Submitted by the expert from The Netherlands

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Proposal for amendments to UN Regulation No. 110 – CNG/LNG vehicles

The text reproduced below was prepared by expert from The Netherlands proposing the introduction of requirements to UN Regulation No. 110 for the state-of-the-art "CNG compressor" and "CNG accumulator" components used in LNG/CNG systems. This document also proposes to correct and introduce references within UN Regulation No. 110. Modifications to the original text are marked in bold for new characters and strikethrough for deleted characters.

I. Proposal

Figure 1-2, amend to read (inserting a new row as reference to Annex 5Q):

"Figure 1-2
Tests applicable to specific classes of components (excluding CNG cylinders and LNG tank)

Test	***Class 0***	***Class 1***	***Class 2***	***Class 3***	***Class 4***	***Class 5***	***Class 6***	***Annex***
Overpressure or strength	X	X	X	X	O	X	X	5A
External leakage	X	X	X	X	O	X	X	5B
Internal leakage	A	A	A	A	O	A	A	5C
Durability tests	A	A	A	A	O	A	A	5L
CNG/LNG compatibility	A	A	A	A	A	A	A	5D
Corrosion resistance	X	X	X	X	X	A	X	5E
Resistance to dry heat	A	A	A	A	A	A	A	5F
Ozone ageing	A	A	A	A	A	A	A	5G
Burst/destructive tests	X	O	O	O	O	A	X	5M
Temperature cycle	A	A	A	A	O	A	A	5H
Pressure cycle	X	O	O	O	O	A	X	5I
Vibration resistance	A	A	A	A	O	A	A	5N
Operating temperatures	X	X	X	X	X	X	X	5O
LNG low temperature	O	O	O	O	O	X	O	5P
Compatibility with heat exchange fluids of non-metallic parts	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**5Q**

X = Applicable
O = Not applicable
A = As applicable

"

Insert a new paragraph 4.75. (Definitions), to read:

"4.75. "CNG compressor" means a device to establish the supply of CNG to the engine by increasing the pressure of the vapour."

Insert a new paragraph 4.78. (Definitions), to read:

"4.78. "CNG accumulator" means a device which is used to store CNG downstream of the LNG vaporizer and/or CNG storage system (cylinder(s))."

Paragraph 8.2., amend to read:

"8.2. Provisions on CNG containers **and CNG accumulator."**

Insert a new paragraph 8.2.3., to read:

"8.2.3. Provisions on the CNG accumulator

The CNG accumulator shall be type approved pursuant to the provisions laid down in Annex 3A to this Regulation, taking into consideration:

(a) The CNG accumulator with a volume ≤ 0.75 liter shall be tested as Class 6;

(b) The CNG accumulator with a volume > 0.75 liter is considered as a CNG container(cylinder) with a maximum pressure of 26 MPa;

(c) The CNG accumulator shall be equipped with at least the following safety components:

(i) Automatic cylinder valve according to paragraph 18.5.1.;

(ii) TPRD according to paragraph 18.5.2.;

(iii) Excess flow limiting according to paragraph 18.5.3.;

(iv) Manual valve according to paragraph 18.5.4.;

(v) Gas tight housing according to paragraph 18.5.5.;

(vi) PRD (pressure triggered) according to paragraph 18.5.6."

Paragraphs 8.4. to 8.11., amend to read:

"

Paragraph	*Component*	*Annex*
8.4.	Automatic valve Check valve or non-return valve Pressure relief valve Pressure relief device (temperature triggered) Excess	4A
8.5.	Flexible fuel line-hose	4B
8.6.	CNG filter	4C
8.7.	**CNG** Pressure regulator **CNG Compressor**	4D
8.8.	Pressure and temperature sensors	4E
8.9.	Filling unit or receptacle	4F
8.10.	Gas flow adjuster and gas/air mixer,	4G
8.11.	Electronic control unit	4H

"

Insert a new paragraph 18.3.2.9., to read:

"18.3.2.9. CNG Compressor"

Paragraph 18.5.1.1., amend to read:

"18.5.1.1. An automatic cylinder valve shall be installed directly on each CNG container and to each CNG accumulator."

Paragraph 18.5.2.1., amend to read:

"18.5.2.1. The pressure relief device (temperature triggered) shall be fitted to the CNG fuel container(s) **and to each CNG accumulator** in such a manner that can discharge into the gas-tight housing if that gas-tight housing fulfils the requirements of paragraph 18.5.5. below."

Paragraph 18.5.3.1., amend to read:

"18.5.3.1. The excess flow limiting device shall be fitted in the CNG fuel container(s) **and on each CNG accumulator** on the automatic cylinder valve."

Insert a new paragraph 18.5.4.2., to read:

"18.5.4.2. For accumulators a manual shut-off valve or a mechanism to empty the accumulator prior to maintenance works shall be added."

