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Proposals for amendments to annexes A and B of ADR: construction and approval of vehicles

6 November 2015

Answers to questions raised in ECE/TRANS/WP.15/2015/17 (Germany) regarding the use of LNG in ADR-certified trucks and to additional comments received from the Netherlands

Transmitted by the representatives from NGV Global and AEGPL

Introduction

Germany submitted a Working Document (ECE/ TRANS/WP.15/2015/17e) that overall is supportive of the gaseous fuels and also is recommending certain amendments to the ADR. Germany has raised some important issues as well as some thoughtful and thought-provoking questions that are addressed and answered by the NGV and LPG experts.

The issues addressed below are summarized as follows:

- Suggesting limits to the amount of alternative fuel (for propulsion purposes only) stored on the vehicle that might be similar to the present limits for diesel. The Germany document leaves blank the limits (XX) for input by NGV/LPG stakeholders;
- Venting from safety valves/melt-able fuses etcetera – away from air inlets, fuel tanks, cargo and hot surfaces of the vehicle; (Language is not contentious and is agreed by NGV Global/AEGPL)
- Prohibiting piping on tanks; Since the submittal of **ECE/TRANS/WP.15/2015/17** there has been some correspondence between the principals that have clarified the meaning and intention of the German-proposed provision that should be dealt with satisfactorily with some refined language, for clarity.
- Removing references to ECE R110 and R67 (proposed by NGV Global/AEGPL amendment) proposed Germany because the ADR wording “*which comply with the pertinent legal provisions*” and makes the reference to these ECE regulations in section 9.2.4 of ADR superfluous.
- Protection of cargo from possible spill of cold fuel (LNG). This language has been discussed at ADR but it appears that further changes to what Germany is now proposing might be acceptable.

In order to facilitate the review and response to the stated concerns, portions of the full German Working Document are included below, with their proposed amendments and either the NGV Global/AEGPL amendment of the same section (for comparison) and/or comments and questions that address Germany’s concerns.

Underlined portions are those being proposed as new language.

Responses to questions and issues posed by Germany

Germany Proposal 1 (Regarding maximum fuel limits on the truck)

1.1.3.2 (a)

13. Subsection 1.1.3.2 (a) could be amended as follows (new text underlined):

“1.1.3.2 Exemptions related to the carriage of gases

The provisions laid down in ADR do not apply to the carriage of:

- (a) Gases contained in the tanks of a vehicle, performing a transport operation and destined for its propulsion or for the operation of any of its equipment used or intended for use during carriage (e.g. refrigerating equipment).

The fuel may be carried in fixed fuel tanks, directly connected to the vehicle's engine and/or auxiliary equipment or transportable pressure vessels, which comply with the pertinent legal provisions.”

The total capacity of the fixed tanks shall not exceed [xx] litres per transport unit and the capacity of a tank fitted to a trailer shall not exceed [xx] litres. These restrictions shall not apply to vehicles operated by the emergency services.”.

NGV Global/AEGPL:

For diesel trucks the ADR section 1.1.3.3 stipulates that liquid fuel capacity of fixed tanks shall not exceed 1500 litres per transport unit and the capacity for a tank fitted to a trailer shall not exceed 500 litres.

CNG cylinders and LNG/LPG tank sizes generally are stated in ‘litres water volume’. But the same liquid volume limits as for diesel on-board fuel storage puts the gaseous fuels at a disadvantage in terms of the amount of stored fuel on an energy equivalency basis. NGV Global/AEGPL suggests that text added to the first sentence in the proposed German text could be:... *or the equivalent amount of energy or mass when gaseous fuels are used.*

If, on the other hand, a volumetric measure equivalent to diesel is to be used then 1500L and 500L respectfully could cover most but not all gaseous fuel applications.

