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Item 4.8.3 of the provisional agenda
1958 Agreement:
Consideration of draft amendments to existing UN Regulations submitted by GRSP

Proposal for 05 series of amendments to UN Regulation No. 94 (Frontal impact)

Submitted by the Working Party on Passive Safety *

The text reproduced below was adopted by the Working Party on Passive Safety (GRSP) at its seventy-third session (ECE/TRANS/WP.29/GRSP/73 para. 23). It is based on ECE/TRANS/WP.29/GRSP/2023/22 as amended by annex V to the report. It is submitted to the World Forum for Harmonization of Vehicle Regulations (WP.29) and to the Administrative Committee (AC.1) for consideration at their November 2023 sessions

* In accordance with the programme of work of the Inland Transport Committee for 2023 as outlined in proposed programme budget for 2023 (A/77/6 (Sect. 20), table 20.6), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

Reference to Consolidated Resolution on the Construction of Vehicles (R.E.3.), in all the text of the UN Regulation, amend to read:

"As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), document ECE/TRANS/WP.29/78/Rev.7, … - https://unece.org/transport/standards/transport/vehicle-regulations-wp29/resolutions"

Paragraphs 2.6. to 2.6.7., amend to read:

"2.6. "*Vehicle type*" means a category of power-driven vehicles which do not differ in such essential respects, in so far as they have an adverse effect on the result of the impact test prescribed in this Regulation, as:

(a) The length and width of the vehicle;

(b) The structure, dimensions, lines and materials of the part of the vehicle forward of the transverse plane through the "R" point of the driver's seat;

(c) The lines and inside dimensions of the passenger compartment and the type of protective system;

(d) The siting (front, rear or centre) and the orientation (transversal or longitudinal) of the engine;

(e) The unladen mass;

(f) The optional arrangements or fittings provided by the manufacturer;

(g) The locations of the REESS[1];

(h) The basic configuration and main characteristics of the compressed hydrogen storage system."

Paragraph 2.7.2., amend to read:

"2.7.2. "Passenger compartment for electric safety and/or hydrogen safety assessment" means the space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing, front bulkhead and rear bulkhead, or back door, as well as by the electrical protection barriers and enclosures provided for protecting the occupants from direct contact with high voltage live parts. "

Insert new paragraphs 2.44. to 2.48., to read:

"2.44. "*Compressed hydrogen storage system (CHSS)"* means a system designed to store compressed hydrogen fuel for a hydrogen-fuelled vehicle and composed of a container, container attachments (if any), and all primary closure devices required to isolate the stored hydrogen from the remainder of the fuel system and the environment.

2.45. "*Container*" (for hydrogen storage) means 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.

2.46. "*Container Attachments*" mean non-pressure bearing parts attached to the container that provide additional support and/or protection to the container and that may be only temporarily removed for maintenance and/or inspection only with the use of tools.

2.47. "*Hydrogen-fuelled vehicle*" means any motor vehicle that uses compressed gaseous 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 14687:2019 and SAE J2719_202003.

[1] See paragraph 2.14.

2.48. "*Shut-off valve (for hydrogen-fuelled vehicles)*" means a valve between the container and the vehicle fuel system that must default to the "closed" position when not connected to a power source."

Amend paragraph 5.2., to read:

"5.2. Specifications

The test of the vehicle carried out in accordance with the method described in Annex 3 shall be considered satisfactory if all the conditions set out in paragraphs 5.2.1. to 5.2.7. below are all satisfied at the same time.

…"

*Paragraphs 5.2.*6. *and 5.2.7.*, amend to read:

"5.2.6. In the case of a vehicle propelled by liquid fuel, no more than slight leakage of liquid from the fuel feed installation shall occur on collision.

5.2.6.1. If there is continuous leakage of liquid from the fuel-feed installation after the collision, the rate of leakage shall not exceed 30 g/min; if the liquid from the fuel-feed system mixes with liquids from the other systems and the various liquids cannot easily be separated and identified,

all the liquids collected shall be taken into account in evaluating the continuous leakage."

Insert new paragraphs 5.2.7 to 5.2.7.3, to read:

"5.2.7. In the case of a compressed hydrogen-fuelled vehicle, compliance with paragraphs 5.2.7.1. to 5.2.7.3. shall be shown.

