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**INFORMATION SUPPORTING LNG VEHICLE AMENDMENTS TO REGULATION No. 110
For GRPE Consideration at the request of the GRSG**

Transmitted by the Chairman of the Informal Group on Gaseous Fuelled Vehicles

Note: The text below was prepared by the experts from the Informal Group on Gaseous Fuelled Vehicles in order to comply with a request by the GRSG. Amendments proposed by the LNG Task Force on incorporating LNG systems into Regulation 110 were approved by the 104th session of the Working Party on General Safety (GRSG) ECE/TRANS/WP.29/GRSG/2013/7. The German delegate, recognizing that potential methane release -- venting from 'boil off' -- is an environmental issue and not a vehicle safety issue, suggested that the issue of holding time for LNG and its venting be brought forward to the GRPE for their consideration. It was understood, however, that informing GRPE of this issue would not change the GRSG's decision to adopt the LNG amendments. The LNG amendments will move

forward to WP29 in November for final consideration as a permanent amendment to R.110, which would take effect in June or July of 2014.

A. THE PROPOSALS ADOPTED AND REQUESTED FOR CONSIDERATION BY GRPE

Shown below are the key provisions in the Amended R.110 that deal with LNG tank 'hold-time', venting management, and testing for 'hold-time' that were of concern to the GRSG. Though consideration of the components and procedures is not deemed to cause safety problems, there are environmental considerations if venting LNG to the atmosphere without mitigation was a continued practice.

Annex 3B : Liquid tanks - Vacuum insulated vessels for the on-board storage of natural gas as a fuel for automotive vehicles.

- 2.6. Leakage and venting
In case LNG tanks are located in enclosed spaces for extended periods of time (e.g. for service), leakage and venting of natural gas (or other flammable substances) from the tank shall be dealt with properly to avoid the dangers due to releasing flammable substances in enclosed spaces.
- 2.7. Vehicle LNG tank(s) shall have a design hold time (build without relieving) minimum of 5 days after being filled net full and at the highest point in the design filling temperature/pressure range.

Part II : Approval of 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

18. Requirements for the installation of specific components for the use of compressed natural gas and/or liquefied natural gas in the propulsion system of a vehicle
- 18.6.7. 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 **by** 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 relief 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.

Annex 3B - Appendix A : Test methods

A.3. Hold-time test

The tank shall be filled within 10 per cent of maximum allowed net quantity of LNG at manufacturer's specified highest point in the design filling temperature / pressure range. Hydrostatic pressure shall be recorded every minute for at least 120 hours at ambient temperature of 20 ± 5 °C. Hydrostatic pressure shall be stable (within 10 kPa) or

increasing throughout duration of test. The combined tank and contents weight shall be measured and verified to be stable (within 1 per cent) throughout duration of test; release of any fluid (bubble tight) during duration of test shall be unacceptable. Acceptable measured hydrostatic pressure at 120 or more hours shall be less than nominal primary relief valve pressure setting of the tank. If hydrostatic pressure is less than nominal primary relief valve pressure setting at 120 hours, the test may be continued until that pressure, and manufacturer's highest point in the design filling temperature / pressure range may be defined as the hydrostatic pressure recorded 120 hours prior to reaching the nominal primary relief valve pressure setting. The manufacturer may also specify a longer hold-time than 120 hours, or a hold-time (longer than 120 hours) versus design filling temperature / pressure relationship based on the recorded hydrostatic pressure time history.

B. JUSTIFICATION/EXPLANATION

Consideration of LNG fuel characteristics

Gaseous methane liquefies at atmospheric pressure when it is cooled to -162° (C) [-259.6° (F)]. LNG (which typically is more than 90% methane) is stored in specially designed vacuum insulated tanks in order to keep it cold when in transit, stored at the fuelling station, or on-board the vehicle. But at each step LNG absorbs a small amount of heat, which causes the temperature and pressure to increase over time. This may require some gas to be consumed, vented, or re-liquefied in order to remain within the pressure limits of the storage tank. At -130° (C) LNG is stored at 8 bar (120 psi), which is typical for an LNG vehicle fuel tank. At this temperature and pressure the gas and liquid phases are in equilibrium.