The text could read, therefore: The total capacity of the fixed tanks shall not exceed 1,500 litres per transport unit and the capacity of a tank fitted to a trailer shall not exceed 500 litres, or the equivalent amount of energy (MJ) or mass (KG) when gaseous fuels are used. These restrictions shall not apply to vehicles operated by the emergency services.”

On an energy basis the following would apply:

The European Directive 2009/33/EC, *Promotion of Clean & Energy Efficient Road Transport Vehicles*, in the Annex at the end of the directive, Table 1, indicates energy content of fuels:

Diesel = 36 MJ/litre

Natural gas/biomethane (also for LNG) = 33-38 MJ/Nm³ → average = 35.5 MJ/Nm³

LPG = 24 MJ/litre

For natural gas, with an average density of 0.7 kg/Nm³, this means: 35.5/0.7 = 50 MJ/kg

1,500 litre of diesel means 1,500 x 36 = 54,000 MJ

For NG this means: $54,000 / 50 = 1,080\text{kg}$

For LPG with an energy content of 24 MJ/litre
1,500 litre of diesel means $1,500 \times 36 = 54,000\text{ MJ}$

For LPG this means: $54,000 / 24 = 2,250\text{ litre}$

In consideration of the volumetric limit as an option the following applies:

For LNG: The largest of the LNG tanks used for trucks currently is, Gross Litre capacity = 647L; Net L capacity = 582L (Chart tank, HLNG-171); Two tanks on a truck, therefore, would be 1294L gross/1164L net. If this 2-tank limit for LNG is the maximum allowable fuel on a volumetric basis then 1500 L would be appropriate and still leave additional opportunity for some more fuel in a different configuration (behind the cab, for example). But Chart has indicated that they also have some trucks with on-board fuel storage of 1565 and 1710 litres for some specialty on-road applications (not ADR).

For CNG: A popular configuration for CNG cylinders on trucks in the U.S. is one that mounts cylinders behind the cab but also has an option to add more storage with two side-tanks (in the diesel tank space). The behind-the-cab- cylinders range from 30 to 160 Diesel Gallons Equivalent (DGE) and with side mounted tanks added as well the maximum CNG capacity is 280 DGE. In such an installation the truck capacity ranges from 40 to 180 DGE so that puts those systems at about 500 litres to 2400 litres with 160 DGE (2100L water volume) being the practical limit. Clearly such a configuration is not possible if the diesel limit of 1500L is enforced.

(Diesel litre equivalent = 0.756 kg natural gas, which currently is adopted by 26 U.S. states for taxation purposes.)

For LPG: Largest single fuel tank for LPG available at this moment has a net capacity of 350 litres. While light and medium duty vehicles are either LPG mono- or gasoline/LPG bi-fuelled, the vast majority of heavy duty vehicles operate in dual fuel mode. As such the need for tank capacities surpassing the total of two tanks (700 litres) is limited. Most applications fall in a range well below that.

As such, NGV Global/AEGPL are not opposed to using the volumetric limit as one option to satisfy most gaseous fuel storage systems. However, in under consideration of the pending introduction of on-board gaseous fuel capacity for marine applications it will be important that any precedent set at WP.15 also be suitable for other (ADN) applications. Thus, it is important that the concept of '*energy equivalent*' and '*mass equivalent*' be introduced within ADR, so that the regulation is '*fuel-equitable*' and provides some flexibility for those gaseous fuel storage systems that could become popular in the future.

The Netherlands proposed to replace *may* with *shall* (in contrast to 1.1.3.3). We would like to bring to attention that at least regulation R.67-01 includes provisions for a service valve to be fitted in the gaseous fuel system of an LPG powered vehicle to fuel the engine via a demountable tank. This applies especially to mono-fuelled LPG vehicles, which cannot resort to a second fuel, should the primary fuel run out or there be a technical problem with the fuel tank(s). The use of the word *shall* would foreclose the use of such a system, based on provisions given by WP.29.

