region geographical database.

4. Conclusion

One of the important constraints in the planning of transportation is the nature of the contest. All transportation plans are based on these constraints. The shortcomings in the implementation of dangerous substances transport in the world and in our country lead to very serious hazards. These problems lead to life, property and very serious environmental disasters. This is not only a matter of transportation, but also of the chemistry, textile and fuel industries. For this reason, the transport of dangerous goods is a highly strategic and important type of transportation. both done in the framework of the safety of the transport of dangerous goods transportation constraints and rules in the world and Turkey is important both in terms of environmental factors. The spread of this consciousness in the country and worldwide will bring with it significant company profits and a cleaner environment and therefore a cleaner world.

References

Andersson, S.E. (1994). “Safe Transport of Dangerous Goods: Road, Rail or Sea, A Screening of Technical and Administrative Factors”. European Journal of Operatianal Research, vol. 75, no. 3, s. 499 – 507.

Çancı, M., Erdal, M. (2003). Uluslararası Taşımacılık Yönetimi. İstanbul: UTİKAD.

Chollet, F.T.,J. Tixier, G. Dusserre ve J.F.Mangin, “Development Of A Spatial Risk Assessment Tool For The Transportation Of Hydrocarbons: Methodologyan Dimplementation İn A Geographical İnformation System ”, Environmental Modelling & Software, 46, 2013, 61-74.

Davis, D.J., Christianson. (1991). Firefighter’s Hazardous Materials Reference Book. New York.

DPT, Denizyolu Ulaşımı Ankara 2007 Özel İhtisas Komisyonu Raporu.

Erkut, E. ve A. Ingolfsson. "Catastrophe avoidance models for hazardous materials route planning", Transportation Science, 34.2: 2000,165-179.

Erkut, E. ve A. Ingolfsson. "Transport risk models for hazardous materials: revisited", Operations Research Letters 33.1: 2005, 81-89.

Erkut, E. ve O. Alp. "Designing a road network for hazardous materials shipments", Computers & Operations Research 34.5: 2007,1389-1405.

Erkut, E. ve V. Verter, "Modeling of transport risk for hazardous materials", Operations Research, 46.5, 1998, 625-642.

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

Fabiano, B., F. Currò, E. Palazzi ve R. Pastorino. "A framework for risk assessment and decision-making strategies in dangerous good transportation", Journal of Hazardous Materials 93.1: 2002, 1-15.

Görçün, Ö.F., Görçün, Ö., Kayıkçı, Y. (2008). “Tehlikeli Madde Taşımacılığı ve Su Koruma Bölgeleri”. TMMOB 2. Su Politikaları Kongresi. Ankara

Huang, B., R. L. Cheu, ve Y. S. Liew. "GIS and genetic algorithms for HAZMAT route planning with security considerations", International Journal of Geographical Information Science, 18.8: 2004, 769-787.

Keskin, M.H. (2006). Lojistik Tedarik Zinciri Yönetimi. Ankara: Nobel.

Lowe, D. (2005). Intermodal Freight Transort. Oxford: Elsevier Butterworth - Heinemann

Meyer, E. (1989). The Chemistry of Hazardous Mterials (2. Edition). New Jersey: Prentice Hall.

Milazzo, M. F., G. Ancione R. Lisi, C. Vianello ve G. Maschio. "Risk management of terrorist attacks in the transport of hazardous materials using dynamic geoevents", Journal of Loss Prevention in The Process Industries 22.5: 2009, 625-633.

Mills, G. S. ve K. S. Neuhauser. "Quantitative methods for environmental justice assessment of transportation", Risk Analysis 20.3: 2000, 377-384.

Samanlioğlu, Funda. "A multi-objective mathematical model for the industrial hazardous waste location-routing problem", European Journal of Operational Research, 226.2: 2013, 332-340.

Spellman, F.R. (2007). Transportation of Hazardous Materials Post – 9/11. Plymouth: Scarecrow

Purdy, G. (1993). "Risk Analysis of The Transportation of Dangerous Goods by Road and Rail". Journal of Hazardous Metarials, vol. 33, no. 2, s. 229 – 259.

Uzun, T. (2012). Uluslararası Hava Taşımalarında Taşıyıcının Sorumluluğu. Ankara: Seçkin.

Wehrstedt, K., Wildner, B., Güthner, T., Holzrichter, K., Mertschenk, B., Ulrich, A. (2009). "Safe Transport of Cyanamide". Journal of Hazardous Materials, no. 170, s. 829 – 835.

William F.M., John, M., Lippitt, P., Paul, J.W. (2000). Hazardous Waste Transportation Safety, Hazardous Waste Handbook. Butterworth - Heinemann.

Yang, J., F. Lİ, J. Zhou, L. Zhang, L. Huang ve J. Bi. "A survey on hazardous materials accidents during road transport in China from 2000 to 2008", Journal of Hazardous Materials 184.1: 2010, 647-653.