RID CARRIAGE OF ETHANE AS AN EXAMPLE OF A FLAMMABLE GAS

Matilda Lazić [1], Miodrag Kovačević [2]

Abstract: In this paper, the conditions for the railway carriage of ethane as an example of the Category of dangerous goods - Flammable gases, were determined. It was assumed that the only permissible conditions for the railway carriage of ethane can be determined by applying the provisions of the international agreement called Convention concerning International Carriage by Rail (COTIF) Appendix C - Regulations concerning the International Carriage of Dangerous Goods by Rail (the RID Regulation). Provisions in terms of prescribed transport conditions are read from Table A: List of dangerous goods in UN number order. The belonging of ethane to Class 2 of dangerous goods (Gases) and Category 2.1 (Flammable gases) predetermines the general, and significantly affects the application of special conditions of the railway carriage. The strict application of the transport conditions, prescribed by the RID Regulation, can have a significant impact on the minimization of transport accidents with ethane in railway traffic.

Key words: RID Regulation, ethane, flammability, flammable gases, carriage by rail, railway transport safety

1. UVOD

Ethane represents an extremely important primary petrochemical product and raw material for the secondary petrochemical industry [1]. Ethane is isolated on an industrial scale from natural gas and as a by-product of petroleum refining. Its chief use is as a petrochemical feedstock for ethylene production, usually by pyrolysis [1], [2]. This pyrolysis is performed for industrial purposes in the presence of steam at around 900°C (steam cracking). Steam is used as a diluent for ethane pyrolysis [3]. Today, ethane is a very attractive raw material for the catalytic process of dry reforming, to obtain syn-gas, from which hydrogen can be extracted, as a very important energy and/or industrial resource [4]. Ethane and ethane derivatives are also used to produce a wide range of industrial chemicals.

Ethane is a gaseous, paraffinic hydrocarbon with a chemical formula of CH_3CH_3. It is colorless and odorless and normally is found in natural gas, usually in small proportions. It is slightly heavier than air and practically insoluble in water. When ignited in atmospheric burning, it produces a pale faintly luminous flame, with little or no smoke production. With excess air during combustion, it produces carbon dioxide and water. With limited air supplies, the combustion process will produce carbon monoxide and water. It forms an explosive mixture with air over a moderate range [5].

If we take into account the possibility of wide industrial application of ethane, studying the question of its carriage e.g. by rail, acquires exceptional importance.

In this paper, the conditions for the railway carriage of ethane as an example of the Category of dangerous goods - Flammable gases, were determined. It was assumed that the safe conditions of rail carriage of ethane, as a flammable gas, are identified by applying Table A: List of dangerous goods in UN number order (hereinafter: Table A) [6], which forms an integral part of the International agreement called Convention concerning International Carriage by Rail (COTIF) Appendix C – Regulations concerning the International Carriage of Dangerous Goods by Rail (hereinafter: RID Regulation) [6]. The paper also shows the measures that must be implemented to protect all exposed persons in the event of transport and/or chemical accidents with ethane (because accidents are the result of inconsistent application of prescribed transport conditions by persons involved in transport activities). Measures can be identified from the safety data sheet of ethane, as a transport document.

[1] Professor of applied studies, Technical College of Applied Sciences in Zrenjanin, Đorđa Stratimirovića 23, Zrenjanin, Republic of Serbia, e-mail: matildalazic@outlook.com

[2]Professor of applied studies, Technical College of Applied Sciences in Zrenjanin, Đorđa Stratimirovića 23, Zrenjanin, Republic of Serbia, e-mail: miodrag.kovacevic.zr@gmail.com

2. RID REGULATION AS A BASIS FOR DETERMINING THE SAFE TRANSPORT CONDITIONS OF ETHANE

The RID Regulation shall apply to the international carriage of dangerous goods by rail on the territory of the RID Contracting States [6].

