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INNOVATIVE ENGINEERING APPROACH IN TRANSPORTATION OF HAZARDOUS MATERIALS

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Abstract

Transport of dangerous substances is a daily occurrence in road traffic. The application of new engineering technologies in the transport of hazardous materials using special means of transport implies the application of new technological solutions in order to increase the level of transport safety. The goal of this paper is to present the transport of hazardous materials in a modern and innovative way. The transport of hazardous materials is regulated by the Law on the Transportation of Hazardous Materials, and we encounter non-compliance with legal provisions every day. In order for a vehicle to receive an ADR Certificate, it must meet the specific requirements imposed by that standard in all segments. This applies both to the complete vehicle and to the cargo space or container in which dangerous substances are transported. The method of attaching the container to the vehicle must be in accordance with the provisions of ADR. It is necessary that the container, the complete vehicle and vehicle equipment, as well as the documentation on the construction of the container, comply with the provisions of ADR. Based on the inspection of the vehicle, container and documents, the purpose is determined and the use permit of the means of transport is granted. The tank must not be damaged or altered, and must have a permanently attached manufacturer's plate with the necessary information about the tank. The paper will list and analyze all the details related to the equipment of means of transport and the way of organizing the transport of dangerous goods.

Key words: *Means of transport, ADR, dangerous goods, transport.*

Introduction

The list of dangerous substances is expanding every day, but the standard ones are explosive, flammable, oxidizing, poisonous, infectious, corrosive, carcinogenic and radioactive substances. In addition to the enormous impact of harm on the environment and the surrounding population, hazardous substances play a major role

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in today's life, and it is almost impossible to imagine a day without the use of some hazardous substance. In order to reduce their harmful effects on the environment and its population, it is necessary to regulate their production, transport and use with positive legal regulations. The legal legislation, which regulates the transport of dangerous goods, was created on the basis of the International Agreement on the Transport of Dangerous Goods by Road Transport. In the part of the legal legislation, the necessary penal provisions for legal and natural persons are prescribed, which came into force in BiH in March 2016.

In order for hazardous materials to be delivered from factory facilities to end consumers, it is necessary to have a distribution chain or channel, i.e. it is necessary to carry out most of the basic logistics activities, which include packaging, initial/final and intermediate operations of transshipment of hazardous materials, storage, transportation and storage of stocks. In the course of these activities, traffic accidents also occur. In the event of accidents with dangerous substances, the timely and professional reaction of the employed staff is very important, therefore the conditions that must be met by the employees are prescribed. In addition to the conditions for employed personnel, it is necessary to provide basic technical conditions for warehouses, transshipment points, for storage equipment, then means for transshipment manipulations and transport means must meet certain conditions in terms of technical characteristics.

Hazardous substances, classification and their properties

The distribution of hazardous materials was carried out according to international regulations that defined the manner of their use, transportation, storage and control. International regulations cover about 50,000 hazardous substances, which are classified into nine classes. After determining the class to which the hazardous substance belongs, it is possible to assign a UN number to that hazardous substance. Depending on the chemical properties, aggregate state and degree of danger, all dangerous substances are classified into nine classes.

Class 1 – Explosive substances

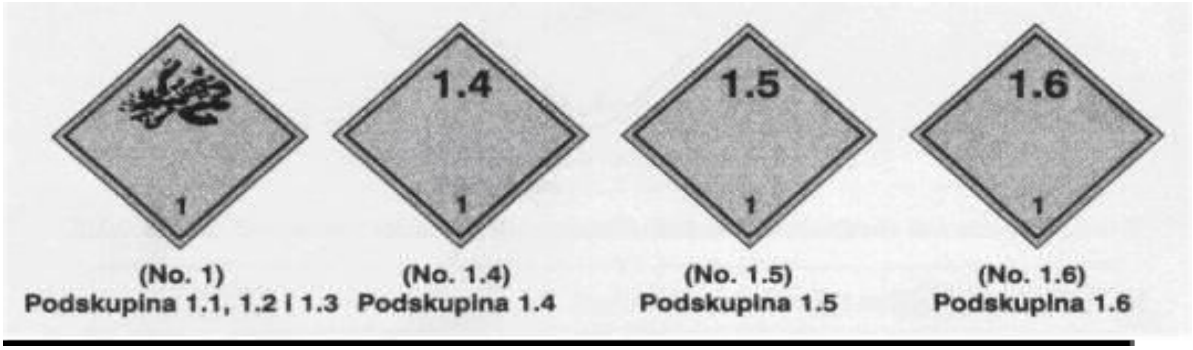

Figure 1. Class 1 - Explosive substances

Explosive substances (class 1) include the following:

- Substances or means (devices) that are sensitive, and there is a risk of explosion

- Substances or means that are dangerous if thrown, but there is no risk of explosion
- Substances or means that can cause fire and are less explosively dangerous
- Substances or means with less risk of exposure and ignition during transport
- Insensitive substances with a risk of explosion
- Extremely insensitive objects where there is no risk of explosion.

