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Fuel cell road vehicles — Performance measurement — Vehicles fuelled with compressed hydrogen

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC *22*, *Road vehicles*, Subcommittee SC 37, *Electrically propelled vehicles.*

This second edition cancels and replaces the first edition (ISO/TR 11954:2008), which has been technically revised.

The main changes compared to the previous edition are as follows:

— revision of the scope;

— addition of normative references;

— addition of terms and definitions, e.g. complete vehicle kerb mass, maximum thirty minutes speed, acceleration, speed uphill and hill starting performance;

— addition of driving performance tests, e.g. maximum thirty minutes speed, acceleration, speed uphill and hill starting performance;

— revision of the method for adjusting the RESS SOC;

— addition of driving mode setting method.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Fuel cell road vehicles — Performance measurement — Vehicles fuelled with compressed hydrogen

1 Scope

This document specifies test methods for the measurement of performance, such as acceleration, maximum speed and hill climbing ability, of fuel cell hybrid electric vehicles (FCHEV) as passenger cars and light duty trucks with a maximum authorized total mass of 3 500 kg and fuelled with compressed hydrogen.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TR 8713:2019, *Electrically propelled road vehicles — Vocabulary*

3 Terms and definitions

For the purposes of this document, the following terms and definitions given in ISO/TR 8713 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
acceleration ability
shortest time required to accelerate the vehicle from speed v_1 to speed v_2

[SOURCE: ISO 8715:2001, 3.7, modified — Note 1 to entry was removed.]

3.2
complete vehicle kerb mass
mass of the vehicle including batteries, without occupants but with fuel, cooling liquid, window washer fluid, lubricating oil, tools and spare wheel, on-board charger, portable charger or part of it, if provided as standard equipment by the vehicle manufacturer

[SOURCE: ISO 8715:2001, 3.1]

3.3
dynamic loaded radius
effective radius of a tyre when it is deformed by the mass of the vehicle loaded to its *test mass* (3.14)

[SOURCE: ISO 8715:2001, 3.4]

3.4
FCHEV operation mode
fuel cell hybrid electric vehicle operation mode
mode of a *fuel cell hybrid electric vehicle (FCHEV)* (3.5) in which both a *rechargeable energy storage system (RESS)* (3.10) and fuel cell system are used sequentially or simultaneously for vehicle propulsion

3.5
FCHEV
fuel cell hybrid electric vehicle
electrically propelled vehicle with a *rechargeable energy storage system (RESS)* (3.10) and a fuel cell system as power sources for vehicle propulsion

[SOURCE: ISO 23828:2022, 3.7]

3.6
hill starting ability
maximum slope on which the vehicle can start moving over a minimum distance of 10 m

[SOURCE: ISO 8715:2001, 3.9]

3.7
maximum design total mass
maximum vehicle mass as specified by the vehicle manufacturer

[SOURCE: ISO 8715:2001, 3.2]

3.8
maximum speed
highest average speed which the vehicle can maintain throughout a specified test

[SOURCE: ISO/TR 8713:2019, 3.89]

3.9
maximum thirty minutes speed
v_{30}
highest average speed which the vehicle can maintain over 30 min

[SOURCE: ISO 8715:2001, 3.6, modified — Note 1 to entry was removed.]

3.10
RESS
rechargeable energy storage system
rechargeable system that stores energy for delivery of electric energy for the electric drive

EXAMPLE Battery, capacitor, flywheel.

[SOURCE: ISO/TR 8713:2019, 3.117]

3.11
RESS SOC
RESS state of charge
residual capacity of a *rechargeable energy storage system (RESS)* (3.10) available to be discharged

3.12
RESS operation mode
rechargeable energy storage system operation mode
mode of an *fuel cell hybrid electric vehicle (FCHEV)* (3.5) using only a *rechargeable energy storage system (RESS)* (3.10) for vehicle propulsion

3.13
speed uphill
highest average speed which the vehicle can maintain on a given slope over a distance of 1 km

[SOURCE: ISO/TR 8715:2001, 3.8]

3.14
test mass
sum of the *complete vehicle kerb mass* (3.2) plus

— the maximum authorized load mass (including driver) if it is equal or less than 180 kg;

— 180 kg, if the maximum authorized load mass exceeds 180 kg but is less than or equal to 360 kg;

— half of the maximum authorized load mass if this load mass exceeds 360 kg

[SOURCE: ISO/TR 8715:2001, 3.3]

4 Parameters, units and accuracy of measurements

Table 1 shows parameters and their units and accuracy.

Table 1 — Parameters, units and accuracy of measurements

Parameter	Unit	Accuracy
Time	s	±0,1 s
Distance	m	±0,1 %
Air temperature	°C	±1 °C
Air pressure	kPa	±1 kPa
Speed	km/h	±1 % or ±0,1 km/h whichever is greater
Mass	kg	±0,5 %
Tyre pressure	kPa	±1,5 %
DC current	A	±0,3 %[a]

[a] For the DC current measurement, a wideband current meter or wideband ampere-hour meter for operation in connection with pulsed power electronics is used. Any errors in the DC electric energy measurement system are less than 1 % of the reading or 0,3 % of full scale.

