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Working Party on the Transport of Dangerous Goods

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

27 April 2015

Safety considerations in the use of liquefied natural gas (LNG) as fuel for vehicles carrying dangerous goods: Responses to ECE/TRANS/WP.15/2015/4 Transmitted by the Government of Germany and ECE/TRANS/WP.15/2015/INF.3, Compressed Natural Gas (CNG) as fuel for vehicles carrying dangerous goods by the Government of Sweden.

Transmitted by the NGV Global (the International Association for Natural Gas Vehicles)

Summary

Executive summary:	At its ninety-sixth session in May 2014, the Working Party adopted amendments to ADR that allow the use of liquefied natural gas (LNG) as fuel for vehicles carrying dangerous goods. These provisions are to enter into force on 1 January 2017. The delegations that had reservations concerning these new provisions were asked to formulate their concerns. Germany and Sweden have responded and provided details of their concerns about the WP15 decision to allow LNG propulsion vehicles – and comments about compressed natural gas (CNG) -- to be registered as ADR-certified.
Action to be taken :	NGV Global, the principal advocate to add LNG and compressed natural gas (CNG) trucks to the list of approved fuels for ADR-certified vehicles, is responding to the detailed concerns of Germany and Sweden to both support the 2014 ADR decision in favour of LNG and to support its additional effort to allow CNG trucks as ADR-certified vehicles. (TRANS/WP.15/2015/6). This document speaks only to LNG and CNG.
Reference documents:	ECE/TRANS/WP.15/-97 INF 23e; ECE/TRANS/WP.15/2014/2 and related informal documents including ECE-TRANS/WP 15-95 INF 23e and INF 25e; ECE-TRANS-WP15-98- GE-inf4e; ECE-TRANS-WP15-2015-06e

Introduction

LNG trucks are experiencing steady growth in various parts of the world as the use of natural gas (fossil-based methane as well as renewable bio-methane) also continues to grow, today consisting of some 20 million vehicles worldwide.[1]

- **China** had 15 LNG fuelling stations in 2008.[2] By 2011 there were 211 LNG stations but the number jumped dramatically to 1800 in 2013 and to 3000 by 2015.[3] This also reflected the strong growth in LNG trucks, from 6,800 in 2010; 17,500 in 2011; to 51,000 by 2012. Today there are an estimated 100,000 heavy vehicles running on LNG in China comprised of about 60,000 trucks and 40,000 buses.[4]
- **The United States** had nearly 6,000 LNG trucks and 209 LNG fuel stations in 2013, with an estimated 75% trucks and 25% buses.[5] LNG has been used as a transportation fuel since the 1970's, although in limited volumes for heavy duty and fleet applications.
- **Europe** had, as of 2014, approximately 1,500 LNG trucks supported by 50 LNG fuelling stations.[6] This number is anticipated to grow due to favourable European Union policies and European Commission-funded projects focused on the expansion of the LNG fuelling infrastructure for trucks and ships.
- **Marine applications** of LNG is growing rapidly. As of 2014 there were 48 LNG fuelled ships operating worldwide and 53 confirmed LNG new-builds. Additionally, there are 370 LNG carriers (most more than 100.000m3 capacity) currently in operation, of which many have been built with turbines and gas operation capabilities.[7]

Despite the growing familiarity with LNG as a clean, safe and economical fuel alternative to petroleum fuels, particularly in trucks and high horsepower engines, some people continue to have concerns about LNG safety. Much of the scepticism is merely a function of unfamiliarity with the fuel, the technology and the fuelling process. There are distinct differences between gaseous fuel and liquid fuel systems so the scepticism is understandable. But with greater familiarity all of the questions and misperceptions typically are resolved. The fact is that natural gas – whether stored as a pressurized gas or

[1] The Gas Vehicles Report, 2015..

[2] Country Report – China, Country Report – China, CATARC, NGV 2010, June 2010.

[3] *Special Report: China's burgeoning NGV market draws on North American knowhow and technology made in China*, NGV Today ,May 2014; and ENN Clean Energy , NGV Days 2014.