Class 2 – Gases

Gases are very often used in transport, so it is necessary to know their appearance and properties. Gases are substances that at a temperature of 50 °C have a pressure greater than 300 kPa (3 bar), and at a temperature of 20 °C and a standard pressure of 101.3 kPa, are in a gaseous state.
In transport, gases can appear in one of the following forms:

- Compressed (compressed) gases,
- Liquid gases,
- Deeply cooled liquid gases, and
- Gases dissolved under pressure.

Figure 2. Class 2 - Gases

Class 3 – Flammable liquid

Flammable liquids are substances or mixtures of liquids that are liquid at a temperature of up to 20°C, and at 50 °C their vapor pressure is up to 300 kPa (3 bar). They have a flash point of up to 61°C.

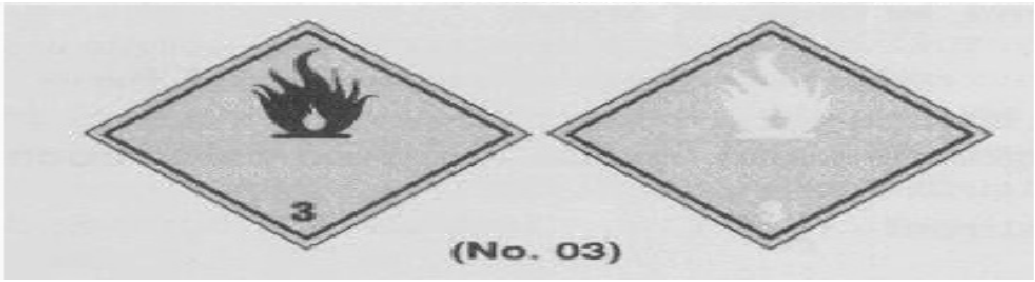

Figure 1. Class 3 – Flammable liquid

Based on the degree of danger, flammable liquids are divided into three groups:

- Very dangerous flammable liquids with a boiling point of up to 35°C, or flammable liquids with a flash point below 23°C, which are very toxic or highly corrosive, various organic compounds, some pesticides, etc.
- Dangerous substances are flammable liquids with a flash point below 23°C, which are not in the first group (ether, kerosene, gasoline, acetone, alcohols,...).
- Less dangerous substances are flammable liquids with a flash point of 23 to 61°C.

Class 4 – Flammable solids

Flammable solids are divided into three groups:

- Flammable solid materials,
- Self-igniting solid materials, and
- Materials that in contact with water develop flammable gases.

Figure 4. Class 4 – Flammable solids

Class 5 – Oxidizing substances and organic peroxides

Oxidizing substances are substances that decompose in contact with other materials and can cause ignition (fire). Oxidation is the process of combining with oxygen. Burning is a process of oxidation with the appearance of heat and light.
Organic peroxides are organic compounds that contain a peroxide functional group, the bonds of which, in contact with other compounds, are easily decomposed and form free radicals. Organic peroxides can cause explosive polymerization of materials with unsaturated chemical bonds, so this process has been used in explosives, which makes them hazardous materials in transportation.

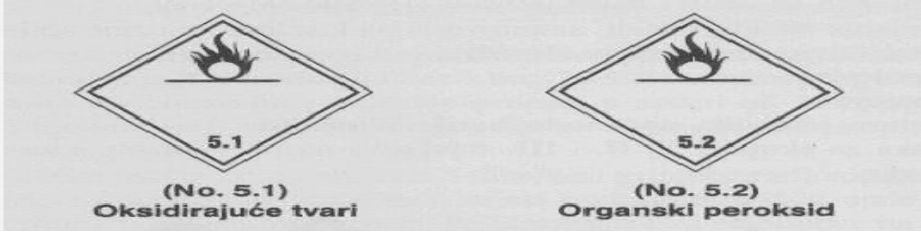

Figure 5. Class 5 – Oxidizing substances

Class 6 – Toxic and infectious substances

Toxic and infectious substances are divided into 2 groups according to their properties:

- A – contagious and infectious substances with a high danger potential,
- B – other contagious and infectious substances, and
- C – empty packaging.