5 Test conditions

5.1 Vehicle conditions

The vehicle is loaded to the test mass according to the specification given for each test.

The vehicle tyres are inflated to the pressure specified by the vehicle manufacturer when the tyres are at ambient temperature.

The viscosity of oils for the mechanical moving parts conforms to the specification of the vehicle manufacturer.

The lighting, signalling and auxiliary devices are off, except those required for testing and usual day-time operation of the vehicle.

All energy storage systems available for other than traction purposes (electric, hydraulic, pneumatic, etc.) are charged up to their maximum level specified by the vehicle manufacturer.

The vehicle is clean, and the windows and air entries, not needed for the correct operation of the vehicle and the drive system, are closed by the normal operating controls.

If batteries are to be operated at temperatures above ambient temperature, the driver follows the procedure recommended by the vehicle manufacturer to keep the battery temperature within its operating range.

The vehicle is driven over at least 300 km before the test(s) with the onboard fuel cell system.

The RESS is in the state of charge required for the test to be performed.

ISO 14687 and the equivalent regional standard apply to the test fuel.

5.2 Atmospheric conditions

5.2.1 Ambient temperature and atmospheric pressure

The outdoor test is performed at an ambient temperature between 5 °C and 32 °C. Indoor tests are performed at a room temperature between 20 °C and 30 °C. The atmospheric pressure is between 91 kPa and 104 kPa. The tests are performed in the absence of rain and fog.

5.2.2 Air density

According to Formula (1), the air density in the test does not change more than 7,5 % compared with the air density in the reference conditions.

Air density calculation is obtained according to Formula (1):

$$d_r = d_0 \times \frac{H_T}{H_0} \times \frac{T_0}{T_T} \quad (1)$$

where

d_0 is the air density in reference conditions [d_0 = 1,189 kg/m^3];

H_T is the pressure during the test;

H_0 is the pressure at reference conditions [H_0 = 100 kPa];

T_T is the absolute temperature during the test, in kelvins;

T_0 is the temperature at reference conditions [T_0 = 293 K (20 °C)].

5.2.3 Wind speed

The average wind speed measured at a height of 1 m above the ground is less than 3 m/s. Gusts are less than 5 m/s.

5.2.4 Relative humidity

The relative humidity is less than 95 % and the track is dry.

5.3 Track conditions

5.3.1 General conditions

The measurements are taken on a dry track, which can be either a straight track or a loop track. The surface of the track is hard, smooth, clean and give good adhesion.

5.3.2 Straight track

The length of the measuring zone is at least 1 000 m.

The length of the launching track is long enough to achieve a stable speed 200 m ahead of the measuring zone. The longitudinal slope on the measuring zone and on the last 200 m of the launching track does not exceed 0,5 %. The longitudinal slope on the launching tracks does not exceed 4 %.

The transverse slope in the measuring zone does not exceed 3 %.

In order to reduce the influence of factors such as road slope and wind direction/speed, the acceleration and the speed tests are executed in both directions of the test track in direct sequence, taking care to use the same stretch of the track.

When conditions preclude performing the test in both directions, a single direction test is carried out as in 5.3.4.

5.3.3 Loop track

The length of the loop track is not less than 1 000 m. For calculating the speeds, the length of run is the distance covered by the vehicle while it is being timed.

The loop track may vary from a perfect circle to straight sections linked by approximately circular sections. The radius of the curves is not less than 200 m.

The longitudinal slope in the measuring zone does not exceed 0,5 %. The effects of centrifugal forces can be compensated by the transverse profile of the curves in such a way that the vehicle holds a normal line without any action on the steering wheel.

5.3.4 Single direction test

Testing in one direction only is permitted if, because of the characteristics of the test track layout, it is not possible for the vehicle to reach its maximum speed in both directions.

The following conditions are fulfilled:

— the track conforms to the information provided in 5.3.2;

— the variation in altitude does not exceed 1 m between any two points;

— the run is repeated twice in immediate succession;

— the components of wind speed parallel to the track does not exceed 2 m/s.

6 Preconditioning of the vehicle

6.1 Hydrogen refuelling

Hydrogen is refuelled to the vehicle’s hydrogen tank according to the vehicle manufacturer's specification. The hydrogen refuelling procedures complies with the relevant hydrogen refuelling standards.

6.2 RESS state of charge preconditioning of externally chargeable FCHEV

Vehicle performance of externally chargeable FCHEV is evaluated under FCHEV operation mode. To avoid the test in RESS operation mode, initial SOC of RESS on performance test is limited in certain level. Before the performance test, SOC of RESS is confirmed in the allowable SOC range. This allowable SOC range can be reached by the following steps.

a) The initial SOC of RESS is set according to the manufacturer's instructions, so that the vehicle system reaches the FCHEV operation mode during the 30 min maximum speed test. If the manufacturer's instructions are not available, initial SOC range could be between 30 % to 70 %.

b) The 30 min maximum speed test is performed. And the profile of the SOC during the test is recorded.

c) The minimum SOC value ($S_{OC,\ V30\_min}$(%)) is obtained during the test. ($S_{OC,\ V30\_min}$ is the minimum SOC level after FC system works during the performance test.) Then, the allowable SOC range of RESS to start performance test is within $S_{OC,\ V30\_min}$ ±10 %.

