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Item 6 (b) of the provisional agenda

**Proposals for amendments to Annexes A and B of ADR:
miscellaneous proposals**

Use of Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG) as fuel for vehicles carrying dangerous goods

Transmitted by AEGPL and NGV Global¹

Summary

- Executive summary:** Amendments to Chapter 9.2 to make the use of compressed natural gas (CNG) and liquefied petroleum gas (LPG) possible as fuel for vehicles carrying dangerous goods.
- Action to be taken:** Amendment to chapters 1.6.5, and 9.2.4 to include CNG and LPG referencing the respective ECE Regulations.
- Reference documents:** ECE/TRANS/WP.15/226,
ECE/TRANS/WP.15/228,
Informal documents INF.3 (Sweden), INF.4 (NGV Global),
INF.12 (NGV Global), INF.15 (AEGPL), INF.16 (AEGPL) of
the ninety-eighth session.

¹ In accordance with the programme of work of the Inland Transport Committee for 2014-2015 (ECE/TRANS/240, para. 100, ECE/TRANS/2014/23, cluster 9, para.9.1).

Introduction

1. The proposals for amendments to ADR (especially Chapter 9.2) to include provisions for vehicles powered by gaseous fuels prompted discussions for which AEGPL and NGV Global were invited to provide further justification. Based on document ECE/TRANS/WP.15/2014/16 both organisations wish to specify the suggested amendments and address additional questions raised by some delegations during the ninety-seventh session (November 2014).
2. The suggested amendments are based on proven reliable technology. There are more than 25 million vehicles worldwide running on liquefied petroleum gas (LPG) and over 21 million natural gas vehicles (NGVs), (including nearly 1.5 million heavy duty trucks and buses). Heavier vehicles with compression ignition engines have been converted to operate on diesel and gaseous fuels simultaneously (referred to as dual-fuel vehicles). The United Nations regulations for LPG and compressed natural gas (CNG) components and their use on road vehicles (ECE Regulations No. 67-01 and No.110 respectively) have been in force for many years. Regulations for dual-fuel vehicles have recently been included in ECE Regulation No. 49 (heavy duty vehicles) and came into force in July 2014. LPG and natural gas (CNG and LNG) are fully legitimized fuels and fuel systems governed within a substantial body of existing United Nations regulations as well as standards and regulations adopted by many nations worldwide.
3. Concurrent with the philosophy of creating a harmonized and consistent regulatory approach to LPG and CNG, AEGPL and NGV Global advocate the specification of these market-proven fuels, fuel systems and vehicles within ADR with reference to the applicable ECE-Regulations (Nos. 67-01 and 110). Both organizations, therefore, support the notion that additional requirements regarding the specifics of dangerous goods transport that are not yet addressed by the World Forum for Harmonization of Vehicle Regulations (WP.29) should be included in ADR. This combination of ECE-Regulations (Nos. 67-01 and 110) and the aforementioned additional requirement will provide sufficient safety provisions to justify the use of CNG and LPG as fuels for heavy goods vehicles carrying dangerous goods. AEGPL and NGV Global propose to amend the wording in ADR accordingly.

Properties of the Gaseous Fuels

4. Both LPG and CNG, gaseous in their natural state under normal atmospheric conditions, exhibit good mixing qualities. Under ventilated conditions (especially outdoors) dissipation is quick enough for the risk to be negligible in practice.
5. Both CNG and LPG are non-oxidant, non-corrosive and do not react with other chemicals.
6. Both CNG and LPG are non-toxic and apart from displacing air (risk of asphyxiation) have no harmful effects on human beings.
7. Both CNG and LPG are dangerous goods, flammable, compressed and low pressure liquefied gases, Class 2 Classification codes 1F and 2F respectively. They have been assigned following UN Nos.: 1971 for CNG and 1965 for LPG.
8. Under prolonged exposure (several hours) LPG in its liquid phase can act as a solvent for certain materials.
9. The accompanying technical documents listed below present the physical properties, safety aspects and potential hazards in more detail:

- Informal documents INF.23 (NGV Global) and INF.24 (AEGPL) of the ninety-seventh session;
- Informal documents INF.4 (NGV Global) and INF.15 (AEGPL) of the ninety-eighth session.