Dangerous goods are assigned to UN numbers and proper shipping names according to their hazard classification and their composition. Dangerous goods commonly carried are listed in the Dangerous Goods List in Chapter 3.2. of RID Regulation. Where an article or substance is specifically listed by name, it shall be identified in transport by the proper shipping name in the Dangerous Goods List. Each entry in the Dangerous Goods List is characterized by a UN number. This list also contains relevant information for each entry, such as hazard class, subsidiary risk(s) (if any), packing group (where assigned), packing and tank transport requirements, etc. [6].

2.1. Explanations on Table A: List of dangerous goods in UN number order

As a rule, each row of Table A deals with the substance(s) or article(s) covered by a specific UN number. Each column of Table A is dedicated to a specific subject as indicated in the explanatory notes below. The intersection of columns and rows (cell) contains information concerning the subject treated in that column, for the substance(s) or article(s) of that row [6]:

- The first four cells identify the substance(s) or article(s) belonging to that row (additional information in that respect may be given by the special provisions referred to in Column (6);
- The following cells give the applicable special provisions, either in the form of complete information or in coded form. The codes cross-refer to detailed information that is to be found in the Part, Chapter, Section, and/or Sub-section indicated in the explanatory notes below. An empty cell means either that there is no special provision and that only the general requirements apply, or that the carriage restriction indicated in the explanatory notes is in force. When used in this Table, an alphanumeric code starting with the letters "SP" designates a special provision of Chapter 3.3 of the RID Regulation [6].

3. METHODOLOGY

The identification of the transport conditions of ethane, as a flammable gas, was done based on the RID Regulation, by applying Table A [6]. By reading and interpreting the data from each column of Table A (ethane, UN number 1035), that is, by applying the content analysis method of the RID Regulation (Volume 1, 2) [6], the only permitted, safe conditions were identified under which ethane can be transported by rail while minimizing the risks of transport and/or chemical accidents and negative effects on human life/health and the environment.

4. RESULTS AND DISCUSSION

By applying Table A [6] to determine the safe conditions of ethane transport in accordance with the RID regulation, the results were obtained, which are presented in this chapter of the work.

The obtained results that apply to the safe rail transport of ethane as a flammable gas will be given individually, for each column in the Table A [6].

Column (1) "UN No." [6]. Ethan was assigned UN number 1035.

Column (2) "Name and description" [6]: ETHANE.

Column (3a) "Class" [6]. Ethane is a dangerous good. Ethane is classified in Class 2 - Gases and Category 2.1 - Flammable gases. The heading of Class 2 covers pure gases, mixtures of gases, mixtures of one or more gases with one or more other substances, and articles containing such substances. Gas is a substance which [6]:

- at 50°C has a vapor pressure greater than 300 kPa (3 bar); or
- is completely gaseous at 20°C at the standard pressure of 101.3 kPa

Column (3b) "Classification code" [6]. Ethan was assigned a classification code of 2F. Substances and articles of Class 2 are assigned to one of the following groups according to their hazardous properties, as follows [6]:

- An asphyxiant;
- O - oxidizing;
- F - flammable;
- T - toxic;
- TF - toxic, flammable;
- TC - toxic, corrosive;
- TO - toxic, oxidizing;
- TFC - toxic, flammable, corrosive;
- TOC - toxic, oxidizing, corrosive.

Flammable gases are gases which at 20°C and a standard pressure of 101.3 kPa [6]:

- are ignitable when in a mixture of 13% or less by volume with air; or
- have a flammable range with the air of at least 12 percentage points regardless of the lower flammable limit.

The classification code and hazard class are interrelated because they are based on the physical, chemical, and Physico-chemical properties of the substance being transported.

Column (4) "Packing group" [6]. Not prescribed for ethane.

Column (5) "Labels" [6]. Specimen labels for ethane are shown in Table 1. [6].

Table 1 – Specimen labels for ethane

Label model No.	Category	Symbol and symbol color	Back-ground	Figure in bottom corner	Specimen labels
2.1	Flammable gases	Flame: black or white	Red	2 (blackor white)	

Therefore, ethane belongs to Class 2 - Gases and Category 2.1. - Flammable gases. The above-mentioned classification of ethane in terms of a dangerous good implies the selection of a sample of the specimen labels and, consequently, its application.