Class 7 – Radioactive substances

Radioactive substances, along with all other characteristics of dangerous substances, have one special feature: they represent a danger even if the substance itself is completely physically separated from the environment, because they emit ionized radiation.

Protection is ensured if protective measures are applied to prevent:

- Dispersion of radioactive material in the environment and entry into the human body,
- Irradiation of persons from radiation emitting radioactive substances from the shipment,
- The possibility of a chain reaction and its initialization in the transported matter
- The danger of high temperatures generated in the package due to the transportation of radioactive materials,
- Damage to package components due to overheating.

Packages containing radioactive substances are marked with stickers, and they must contain the following details:

- The name of the radionuclide,
- Activity in Bq,
- Overall activity, and
- Transport index.

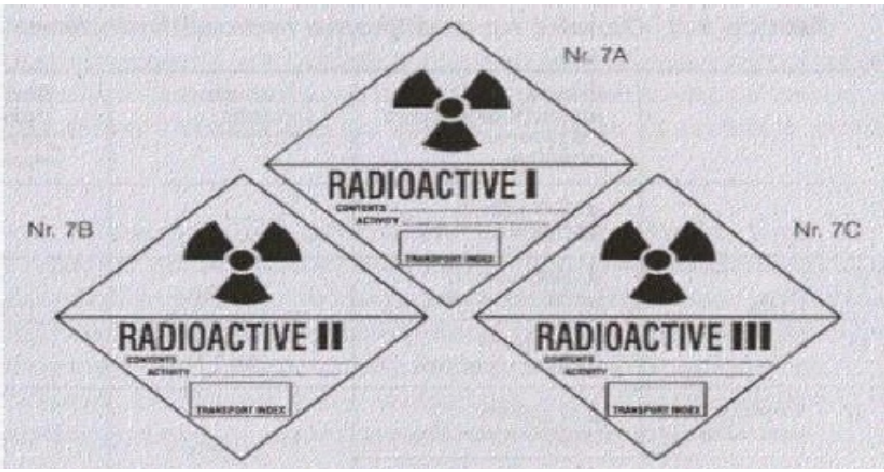

Figure 6. Class 7 – Danger signs for different categories of radioactive packages

Class 8 – The rest are dangerous substances

Other dangerous substances include:

- Magnetized substances,
- Asbestos
- Carbon (IV) oxide,
- Solid (dry) ice,
- Zinc dithionate,
- Equipment for means of transport (air bags, belt tensioners,..), and
- Substances that can stain or pollute the environment (liquid and solid).

Transportation of hazardous substances

Packaging, transshipment operations, storage and transport of hazardous materials further increases the danger. On the one hand, these dangers are reflected as a possible risk that can be seen as a consequence of bad packaging, errors during load manipulations in transshipment operations, inadequate storage, and the basic characteristics of the vehicle that transports dangerous goods. On the other hand, they are reflected through the development of transport, i.e. their participation in traffic, the possibility of participation in traffic accidents, etc.
In order to prevent the occurrence of damages due to the development of basic logistics activities, agreements were signed on the handling and transport of these materials in international and domestic transport.

European legal legislation in the transport of dangerous substances

European agreements on dangerous substances, on the basis of which domestic laws are formed, can be divided according to the type of traffic into:

- European Agreement on the International Road Transport of Dangerous Goods ADR,
- European Agreement on the International Transport of Dangerous Goods by Rail RID,
- European Agreement on the International Carriage of Dangerous Goods by Air ICAO-TI,
- European agreement on the international transport of dangerous goods by sea IMDG-Code,
- European Agreement on the International Transport of Dangerous Goods in River Transport ADN.

According to the European Agreement on the International Transport of Dangerous Goods by Road ADR, dangerous goods are substances and objects whose international road transport is prohibited or approved under special conditions in Annexes A and B.
Annex A, in addition to the definition, stipulates:

- Which dangerous substances are excluded from international transport,

- Which substances can be transported under certain conditions,
- A list of dangerous substances and special regulations for various classes is given,
- Conditions for sending goods unpackaged, in containers and in tanks,
- Sending method and sending restrictions.