Gaseous Fuel Systems including Fuel Tanks and Cylinders

10. The technical requirements in the existing regulations (ECE 67-01 & 110) account for the differences of the respective fuels to provide levels of safety comparable to that of liquid fuels.
11. Fuel tanks (for LPG) and cylinders (for CNG) are required to withstand the elevated pressures needed to store the fuels. Respective regulations include requirements, which are stricter than for tanks for liquid fuels.
12. The attachment of the LPG tanks and CNG cylinders to the vehicle frame is required to withstand severe mechanical stresses. The fastenings are required to absorb accelerations exceeding 5.5 g.
13. Through their specific ECE-Regulations, LPG tanks and CNG cylinders are required to be equipped with automatic shut-off valves that close off the fuel flow from the container to the engine system in case of an accident when the engine stops and prevents fuel from leaking through ruptured fuel lines.
14. As no significant volume of fuel is contained in the fuel lines the release of gas is limited, considerably lowering the risk of a truck fire. As such, CNG and LPG fuel systems are at least equally robust as diesel fuel systems and are unlikely to result in substantial fuel leakage.
15. LPG tanks and CNG cylinders are designed with integral fire protection. The suitability of each fuel storage system design is certified through bon-fire tests in which the container filled to its rated capacity is exposed to a uniform fire source completely engulfing it in flames. The pressure relief valve gradually releases the pressure in a controlled manner until no fuel is left, thereby preventing the container from bursting..
16. The electrical equipment in CNG and LPG fuel systems complying with the provisions in their respective regulations, may not necessarily fulfil the provisions given in 9.2.2.², thus the electrical equipment may need to be modified and approved accordingly.
17. More in-depth evaluation of the potential hazards and technical means by which they are addressed can be found in the respective informal documents provided for CNG and LPG that support this Working Document. (Reference in paragraph 9, above.)

² There are clear requirements regarding electronic equipment and electrical wiring laid down in ADR that are fully applicable to the gas equipment. If the requirements for electric component safety are deemed insufficient in R.110, however, the process can be handled in the manner of diesel engine suppliers, who produce an 'ADR package' that is prepared for the ADR application but the engine is not altered. In the case of CNG and LPG components for ADR applications, the vehicle manufacturer or system installer must request an approval through a notified body for the applicable electric components. Approval at the national level by the appropriate authorities of the Contracting Party ultimately can implement the final safety provisions for individual vehicles in the vehicle certification (or inspection) process.

Proposals

18. The following proposed amendments are based on the new text of ADR 2017 as agreed in the May 2014 meeting (ninety-sixth Session) appearing in ECE/TRANS/WP.15/224 also taking into account the comments of the delegations given to both organisations after the ninety-seventh Session (see ECE/TRANS/WP.15/226).

19. Deletions will be shown as stricken through and new text will be shown in *italics and underlined*.

20. Amend the definitions in 1.2.1 to read as follows:

“Compressed Natural Gas (CNG)” means a compressed gas composed of natural gas with a high methane content assigned to UN Number 1971.

“Liquefied Natural Gas (LNG)” means a refrigerated liquefied gas composed of natural gas with a high methane content assigned to UN Number 1972.

21. Amend 1.6.5.17 to read as follows:

“1.6.5.17 FL and OX vehicles registered before 1 July 2017, fitted with an LNG, *CNG* or *LPG* fuel system, not fully in compliance with the provisions found in ECE Regulations No. 110 and *No. 67-01* respectively, may still be used with the approval of the competent authority of the country of registration, if an equal level of safety can be demonstrated.”

22. Amend 9.2.4.3 to read as follows:

“9.2.4.3 Fuel tanks *and cylinders*

The fuel tanks and cylinders supplying the engine of the vehicle shall meet the following requirements:

(a) In the event of any leakage ~~in~~ *under* normal ~~operating~~ *conditions of carriage*, the *liquid fuel or the liquid phase of a gaseous* fuel shall *drain to the ground and* not come into contact with *the load or* hot parts of the vehicle ~~or of the load~~;

(b) Fuel tanks for liquid fuels shall meet the requirements of ECE Regulation No. 34⁶; fuel tanks containing petrol shall be equipped with an effective flame trap at the filler opening or with a closure enabling the opening to be kept hermetically sealed. *Fuel tanks and cylinders for LNG and for CNG respectively shall meet the relevant requirements of ECE Regulation No. 110⁷. Fuel tanks for LPG shall meet the requirements of ECE Regulation No. 67-01.*

