D. Rationale for scope, definitions and applicability

1. Rationale for paragraph 2 (Scope)

…~~.~~

36. This gtr provides requirements for fuel system integrity in vehicle crash conditions, but does not specify vehicle crash conditions. Contracting Parties to the 1998 Agreement are expected to execute crash conditions as specified in their national regulations.

Whereas phase 1 of the development of gtr 13 focused on passenger cars (vehicle classes 1-1 and 1-2 with a gross vehicle mass (gvm) of less than 4,536kg), phase 2 aims to include heavy-duty vehicles (classes 1-2 above 4,536kg gvm and 2) into the scope. This reflects the increasing demand for alternative fuel technologies in commercial deployment. The use of compressed gaseous hydrogen systems in commercial buses already has shown the feasibility, benefit as well as the safety of the systems installed in the vehicle class 1-2 with more than 4,536 kg gross vehicle mass. The inclusion of vehicle class 2 will promote the collection of data regarding the applicability for these vehicles. For development of the requirements and test procedures for heavy duty vehicles, typical natures for such vehicles like; various configuration and use cases, larger mass and dimensions, safety concept (e.g. availability of crash test procedures, speed and other restrictions, etc.), longer service life and use cases should be taken into account.

…

3. Rationale for paragraph 4 (Applicability of requirements)

39. The performance requirements in paragraph 5. address the design qualification for on-road service.

40. It is expected that all Contracting Parties will recognize vehicles that meet the full requirements of this gtr as suitable for on-road service within their jurisdictions. Contracting Parties with type approval systems may require, in addition, compliance with their requirements for conformity of production, material qualification and hydrogen embrittlement. ~~Contracting Parties may also elect to allow alternative methods to demonstration that requirements are met, for instance on the basis of established equivalence.~~

…

E.Rationale for paragraph 5. (Performance requirements)

2. Vehicle fuel system requirements and safety needs

…

(b) Post crash requirements

XX. As described in para. 36, existing vehicle crash test procedures shall be used to evaluate post-crash hydrogen leakage but knowing the unavailability of vehicle crash tests for heady–duty vehicles, alternative means of demonstrating that post-crash safety may need to be introduced. In this regards, acceleration tests of gas storage containers and ~~its~~their fixtures have~~s~~ been well established in *inter alia* UN Regulation No 67 on liquefied petroleum gases (LPG), UN Regulation No 110 on compressed natural gas (CNG) and liquefied natural gas (LNG), as well as European Union Regulation (EC) No 406/2010, implementing Regulation (EC) No 79/2009 on hydrogen safety. In this respect it is thought

コメントの追加 [IM昌1]: Better to add something here for HDV issues.

コメントの追加 [IM昌2]: Not necessary,

that its rigorous implementation has indeed contributed to a high level of safety in the field, supported by the observed absence of relevant failures in the vehicle fleet that has been subject to these particular regional requirements.

(i) *Rationale for paragraph 5.2.2.1. post-crash test leakage limit*

85. Allowable post-crash leakage in …

(ii) *Rationale for paragraph 5.2.2.2. post-crash concentration limit in enclosed spaces*

89. This test requirement has been…

(iii) *Rationale for paragraph 5.2.2.3. container displacement.*

90. One of the crash safety regulations for vehicles with compressed gas fuel systems is Canada's Motor Vehicle Safety Standard (CMVSS) 301. Its characteristic provisions include the fuel container installation requirement for prevention of displacement.