Column (6) "Special provisions" [6]. The special provision applicable to ethane is 662. Cylinders not conforming to the provisions of Chapter 6.2 of the RID Regulation which are used exclusively on board a ship or aircraft, may be carried to fill or inspection and subsequent return, provided the cylinders are designed and constructed by a standard recognized by the competent authority of the country of approval and all the other relevant requirements of the RID are met including:

- The cylinders shall be carried with valve protection in conformity with 4.1.6.8 of the RID Regulation;
- The cylinders shall be marked and labeled in conformity with 5.2.1 and 5.2.2 of the RID.

The transport document shall include the following statement: "CARRIAGE by SPECIAL PROVISION 662" [6].

Column (7a) "Limited quantities" [6]. The applicable quantity limit for the inner packaging or article is specified for each substance in Column (7a) of Table A. In addition, the quantity "0" has

been indicated in this column for each entry not permitted to be carried out by Chapter 3.2 of the RID Regulation.

Column (7b) "Excepted Quantities" [6]. Ethane may be carried as excepted quantities by the provisions of Chapter 3.2. of the RID Regulation, but an alphanumeric code is "EO" (Table 2. [6]).

Table 2 – Meaning of alphanumeric code "EO" for ethane

Code	Maximum net quantity per inner packaging (in ml for gases)	Maximum net quantity per outer packaging (in ml for gases)
E0	Not permitted as Excepted Quantity	

Column (8) "Packing instructions" [6]. The alphanumeric code of the applicable packing instructions is P200. Type of packaging: Cylinders, tubes, pressure drums, and bundles of cylinders. Pressure receptacles shall be so closed and leakproof as to prevent the escape of the gases. The minimum test pressure required is 1 MPa (10 bar). Periodic inspections are necessary.

Column (9a) "Special packing provisions" [6]. Not prescribed for ethane.

Column (9b) "Mixed packing provisions" [6]. The alphanumeric code is "MP9".

Column (10) "Portable tank and bulk container instructions" [6]. The "M" instruction applies but is optional. The general requirements for the design, construction, equipment, type approval, testing, and marking of portable tanks are to be found in Chapter 6.7 of the RID Regulation.

Column (11) "Portable tank and bulk container special provisions" [6]. Not prescribed for ethane.

Column (12) "Tank codes for RID tanks" [6]. The alphanumeric code PxBN(M) describes a tank type, by 4.3.3.1.1 [6] for gases of Class 2.

Column (13) "Special provisions for RID tanks" [6]. The alphanumeric codes of the special provisions for RID tanks: are TU38, TE22, TA4, TT9, and TM6. A more detailed interpretation is given in 4.3.5 and 6.8.4 of the RID Regulation.

Column (14) (Reserved) [6]. *Reserved*.

Column (15) "Transport category" [6]. Exemptions related to the nature of the transport operation (1.1.3.1. (c) of the RID Regulation). Transport Category is 2 (Class 2, group F). Group F includes flammable gases.

Column (16) "Special provisions for carriage – Packages" [6]. Not prescribed for ethane.

Column (17) "Special provisions for carriage – Bulk" [6]. Not prescribed for ethane.

Column (18) "Special provisions for carriage – Loading, unloading and handling" [6]. CW 9 - Packages shall not be thrown or subjected to impact. CW 10 - Cylinders as defined in 1.2.1 of the RID Regulation, shall be laid parallel to or at right angles to the longitudinal axis of the wagon or container; however, those situated near the forward transverse wall shall be laid at right angles to the said axis. CW 36 - Packages shall preferably be loaded in open or ventilated wagons or open or ventilated containers. If this is not feasible and packages are carried in other closed wagons or containers, gas exchange between the load compartment and accessible compartments during carriage shall be prevented and the cargo doors of the wagons or containers shall be marked with the following in letters not less than 25 mm high: This shall be in a language considered appropriate by the consignor.