[4] Research in China: China Refuelling Station Industry Report, 2011-2012; *Natural Gas Vehicle Fueling Infrastructure*, Navigant, http://ngvtoday.org/2013/08/18/navigant-sanford-bernstein-point-to-growing-global-ngv-market-40-of-new-global-ngv-fueling-in-north-america/ ; NGV Today, Special Report: China's burgeoning NGV market draws on North American knowhow and technology made in China, May 2014; and Personal communication with B. Smith, Gas Advisers, Hong Kong. 2015 03.

[5] Zeus Intelligence, Development of LNG Fueling Stations in China vs. in U.S., January 2014.

[6] Natural Gas Vehicle Association Europe statistics.

[7] Opportunities and Challenges Fuelling LNG Ships, Erik Skramstad, DNV-GL, at CNG & LNG Safety: Perception & Reality, 9 October 2014, Brussels. Data updated 1 September 2014.

as a cryogenic liquid – performs in engines very much like petroleum-fuels and is as safe or safer than diesel or gasoline.

Germany and Sweden have raised many specific issues and concerns about the use of LNG (and CNG) in ADR-certified trucks. This document addresses the issues for LNG in hope that, through better understanding of the realities of LNG as a safe fuel for ADR trucks, regulations can be adapted so that the customer demand for LNG trucks can be fulfilled.

Responses to the detailed concerns of Germany and Sweden

ECE-TRANS-WP15-2015-04e (Germany) and ECE-TRANS-WP15-98-GE-inf3e_01 (Sweden)

Please note, numbered 'items' indicated in these responses relate to Germany's document ECE/TRANS/WP.15/2015/4, provided here for easier reference, along with the answers to the German (and Swedish, where noted) concerns.

Introduction of new provisions into section 9.2.4 Prevention of fires (Item 8):

Germany is concerned that flammability as well as the impact of cryogenic fuel exposure or leakage are important safety factors that must be considered. Both Germany and Sweden believe that more sophisticated research about all hazards of LNG fuel with respect to the possible impacts for the dangerous goods loaded on the vehicle should be performed.

Response:

LNG has been transported around the world by ship since 1959 and has a proven safety record as a cargo and a fuel for LNG transport ships (using the 'boil-off' as a propulsion fuel). LNG is used regularly as a supplement to pipeline gas. Due to its favourable economics and environmental benefits over diesel LNG is being used as a primary propulsion fuel in nearly 70,000 trucks and over 400 ships worldwide. Overall there is no evidence that, if handled with the appropriate precautions taken for other fuels, LNG possesses greater hazards than gasoline or diesel; and is safer in many respects.

For road transportation of LNG in tankers (not as a vehicle fuel), 23 incidents/accidents have been reported since 1971 in the US and Europe. Six incidents involved accidents with other vehicles, some involving violent collisions. Ten incidents involved vehicle roll-overs, most without loss of the load. Of these, only two led to fires. This is a reflection of the design and safeguards of the LNG tanks to any loss of cargo. Only one incident resulted in the driver death due to an LNG fire, which also burned one member of the public. Otherwise there have been no serious injuries suffered.[8]

Three incidents involving trucks fuelled by LNG were detailed in WP15/95/INF (submitted by KIWA,(November 2013). Two involved roll-overs where the LNG tanks remained intact. One accident caused by leaking hydraulic oil on an LNG test bus in Poland in 2008, resulted in a fire that consumed the bus and its LNG tanks. Relief valves operated as

[8] CH---IV International. "History of International LNG Operations." Technical document TD---02109 (March 2009).

designed but the LNG ignited as it vented from the vehicle but did not explode and was not a part of the fire-related cause.

NGV global does not believe that, with these experiences and incidents over numbers of years with LNG truck-tankers and LNG fuelled trucks, ‘more sophisticated research’ is necessary. LNG is an appropriate fuel for ADR-certified trucks with a safety record demonstrating that LNG fuelled vehicles would present no significant hazards or potential liability that exceed those of diesel fuelled trucks.