…

1. Rationale for storage and fuel system integrity tests

(a) *Rationale for paragraph 6.1.1. test procedure for post-crash leak test procedure for compressed hydrogen storage systems*

~~000. As a general principle, the crash tests used to evaluate post-crash hydrogen leakage are those already applied by the respective contracting parties.~~

108. The post-crash leak test is …

(b) *Rationale for paragraph 6.1.2. (Test procedure for post-crash concentration test in enclosed spaces for vehicles with compressed hydrogen storage systems)*

113. The test may be conducted by….

(c) *Rationale for paragraph 6.1.7. (*Acceleration tests alternative to vehicle crash tests*)*

XXX. The acceleration levels have been established in UN Regulation No 67 on liquefied petroleum gases (LPG), UN Regulation No 110 on compressed natural gas (CNG) and liquefied natural gas (LNG) and UN Regulation No. 134 on hydrogen and fuel cell vehicles (HFCV). ~~However, to account for technical progress, the European Commission has carried out an analysis of world-wide crash and crash test data for all respective vehicle categories (acknowledged to be limited in certain cases). It was carried out with a view to review and adjust, where necessary, the specified accelerations in order to align more appropriately with the acceleration levels observed in the available crash and test data attributed to the respective vehicle categories. The relevant updated values are therefore incorporated in the regulatory text encompassed in paragraph 6.1.7.1~~

…

コメントの追加 **[IM昌3]:** Subject to further discussion.

コメントの追加 **[ANNETT4R3]:** In GRSP EC has withdrawn / tabled their discussion on the new pulses due to lack of field data. Peter said, he will come back to the study once the EC reviews their general safety provisions due in 2027.

II. Text of the Regulation

1. Purpose

This regulation specifies safety-related performance requirements for hydrogen-fuelled vehicles. The purpose of this regulation is to minimize

human harm that may occur as a result of fire, burst or explosion related to the vehicle fuel system.

2. Scope

This regulation applies to all hydrogen-fuelled vehicles of Category 1-1 and 1-2, with a gross vehicle mass (GVM) of 4,536 kilograms or less.

3. Definitions

For the purpose of this regulation, the following definitions shall apply:

3.3. " *Burst disc"* is the non-reclosing operating part of a pressure relief device which, when installed in the device, is designed to burst at a predetermined pressure to permit the discharge of compressed hydrogen.

3.4. "*Check valve"* is a non-return valve that prevents reverse flow in the vehicle fuel line.

3.5. "*Hydrogen concentration"* is the percentage of the hydrogen moles (or molecules) within the mixture of hydrogen and air (Equivalent to the partial volume of hydrogen gas).

3.6. "*Container*" (for hydrogen storage) is the pressure-bearing component on the vehicle that stores the primary volume of hydrogen fuel in a single chamber or in multiple permanently interconnected chambers.

3.7 "*Container Attachments*" are non-pressure bearing parts attached to the container that provide additional support and/or protection to the container.

3.8 "*Container Assembly*" is the container along with its container attachments (if any).

3.x "*Compressed hydrogen storage system (CHSS)*" is a system designed to store compressed hydrogen fuel for a hydrogen-fuelled vehicle, composed of a container, container attachments (if any), and all primary closure devices (such as shut-off valve, check valve, and TPRD) required to isolate the stored hydrogen from the remainder of the fuel system and the environment.

3.9. "*Date of removal from service"* is the date (month and year) specified for removal from service.

3.10. "*Date of manufacture"* (of a compressed hydrogen container) is the date (month and year) of the proof pressure test or final inspection test carried out by the container manufacturer.

3.12. "*Enclosed or semi-enclosed spaces"* indicates the special volumes within the vehicle (or the vehicle outline across openings) that are external to the hydrogen system (storage system, fuel cell system and fuel flow management system) and its housings (if any) where hydrogen may accumulate (and thereby pose a hazard), as it may occur in the passenger compartment, luggage compartment, and cargo compartment.

3.21. "*Exhaust point of discharge"* is the geometric centre of the area where fuel cell purged gas is discharged from the vehicle.

3.24. "*Fuel cell system"* is a system containing the fuel cell stack(s), air processing system, fuel flow control system, exhaust system, thermal management system and water management system.

3.25. "*Fuelling receptacle"* is the equipment to which a fuelling station nozzle attaches to the vehicle and through which fuel is transferred to the vehicle. The fuelling receptacle is used as an alternative to a fuelling port.