In Annex B, in addition to the definition, general regulations for the transportation of dangerous goods of all classes are prescribed, namely:

- Conditions that must be met by all vehicles and their equipment,
- Work of the vehicle crew,
- Special prescribed loading, unloading and manipulation.

In accordance with the Convention on the International Carriage of Dangerous Goods by Road - ADR, it was adopted in Geneva in 1957 with subsequently accepted annexes and additions. In the course of the past years, a number of regulations, legal and by-laws and regulations were passed in Bosnia and Herzegovina, which prescribe the method of production, transport, packaging, storage and loading or unloading of hazardous materials in order to protect the environment and human health.
Most of the provisions, legal and by-laws and regulations were taken from the legislation of the former SFRY, but certain corrections were made. Due to the great danger that can arise during the transportation or handling of dangerous substances, strict normative legal acts have been prescribed, which also prescribe strict penal provisions for violation of the prescribed provisions.

Movement and marking of vehicles transporting dangerous substances

All vehicles transporting dangerous goods must be properly marked, in accordance with ADR, with a plate that is orange in color with a black border 15 mm thick, and is divided by a black horizontal line 15 mm thick into two equal parts. The numbers in the fields of the plate are 100 mm high, and their thickness must be 15 mm. The indicated numbers must be legible and visible after 15 minutes of exposure to fire.
When tank vehicles or transport units with one or more containers intended for the transport of dangerous substances UN numbers 1202, 1203, 1223 or aviation fuel UN numbers 1268 or 1863, but not other dangerous substances, it is not necessary to place orange plates on the sides as previously described if plates with UN numbers and hazard symbols of substances with the lowest flash point are placed on the front and rear sides of the vehicle.
The sign of substances with an elevated temperature consists of a red-bordered triangle with side lengths of at least 250 mm, in the center of which is a symbolic display of a thermometer. According to ADR, warning labels, measuring 100x100 mm, must be affixed to the external surfaces of vehicles, containers, MEGCs (Multiple Element Gas Containers), container and portable tanks. Apart from the special provisions for sheet 7D, all others must have pages of a minimum length of 250 mm. Parallel to the edges must be the black colors of the symbols, separated from the edges by 12.5 mm. The height of the letters must not be less than 25 mm. Sheet 7D must have sides 250 mm long, parallel to the edges there must be black lines spaced 5 mm from the edges. The height of the number must not be less than 25 mm. The color of the

upper half must be yellow, and the lower half must be white. The symbol must be black and the text RADIOACTIVE can be replaced by an appropriate UN number.
Containers, MEGCs, container containers, portable containers, as well as vehicles that transport dangerous substances or objects of two or more classes do not have to carry additional sheets for substances with the same danger expressed in additional sheets. The speed of a motor vehicle loaded with dangerous substances must not exceed 70 km/h. According to ADR, all vehicles transporting dangerous goods must be marked with illuminated signs. The sign on the vehicle from the front and back is rectangular in shape with an orange luminous base, dimensions 30 x 40 cm. The rectangle is divided into two parts: the upper part contains the number of hazards, and the lower part the number of substances according to the UN list.

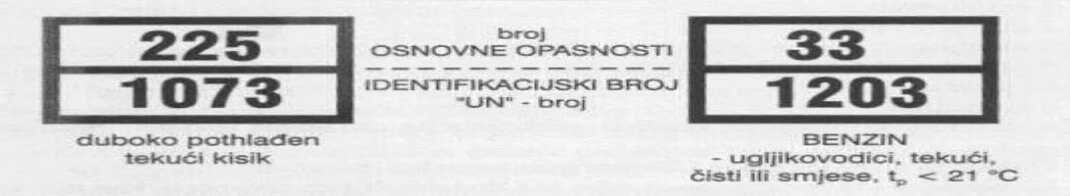

Figure 2. Danger tiles

Figure 3. Danger of contact of the substance with water

Mixed cargo

Certain dangerous substances can dangerously react with each other, for this reason they must not be together in the cargo space of a vehicle or container. From the table shown in Figure 10.
When the note "MIXED GOODS" is written in the bill of lading, it means that the goods must be loaded or have been loaded according to regulations on mixed cargo, and then the mutual relationship of individual dangerous substances must be known. The goods must be in the original packaging and according to the requirements of ADR

regulations, which is the obligation and responsibility of the sender.

