DRAFT INTERNATIONAL STANDARD ISO/DIS 23828-1

ISO/TC **22**/SC **21** Secretariat: **DIN**

Voting begins on: **2007-01-11** Voting terminates on: **2007-06-11**

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Fuel cell road vehicles - Energy consumption measurement —

Part 1:
Vehicles fuelled with compressed hydrogen

Véhicules électriques routiers hybrides avec pile à combustible — Mesurage de consomation d'énergie —

Partie 1: Avec hydrogène comprimé

ICS 43.120

In accordance with the provisions of Council Resolution 15/1993 this document is circulated in the English language only.

Conformément aux dispositions de la Résolution du Conseil 15/1993, ce document est distribué en version anglaise seulement.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

Contents

Page

Foreword iv
1 Scope 1
2 Normative reference 1
3 Terms and definitions (after the terminology Discussion) 2
4 Measurement accuracy 2
5 Hydrogen consumption measurement 3
5.1 Pressure method 3
5.2 Gravimetric method 3
5.3 Flow method 3
6 Test procedure 3
6.1 General condition 3
6.2 Vehicle condition 3
6.3 Chassis dynamometer conditions 4
6.4 Fuel consumption tests 5
6.5 Measurement over scheduled driving test 5
6.6 Correction of the test results for FCHEV 6
7 Presentation of results 6
Annex A (normative) Test procedure in Japan 7
Annex B (normative) Test procedure in Europe 12
Annex C (normative) Test procedure in the U.S.A. 16
Annex D (normative) Pressure method 22
Annex E (normative) Gravimetric method 24
Annex F (normative) Flow method 26
Annex G (informative) Current method 27
Annex H (informative) Estimation of interior temperature of tank 29
Annex I (informative) Test results of hydrogen consumption of test vehicle 32
Annex J (normative) Allowable energy change 34
Annex K (normative) Linear correction method using a correction coefficient (not applicable for PFCEV) 36
Annex L (informative) Procedure to obtain correction coefficient for FCHEV 37

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 21, *Electrically propelled road vehicles*.

Introduction

Fuel Cell Vehicles (FCV) include the following types:

— Pure Fuel Cell Vehicle (PFCV), in which the fuel cell system is the only on-board energy source for propulsion and auxiliary systems

— Fuel Cell Hybrid Electric Vehicle (FCHEV), in which the fuel cell system is integrated with an on-board rechargeable energy storage system (RESS) for electric energy supply to propulsion and auxiliary systems

FCHEV design options include:

1) Externally chargeable or non externally chargeable.

2) Rechargeable Energy Storage System (RESS): battery or capacitor

3) Driver-selected operating modes: If the FCHEV has no driver-selected operating mode, it has only a FCHEV mode.

Table – FCHEV Classification

	Chargeability	Operating mode
FCHEV	Externally chargeable	FCHEV mode
		EV mode
	Non externally chargeable	**FCHEV mode**
		EV mode

The present standard is applicable to the PFCV and to the FCHEV non externally chargeable with FCHEV mode only (see in bold).

Fuel cell road vehicles - Energy consumption measurement —

Part 1:
Vehicles fuelled with compressed hydrogen

1 Scope

This International Standard specifies the procedures for measuring the energy consumption of fuel cell passenger cars and light duty trucks that use compressed hydrogen and are not externally chargeable, operating in the regions as defined in annexes.

2 Normative reference

The following publications form a part of this International Standard to the extent specified herein. For dated documents, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendment) applies.