New provisions in sub-section 9.2.4.3 Fuel Tank, sub-paragraph (a)

“Normal operating conditions”:

From the point of view of the Government of Germany, the insertion “in the normal operating conditions of the vehicle” does not make sense. It is to be assumed that, due to the general technical provisions applicable to motor vehicles, fuel tanks are designed so as to prevent leakage under normal operating conditions. The ADR lays down further requirements that result from the vehicle's special load consisting of dangerous goods. These requirements, here under the heading “Prevention of fire risks”, apply particularly to the protection of the load and the limitation the consequences in the case of incidents and accidents. The activation of a safety valve in the fuel system is not a leakage in the case of a damaged or perforated fuel tank

Response:

As stated in ECE/Trans/WP.15/2015/6, the term ‘under normal operating conditions’ has caused some confusion. As such, AEGPL/NGV Global have recommended in B, Proposal 2, that Section 9.2.4.3 (Annex II) be amended with a new section 9.2.4.3 that specifies when a vehicle is upright, Referencing Regulation 111 a new footnote 6, that a vehicle can be considered upright when it is “*inclined no more than 23 ° to either side according to ECE Regulation No. 111 (Uniform provisions concerning the approval of tank vehicles of categories N and O with regard to rollover stability).*

As for the Germany’s very justifiable concern about the language **“shall not come into contact with hot parts of the vehicle or *of* the load”** changing the meaning of the original intent, the AEGPL/NGV Global agrees with Germany and the amendment now proposes to remove the word ‘of’ the hot parts of the load in order to re-establish the original meaning of this language.

This same Item 9 Germany has said that, “*Actively keeping the LNG fuel released during an accident or incident from a leaking fuel tank away from the vehicle or the load is only conceivable for the liquid phase. When LNG is released in normal atmospheric conditions,* ***it quickly turns into a cryogenic gas cloud that cannot be actively kept away from the vehicle.*”** This is incorrect because LNG, when released in normal atmospheric conditions is no longer cryogenic and is no different than CNG or methane in its normal gaseous state. As such, the gas will warm up and rapidly dissipate upwards to atmosphere (the gas being lighter than air) outside of the flammability range, particularly if there is any air movement or wind, and will have no effect on vehicle or the load.

Item 9 (a): LNG fuel tanks have a limited specific holding time before the pressure build is relieved, which must be sufficient for the maximum transport time. An operation schedule might be necessary.

Response:

Minimum hold time is specified in R.110 and it already is common practice for LNG truck fleets to maintain operational schedules that account for the potential release of vaporized LNG under pressure as it warms.

Item 9 (b): A defined scenario usual for incident/accident, with an upright or tilted vehicle.

Response:

There already exist in R.110 specific and substantial crash test requirements that specify 'G' forces in case of frontal and side crashes. While these are not "defined scenario for accidents' the intention of the regulation is to take into consideration equivalent forces related to the most typical crash scenarios. The requirements from R.110 are specified below:

18.4.4. The fuel container(s) and/or tank(s) shall be mounted and fixed so that the following accelerations can be absorbed (without damage occurring) when the container(s) and/or tank(s) are full:

Vehicles of categories M_1 and N_1:

(a) 20 g in the direction of travel;

(b) 8 g horizontally perpendicular to the direction of travel.

Vehicles of categories M_2 and N_2:

(a) 10 g in the direction of travel;

(b) 5 g horizontally perpendicular to the direction of travel.

Vehicles of categories M_3 and N_3:

(a) 6.6 g in the direction of travel;

(b) 5 g horizontally perpendicular to the direction of travel.

Additionally, the LNG tanks are also subject to a drop test (ECE R110 Annex 3B Appendix A, paragraph A2). "Drop tests shall include a 9 m drop test of the fuel tank on the most critical area of the tank (other than the piping end) and 3 m drop test on the piping end" and shall not leak. This also would simulate a severe on-road crash that could characterize incidents in many different scenarios.