Further, the installation of fuel tanks in trailers has been discussed theoretically, but none of the stakeholders contacted by either trade association have brought this issue forward as imminent or pressing. NGV Global/AEGPL feel that this application does not need to be regulated at the time, especially since the applicable ECE-Regulations do not include class O vehicles (trailers) in their scope. (Additional remarks on Netherland's safety concerns are addressed in the last section of this document.)

NGV Global/AEGPL suggest postponing discussions of fuel tanks mounted on trailers of ADR vehicles and, rather, focus on the current proposed amendments without introducing entirely new concepts at this time.

Germany Proposal 2 ((a) Regarding fuel leakage and contact with the load; (b) eliminating reference to R.110/R.67) and (c) no ‘pipes on tank’

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

14. Subsection 9.2.4.3 (a) of ADR 2017 (see ECE/TRANS/WP.15/224; Annex II) could be amended to read as follows (new text underlined):

Germany Proposed Amendment (part (a): leaking fuel not contacting the load

“9.2.4.3 (a) In the event of any leakage in the normal operating conditions of the vehicle, the liquid or gaseous fuel shall not come into contact with the load or with hot parts of the vehicle ~~or of the load~~.”

By Comparison:

NGV Global/AEGPL proposed amendment states (WP15/2015/16e):

"9.2.4.3 Fuel tanks *and cylinders*

(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~~;

Germany proposes to eliminate the reference to the downward directional flow of the fuel in this paragraph, which is fine. The sentence about not coming into contact with the load or hot parts is the same between Germany and NGV Global/AEGPL (WP15/2015/16e).

Germany Proposed Amendment (part B, removing references to R110/R67)

15. Subsection 9.2.4.3 (b) of ADR 2017 could be amended to read as follows (new text underlined):

“9.2.4.3 b) ~~Fuel tanks for liquid fuels shall comply with 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.~~ Any liquid or liquefied fuel shall drain to the ground.”

By Comparison:

NGV Global/AEGPL recommended changes (WP15/2015/16e) are:

(b) Fuel tanks for liquid fuels shall meet the requirements of ECE Regulation No. 34⁷; 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.

NGV Global/AEGPL Comment: The sentence recommended by Germany regarding ‘Any liquid or liquefied fuel shall drain to the ground’ fulfils the intention of NGV Global/AEGPL in (a) but is phrased more simply by Germany in (b). Since the language does not address CNG there is no requirement to ‘drain to the ground’. LNG and LPG

initially drain to the ground so the German language would seem to accomplish the same objective.

But regulators must understand that gaseous fuels in their liquefied state do not ONLY flow to the ground but also simultaneously begins to vaporize into the atmosphere.

- For LNG, as was stated in ECE-TRANS-WP15-98-GE-inf12e, in case of a breach of an LNG tank causing fuel to flow out, “Initially the reduction in pressure forces some of the internal heat of the liquid to flash boil itself. This is a thermodynamic certainty for the liquid to establish itself at ambient pressures. This vaporizes between 5 and 25 % of the liquid depending on its initial pressure. The remaining liquid stream breaks up and atomizes in the air. This break up accelerates the heat transfer from the air and further evaporates another 15-20 % of the stream depending on the velocity. What remains, lands on the ground. Before it can settle into a puddle, it must cool the surrounding ground to cryogenic temperatures. Depending on the thermal mass of the surroundings, this can quickly evaporate an additional 20-25% of the liquid.” (*An Initial Qualitative Discussion on Safety Considerations for LNG Use in Transportation*”, National Petroleum Council, USA, August 2012.)
- Similarly, LPG flowing from a breach in a tank will flow to the ground in its liquefied state. The vaporisation of LPG depends strongly on its composition and outside temperature. Boiling temperature at ambient pressures is in the range of ambient temperatures. Also LPG in its the vapour phase will move downward since it is heavier than air, however, it also will disperse to atmosphere in a very short amount of time.