If SOC information is not available or feasible at some special situation, quantity of electricity measurement of the RESS (Q_{RESS}(Ah)) can be applied instead of SOC(%). Details of the procedure are listed in Annex B. The procedure in B.1 uses full charge operation to initiate the quantity of electricity value by referring the nominal capacity ($Q_{NOMINAL}$) and also uses discharge operation to adjust SOC to the initial SOC ($S_{OC,\ INI}$) before the 30 min maximum speed test. For FCHEV with large RESS, the procedure in B.2 can be used to set $S_{OC,\ INI}$ to avoid drawbacks of the associated power loss and time required.

6.3 Warming up

The vehicle is driven over a distance of about 5 000 m at 80 % of the manufacturer's estimated maximum thirty minutes speed in order to warm up the motor and transmission gears.

6.4 Selection of driving mode

If the vehicle has multiple driving modes (e.g. intelligent mode, sports mode), and if the vehicle has a main or default mode, it is operated in main or default mode. If the vehicle has no main or default mode, the driving mode recommended by the vehicle manufacturer is selected and noted in the record of Annex A.

7 Test sequence

7.1 Test sequence for non-externally chargeable FCHEV

Test for non-externally chargeable FCHEV is performed by following steps.

a) The vehicle is loaded to the test mass (see 3.14).

b) Vehicle is preconditioned without SOC preconditioning (see 6.1).

c) The warming up operation is performed (see 6.3).

d) The driving mode is selected (see 6.4).

e) The FCHEV operation mode test items number 1 to 4 in Table 2 are performed sequentially.

f) The vehicle is loaded to its maximum design total mass.

g) The FCHEV operation mode test items number 5 and 6 in Table 2 are performed sequentially.

7.2 Test sequence for externally chargeable FCHEV

Test for externally chargeable FCHEV is performed by following steps.

a) The vehicle is loaded to the test mass (see 3.14).

b) Vehicle is preconditioned with SOC preconditioning (see 6.1, 6.2).

c) The warming up operation is performed. (It can be skipped if test is performed in a short pause.)

d) The driving mode is selected (see 6.4).

e) The FCHEV operation mode test items number 1 to 4 in Table 2 are performed sequentially. Each test starts within the allowable SOC range of RESS described in 6.2, B.1 or B.2.

f) The vehicle is loaded to its maximum design total mass.

g) The FCHEV operation mode test items number 5 and 6 in Table 2 are performed sequentially. Each test starts within the allowable SOC range of RESS described in 6.2, B.1 or B.2.

According to the manufacturer's requirements, the maximum speed and acceleration ability test according test item number 7 to 8 of Table 2 in the mode recommended by the manufacturer can be added. Therefore, the RESS SOC of the vehicle can be adjusted according to the manufacturer's requirements.

Table 2 — Test procedure

NO.	Reference	Items	Note
1	6	Preconditioning	
2	8.1	Maximum speed in FCHEV operation mode	Mandatory
3	8.2	Maximum thirty minutes speed in FCHEV operation mode	Mandatory
4	8.3	Acceleration ability in FCHEV operation mode	Mandatory
5	8.4	Speed uphill in FCHEV operation mode	Mandatory
6	8.5	Hill starting ability in FCHEV operation mode	Mandatory
7	8.1	Maximum speed in the mode recommended by the manufacturer	Optional
8	8.3	Acceleration ability in the mode recommended by the manufacturer	Optional
9	ISO 8715	Maximum speed in RESS operation mode	Optional
10	ISO 8715	Acceleration ability in RESS operation mode	Optional
11	ISO 8715	Speed uphill in RESS operation mode	Optional
12	ISO 8715	Hill starting ability in RESS operation mode	Optional

8 Test procedure

8.1 Maximum speed

8.1.1 Standard test procedure

The test procedure is as follows.

a) The vehicle is brought to a maximum speed on the straight or loop track and it is maintained at this speed over a distance of 1 km.

b) The same test is performed immediately in the opposite track direction.

The maximum speed value in kilometres per hour (km/h) is the arithmetic average between the two measured values.

8.1.2 Single direction test procedure

The test procedure is as follows.

a) The vehicle is brought to a maximum speed and it is maintained at this speed over a distance of 1 km.

b) The single direction test is carried out using a test track as in 5.3.4, The speed results for the two runs, $v_{mes\_r\_n}$, the maximum speed per run corrected by the wind speed, $v_{max\_r\_n}$, and the maximum speed v_{max} is determined according to Formulae (2) to (4):

$$v_{mes\_r\_n} = L_n / t_n \quad (2)$$

$$v_{max\_r\_n} = (v_{mes\_r\_n} \pm v_w \times f) \times 3{,}6 \quad (3)$$