Item 9 (c): Effects of deep cold LNG with – 162 °C released from a damaged LNG fuel tank or system towards the tank for the load. As laid down in paragraph 6.8.2.1.8 of ADR these tanks are constructed for a temperature of – 20 °C only. Keywords: spillage, brittle fracture, Joule Thomson Effect.

Response:

In the unlikely event of an incident powerful enough to cause an LNG tank to rupture, leaking LNG would flow to the ground, however, it also immediately begins to vaporize. Embrittlement of a tank of the load would require the LNG to bathe the load in cryogenic fuel. The volume of LNG carried as a propulsion fuel could not engulf the large load even if the truck was lying on its side and spilled fuel came in to brief contact with the tank or its load.

Details of the effects of cold LNG leakage and embrittlement are addressed by the National Petroleum Council in the USA, in their document, "*An Initial Qualitative Discussion on Safety Considerations for LNG Use in Transportation*", August 2012 in the following text:

"VI.B. Pooling and Brittle Failure

Any brittle fracture of structural steels would require that the material soak in cryogenic fluid for a period of time. Creating a standing pool of LNG is not easy. The liquid is always under some level of pressure. When it is ejected from a breach in a container a large portion of the liquid vaporizes before it can settle into a puddle of standing liquid. 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 remain 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. All of this happens as the mass is ejected from the breach. Usually the mechanisms of flash and atomization result in no liquid surviving to the ground. In rare cases a puddle will begin, but the net volume of any such puddle is a small fraction of the initial volume. This all means that the practical extended exposure to cryogenic temperature is limited. Direct liquid spray is a local concern and can create local cracking, A diesel or gasoline spill has some additional risk due to the persistence of the spill. While LNG evaporates and disperses quickly, diesel and gasoline spills remain on the ground for a sustained period extending the duration of the safety risk. Gasoline spills, for example, will not have such vaporization but will create larger pools. The larger pool and its ability to run extends the range of the potential fire from the spill. This leads to a longer potential duration of a dangerous situation if left un-managed. Spills of diesel fuel often result in expensive clean-up measures to protect surface water and groundwater."

As for the Joule Thomson effect, this only occurs when the pressurized gas would flow very rapidly through a throttling device (typically a valve) which must be very well insulated to prevent any heat transfer to or from the gas expanding rapidly, resulting in a cooling effect. The Joule Thomson condition is unlikely in any crash scenario and, if it did occur, the cold temperature would last only momentarily and only in the immediate area of the orifice from which the gas is leaking.

Item 9 (d): Have studies been carried out on the compatibility of the load of the different hazard classes that are permitted to be carried in FL, OX and EX vehicles? And from the other document, "Sweden believes that there are too many uncertainties concerning the introduction of gaseous fuels for FL- and OX-vehicles in ADR."

Response:

In the initial proposal to allow LNG as a fuel for ADR-certified vehicles NGV Global agreed that LNG would not be allowed as a fuel on EX class vehicles , so there is no issue for this class of trucks carrying explosives. As for FL Vehicles (carrying liquids having a flash-point of not more than 61°(C) or gaseous fuels in various containers) and OX vehicles (those carrying hydrogen peroxide) there have been no studies we are aware of that determine the impact on co-mingling of LNG with the wide range of these liquids and gases able to be carried on ADR-certified vehicles.

NGV Global deems further in-depth study as unnecessary due to the conditions described in the response to Item 9 (c), above. Furthermore, any accident scenario that would cause the failure and leakage of both the load and the LNG fuel tanks would be so catastrophic that the effect of the relatively small amount of LNG on-board would be an insignificant part of the overall crash scenario causing such damage.