ISO 1176:*1990, Road vehicle – Masses – Vocabulary and codes*

ISO 3833:1977, *Road vehicles – Types – Terms and definitions*

ISO 8713: 2005, *Electric road vehicles - Vocabulary*

ISO 8714:2002, *Electric road vehicles* – Reference energy consumption and range – Test procedures for passenger cars and light commercial vehicles

ISO 8715:2001, *Electric road vehicles – Road operating characteristics*

ISO 10521:1992, *Motor vehicle road load – Determination under reference atmospheric conditions and reproduction on chassis dynamome*ter

ECE-R 83, *Uniform provisions concerning the approval of vehicles with regard to the emission of pollutants according to engine fuel requirements*

ECE-R 101, *Uniform provisions concerning the approval of passenger cars with regard to the emission of carbon dioxide and fuel consumption and/or the measurement of the electric energy consumption and electric range, and of category M1 and N1 vehicles powered by an electric power train only with regard to the measurement of electric energy consumption and electric range*

United States Code of Federal Regulations, Title 40, Protection of the Environment, Part 86, Control of air pollution from new and in-use motor vehicles and new and in-use motor vehicle engines: Certification and test procedures, Appendix I

United States Code of Federal Regulations, Title 40, protection of the Environment, Part 600, Fuel Economy of Motor Vehicles, Appendix I

TRIAS 5-3-1996, *Fuel consumption test method of gasoline engine vehicle on 10 · 15 mode driving cycles*

Safety Regulations for Road Vehicles (Ministry of Transportation Ordinance N. 67 of 1951) (for Japan test procedure) USA procedure

SAE J *2572-Aug2006, Recommended practice for Measuring the fuel Consumption and Range of Fuel Cell and Hybrid Fuel Cell Vehicles fuelled with compressed Gaseous Hydrogen*

3 Terms and definitions (after the terminology Discussion)

For the purpose of this document, the terms and definitions given in ISO 3833:1977 and ISO 1176:1990 the following apply.

3.1
battery state of charge (SOC) (apply to FCHEV)
residual capacity of battery available to be discharged normally expressed as a percentage of full charge

3.2
charge balance of battery (apply to FCHEV)
change of charge in battery during test period normally expressed in Ah

3.3
EV operation mode (apply to FCHEV)
mode of an FCHEV in which only the RESS is used for the vehicle propulsion and possibly auxiliary systems

3.4
FCHEV operation mode (apply to FCHEV)
mode of an FCHEV in which both RESS and FC system are used sequentially or simultaneously for vehicle propulsion

Note: The FC system may also charge the RESS during propulsion or standstill.

3.5
Fuel cell vehicle (FCV)
vehicle that receives propulsion power from an on-board fuel cell power system

3.6
Fuel cell hybrid electric vehicle (FCHEV)
fuel cell vehicle with RESS

3.7
Pure fuel cell vehicle (pure FCV)
fuel cell vehicle without RESS

3.8
rechargeable energy storage system (RESS) (apply to FCHEV)
system that stores energy, for example, batteries or capacitors, and is rechargeable by on-board and/or external energy sources, and associated controls, if any

3.9
test mass
mass of a vehicle prepared for a defined test procedure

4 Measurement accuracy

Test apparatus shall assure the accuracy of measurement of ± 1 % for the total mass of hydrogen consumption during the test cycle, unless otherwise specified in the relevant annexes.

5 Hydrogen consumption measurement

According to the present status of the studies various methods for the measurement of hydrogen consumption have been developed. Those listed below have shown to give sufficiently equivalent results. They are reported in detail in Annex D, E, and F (normative). One of the methods shall be used. Other methods may also become applicable if they show comparable equivalence and reliability.

5.1 Pressure method

Hydrogen consumption is calculated by measuring the pressure and temperature of gas in the high-pressure hydrogen tank before and after the test. The hydrogen consumption can be determined by calculating the change in the number of moles of gas in the storage by applying the measured values of pressure and temperature to the state equation. A tank with known internal volume that allows measurement of gas pressure and temperature shall be used for the test.

5.2 Gravimetric method

Hydrogen consumption is calculated by measuring the weight of the high-pressure hydrogen tank before and after the test. The tank used for the test shall be suitable for measuring weight.

5.3 Flow method

The amount of hydrogen supplied to and consumed by a vehicle is measured by a flow meter.

6 Test procedure

6.1 General condition

The test shall be conducted after preparation of the vehicle and test apparatus as follows.