Paragraph 18.5.5.1., amend to read:

"18.5.5.1. A gas-tight housing over the CNG container(s)/**CNG accumulator** fittings, which fulfils the requirements of paragraphs 18.5.5.2. to 18.5.5.5. shall be fitted to the CNG fuel container/**CNG accumulator**, unless the CNG container(s)/**CNG accumulator** is installed outside the vehicle, **outside enclosed spaces such as passenger compartment or cargo area or engine compartment**."

Paragraph 18.5.6.2., amend to read:

"18.5.6.2. The PRD (pressure triggered) shall be fitted to the fuel container(s) **and to the CNG accumulator** in such a manner that it can discharge into the gas-tight housing if that gas-tight housing fulfils the requirements of paragraph 18.5.5. above.

However, in case of vehicles of category M and N where the container(s) **and/or CNG accumulator is** (are) fitted outside the vehicle and on the roof or on the top of the bodywork of the vehicle, the pressure relief device (pressure triggered) shall be fitted to the fuel container(s) **and/or to the CNG accumulator** in such a manner that it can discharge the CNG only in a vertical upward direction."

Insert a new paragraph 18.5.6.3., to read:

"18.5.6.3. CNG accumulators shall not be mounted inside the engine compartment or be mounted in the crash zone of the vehicle only inside the frame of the vehicle."

Annex 1A,

Paragraph 1.2.4.5.2., amend to read:

"1.2.4.5.2. CNG Pressure regulator(s): yes/no[1]

CNG Compressor: yes/no[1] "

Paragraph 1.2.4.5.7., amend to read:

"1.2.4.5.7. CNG container(s) or cylinder(s): yes/no[1]

LNG tank(s) or vessel(s): yes/no[1]

CNG accumulator(s): yes/no[1] "

Annex 1B,

Paragraph 1.2.4.5.2., amend to read:

"1.2.4.5.2. **CNG** Pressure regulator(s):

CNG Compressor:"

Paragraph 1.2.4.5.7., amend to read:

"1.2.4.5.7. CNG container(s) or cylinder(s): yes/no[1]

LNG tank(s) or vessel(s): yes/no[1]

CNG accumulator(s): yes/no[1] "

Annex 2B,

Items 1, amend to read:

"1. CNG/LNG component considered:

Container(s) or cylinder(s)[2]

Tank(s) or vessel(s)[2]
CNG accumulator(s)[2]

Pressure indicator[2]

Pressure relief valve[2]

…

Gas injectors[2]

CNG Compressor[2]

…"

Annex 2B, Addendum

Items 1.1. to 1.2.1., amend to read:

"1.1. Natural Gas Storage System

1.1.1. Container(s) or cylinder(s) (for CNG system)

1.1.1.1. Dimensions:.....

1.1.1.2. Material:.....

1.1.2. Tank(s) or vessel(s) (for LNG system)

1.1.2.1. Capacity:.....

1.1.2.2. Material:.....

1.1.3. CNG accumulator

1.1.3.1. Dimensions:.....

1.1.3.2. Material:.....

1.1.3.3. Capacity:……..

1.2. Pressure indicator

1.2.1. Working pressure(s):[1].. .....MPa"

Insert new items 1.32. to 1.32.2., to read:

"1.32. CNG Compressor

1.32.1. Working pressure(s):1 ..... MPa

1.32.2. Material:....."

Annex 4D,

The title, amend to read:

"Annex 4D Provisions on the approval of the CNG pressure regulator **and CNG compressor."**

Paragraph 1., amend to read:

"1. The purpose of this annex is to determine the provisions on the approval of the **CNG** pressure regulator **and CNG compressor**."

Paragraph 2.2., amend to read (inserting a new reference to Annex 5Q):

"2.2. The materials constituting the regulator which are in contact with the heat exchange medium of the regulator when operating, shall be compatible with that fluid, **the procedure in Annex 5Q shall be used**."

Insert new paragraphs 4. to 5.3.2., to read:

"4. CNG compressor

4.1. The material constituting the CNG compressor which is in contact with the compressed natural gas when operating shall be compatible with the test CNG. In order to verify this compatibility, the procedure in Annex 5D shall be used.

4.2. The materials constituting the CNG compressor which are in contact with the heat exchange medium of the CNG compressor when operating, shall be compatible with that fluid. In order to verify this compatibility, the procedure in Annex 5Q shall be used.

4.3. The component shall comply with the test procedures for the Class of components according to the scheme in Figure 1-1 of paragraph 3 of this Regulation.

4.4. The electrical system, if existing, shall be isolated from the body of the CNG Compressor. Isolation resistance shall be > 10 MΩ.