Both at the fuelling station and on-board the vehicle, the systems are designed to be operated vent free and, when properly maintained and controlled, the operators of the LNG vehicles and/or the LNG fuelling stations can use various techniques to avoid having their 'money' (i.e. LNG fuel) being blown off into the atmosphere.

Acceptable hold-time for LNG storage on board a vehicle

When a typical 437 liter (115 US gallon) vehicle fuel tank with relief pressure 15.9 bar (230 psig) is filled to normal filling procedure, so that the initial saturation of LNG in the tank is 8.3 bar (120 psig) and the vehicle is left unused in stationary situation, the holding time (non-venting time) is five days. Lower initial saturation temperature would result in a longer holding time. The five day holding requirement has been set in accordance with the U.S. Society of Automotive Engineers (SAE) J2343, which is the most severe requirement of its kind in the industry.

Venting Management Systems and Techniques

Maintaining a stable pressure during operation of a vehicle is done by a pressure regulator (also called an economizer regulator). The LNG tank has pipework connections at top (gas space) and bottom (liquid). At high pressure the economiser opens and gas is fed to the engine, reducing the tank pressure. At the design pressure or below the economiser closes and the fuel is fed to the engine. Thus the tank pressure is controlled to the design value in normal driving.

If, for any reason the tank pressure is increasing, it could be collapsed during refuelling by condensation due to the low temperature of liquid added into the tank (normally done by a 'shower' rather than flowing in a single stream). This is a single hose filling without any vapor return back to the station and without any

venting to the atmosphere. (See Figure 1 at the end of this document, showing the principal elements in the LNG vehicle fuelling system.)

The simplest way to prevent an LNG vehicle from venting gas would be to turn on the engine or drive it for a short period of time, thus consuming fuel and reducing the pressure in the tank. Venting to the atmosphere also can be prevented by using a 'de-fuelling tank' system that captures the excess vented gas.

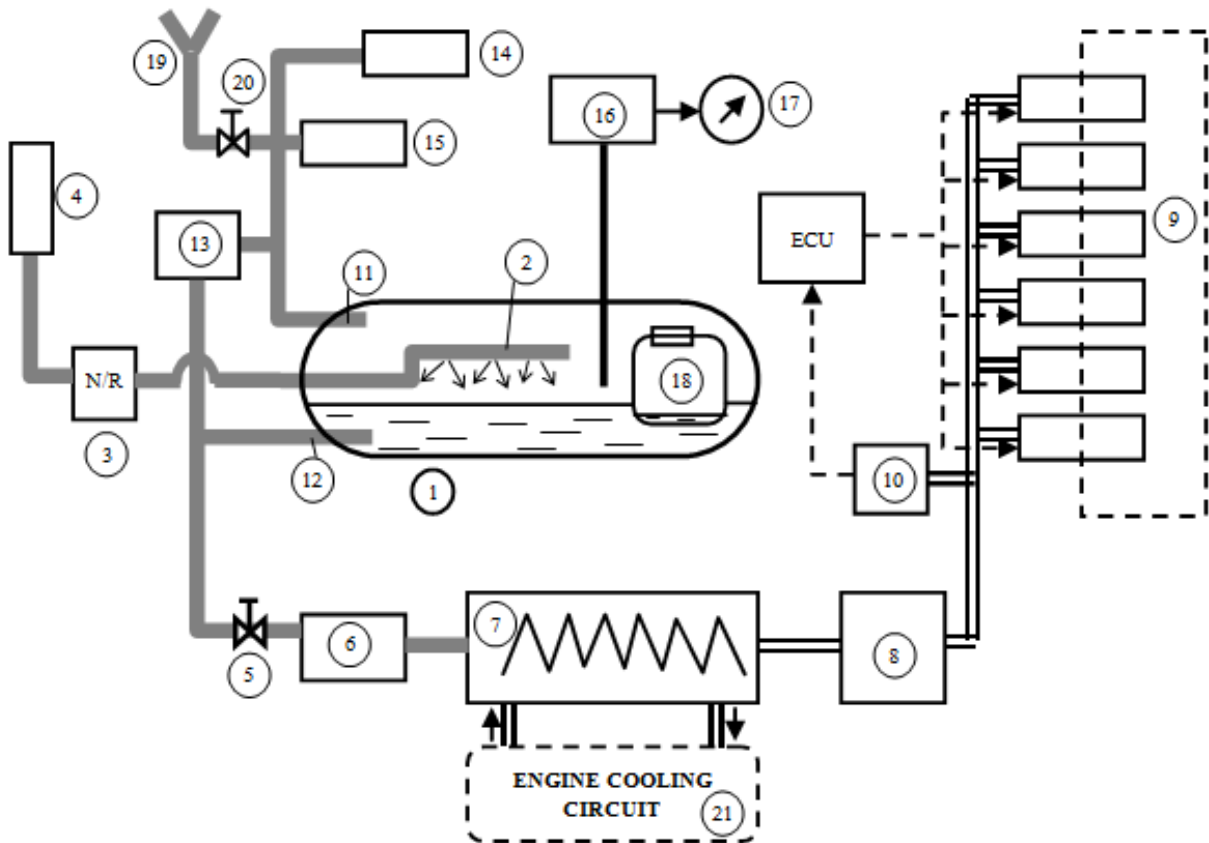
In a case when the pressure in the vehicle storage for any reason is at or close to the design relief pressure, part of the vapor could be returned back into the fuel station LNG storage tank. For this, however, the station must be equipped with a vapor return hose, which has to be connected to the vehicle fuel tank vent connector. The vapor is vented to the bottom of the stationary fuel storage tank where it condenses in the colder liquid.