6.2 Vehicle condition

6.2.1 General

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

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

6.2.2 Vehicle stabilization

Prior to testing, the test vehicle shall be stabilized, which includes vehicle mileage accumulation according to a manufacturer-determined distance unless otherwise specified in the relevant annexes A, B or C.

6.2.3 Vehicle appendages

Vehicles shall be tested with normal appendages (mirrors, bumpers, etc.). Certain items (e.g., hub caps) may be removed where necessary for safety on the dynamometer.

6.2.4 Vehicle test mass

The vehicle test mass shall be selected according to Annex A, B, or C.

6.2.5 Tires

Vehicle manufacturer's recommended tires shall be used.

6.2.5.1 Tire pressure

The vehicle tires shall be inflated, when the tires are at ambient temperature, to the pressure specified by the vehicle manufacturer for the chosen test (track or chassis dynamometer)..

6.2.5.2 Tire conditioning

Tires shall be conditioned as recommended by the vehicle manufacturer. See Annex A, B, or C for additional requirements.

6.2.6 Lubricants

The vehicle lubricants specified by the manufacturer shall be used.

6.2.7 Gear shifting

If the vehicle is fitted with a manually shifted gear box, gear shifting positions corresponds to the test procedure mentioned in Annex A, B and C. However, the shift positions may be selected and determined previously in accordance with the vehicle characteristics.

6.2.8 Regenerative braking

If the vehicle has regenerative braking, the regenerative braking system shall be enabled for all dynamometer testing. If a vehicle is equipped with an Antilock Braking System or a Traction Control System and is tested on a single-roll dynamometer, these systems may inadvertently interpret the non-movement of the set of wheels that are off the dynamometer as a malfunctioning system. If so, modifications to these systems shall be made to achieve normal operation of the remaining vehicle systems, including the regenerative braking system.

6.2.9 RESS stabilization

The RESS shall have been stabilized with the vehicle as defined in 6.2.1 or by equivalent conditioning.

6.3 Chassis dynamometer conditions

6.3.1 General

The vehicle generally should be tested on single-roll chassis dynamometer. The vehicle with four-wheel-drive shall be tested by modifying the drive train of the vehicle. When the vehicle is modified, the details shall be explained in the test report.

A double roll dynamometer test may be performed when a modification for single roll dynamometer test is not possible for the specific 4-wheel driven vehicle.

6.3.2 Dynamometer calibration

The dynamometer shall be calibrated according to the specifications indicated in the service manual provided by the dynamometer manufacturers.

6.3.3 Dynamometer warm-up

The dynamometer shall be warmed up sufficiently prior to the testing.

6.3.4 Determining the dynamometer load coefficient

The determination of vehicle road load and the reproduction on a chassis dynamometer shall conform to ISO 10521. Vehicles equipped with regenerative braking systems that are activated at least in part when the brake pedal is not depressed shall have regenerative braking disabled during the deceleration portion of coast-down testing on both the test track and dynamometer.

6.4 Fuel consumption tests

6.4.1 General

A region-dependent procedure shall be selected from Annex A, B, or C, for Japan, Europe or the U.S.A. respectively. Details and common procedures for each test mode are described below.

6.4.2 Vehicle preconditioning

Vehicle preconditioning shall be carried out according to the Annex appropriate for the region. In the case of FCHEV, the RESS SOC may be pre-adjusted by charging or discharging, to obtain a suitable energy difference in RESS between the beginning and the end of test.

6.4.3 Vehicle soak

The vehicle shall be soaked according to the regional procedure in Annex A, B, or C.

6.5 Measurement over scheduled driving test

For the measurement of hydrogen consumption, the test vehicle shall be driven on the chassis dynamometer according to the running mode prescribed for the region (see Annex A, B, or C as appropriate). The hydrogen consumption can be measured by one of the methods described in Annex D, E, or F, or by an alternative method that provides equivalent accuracy.