3.28. "*Hydrogen-fuelled vehicle"* indicates any motor vehicle that uses compressed gaseous or liquefied hydrogen as a fuel to propel the vehicle, including fuel cell and internal combustion engine vehicles. Hydrogen fuel for the vehicles is specified in ISO 14687 and SAE J2719.

3.32. "*Luggage compartment"* is the space in the vehicle for luggage and/or goods accommodation, bounded by the roof, hood, floor, side walls being separated from the passenger compartment by the front bulkhead or the rear bulkhead.

3.33. "*Liquefied hydrogen storage system"* indicates liquefied hydrogen storage container(s) PRDs, shut off device, a boil-off system and the interconnection piping (if any) and fittings between the above components.

3.34. "*Lower flammability limit (LFL)"* is the lowest concentration of fuel at which a gaseous fuel mixture is flammable at normal temperature and pressure. The lower flammability limit for hydrogen gas in air is conservatively 4 per cent by volume based on quiescent environment (para. 83 of the *Preamble*).

3.35. "*Maximum allowable working pressure (MAWP)*" is the highest gauge pressure to which a pressure container or storage system is permitted to operate under normal operating conditions.

3.36. "*Maximum fuelling pressure (MFP)*" is the maximum pressure applied to compressed system during fuelling. The maximum fuelling pressure is 125 per cent of the Nominal Working Pressure.

3.37. "*Nominal working pressure (NWP)*" is the gauge pressure that characterizes typical operation of a system. For compressed hydrogen gas containers, NWP is the settled pressure of compressed gas in fully fuelled container or storage system at a uniform temperature of 15 °C.

3.40. "*Passenger compartment"* is the space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing, front bulkhead and rear bulkhead - or rear gate.

3.41. "*Pressure relief device (PRD)*" is a device that, when activated under specified performance conditions, is used to release hydrogen from a pressurized system and thereby prevent failure of the system.

3.42. "*Pressure relief valve"* is a pressure relief device that opens at a preset pressure level and can re-close.

3.45. "*Rechargeable energy storage system* (REESS)" is the rechargeable energy storage system that provides electric energy for electrical propulsion.

3.46. "*Rupture* or *burst"* both mean to come apart suddenly and violently, break open or fly into pieces due to the force of internal pressure.

3.48. "*Service life"* (of a compressed hydrogen container) indicates the time frame during which service (usage) is authorized.

3.49. "*Shut-off valve"* is a valve between the storage container and the vehicle fuel system that can be automatically activated; this valve defaults to "closed" position when not connected to a power source.

3.50. "*Single failure"* is a failure caused by a single event, including any consequential failures resulting from this failure.

3.xx "*Specific Heat Release Rate (HRR/A)*" is the heat release from a fire per unit area of the burner where the heat release is based on the rate of fuel being combusted multiplied by the lower heating value (LHV) of the fuel. The LHV (sometimes called the Net Heating Value) is appropriate for the characterization of vehicle fires since the product water from combustion remains a vapor. The LHV is approximately 46 MJ/kg but needs to be determined at each site based on the actual LPG composition.

3.51 "State of charge (SOC)" means the density ratio of hydrogen in the CHSS between the actual CHSS condition and that at NWP with the CHSS equilibrated to 15 °C. SOC is expressed as a percentage using the formula:

$$SOC(\%) = \frac{\rho(P,T)}{\rho(NWP,15°C)} x100$$

The density of hydrogen at different pressure and temperature are listed in the Table below using the density correlation in SAE J2600 for calculating SOC during vehicle fuelling based on NIST data.