German Proposal Part (c): Venting direction and pipes not fixed on the shell

“9.2.4.3 (c) The discharge opening(s) of pressure relief devices and/or pressure relief valves of fuel tanks containing gaseous fuels shall be directed away from air intakes, fuel tanks, the load or hot parts of the vehicle. Pipes shall not be fixed on the shell.”

By Comparison:

NGV Global/AEGPL recommended amendment reads:

(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.”

NGV Global/AEGPL Comments:

For the first sentence, the language proposed by Germany includes the same intention as NGV Global/AEGPL but is less specific. The German version is an acceptable alternative.

Regarding the last sentence in 9.2.4.3 (c) ‘pipes shall not be fixed to the shell’ NGV Global/AEGPL requested and received clarification from Germany on this issue because all gaseous fuel cylinders and tanks have some sort of piping, valves (manual and/or automatic) on the exterior surface of the vessel. Some LNG tanks have a ‘manifold’ with pipes and valves mounted on the side of the tank wall (as opposed to the end).

Ms. Silvia Prinz (Bundesministerium für Verkehr und digitale Infrastruktur

Referat G 24 – Beförderung gefährlicher Güter) informed NGV Global in a private communication on 23 October 2015 that this language might be further refined as “*Pipes*

shall not be fixed on the shell of the fixed tank”, and referenced 1.2.1 ADR: Definitions “fixed tank”. In this context the understanding would be the fixed tank of the load and not the fuel tank. NGV Global/AEGPL do not have a problem if the original sentence in the proposed 9.2.4.3 is replaced with the language provided by Ms. Prinz, otherwise it is unclear and unacceptable as currently worded.

Germany Proposal 3 (References to other ECE regulations & prohibition for vehicles carrying explosives.)

9.2.4.4

18. Subsection 9.2.4.4 of ADR 2017 could be amended to read as follows (new text underlined, deleted text as strikethrough):

“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 liquefied natural gas (LNG) as fuel shall be permitted only if the specific components for LNG are approved according ECE Regulation No. 1107 and their installation on the vehicle complies with the technical requirements of ECE Regulation No.110⁷.~~

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 including liquefied gases shall not be used.”

NGV Global/AEGPL Comments: Germany’s rationale (see below) for removing references to R.110/R.67 are acceptable but references to R.110/R.67 might help vehicle inspectors and certification officials to understand the genesis of the safety regulations related to the gaseous fuels. (Please see below, comments on the ‘rationale’ section.)

As for EX/II and EX/III vehicles (carrying explosive) NGV Global/AEGPL never proposed that the gaseous fuels be used for trucks with such cargo. This is not to say that these fuels would be unsafe on such vehicles, however, it is not desired to create further controversy or questions and, since EX-class trucks would represent a very small fraction of the total gaseous fuel ADR truck market, there is no problem with prohibiting these classification vehicles from being propelled by gaseous fuels.

Germany Proposal 4

9.2.X

20. The following new section 9.2.X could be inserted into ADR:

“9.2.X Prevention of other risks caused by fuels

9.2.X.1 An engine propelling the vehicle by means of liquefied natural gas shall be so equipped and situated to avoid any danger to the load due to the gas being refrigerated.”

NGV Global/AEGPL comment:

This new section and new clause 9.2.X.1 is already self-evident. All truck engines are located at the front of the vehicle and, as such, are ‘situated to avoid any danger to the

load.” Furthermore, the gas is only ‘refrigerated’ (i.e. cryogenic) when it is stored in the fuel tank. So this added language is superfluous, redundant and has the potential to result in too much latitude on the part of any individual vehicle approval and inspection authority to prevent gaseous fuels on ADR vehicles due to the broad nature of the wording. The use of ‘any’ danger also is encompassing and could be subject to interpretation, particularly if the inspection authority is not generally knowledgeable about LNG as a fuel for vehicles.