4.4.1. Means shall be provided to ensure safe discharge of static electricity in the compressor.

4.5. The CNG compressor shall be provided with a pressure control device to maintain the pressure within the operating pressure range.

4.5.1. The limitation of the power supplied by the actuating mechanism can be accepted in lieu of pressure control device.

4.5.2. An electronic control system can be accepted in lieu of a pressure control device.

4.5.3. The pressure control device may function by restricting or closing off the inlet to the compressor.

4.5.4. The pressure control device is not allowed to vent natural gas to atmosphere during normal function.

4.6. The CNG Compressor shall be provided with a pressure relief valve to limit the pressure to the maximum safe working pressure of the compressor.

4.6.1. A fuel system pressure relief valve may be used instead of a pump pressure relief valve if, by relieving system pressure, it relieves the pump pressure.

4.7. The CNG compressor is allowed to function before the engine is started or during commanded stop phases to produce required pressure in the fuel system. This function shall be achieved without delivering fuel to the engine if the engine is not running.

4.8. Durability test (continued operation) of the CNG compressor:

The CNG compressor shall be able to withstand 50,000 cycles without any failure when tested according to the following procedure:

(a) Cycle the CNG compressor for 95 per cent of the total number of cycles at room temperature and at the service pressure. Each cycle shall consist of flow until stable outlet pressure has been obtained, after which the gas flow shall be shut off by a downstream valve within 1 s, until the downstream lock-up pressure has stabilized. Stabilized outlet pressures are defined as set pressure ±15 per cent for at least 5 s.

(b) Cycle the inlet pressure of the CNG compressor for 1 per cent of the total number of cycles at room temperature from 100 per cent to 50 per cent of the service pressure. The duration of each cycle shall be no less than 10 s.

(c) Repeat the cycling procedure of (a) at 85 °C, 105 °C or 120 °C, as applicable, at the service pressure for 1 per cent of the total number of cycles.

(d) Repeat the cycling procedure of (b) at 85 °C, 105 °C or 120 °C, as applicable, at the service pressure for 1 per cent of the total number of cycles.

(e) Repeat the cycling procedure of (a) at -40 °C or -20 °C, as applicable, and 50 per cent of service pressure for 1 per cent of the total number of cycles.

(f) Repeat the cycling procedure of (b) at -40 °C or -20 °C, as applicable, and 50 per cent of service pressure for 1 per cent of the total number of cycles.

(g) At the completion of all tests indicated in subparagraphs (a), (b), (c), (d), (e) and (f) above, the CNG compressor shall be leak proof (see Annex 5B) at the temperatures of -40 °C or -20 °C, as applicable, and at room temperature and at the temperature of 85 °C, 105 °C or 120 °C, as applicable.

5. Classification and test pressures

5.1. The part of the CNG compressor which is in contact with the pressure of the container is regarded as Class 0.

5.1.1. The Class 0 part of the CNG compressor shall be leak-proof (see Annex 5B) at a pressure up to 1.5 times the working pressure (MPa) with the outlet(s) of that part closed off.

5.1.2. The Class 0 part of the CNG compressor shall withstand a pressure of up to 1.5 times the working pressure (MPa).

5.1.3. The Class 1 and Class 2 part of the CNG compressor shall be leak-proof (see Annex 5B) at a pressure of up to twice the working pressure.

5.1.4. The Class 1 and Class 2 part of the CNG compressor shall withstand a pressure of up to twice the working pressure.

5.1.5. The Class 3 part of the CNG compressor shall withstand a pressure of up to twice the relief pressure of the pressure relief valve, on which it is subject.

5.2. The part of the CNG compressor which is in contact with a pressure higher than 26 MPa is regarded as Class 6.

5.2.1. The Class 6 part of the CNG compressor shall be leak-proof (see Annex 5B) at a pressure of up to 1.5 times the working pressure (MPa) declared by the manufacturer with the outlet(s) of that part closed off.

5.2.2. The Class 6 part of the CNG compressor shall withstand a pressure of up to 1.5 times the working pressure (MPa) declared by the manufacturer.

5.2.3. The part of the CNG compressor that is in contact with a pressure below 26 MPa is classified as per Part I, Section 3, of this Regulation.

5.3. The CNG compressor shall be so designed as to operate at the temperatures as specified in Annex 5O.

5.3.1. Where the CNG compressor is cooled by inclusion in the engine coolant circuit it shall be considered as engine mounted in Annex 5O

5.3.2. Where the CNG compressor is using heat exchange fluids, the non metallic parts in contact with the fluid shall comply with Annex 5Q."

Annex 4I,

Paragraph 2.2., amend to read; as reference to Annex 5Q:

"2.2. The material constituting the LNG heat exchanger - vaporizer which is in contact with the CNG when operating shall be compatible with the test CNG. In order to verify this compatibility, the procedure in Annex 5D shall be used.