Item 9 (e): Fire of the vehicle (tire fire, fire in the engine), of flammable substance transported in the tank or fire around the vehicle (for example accident of other vehicles) with a release from or a serious damage of the LNG fuel tank. Sweden also is concerned that, in case of an incident or accident, it should be of uttermost importance for the

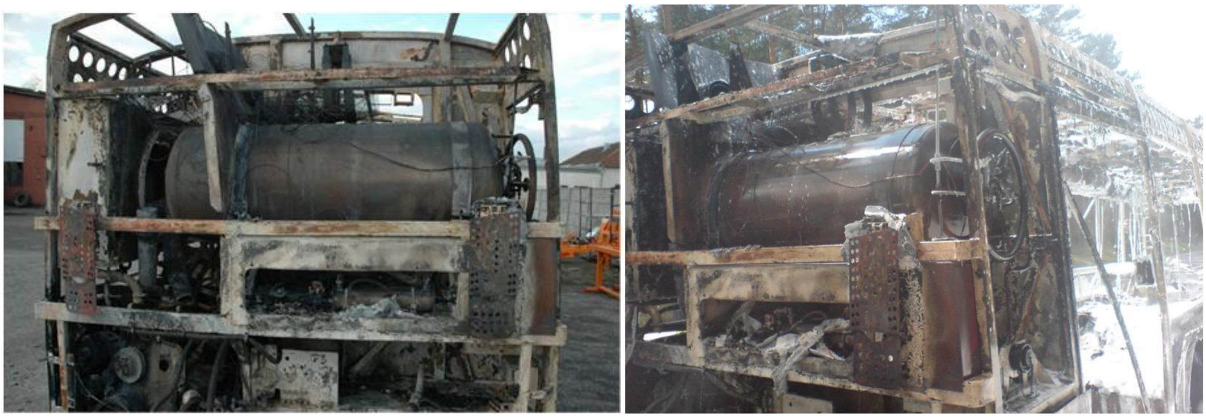
rescue services to identify what kind of fuels that are involved, especially when the load contains dangerous goods.

- Will there be cumulative effects with a load especially, but not only, consisting of flammable or gaseous substances in the tank of the vehicle?

Response: The vacuum insulation of the LNG tank that keeps the ambient temperature from reaching the inner tank also keeps the much higher fire temperatures from exterior sources reaching the inner tank. Case in point was the 2008 Polish LNG bus on a test ride that caught fire due to the cracked hose carrying hydraulic oil which ignited in the engine space. The fire spread to the inside of the bus which burned out completely. The engine and neighbouring LNG tanks were in the hottest part of the fire where temperatures were hot enough to melt aluminum materials. The LNG tank and safeguards functioned as designed, releasing its methane through the primary and secondary pressure relief devices which ejected the gas in a safe direction. The gas combusted but did not add to the burning of the bus itself and the tanks depressurized without any explosive activity.[9]

Figure 1 shows the result of this fire and that the LNG tank ‘survived’ intact despite the melt-down of much of the rest of the vehicle.

Figure 1: Results of engulfing fire on Polish LNG-fuelled bus (Source: Solbus[10])



- Shall the emergency response forces be informed about the additional danger, that there is an LNG fuel tank on board the vehicle carrying dangerous goods?

Response: For clarification, there is no ‘additional danger that there is an LNG fuel tank on board” although there may be *different* safety considerations than from diesel fuel. We fully agree that emergency responders should be fully informed and trained on the appropriate actions that need to be taken in case of a fire on a truck carrying LNG.

9 **An Initial Qualitative Discussion on Safety Considerations for LNG Use in Transportation**, National Petroleum Council, USA, August 2012 and ECE-TRANS-WP15-95-inf25e (LNG: A Safe Fuel for Trucks) presented by KIWA at ADR 95, November 2013.

10 Ibid.

There are many established procedures and instructions in various countries to deal with LNG in fires and accidents that inform emergency response forces how to deal with situations involving LNG. This includes: *Procedures for emergencies arising during the transportation of liquid methane (LNG and LBG)*, Swedish Gas Association, Energigas Sverige, Stockholm, 2013-04-04. This document contains in section 5, Emergency procedures, five different scenarios with specific instructions for fire fighters related to:

- Transport unit judged to be sound;
- Transport unit leaking gas with no fire;
- Transport unit leaking liquid with no fire;
- Transport unit leaking with fire;
- External fire affecting transport unit.