5.2.7.1. The hydrogen leakage rate (V_{H2}) determined in accordance with either, paragraph 4. of Annex 12 for hydrogen, or paragraph 5. of Annex 12 for helium, shall not exceed an average of 118 NL per minute for the time interval, Δt minutes, after the crash.

5.2.7.2. The gas (hydrogen or helium as applicable) concentration by volume in air values determined for the passenger and luggage compartments in accordance with paragraph 6. of Annex 12, shall not exceed 4.0 per cent for hydrogen or 3.0 per cent for helium, at any time throughout the 60 minutes post-crash measurement period. This requirement is satisfied if it is confirmed that the shut-off valve of each compressed hydrogen storage system has closed within five seconds of first vehicle contact with the barrier and there is no leakage from the compressed hydrogen storage system(s).

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

Paragraph 12 to 12.4., amend to read:

"12. Transitional Provisions

12.1. As from the official date of entry into force of the 05 series of amendments, no Contracting Party applying this Regulation shall refuse to grant or refuse to accept type-approvals under this Regulation as amended by the 05 series of amendments.

12.2. As from 1 September 2027, Contracting Parties applying this Regulation shall not be obliged to accept type-approvals of vehicles according to the preceding series of amendments, first issued after 1 September 2027.

12.3. Contracting Parties applying this Regulation shall continue to accept type-approvals of vehicles according to the preceding series of amendments, first issued before 1 September 2027 provided the transitional provisions in these respective previous series of amendments foresee this possibility.

12.4. Contracting Parties applying this Regulation may grant type approvals according to any preceding series of amendments to this Regulation."

Insert new paragraphs 12.5., to read:

"12.5. Contracting Parties applying this Regulation shall continue to grant extensions of existing approvals to any preceding series of amendments to this Regulation."

Paragraph 12.5. (former), renumber as paragraph 12.6.

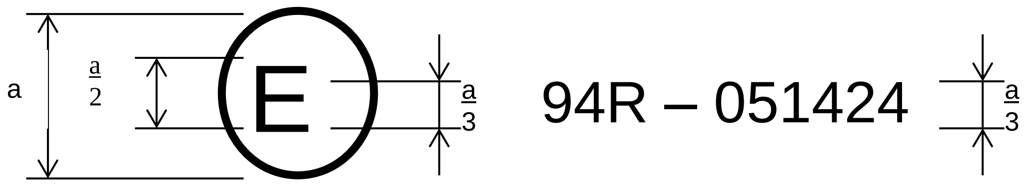
Annex 2, amend to read:

"Annex 2

Arrangements of Approval Marks

Model A

(See paragraph 4.4. of this Regulation)

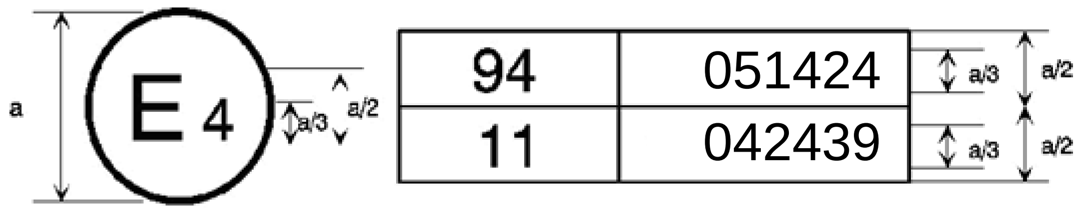


a = 8 mm min.

The above approval mark affixed to a vehicle shows that the vehicle type concerned has, with regard to the protection of the occupants in the event of a frontal collision, been approved in the Netherlands (E 4) pursuant to UN Regulation No. 94 under approval number 0**5**1424. The approval number indicates that the approval was granted in accordance with the requirements of UN Regulation No. 94 as amended by the 0**4** series of amendments.

Model B

(See paragraph 4.5. of this Regulation)



a = 8 mm min.

The first two digits of the approval numbers indicate that, at the dates when the respective approvals were granted, UN Regulation No. 94 incorporated the 05 series of amendments and UN Regulation No. 11 incorporated the 04 series of amendments."