COMMENTS ON THE JUSTIFICATION SECTION of ECE/TRANS/WP.15/2015/17

Comments on III. Justification for proposals

Justification for Proposal 1

1.1.3.2 (a)

22. The amendment to 1.1.3.2 (a) second sentence is taken by analogy from 1.1.3.3 (a) second sentence of ADR for the carriage of gases. The wording “which comply with the pertinent legal provisions” makes the reference to the entire ECE regulations in section 9.2.4 of ADR superfluous. Only additional, dangerous goods specific provisions going beyond the ECE regulations need to be added to that section. Gas cylinders need to comply with the relevant requirements laid down, among other things, in dangerous goods legislation.

24. The question of a quantity limitation for gases should be considered in the light of existing relevant scientific opinions in the field of automotive engineering. These opinions should, if possible, include an assessment of additional factors related to the new gaseous phase and its risks with regard to the dangerous good carried.

NGV Global/AEGPL comments:

Comment on paragraph 22:References to R.110 and R.67. NGV Global/AEGPL believe that reference to the UNECE safety regulations for natural gas and LPG can help users of these regulations understand the background and safety references for the gaseous fuels. But, if WP15 is of the opinion this is ‘superfluous’ and that the wording “which comply with the pertinent legal provisions” adequately covers these references then there is no objection to removing the references to R110 and R67.

Comment on paragraph 24: Quantity of gas stored on board the vehicle. There is no ‘existing relevant scientific opinions in the field of automotive engineering’ that we know of that have determined optimum safety related to the quantity of fuel stored on board the vehicle for the purposes of propulsion. Mostly manufacturers try to install as much fuel as possible on the vehicle to maximize range which, for gaseous fuels could be 30-60% less than for a comparable diesel-fuelled vehicle that have tank volumes the same as diesel on a water volume basis. (And how will this so-called risk be determined?) Alignment with the diesel maximum amount of fuel could be satisfactory since this does not restrict the most commonly used tankage (CNG or LNG) on trucks. However, the scientific and equitable approach, as stated above, is to state the fuel limitations in energy equivalence or to allow flexibility, as proposed in NGV Global/AEGPL’s alternative language, to use either volumetric or energy equivalence but not to restrict gaseous fuel quantities to the same volumetric measures as for diesel.

Justification for Proposal 2

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

25. This amendment to 9.2.4.3 (a) clarifies two issues:

- Both liquid and gaseous fuels may be used. This corresponds to the two exemptions in 1.1.3.3 (a) and 1.1.3.2 (a) of ADR.
- This suggestion had already been made during the session of the Working Party in May 2015 by a delegation and clarifies that the fuel must not come into contact with the load as a whole or with hot parts of the vehicle.

27. The requirement that liquid fuels should drain to the ground in ADR 2015 and earlier has not been identified as being fundamentally wrong. However, it must be clarified that this requirement only makes sense if, on the one hand, it applies to liquid fuels – or liquefied fuels such as LPG – while, on the other hand, not excluding gaseous fuels.

NGV Global/AEGPL Comments

Paragraph 25, Contact with the load or hot parts: Generally speaking contact with the load or hot parts of the vehicle is not a safety issue unless and until there is a source of ignition. NGV Global has already addressed the issue of spilled LNG – and CNG – not coming into contact with the load in ECE-TRANS-WP15-98-GE-inf12e), as stated and referenced above that between 40-70% of the LNG will vaporize when the fuel goes to ground and there is little likelihood of the quantity of LNG from a fuel tank in ever forming a puddle the way gasoline or diesel would in the event of a spill.

Paragraph 27, fuel draining to the ground: When the clause applies only to liquid or ‘liquefied’ fuels (or fuels in their liquid phase) then ‘fuel draining to the ground’ is appropriate so long as CNG is excluded. But the above rationale indicates that gaseous fuels are NOT excluded. The proposed language in 9.2.4.3 (b) omits CNG.