Section 6 deals with "Responsibility and information on site and Appendix 3 deals with "Written Instructions in Accordance with ADR."

The National Fire Protection Association (U.S.A.) standards 59A and 52 also contain extensive materials on fire safety and response.

Furthermore, Regulation 110 Annex 7 requires N2 and N3 LNG vehicles to have specific labelling on the rear and front of the vehicles in order to alert emergency response forces to identify that the vehicle is fuelled by something other than diesel. (Annex 6 prescribes labelling of M2 and M3 CNG vehicles.) . Figure 2 shows the LNG signage and specifications for trucks.

Figure2: Provisions on LNG identification mark for vehicles of categories M2 and M3, N2 and N3

The sign consists of a sticker which shall be weather resistant.
The colour and dimensions of the sticker shall fulfil the following requirements:
Background: green
Border: white or white reflecting
Letters: white or white reflecting
Dimensions:
Border width:4 - 6 mm
Character height:≥ 25 mm
Character thickness:≥ 4 mm
Sticker width:110 - 150 mm
Sticker height:80 - 110 mm
The word "LNG" shall be centred in the middle of the sticker.

- Is the already established fire fighting equipment (8.1.4 of ADR) sufficient, if the fuel is LNG?

Response: The fire extinguishers required in Volume II, 8.1.4 of ADR are sufficient for vehicles fuelled by LNG. As important, however, is that drivers receive proper training as to what must be done in case of a fire or accident (as would be for diesel vehicles as well).

Item 9 (f): The load in the tank of the vehicle may be for example a corrosive liquid. If released by incident/accident, can the LNG fuel tank withstand this corrosive substance dripping on it or flowing over it? The reaction of the released dangerous goods load with the LNG fuel has to be surveyed.

Response:

Regulation 110, Annex 3B paragraph 2.5. 'External surfaces' directly addresses the requirements for tank integrity exposed to various substances saying, "Tanks are not designed for continuous exposure to mechanical or chemical attack, e.g. leakage from cargo that may be carried on vehicles or severe abrasion damage from road conditions, and shall comply with recognized installation standards. However, tank external surfaces may be inadvertently

exposed to:

(a) Solvents, acids and alkalis, fertilizers; and

(b) Automotive fluids, including gasoline, hydraulic fluids, glycol and oils.

LNG tanks are double wall stainless steel. To destroy a steel LNG tank a corrosive liquid would have to be in prolonged contact with the tank. Even if the outer skin of the LNG tank were compromised, the inner steel tank also would have to be substantially exposed to the corrosive material. Unless the LNG tank was more-or-less submerged in the corrosive liquid the double-wall steel container would not likely be compromised. The likelihood of the load of an ADR tank submerging the LNG tanks is very low.

Item 9 (g): The load might consist of Class 2 products. Will the LNG fuel system withstand any incident with exploding gas?

Response: LNG tanks are extremely robust; far more so than diesel (or gasoline). Diesel fuel systems would not withstand *any* incident with "exploding gas", therefore, it seems irrelevant in the case of a large-scale explosion to suggest that an LNG fuel tank would contribute any more hazard than that of a diesel tank. Reference the response to 9(b), above.

Item 9(h): With regard to the discharge via or activation of the safety valves of the LNG fuel system, the question of how the discharge is to be controlled to protect the tanks and/or the load is essential. The amendments proposed for the 2017 version do not say anything in this regard. Neither does ECE Regulation No. 110.

- In the case of a potential jetfire, the cargo tank of an AT or OX vehicle or the packages on an EX vehicle might be damaged and the load might be released, catch fire or explode.
- Are the directions/settings in which the discharge is to be directed away from the vehicle and the cargo clearly defined as a standard or design specification for the vehicle?
- How can the operational safety of the safety device be ensured?
- What happens e.g. if the safety valve is jammed or blocked as a result of an accident?