The materials constituting the LNG heat exchanger - vaporizer which are in contact with the heat exchange medium of the regulator when operating,

shall be compatible with that fluid, the procedure in Annex 5Q shall be used."

Annex 5,

Table 5.1, amend to read; insert a new row as reference to Annex 5Q:

"Table 5.1

Test	***Class 0***	***Class 1***	***Class 2***	***Class 3***	***Class 4***	***Class 5***	***Class 6***	***Annex***
Overpressure or strength	X	X	X	X	O	X	X	5A
External leakage	X	X	X	X	O	X	X	5B
Internal leakage	A	A	A	A	O	A	A	5C
Durability tests	A	A	A	A	O	A	A	5L
CNG/LNG compatibility	A	A	A	A	A	A	A	5D
Corrosion resistance	X	X	X	X	X	A	X	5E
Resistance to dry heat	A	A	A	A	A	A	A	5F
Ozone ageing	A	A	A	A	A	A	A	5G
Burst/destructive tests	X	O	O	O	O	A	X	5M
Temperature cycle	A	A	A	A	O	A	A	5H
Pressure cycle	X	O	O	O	O	A	X	5I
Vibration resistance	A	A	A	A	O	A	A	5N
Operating temperatures	X	X	X	X	X	X	X	5O
LNG low temperature	O	O	O	O	O	X	O	5P
Compatibility with heat exchange fluids of non-metallic parts	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**5Q**

X = Applicable
O = Not applicable
A = As applicable

Remarks:

(a) Internal leakage: Applicable if the Class of the component consists of internal valve seats that are normally closed during engine "OFF" condition;

(b) Durability test: Applicable if the Class of the component consists of integral parts that will move repeatedly during engine operation;

(c) CNG compatibility, resistance to dry heat, ozone ageing: Applicable if the class of the component consists of synthetic / non-metallic parts;

(d) Temperature cyclic test: Applicable if the class of the component consists of synthetic / non-metallic parts;

(e) Vibration resistance test: Applicable if the Class of the component consists of integral parts that will move repeatedly during engine operation.

(f) Compatibility with heat exchange fluids of non-metallic parts: Applicable, if the Class of the components consists out of material in contact with the heat exchange fluid."

II. Justifications

1. This document is intended to serve as a discussion paper for the experts to investigate the development of requirements for the "CNG compressor" and "CNG accumulator" type of components.
2. The CNG engines development requires a stable pressure. To require such a stable pressure coming from LNG systems an intermediate buffer (CNG accumulator) is necessary. Also in CNG engine systems, the expert from The Netherlands see that the working pressure on the injectors is more and more going into higher working pressures as stored in the CNG cylinders.
3. In UN Regulation No. 110, the possibility to use a CNG accumulator is mentioned (para. 18.3.2.8. CNG accumulator). However, there are neither requirements nor a possibility to certify such components.
4. For LNG systems, the CNG accumulator is used to stabilize the gas pressure and to allow engine operation while the LNG fuel supply system is not able to deliver fuel.
5. LNG has about half the energy density of diesel which constrains the range of LNG vehicles. In order to increase the capacity of LNG tanks, the LNG can be stored at lower temperature to increase its density. This reduces its saturation pressure, so a compressor is necessary to deliver fuel to the engine at a suitable pressure.
6. In addition, LNG suppliers' bulk LNG storage is typically at 1 bar or less and close to -162 °C. This allows to store LNG for longer periods before the LNG warms and vents methane to the atmosphere. However, this requires complex systems to warm LNG to a suitable temperature for dispensing to vehicles requiring pressures ranging from 6 to 12 bar and differing between vehicles. Some LNG suppliers do not provide such systems, meaning systems must be provided on vehicles to raise the pressure to that suitable for the engine's requirements.
7. Also in CNG engine systems we see that the working pressure on the injectors is more and more going into higher working pressures than the storage pressure in the CNG cylinders.
8. In UN Regulation No. 110, there are no requirements for CNG compressors, nor the possibility to certify such components.
9. By introducing the above given requirements, The Netherlands aims to make this technology available and, at the same time, ensuring an adequate safety level.
10. Currently, the test requirement "Compatibility with heat exchange fluids of non-metallic parts" Annex 5Q is part of UN Regulation No. 110. In Annex 4D, the wording "Compatibility with heat exchange fluids" is used but there is no reference to the applicable tests.
11. In Annex 4I, the component "LNG heat exchanger – vaporizer" consist out of material in contact with the heat exchange fluid. Therefore, reference to this Annex 5Q should be made.
12. Also in the general overview Figure 1-2, with all tests from Annex 5, and Table 5.1 in Annex 5 does not have any reference to the mentioned test, already present in the current revision of UN Regulation No. 110.