Justification Proposal 3

9.2.4.4

29. The requirement that the fuel tank has to comply with ECE Regulation 67-01 or 110 can be deleted, as it follows in general from the exemption provision in 1.1.3.3 (a) for liquid fuels and analogously from the proposed recast of the exemption provision in 1.1.3.2 (a) for gases. General automotive engineering regulations that apply equally to all vehicles are not part of the ADR.

NGV Global comment:

It was our collective feeling (NGVG and AEGPL) that reference to R67 & R110 would contribute to ‘safety’ and prevent a ‘rogue cylinder or tank’ or components being used (i.e. ‘knock-off’ or ‘copied’ components). Also, referencing the existing safety regulations might be an advantage to the professionals or notified bodies – public or private – who will be responsible for inspecting the ADR vehicles and enforcing compliance. If Germany feels that compliance is well-covered by the phrase ‘pertinent legal provisions’ then we would not dispute this.

30. The last sentence in sub-section 9.2.4.4 also takes into account the Swedish concerns discussed in INF.3 in the WP.15 session in May.

NGV Global/AEGPL comment:

In the case of EXII and EXIII vehicles (carrying explosives) the gaseous fuel advocates have not included these vehicles in our amendments, therefore, we are in agreement with Germany and Sweden. Note, however, EX vehicles were not included because we do not believe that the gaseous fuels would be just as safe or safer than diesel on EX vehicles. Rather, we felt by doing so it would further compound the challenges of allowing the gaseous fuels on ADR vehicles. Since such applications are only in a very small percentage of ADR vehicle applications it is not an issue worth further debate.

Justification for Proposal 4**9.2.X**

31. This amendment addresses the fact that the fire hazard emanating from LNG as a fuel is smaller than the hazards resulting from its cryogenic state with temperatures of as low as -162 °C.

NGV Global/AEGPL comment:

We agree with the rationale, however, are concerned that the ambiguous language proposed could lead to trucks being deemed unsafe by certification authorities.

Some additional comments and issues about ‘critical safety points’ raised in private communications by the Netherlands in relation to fuel on-board trucks and trailers also need to be addressed:

Netherlands comment: The exposed tanks under the chassis of the semi-trailer may have little protection from a fire from below.

NGV Global/AEGPL remark: While it *may* be correct (but certainly not in all cases) that tanks/cylinders mounted under the trailer would not have any additional protection against fire from below, this is also the case for all fuel tanks mounted on motor vehicles of classes M and N. Gaseous fuel cylinders and tanks are subjected to severe abuse and bonfire testing as part of the certification process so it is not expected that additional protection from fire is required (although many undercarriage mountings of CNG cylinders frequently are protected by ‘stone guards’ to avoid potential damage to the exterior of the tank).

Netherlands comment: The temperature related safety devices and pressure relief devices on the tanks discharges sideways of the vehicle at a relative low level.

NGV Global/AEGPL remark: The issue of discharge angle is as relevant to class O vehicles as it is to other classes. The same conditions apply. In the case of under-chassis mounted CNG cylinders discharge can be aimed at the ground and not horizontally.

Netherlands comment: the functioning of the automatic closing feed valve(s) on each tank when the vehicle engine stops or when the connection is broken or leaking.

NGV Global/AEGPL remark: Automatic shutoff valves are always closed unless they receive a positive electronic signal that the engine is running. In the event of any interruption of the signal such as when the engine stops or due to any other failure or interruption of the electronic signal to the valve it will automatically close. The installation on the trailer shall fulfil the same requirements as for motor vehicles.

Netherlands comment: - the vulnerability of the connector between trailer and motor vehicle.

NGV Global/AEGPL remark: The flexible conduit (steel braided hose, corrugated tube or class 3 hose) with suitable protection between the motor vehicle and the trailer has been used in other vehicle applications (e.g. articulated urban buses) and does not pose any additional safety hazard or concerns.