Response: ECE Regulation 110 *does* address safety valves and venting in Section 18.6.8, Venting Management System, which says:

18.6.8. Venting management system

The primary pressure relief valve shall be piped to a vent stack which extends to a high level. The primary and secondary relief valve outlets shall be protected from fouling by dirt, debris, snow, ice and/or water. The vent stack shall be sized to prevent flow restriction due to pressure drop. Gas exiting the vent stack or secondary relieve valve shall not impinge on enclosed areas, other vehicles, exterior-mounted systems with air intake (i.e. air-conditioning systems), engine intakes, or engine exhaust. In the case of dual tanks, the primary relief valve outlets piping for each tank may be manifold to a common stack.

- **Response: Jet fire**: "In the event of a tank failure, liquid or vapors will not discharge in a high velocity jet due to the relatively low pressures of LNG storage, reducing the likelihood of a jet fire or 'torch fire'."[11]
- **Response:** Directional settings of discharge: Refer to R.110, section *18.6.8.Venting management system*, indicted above.
- **Response:** Ensuring operational safety of a safety device: Regulation 110, Annex 5 mandates extensive test procedures. "The materials used for the components shall have written specifications that fulfil at least or exceed the (test) requirements laid down in this annex with respect to: (a) Temperature; (b) Pressure; (c) CNG/LNG compatibility; and (d) Durability.

Testing for LNG *tanks and components* in these sections of Annex include:

5A: Over pressure test (strength test);

5B: External leakage test;

5C: Internal leakage test;

5D: CNG/LNG compatibility test;

5E: Corrosion resistance test;

5F: Resistance to dry heat;

5G: Ozone ageing test;

5H: Temperature cycle test;

5N: Vibration test;

5O: Operating temperatures;

5P: LNG low temperature test;

5Q: Compatibility with heat exchange fluids of non-metallic parts

With such a strict testing regime, regulators and operators of LNG trucks can be reasonably comfortable and assured that LNG systems on their trucks have been vetted for the widest possible range of safety conditions. Although 100% compliance with any mechanical system can never be assured, it can be assured that LNG tanks and components operational safety is to the highest possible levels; also due to the excellent safety record of LNG trucks. The question that follows is: Can diesel tanks, components as well as the operational safety of diesel be assured to the same level as LNG?

Response: Blockage or jamming of a safety valve as a result of an accident: Regulation 110, section 18.6.8 (see above) states that, "*The primary and secondary relief valve outlets shall be protected from fouling by dirt, debris, snow, ice and/or water.*" LNG tanks and their systems are highly resistant to destructive damage and it is difficult to conceive of a specific type of accident that would 'block or jam' a safety valve without having extensive damage to the truck itself. With no fire present to heat the tank without a method of venting a pressure build-up could occur to the point of destruction of the tank. But redundancy of safety systems are such that this particular scenario is highly unlikely.

[11] An Initial Qualitative Discussion on Safety Considerations for LNG Use in Transportation, National Petroleum Council, USA, August 2012, Summary section.

ECE Regulation No. 34:

ECE Regulation No. 34 does not cover LNG as fuel.

See 4.6 of that regulation: *"Liquid fuel" means a fuel which is liquid in normal conditions of temperature and pressure.*

LNG is a cryogenic liquid.

Response: As regards to Regulation 34, *Uniform Provisions Concerning the Approval of Vehicles with Regard to the Prevention of Fire Risks*, the entire regulation concerns liquid fuels. Gaseous fuels are not addressed. The same or very similar issues in R.34 are, however, addressed in R.110; some in very similar ways. If Contracting Parties and the various stakeholders believe that R.34 should be amended to include sections on Gaseous Fuels then this is possible. Alternatively, a remark/amendment can be made that, for natural gas, reference should be made to the appropriate provisions in R.110. In the current discussion it is immaterial that R.34 only pertains to liquid fuels. Safety of gaseous fuels is fully covered elsewhere.