Column (19) "Colis express (express parcels)" [6]. This column contains the alphanumeric code "CE3" for the requirements applicable to forwarding as Colis Express (express parcels).

Column (20) "Hazard identification number" [6]. The hazard identification numbers listed in Column (20) for ethane have the following meanings: 23 - Flammable gas.

The results showed that ethane was identified as a highly flammable gas, which must be transported by the clearly defined general and special provisions of the RID Regulation. In case of

non-observance of the prescribed transport conditions, during any transport operation, transport and/or chemical accidents may occur and the consequences of negative effects on the life/health of persons (participating in transport operations) and on the environment may occur.

4.1. Prevention, safety instructions, measures for extinguishing fires, measures in case of accidents

To prevent chemical and/or transport accidents, during the transport of ethane, it is necessary to comply with all safety instructions related primarily to: handling dangerous goods of class 2, category 2.1 (Flammable gases) [6], marked with safety data sheet and accompanying danger notices; the way of packing; all special provisions that apply to the construction and filling of RID tanks for ethane, that is, the construction of vehicles.

Prevention, safety instructions, measures for extinguishing fires, measures in case of accidents can be read from e.g. safety data sheet. In this paper, the ethane safety data sheet of the producer/distributor „Linde“ is used as an example.

Chemical and/or transportation accidents may occur if the safety procedures identified in Table A [6] are not followed and the precautions specified in the ethane safety data sheet [7] are not followed.

Fire hazard [7]: Flammable gas. If venting or leaking gas catches fire, do not extinguish flames. Flammable vapors may spread from a leak, creating an explosive reignition hazard. Vapors can be ignited by pilot lights, other flames, smoking, sparks, heaters, electrical equipment, static discharge, or other ignition sources at locations distant from the product handling point. Explosive atmospheres may linger. Before entering an area, especially a confined area, check the atmosphere with an appropriate device [7].

Explosion hazard [7]: Flammable gas. Forms explosive mixtures with air and oxidizing agent.

Special protective equipment for firefighters [7]: Standard protective clothing and equipment (Self Contained Breathing Apparatus) for firefighters.

Accidental release measures [7]: Forms explosive mixtures with air. Immediately evacuate all personnel from the danger area. Use self-contained breathing apparatus where needed. Remove all sources of ignition if safe to do so. Reduce vapors with fog or fine water spray, taking care not to spread liquid with water. Shut off flow if safe to do so. Ventilate the area or move containers/tanks to a well-ventilated area. Flammable vapors may spread from a leak and could explode if reignited by sparks or flames. Explosive atmospheres may linger. Before entering an area, especially confined areas, check the atmosphere with an appropriate device.

Environmental precautions [7]: Prevent waste from contaminating the surrounding environment. Prevent soil and water pollution.

5. CONCLUSION

The conditions for the railway carriage of ethane are determined by applying Table A, which is part of the RID Regulation. According to the provisions of the RID Regulation, which define the classification of dangerous goods, ethane belongs to Class 2 (Gases) and Category 2.1. (Flammable gases) i.e. group F. The classification of ethane is based on the physical and chemical properties of ethane and predetermines the selection of the specimen labels. Also, other general and special provisions stem from the conditions of classification, i.e. flammability as a physical property of ethane.

It must be emphasized that ethane is only one representative of the group of Flammable gases and that the results obtained in this work cannot be applied universally, but to define the transport conditions of individual substances, their specificities must be considered.

The strict application of the transport conditions prescribed by the RID Regulation can have a significant impact on the minimization of accidents with ethane in railway traffic.

In case of non-observance of the prescribed transport conditions, during any transport operation, transport and/or chemical accidents may occur and the consequences of negative effects on the life/health of persons (participating in transport operations) and on the environment may occur.

It was noted that the conditions of ethane carriage have not changed compared to the previous version of the RID Regulation, which was valid in the period from 2019 to 2021 years.

A further course of work could include determining the conditions for the safe transport of ethane in road carriage and comparing them with the conditions in the railway carriage, which were obtained in this paper.

6. REFERENCES

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