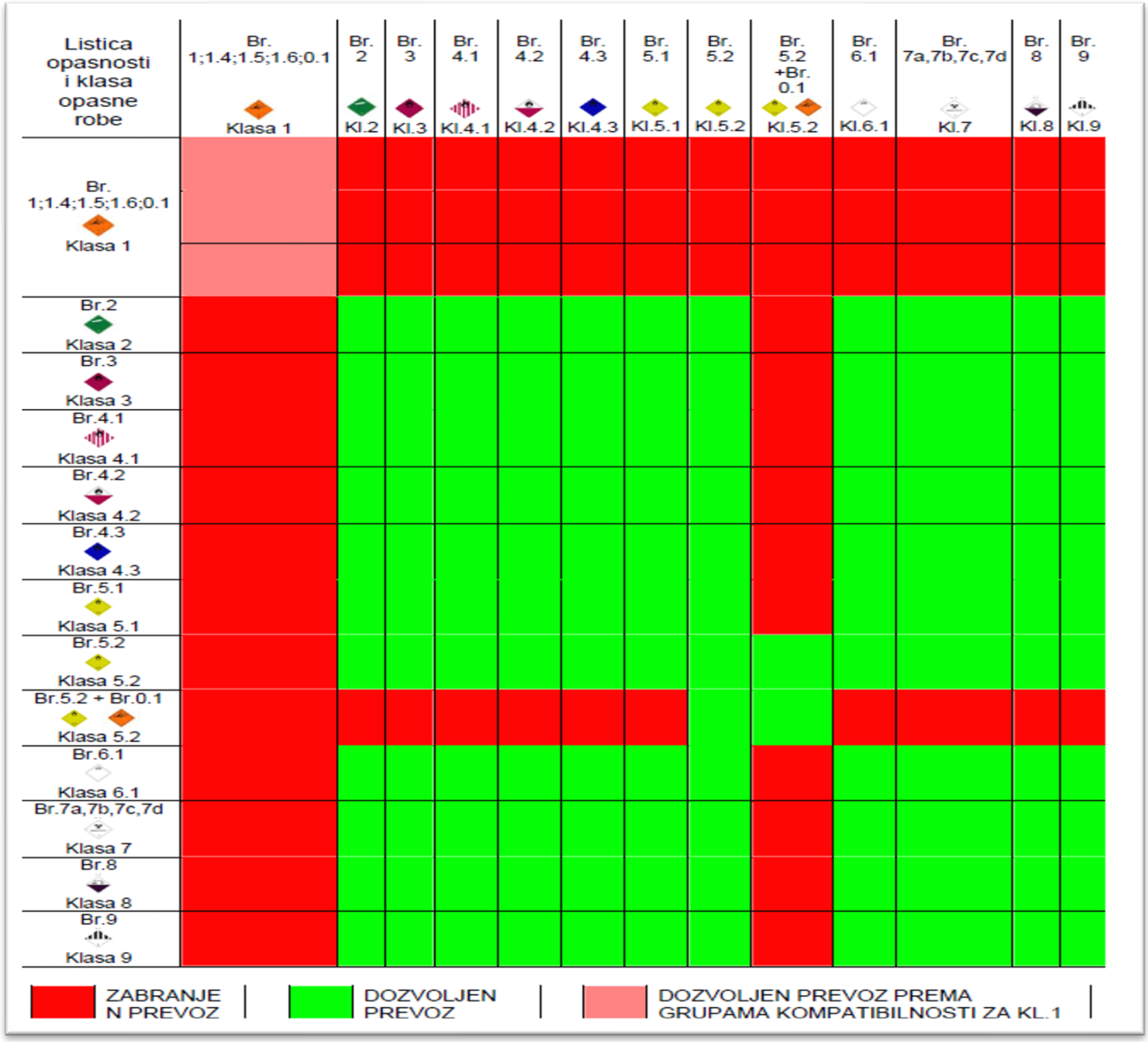

Figure 9. Compatibility of hazardous substances

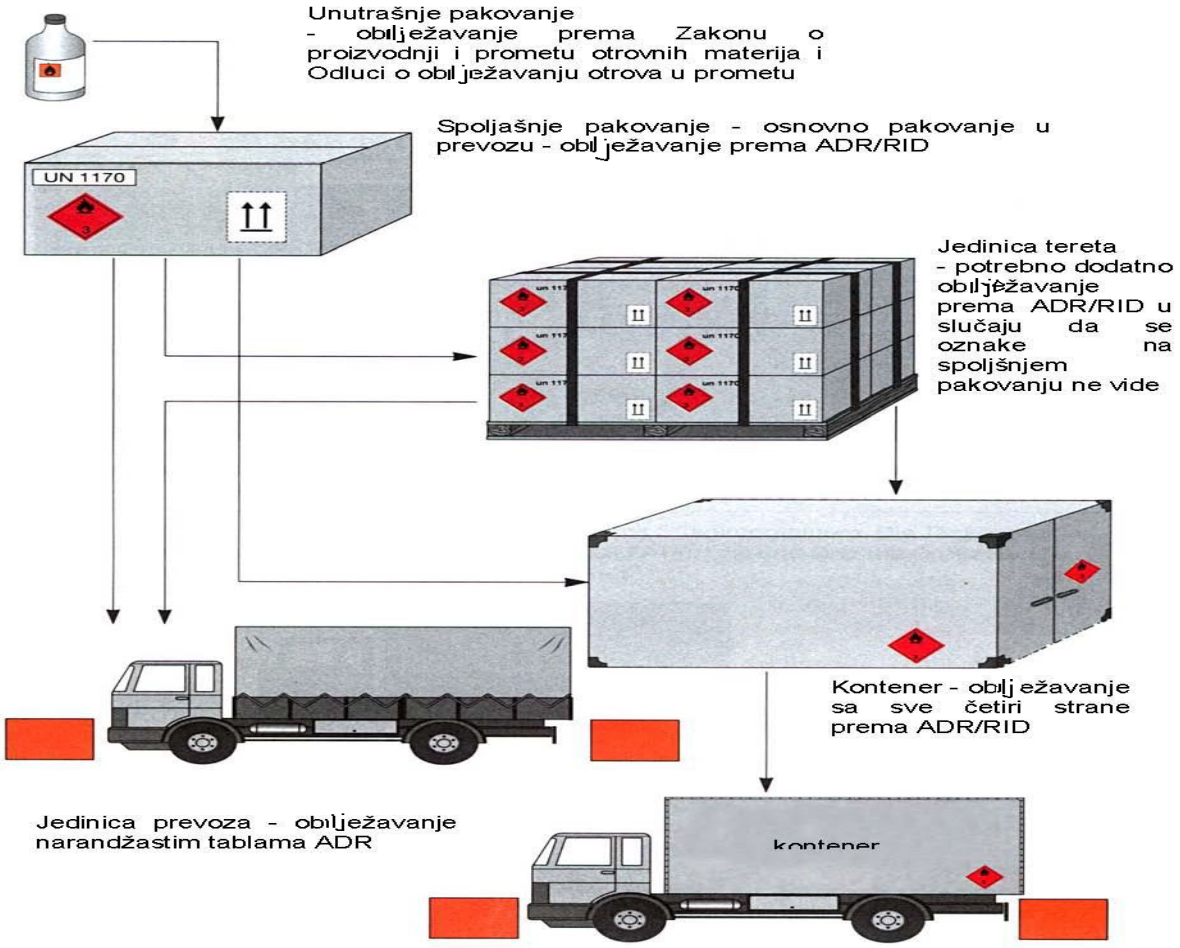

Figure 10. Marking of mixed cargo

Conclusion

The transport of hazardous materials in BiH constitutes one fifth of the total transport of goods, and the security situation cannot be assessed as satisfactory either in terms of normative adaptation, or in terms of the construction of a dedicated infrastructure network, nor in terms of operations for the transport of this category of goods. The long-term improvement of the safety of the transportation of dangerous goods must be based on the creation of a master plan of the intermodal transport network, which will enable the redirection of the flows of this category of goods to safer and more environmentally friendly options of other modes of transport, where we primarily mean rail and water transport.

Furthermore, it is necessary to adapt modern technologies of transport and manipulation of goods, which will match the requirements of interoperability, as well as the standards and best practices of goods transport, including the transport of dangerous goods. Long-term traffic development is primarily conditioned by high-quality transport and logistics education. Transportation of hazardous materials requires greater precautions than packaging and storage. There are also additional

risks in transportation, such as the action of changing forces, changes in micro and macro climate conditions, and possible traffic accidents that can cause real disasters caused by the action of dangerous substances. Due to all of the above, each country determines the laws according to which the transportation of dangerous goods is carried out and the actions that are necessary for handling such goods. In addition, the state prescribes and implements strict measures of supervision over the observance of legal legislation, which regulates the area of packaging, manipulative actions, transportation and storage of dangerous substances.

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