ECE Regulation No. 110:

In ECE Regulation No. 110, according to paragraph 4.11, the LNG system includes the "tanks" and according to paragraph 4.6 "Specific Components" are, among others *"(a) Container (cylinder or tank)", "(b) Accessories fitted to the container"* and *"(j) Filling unit or receptacle"* which are deemed to be parts of the LNG fuel tank. According to paragraph 4.16 a "Container" (or cylinder) means any storage system used for compressed natural gas.

Because of that, a reference to ECE Regulation No. 110 in this subsection dealing with the "Fuel tank" is missing. An argument for this demand is the new transitional provision 1.6.5.17 of ADR, concerning the "LNG fuel system" (see also ECE/TRANS/WP.15/224, annex II).

Response: R.110, Section 4.14 includes: *"Tank"* (or vessel) means any storage system used for liquefied natural gas. Section 4.15 *"Type of tank"* means tanks that do not differ in respect of the dimensional and material characteristics as specified in Annex 3B.

10. New provisions in sub-section 9.2.4.4 Engine

ECE Regulation No. 110

The engine itself is not part of the *"LNG system"* according to paragraph 4.11 of ECE Regulation No. 110 and not a "*Special component*" according to the list in paragraph 4.6.

Some of the components covered by Regulation No. 110 might be included in the engine "equipment" mentioned indirectly in 9.2.4.4 of ADR. If more detailed technical requirements are specified for this engine equipment, which is more extensive in the case of an LNG fuel system, the heading of the sub-section should be amended, e.g. by adding "and fuel system".

Response: It makes sense to try and harmonize and align appropriate components listed in R.110 and in the ADR. LNG engines are no more "extensive" than diesel engines although there are some *different* components. Adding the words *'and fuel system'* to the section on *Engines* could be redundant. Fuel tanks are part of the 'system' and also are covered in ADR Vol II 9.2.4.3 "Fuel Tanks." It would be premature to suggest that the heading of the subsection ***should*** be amended. These are details that typically occur in the melding of technologies and regulations that should be considered by the Contracting Parties and the stakeholders.

Electronic control unit

The list in paragraph 4.6.of ECE Regulation No. 110 with the title “Specific components” also includes some electronic elements.

It could be clarified whether these elements comply with the requirements in section 9.7.8 (Electrical equipment).

Response: The only electronic component in paragraph 4.6 is (r) the electronic control unit, which is described in section 4.38 as, *"Electronic control unit (CNG/LNG)"* means a device that controls the gas demand of the engine, and other engine parameters, and cuts off automatically the automatic valve, required by safety reason.

References to electric components in R.110 include:

8.1.1 The specific components of vehicles using CNG/LNG in their propulsion system shall comply with relevant electromagnetic compatibility (EMC) requirements according to Regulation No. 10, 03 series of amendments, or equivalent.

18.11.1. The electrical components of the CNG/LNG system shall be protected against overloads.

Annex 4A 2.3. The electrical system, if existing, shall be isolated from the body of the automatic valve. Isolation resistance shall be > 10 MΩ.

18.1.2.1. Notwithstanding the provisions of paragraph 18.1.2. above, no separate type approval of the CNG/LNG electronic control unit is required if the CNG/LNG electronic control unit is integrated into the engine electronic control unit and is covered with a vehicle installation type approval according to Part II of this Regulation and to Regulation No. 10. The vehicle type approval shall also be pursuant to the applicable provisions laid down in Annex 4H of this Regulation (R.110)

ADR Section 9.7.8 pertains to FL vehicles, which also carry flammable gaseous fuels. The ECU of a natural gas vehicle system already operates safely in a ‘gaseous fuel environment’ in the engine compartment that is propelling the vehicle and that also has LNG storage tanks on board the vehicle. Additionally the use of gas tight housing also requires that the natural gas system shall be spark-free. Thus, there should be no safety incompatibility with an LNG vehicle that includes similarly flammable fuels in the load. But, we understand that this and the R.110 provisions do not make the electric component compliant with ATEX or comparable requirements.

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 LNG 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 (as is done in Germany).