(c) *The discharge opening(s) of pressure relief devices and/or pressure relief valves shall be directed away from the load, fuel tanks, hot parts of the vehicle and shall not impinge on enclosed areas, other vehicles, exterior-mounted systems with air intake (i.e. air-conditioning systems), engine intakes, or engine exhaust.”*

⁶ ECE Regulation No. 34 (Uniform provisions concerning the approval of vehicles with regard to the prevention of fire risks)

⁷ ECE Regulation No. 110 (Uniform provisions concerning the approval of:

I. *Specific components of motor vehicles using compressed natural gas (CNG) and/or liquefied natural gas (LNG) in their propulsion systems;*

II. *Vehicles with regard to the installation of specific components of an approved type for the use of compressed natural gas (CNG) and/or liquefied natural gas (LNG) in their propulsion system).*

⁸ ECE Regulation No. 67-01 (Uniform provisions concerning the approval of:

I. Approval of specific equipment of vehicles of category M and N using liquefied petroleum gases in their propulsion system

II. Approval of vehicles of category M and N fitted with specific equipment for the use of liquefied petroleum gases in their propulsion system with regard to the installation of such equipment

23. Amend subsection 9.2.4.4 to read:

"9.2.4.4 Engine

The engine propelling the vehicle shall be so equipped and situated to avoid any danger to the load through heating or ignition. The use of ~~CNG or liquefied natural gas (LNG)~~ as fuel shall be permitted only if the specific components for ~~CNG and~~ LNG are approved according to ECE Regulation No. 110⁷ and ~~meet the provisions of 9.2.2. The their~~ installation on the vehicle ~~complies with~~ shall meet the technical requirements of 9.2.2 and ECE Regulation No. 110⁷ ~~The use of LPG as fuel shall be permitted only if the specific components for LPG are approved according to ECE Regulation No. 67-01⁸ and meet the provisions of 9.2.2. The installation on the vehicle shall meet the technical requirements of 9.2.2 and ECE Regulation No. 67-01⁸.~~ In the case of EX/II and EX/III vehicles the engine shall be of compression-ignition construction using only liquid fuels with a flashpoint above 55 °C. Gases shall not be used.".

⁷ ECE Regulation No. 110 (Uniform provisions concerning the approval of:

I. Specific components of motor vehicles using compressed natural gas (CNG) and/or liquefied natural gas (LNG) in their propulsion systems;

II. Vehicles with regard to the installation of specific components of an approved type for the use of compressed natural gas (CNG) and/or liquefied natural gas (LNG) in their propulsion system).

⁸ ECE Regulation No. 67-01 (Uniform provisions concerning the approval of:

I. Approval of specific equipment of vehicles of category M and N using liquefied petroleum gases in their propulsion system

II. Approval of vehicles of category M and N fitted with specific equipment for the use of liquefied petroleum gases in their propulsion system with regard to the installation of such equipment

Renumber existing footnotes accordingly.

24. Insert new subsection 9.2.4.X to read:

"9.2.4.X Prevention of damage through cryogenic cooling

Fuel systems for engines fuelled by a refrigerated liquefied gas (LNG) shall be designed and equipped to avoid any danger to the load through cryogenic cooling.".

Justification for proposals

1.6.5.17

25. Vehicles using gaseous fuels (LNG, CNG and LPG) are being used for the transport of dangerous goods by Contracting Parties where they have been approved for service interpreting the current rules of ADR by the respective competent authorities. As such, transitional measures are necessary to enable continued operation of these gaseous fuelled vehicles in accordance with their current approvals.

9.2.4.3 (a), (b) and (c)

26. The wording now used also addresses the initial intention to regulate general behaviour of the fuels in (a), and technical requirements for the tank in (b) adding (c) for requirements for further equipment related to the tank.