The hydrogen consumption is determined using one of the following equations.

$$FC1 = \frac{b_{t0} \times 10^{-3}}{L} = \frac{w \times \frac{22.414}{m} \times 10^{-3}}{L}$$

$$FC2 = \frac{w \times 10^{-3}}{L} = \frac{b_{t0} \times \frac{m}{22.414} \times 10^{-3}}{L}$$

$$FC3 = \frac{b_{t0} \times 10^{-3} \times Q_H}{L} = \frac{w \times \frac{22.414}{m} \times 10^{-3} \times Q_H}{L}$$

wherein,

$FC1$ Hydrogen consumption per unit distance (Nm^3/km) referred to volume

$FC2$ Hydrogen consumption per unit distance (kg/km) referred to weight

$FC3$ Hydrogen consumption per unit distance (MJ/km) referred to caloric value

L distance (km)

b_{t0} Hydrogen consumption (ℓ at 273 K, 101.3 kPa)

w Hydrogen consumption amount (g)

m Molecular weight of hydrogen (2.016)

Q_H Lower calorific value of hydrogen (10.8 MJ/Nm^3)

6.6 Correction of the test results for FCHEV

6.6.1 General

After the FCHEV has been tested, the hydrogen consumption shall be corrected if the energy difference in the RESS between the end and the start of the test is above the limit described in 6.6.2.

6.6.2 Allowable limit for RESS energy change for FCHEV

The allowable limit for RESS energy change is

$$| \Delta E_{RESS} | \leq 0{,}01 \times E_{CF};$$

where

ΔE_{RESS} is the energy change in RESS over the test cycle;

E_{CF} is the energy of consumed fuel over the test cycle.

Energy change in the RESS and maximum allowable energy change in the RESS are described in Annex J.

Correction procedure by correction coefficient for FCHEV

The vehicle manufacturer shall provide the correction coefficient for calculation of hydrogen consumption at $\Delta E_{RESS} = 0$. The correction coefficient can be obtained according to Annex K.

7 Presentation of results

Test results should be recorded according to the Annex I. The fourth significant digit should be rounded off to provide the hydrogen consumption rate to three significant digits.

Other data should be recorded as required by the regional regulations.

Annex A
(normative)

Test procedure in Japan

A.1 Scope

This Annex describes the typical procedures and related conditions in Japan to measure fuel consumption of the passenger cars and light duty trucks defined in Japan regulation. .

A.2 Accuracy for determining vehicle road load and others

Accuracy of determining road load shall conform to the ISO 10521.

A.3 Driving procedure

The gear manipulation in each operational condition specified in Tables A.1 and A.2 shall be performed smoothly and quickly according to the following instructions.

A.3.1 Vehicles with manual transmission

A.3.1.1 The idling operation refers to a condition in which the accelerator pedal is not depressed, with the transmission gear in neutral.

A.3.1.2 The transmission gear shall be shifted to the low gear position (or such a gear in instances where the “low” gear position should read otherwise in Table A.1 and A.2) five second before the idling operation mode is switched to the acceleration mode.

A.3.1.3 For deceleration, the clutch shall be disengaged at a speed of 10 km/h during the 20-0 km/h deceleration operation and at a speed of 20 km/h during the 40-0 deceleration operation as specified in Table A.1 and A.2. In the same way, the clutch shall be disengaged at a speed of 30 km/h during the 70-0 deceleration operation as specified in Table A.2.

A.3.1.4 On vehicles with a 6-speed transmission in which driving by operating the shift lever in respective gear positions as specified in Table A.2 can not be performed because of the running performance of the vehicle, driving may be carried out according to the example of the 5-speed transmission specified in Table A.2.

A.3.1.5 If the revolutions of the motor of the test vehicle exceed the revolution speed at which the motor delivers its maximum output during the operation of the test vehicle, the gear position that is one step higher than the original gear may be used. In this case, the vehicle speed at which the gearshift takes place shall be the vehicle speed corresponding to the revolution speed at which the motor delivers its maximum output.

A.3.2 Vehicle with automatic transmission

The selector position shall remain in drive position. No further manipulation shall be made.

A.3.3 Vehicles with other transmissions

Gear changes shall be made considering the running characteristics of the tested vehicle with transmissions other than those described in A.3.1 and A.3.2.