Table 1 Compressed Hydrogen Density (g/l)

TEMPERATURE	PRESSURE (MPa)												
(°C)	1	10	20	30	35	40	50	60	65	70	75	80	87.5
-40	1.0	9.7	18.1	25.4	28.6	31.7	37.2	42.1	44.3	46.4	48.4	50.3	53.0
-30	1.0	9.4	17.5	24.5	27.7	30.6	36.0	40.8	43.0	45.1	47.1	49.0	51.7
-20	1.0	9.0	16.8	23.7	26.8	29.7	35.0	39.7	41.9	43.9	45.9	47.8	50.4
-10	0.9	8.7	16.2	22.9	25.9	28.7	33.9	38.6	40.7	42.8	44.7	46.6	49.2
0	0.9	8.4	15.7	22.2	25.1	27.9	33.0	37.6	39.7	41.7	43.6	45.5	48.1
10	0.9	8.1	15.2	21.5	24.4	27.1	32.1	36.6	38.7	40.7	42.6	44.4	47.0
15	0.8	7.9	14.9	21.2	24.0	26.7	31.7	36.1	38.2	40.2	42.1	43.9	46.5
20	0.8	7.8	14.7	20.8	23.7	26.3	31.2	35.7	37.7	39.7	41.6	43.4	46.0
30	0.8	7.6	14.3	20.3	23.0	25.6	30.4	34.8	36.8	38.8	40.6	42.4	45.0
40	0.8	7.3	13.9	19.7	22.4	24.9	29.7	34.0	36.0	37.9	39.7	41.5	44.0
50	0.7	7.1	13.5	19.2	21.8	24.3	28.9	33.2	35.2	37.1	38.9	40.6	43.1
60	0.7	6.9	13.1	18.7	21.2	23.7	28.3	32.4	34.4	36.3	38.1	39.8	42.3
70	0.7	6.7	12.7	18.2	20.7	23.1	27.6	31.7	33.6	35.5	37.3	39.0	41.4
80	0.7	6.5	12.4	17.7	20.2	22.6	27.0	31.0	32.9	34.7	36.5	38.2	40.6
85	0.7	6.4	12.2	17.5	20.0	22.3	26.7	30.7	32.6	34.4	36.1	37.8	40.2

3.52. "*Thermally-activated pressure relief device (TPRD)*" is a non- reclosing PRD that is activated by temperature to open and release hydrogen gas.

3.53. "*Type approval"* indicates a certification of a recognised body stating that prototype or pre-production samples of a specific vehicle, vehicle system or vehicle system component meet the relevant specified performance standards, and that the final production versions also comply, as long as conformity of production is confirmed.

3.54. "*Vehicle fuel system"* is an assembly of components used to store or supply hydrogen fuel to a fuel cell (FC) or internal combustion engine (ICE).

4. Applicability of requirements

4.1. The requirements of paragraph 5. (using test conditions and procedures in paragraph 6.) apply to all compressed hydrogen-fuelled vehicles.

~~4.2. Each contracting party under the UN 1998 Agreement shall maintain its existing national crash tests (frontal, side, rear and rollover) and use the limit values of section paragraph 5.2.2. for compliance. In absence of any such test or as an alternative to existing tests, the acceleration tests of paragraph 6.1.1. may be applied instead, to the discretion of each contracting party.~~

コメントの追加 **[IM昌5]:** Move to 5.2.2.

5. Performance requirements

5.1. Compressed hydrogen storage system

5.2. Vehicle fuel system

This section specifies requirements for the vehicle fuel system, which includes the compressed hydrogen storage system, piping, joints, and components in which hydrogen is present.

5.2.1. In-use fuel system integrity

…

5.2.2. Post-crash fuel system integrity

Each Contracting Party may maintain its existing national crash tests (frontal, side, rear and rollover) and shall use the limit values of paragraphs 5.2.2.1. to 5.2.2.3.

In absence of any such vehicle tests or as an alternative to existing tests, at the discretion of each Contracting Party, the acceleration tests of paragraph 6.1.7. may be applied instead of vehicle crash tests. In this case, the performance criterion in paragraph 5.5.2.3. shall apply and additional conditions for the installation in the vehicle may also be applied as appropriate.

コメントの追加 **[IM昌6]:** Moved from para.4.2. Installation requirements as in R134 may be applied as national/regional requirements since the removal of such requirements could not be justified.