27. The reference to liquid leakage was reintroduced in order to more clearly distinguish the behaviour of liquid fuels and those gaseous fuels that also can be in 'liquid phase.' Dousing the load with a liquid fuel will have a more intense effect than a gaseous fuel transitioning from its liquid to gaseous phase that might have brief contact with the load if, for example, air turbulence (wind) happens to cause some contact with the load as the gaseous fuel is dissipating into the atmosphere. As such, this change seems justified in order to clarify differences in liquid and gaseous fuels that might have 'contact with the load' in the event of an accident severe enough to involve a fuel leak or spill.

28. Gaseous fuels cool when decompressed (Joule-Thomson-effect). Natural gas will cool to about -20 °C but only for a very short amount of time as the gas dissipates. This poses no harm to the equipment, all of which is required to be designed to withstand -20 °C in the provisions laid down in ADR.

29. LPG, when leaking in liquid phase evaporates quickly and cools in the process. The final temperature of the liquid remaining will be defined by the ambient pressure, around -42 °C. As some materials lose ductility at lower temperatures, the chance of brittle fractures may increase. This needs to be taken into account depending on the tank material. In most cases where liquefied gases are filled into the tank, the exact same effect takes place inside the tank so the equipment needs to be designed to withstand the stresses of filling.

30. Fuel tanks and cylinders for gaseous fuels are by regulation tested in fire conditions where a pressure build-up could cause a rupture. The specific regulations (ECE Regulations Nos. 67-01 and 110) contain requirements and tests to type approve fuel tanks and cylinders to prove their fire resistance and safety. The bonfire tests specified in the respective regulations assume an engulfing pool fire. The temperature must reach a set level in a defined period of time in order to ensure the required intensity. The container is required to discharge fuel exclusively through the PRD. The test lasts until the pressure in the container has been reduced to atmospheric.

31. Fuel tanks and cylinders for LPG and CNG are equipped with components that are designed to withstand the heat influx of external fires. No additional measures are required for the transport of dangerous goods as fires with greater intensities than a pool fire, described in ECE Regulations Nos. 67-01 and 110, will affect the load to a greater extent than the gaseous fuel, its tank or cylinder and its equipment. A comparable level of safety for fuel tanks and cylinders for LPG, LNG and CNG fulfilling the requirements of ECE Regulations Nos. 67-01 or 110 is assured.

32. In case of a vehicle fire the correct orientation of the pressure relief devices (PRDs) or pressure relief valves (PRVs) shall prevent additional heat influx to the load. Although 9.2.4.3 (a) already requires liquid fuel or the liquid phase of the gaseous fuel not to come into contact "with hot parts of the vehicle or the load", directing the efflux of the PRD/PRV away from the load is an additional measure to minimise heat influx to the load.

9.2.4.4

33. The safety requirements for the fuel systems for LPG and natural gas (CNG and LNG) are elaborated in the respective ECE Regulations No. 67-01 and No. 110. Both ECE Regulations are approved by WP.29. Although these regulations do not take into

account the specialties of operation in vehicles for the carriage of dangerous goods, they do address the primary safety requirements such as robustness and resilience against damage.

34. The design of the system depends on the type approval of the components themselves as well as the correct installation on the vehicle, thus guaranteeing trouble-free interaction as well as correct function.

35. Although the ECE Regulations for LPG and natural gas include provisions regarding the design of electrical equipment, these provisions are not always sufficient to fulfil the prescriptions laid down in 9.2.2. Reference to 9.2.2 ADR is included in 9.2.4.4 to highlight this fact.

General justification

- Safety:
- The safety of the gaseous fuel systems has been demonstrated taking into account not only normal operating conditions but also considering the more common incidents like fires (engine, tire and load) or collisions.
 - No additional fire extinguishing equipment is needed.
 - Refuelling equipment for CNG and LPG has been designed to standards accommodating unsupervised operation by the ordinary driving public. The procedures have been optimised for safe, quick, uncomplicated refuelling.
See specifics in respective informal documents provided for each fuel.
- Feasibility: Individual Contracting Parties have already approved the operation of gaseous fuelled vehicles and have gathered extensive experience with CNG and LPG. Transporters and heavy goods vehicles manufacturers will have the option to have vehicles of this type approved for the carriage of dangerous goods.
- Enforceability: In order to guarantee correct functioning of the system during normal operations as well as the correct functioning of the safety equipment, the installation itself should be approved by the competent authority according to the respective ECE Regulation as well as the additional provisions made in the text of the ADR.
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