Insert new Annex 12, to read:

"Annex 12

Test Conditions and Procedures for the Assessment of Post-Crash Hydrogen Fuel System Integrity

1. Purpose

Determination of compliance with the requirements of paragraph 5.2.7. of this Regulation.

2. Definitions

For the purposes of this Annex:

2.1. "*Enclosed spaces*" means the special volumes within the vehicle (or the vehicle outline across openings) that are external to the hydrogen system (storage system, fuel cell system, internal combustion engine (ICE) and fuel flow management system).

2.2. "*Luggage compartment*" means 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.

2.3. "*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 a fully fuelled container or storage system at a uniform temperature of 15 °C.

3. Preparation, Instrumentation and Test Conditions

3.1. Compressed hydrogen storage systems and downstream piping

3.1.1. Prior to conducting the crash test, instrumentation is installed in the hydrogen storage system to perform the required pressure and temperature measurements if the standard vehicle does not already possess instrumentation with the required accuracy.

3.1.2. The hydrogen storage system is then purged, if necessary, following manufacturer directions to remove impurities from the container before filling the storage system with compressed hydrogen or helium gas. Since the storage system pressure varies with temperature, the targeted fill pressure is a function of the temperature. The target pressure shall be determined from the following equation:

$$P_{target} = NWP \text{ x } (273 + T_o) / 288$$

where NWP is the nominal working pressure (MPa), T_o is the ambient temperature to which the storage system is expected to settle, and P_{target} is the targeted fill pressure after the temperature settles.

3.1.3. The container is filled to a minimum of 95 per cent of the targeted fill pressure and allowed to settle (stabilize) prior to conducting the crash test.

3.1.4. The main stop valve and shut-off valves for hydrogen gas, located in the downstream hydrogen gas piping, are in the normal driving condition–kept open immediately prior to the impact.

3.2. Enclosed spaces

3.2.1. Sensors are selected to measure either the build-up of the hydrogen or helium gas or the reduction in oxygen (due to displacement of air by leaking hydrogen/helium).

3.2.2. Sensors are calibrated to traceable references to ensure an accuracy of ±5 per cent at the targeted criteria of 4 per cent hydrogen or 3 per cent helium by volume in air, and a full scale measurement capability of at least 25 per cent above the target criteria. The sensor shall be capable of a 90 per cent response to a full scale change in concentration within 10 seconds.

3.2.3. Prior to the crash impact, the sensors are located in the passenger and luggage compartments of the vehicle as follows:

(a) At a distance within 250 mm of the headliner above the driver's seat or near the top centre of the passenger compartment;

(b) At a distance within 250 mm of the floor in front of the rear (or rear most) seat in the passenger compartment; and

(c) At a distance within 100 mm of the top of luggage compartments inside the vehicle that are not directly affected by the particular crash impact to be conducted.

3.2.4. The sensors are securely mounted on the vehicle structure or seats and protected for the planned crash test from debris, air bag exhaust gas and projectiles. The measurements following the crash are recorded by instruments located in the vehicle or by remote transmission.

3.2.5. The test may be conducted either outdoors in an area protected from the wind and possible solar effects, or indoors in a space that is large enough or ventilated to prevent the build-up of hydrogen to more than 10 per cent of the targeted criteria in the passenger and luggage compartments.

4. Post-Crash Leak Test Measurement for a Compressed Hydrogen Storage System Filled with Compressed Hydrogen

4.1. The hydrogen gas pressure, P_0 (MPa), and temperature, T_0 (°C), are measured immediately before the impact and then at a time interval, Δt (min), after the impact.

4.1.1. The time interval, Δt, starts when the vehicle comes to rest after the impact and continues for at least 60 minutes.

4.1.2. The time interval, Δt shall be increased if necessary in order to accommodate measurement accuracy for a storage system with a large volume operating up to 70MPa; in that case, Δt can be calculated from the following formula:

$$\Delta t = V_{CHSS} \text{ x } NWP / 1,000 \text{ x } ((-0.027 \text{ x } NWP + 4) \text{ x } R_s - 0.21) - 1.7 \text{ x } R_s$$

where $R_s = P_s$ / NWP, P_s is the pressure range of the pressure sensor (MPa), NWP is the Nominal Working Pressure (MPa), V_{CHSS} is the volume of the compressed hydrogen storage system (L), and Δt is the time interval (min).