5.2.2.1. Fuel leakage limit

The volumetric flow of hydrogen gas leakage shall not exceed an average of 118 NL per minute for the time interval, Δt, as determined in accordance with paragraph 6.1.1.1 or 6.1.1.2 (para. 6.1.1. test procedures).

5.2.2.2. Concentration limit in enclosed spaces

Hydrogen gas leakage shall not result in a hydrogen concentration in the air greater than 3 ± 1.0 per cent by volume in the passenger and luggage compartments (para. 6.1.2. test procedures). The requirement is satisfied if it is confirmed that the shut-off valve of the storage system has closed within 5 seconds of the crash and no leakage from the storage system.

5.2.2.3. Container displacement

The storage container(s) shall remain attached to the vehicle at a minimum of one attachment point.

6. Test conditions and procedures

6.1. Compliance tests for fuel system integrity

6.1.1. Post-crash compressed hydrogen storage system leak test

The crash tests used to evaluate post-crash hydrogen leakage are those already applied in the jurisdictions of each contracting party.

~~In case that a crash test as specified above is not applicable, or as an alternative thereto, the vehicle fuel system may, instead, be subject to the relevant alternative accelerations specified below, to the discretion of each contracting party, [so that the following accelerations can be absorbed without breaking of the fixation or loosening of the container(s).] [A calculation method can be used instead of practical testing if its equivalence can be demonstrated.] [[The hydrogen storage system shall in such case be installed in a position satisfying the requirements in paragraph XXX]. The accelerations shall be measured at the location where the hydrogen storage system is installed. The vehicle fuel system shall be mounted and fixed on the representative part of the vehicle. The mass used shall be representative for a fully equipped and filled container or container assembly.~~

6.1.6. Installation verification

The system is visually inspected for compliance.

~~...~~

The CHSS and its fixture to the vehicle structures shall be subject to the relevant alternative accelerations specified below in order to verify that the following accelerations can be absorbed without breaking of the fixation or loosening of the container(s). [A calculation method can be used instead of practical testing if its equivalence can be demonstrated.] The accelerations shall be measured at the location where the CHSS is installed. The CHSS shall be mounted and fixed on the representative part of the vehicle. The mass used shall be representative for a fully equipped and filled CHSS.

(a) Accelerations for LDV:

(i) [20 ~~or 26~~] g in the direction of travel (forward and rearward direction);

(ii) [8 ~~or 12~~] g horizontally perpendicular to the direction of travel (to left and right).

(b) Accelerations for HDV of category 1-2 with a gross vehicle mass (GVM) not exceeding 5,000 kg and category 2 with a gross vehicle mass (GVM) not exceeding 12,000 kg:

(i) 10 g in the direction of travel (forward and rearward direction);

(ii) [5 ~~or 8~~] g horizontally perpendicular to the direction of travel (to left and right).

(c) Accelerations for HDV of category 1-2 with a gross vehicle mass (GVM) exceeding 5,000 kg and category 2 with a gross vehicle mass (GVM) exceeding 12,000 kg

(i) [6.6 ~~or 8~~] g in the direction of travel (forward and rearward direction);

コメントの追加 [BP(7]: If the acceleration tests are performed instead of a real crash test, do we want to impose additional installation requirements, such as in R134.02?

7.2.4.2. Requirements on installation of the hydrogen storage system not subject to the lateral impact test: The container shall be mounted in a position which is between the two vertical planes parallel to the centre line of the vehicle located 200 mm inside from the both outermost edge of the vehicle in the proximity of its container(s).

If this is the case, we must insert a new paragraph XXX with such requirements.

EC position is to **delete** the acceptable simple notion (in EU Regulations 79/2009 and 406/2010) that fixation or loosening of containers is the only requirements which can be demonstrated by equivalent calculation check. Instead we want to apply the post-crash leakage rate check to be fully consistent with **performance requirements in GTR**. If that is agreed, the installation limitations like the 200 mm should in our opinion also be deleted.

(ii) [5 ~~or 8~~] g horizontally perpendicular to the direction of travel (to left and right).

6.2. Test procedures for compressed hydrogen storage

…