In any event, techniques are available to prevent venting if, during normal operations it is anticipated that some vehicles might be left past the five day holding time.

Conclusions

As with all fuels, LNG has specific features that require special handling and consideration when used as a vehicle fuel. Though LNG storage and vehicle systems are designed to be vent-free it is not possible to prevent some minimal methane escaping into the atmosphere under certain very specific conditions and that are generally avoided in standard commercial vehicle operation. LNG venting is minimised or eliminated by matching LNG bulk deliveries to the anticipated vehicle fuel consumption in order to minimise fuel storage time in bulk storage and vehicle tanks. Technologies and techniques have been designed or learned through best practices to mitigate excessive leakage of methane from vehicles, not so much due to environmental concerns but more due to economics and safety. Commercial vehicle operators typically cannot afford any five day or more period of inactivity so venting is equally unlikely. As such, the amendments for LNG vehicles to UNECE Regulation 110 have been crafted carefully, considering industry best practices, state-of-the-art technologies, and in the best interest of safety for operators and the public. It is anticipated that as more LNG vehicles come into commercial operation there will be new technologies and techniques developed to further reduce the possibility of releasing methane into the atmosphere of LNG in transport, storage, or used on-board a vehicle as the principle fuel.

Figure 1: LNG vehicle fuel system schematic.



Legend			
1	LNG Tank (*)	12	Liquid withdrawal tube
2	Liquid Spray (filling) (*)	13	Tank pressure controller(*)
3	No return valve (*)	14	Primary relief valve
4	Filling connector (*)	15	Tank pressure gauge
5	Manual valve (*)	16	Liquid level transmitter (*)
6	Excess flow valve (*)	17	Fuel gauge (Dash board)
7	Vaporizer (*)	18	Vapor space
8	Pressure regulator	19	Venting system
9	Engine gas injectors	20	Manual vent valve
10	Pressure/temperature transmitter	21	Engine cooling circuit
11	Vapor withdrawal tube		

(*) Cryogenic component

Source: ISO/TC22/SC25 N°329 WG4 “LNG on board components” - ISO Standardization Committee