4.1.3. If the calculated value of Δt is less than 60 minutes, Δt is set to 60 minutes.

4.2. The initial mass of hydrogen in the storage system can be calculated as follows:

$$P_o' = P_o \text{ x } 288 / (273 + T_0)$$

$$\rho_o' = -0.0027 \text{ x } (P_0')^2 + 0.75 \text{ x } P_0' + 1.07$$

$$M_o = \rho_o' \text{ x } V_{CHSS}$$

4.3. Correspondingly, the final mass of hydrogen in the storage system, M_f, at the end of the time interval, Δt, can be calculated as follows:

$$P_f' = P_f \text{ x } 288 / (273 + T_f)$$

$\rho_f' = -0.0027 \times (P_f')^2 + 0.75 \times P_f' + 1.07$

$M_f = \rho_f' \times V_{CHSS}$

where P_f is the measured final pressure (MPa) at the end of the time interval, and T_f is the measured final temperature (°C).

4.4. The average hydrogen flow rate over the time interval is therefore:

$V_{H2} = (M_f - M_o) / \Delta t \times 22.41 / 2.016 \times (P_{target} / P_o)$

where V_{H2} is the average volumetric flow rate (NL/min) over the time interval and the term (P_{target}/P_o) is used to compensate for differences between the measured initial pressure (P_o) and the targeted fill pressure (P_{target}).

5. Post-Crash Leak Test Measurement for a Compressed Hydrogen Storage System Filled with Compressed Helium

5.1. The helium gas pressure, P_0 (MPa), and temperature T_0 (°C), are measured immediately before the impact and then at a predetermined time interval after the impact.

5.1.1. The time interval, Δt, starts when the vehicle comes to rest after the impact and continues for at least 60 minutes.

5.1.2. The time interval, Δt, shall be increased, if necessary, in order to accommodate measurement accuracy for a storage system with a large volume operating up to 70 MPa; in that case, Δt can be calculated from the following equation:

$\Delta t = V_{CHSS} \times NWP / 1000 \times ((-0.028 \times NWP + 5.5) \times R_s - 0.3) - 2.6 \times R_s$

where $R_s = P_s / NWP$, P_s is the pressure range of the pressure sensor (MPa), NWP is the Nominal Working Pressure (MPa), V_{CHSS} is the volume of the compressed storage system (L), and Δt is the time interval (min).

5.1.3. If the value of Δt is less than 60 minutes, Δt is set to 60 minutes.

5.2. The initial mass of helium in the storage system is calculated as follows:

$P_o' = P_o \times 288 / (273 + T_0)$

$\rho_o' = -0.0043 \times (P_0')^2 + 1.53 \times P_0' + 1.49$

$M_o = \rho_o' \times V_{CHSS}$

5.3. The final mass of helium in the storage system at the end of the time interval, Δt, is calculated as follows:

$P_f' = P_f \times 288 / (273 + T_f)$

$\rho_f' = -0.0043 \times (P_f')^2 + 1.53 \times P_f' + 1.49$

$M_f = \rho_f' \times V_{CHSS}$

where P_f is the measured final pressure (MPa) at the end of the time interval, and T_f is the measured final temperature (°C).

5.4. The average helium flow rate over the time interval is therefore:

$V_{He} = (M_f - M_o) / \Delta t \times 22.41 / 4.003 \times (P_{target} / P_o)$

where V_{He} is the average volumetric flow rate (NL/min) over the time interval and the term (P_{target}/P_o) is used to compensate for differences between the measured initial pressure (P_o) and the targeted fill pressure (P_{target}).

5.5. Conversion of the average volumetric flow of helium to the average hydrogen flow is calculated with the following formula:

$V_{H2} = V_{He} / 0.75$

where V_{H2} is the corresponding average volumetric flow of hydrogen.

6. Post-Crash Concentration Measurement for Enclosed Spaces

6.1. Post-crash data collection in enclosed spaces commences when the vehicle comes to a rest. Data from the sensors installed in accordance with paragraph 3.2. of this annex are collected at least every five seconds and continue for a period of 60 minutes after the test. A first-order lag (time constant) up to a maximum of five seconds may be applied to the measurements to provide "smoothing" and filter the effects of spurious data points."