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**Fuel cell road vehicles — Safety  
specifications —**

**Part 2:  
Protection against hydrogen hazards for  
vehicles fuelled with compressed  
hydrogen**

*Véhicules routiers alimentés par pile à combustible — Spécifications de  
sécurité —*

*Partie 2: Protection contre les dangers de l'hydrogène pour les  
véhicules utilisant de l'hydrogène comprimé*



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## Foreword

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ISO 23273-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 21, *Electrically propelled road vehicles*.

ISO 23273 consists of the following parts, under the general title *Fuel cell road vehicles — Safety specifications*:

- *Part 1: Vehicle functional safety*
- *Part 2: Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen*
- *Part 3: Protection of persons against electric shock*

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# Fuel cell road vehicles — Safety specifications —

## Part 2:

# Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen

## 1 Scope

This part of ISO 23273 specifies the essential requirements for fuel cell vehicles (FCV) with respect to the protection of persons and the environment inside and outside the vehicle against hydrogen related hazards.

It applies only to such FCV where compressed hydrogen is used as fuel for the fuel cell system.

This part of ISO 23273 does not apply to manufacturing, maintenance and repair.

The requirements of this part of ISO 23273 address both normal operating (fault free) and single fault conditions of the vehicles.

## 2 Normative references

The following referenced documents are indispensable for the application 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 17268, *Compressed hydrogen surface vehicle refuelling connection devices*

ISO 23273-1, *Fuel cell road vehicles — Safety specifications — Part 1: Vehicle functional safety*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

### 3.1

#### **air processing system**

system that processes (i.e. that filters, meters, conditions and pressurizes) the incoming air for the fuel cell system

### 3.2

#### **contaminant**

substances within raw fuel, such as sulphur, that, at or above a specified concentration level, may poison reaction catalysts

### 3.3

#### **electric chassis**

conductive mechanical structure of the vehicle including all associated electric and electronic components, whose parts are electrically connected and whose potential is taken as reference

- 3.4**  
**excess flow valve**  
valve which automatically shuts off or limits the gas flow when the flow exceeds a set design value
- 3.5**  
**fuel cell**  
electrochemical device that generates electricity by the conversion of fuel and an oxidant without any physical or chemical consumption of the electrodes or electrolyte
- 3.6**  
**fuel cell stack**  
assembly of two or more fuel cells, which are electrically connected
- 3.7**  
**fuel cell system**  
system typically containing the following subsystems: fuel cell stack, air processing system, fuel processing system, thermal management, water management and their control system
- 3.8**  
**fuel cell vehicle**  
**FCV**  
vehicle that receives propulsion power from an on-board fuel cell power system
- NOTE The general term FCV also includes vehicles with an additional other source of propulsion power.
- 3.9**  
**fuel processing system**  
system that converts (if necessary), and/or conditions the fuel as stored in the on-board fuel storage into fuel suitable for operation in the fuel cell stack
- 3.10**  
**fuel system**  
combination of the on-board fuel storage, the fuel processing system, and the fuel cell stack
- 3.11**  
**main hydrogen shut-off valve**  
valve designed to automatically isolate the high pressure hydrogen source
- 3.12**  
**maximum allowable working pressure**  
**MAWP**  
maximum working pressure at which a component or system may be normally operated without damage, including leakage and deformation
- NOTE The maximum allowable working pressure is used in determining the setting of pressure-limiting/relieving devices installed to protect the part or system from accidental over-pressurizing.
- 3.13**  
**nominal working pressure**  
pressure level at which a component typically operates
- NOTE For fuel containers it is the settled pressure at a uniformed temperature of 15 °C (288 K) for a full fuel container.
- 3.14**  
**purge**  
process to eliminate unwanted gas constituents from the hydrogen system
- 3.15**  
**temperature-triggered pressure relief device**  
**PRD**  
excessive temperature-triggered, activated non-reclosing resealing device which vents gas to protect the fuel container from rupture when subjected to a standard fire test

## 4 Environmental and operational conditions

The requirement given in this part of ISO 23273 shall be met across the range of environmental and operational conditions for which the vehicle is designed to operate, as specified by the vehicle manufacturer.

## 5 Design and performance requirements of the fuel system

### 5.1 General

The fuel system consists of a high pressure section, where the inner pressure is the same as in the fuel container, and an intermediate to low pressure section, where the inner pressure is lower than that of the high pressure section.

The fuel system shall be equipped with:

- a fire protection system incorporating one or more temperature-triggered PRD(s);
- a main hydrogen shut-off valve that shall be closed when the energizing power to the valve is lost, and which shall also be closed when the vehicle fuel cell system is not operating;
- hydrogen shut-off system according to 5.2.4; and
- an excess flow valve or a system providing the same function.

### 5.2 Components

#### 5.2.1 General

The components of the fuel system shall satisfy the following requirements.

The components shall be designed, installed and serviced in such a way that they can operate safely under the environmental and operational conditions as specified by the manufacturer.

All components used in the high pressure section shall have an adequate pressure rating based on the nominal working pressure.

All components used in the intermediate and low pressure sections shall have an adequate pressure rating based on the maximum allowable working pressure.

Electrically conductive housings of components in possible flammable areas should be bonded grounded to the electric chassis to prevent inadvertent ignition of hydrogen discharges.

#### 5.2.2 Fuel container

A vehicle fuel container according to legal requirements, if applicable, shall be used. Otherwise, requirements shall be specified by the vehicle manufacturer.

The fuel container system shall be equipped with at least one temperature-triggered PRD located near the hydrogen fuel container(s) so that hydrogen in the fuel container can be discharged before rupture (see also 5.3).

#### 5.2.3 Overpressure protection

Any parts located in the intermediate or low pressure section shall be capable of withstanding or be protected against an extraordinary pressure increase due to a single failure of the first pressure regulator upstream.

NOTE For guidance see SAE J2578.

#### 5.2.4 Hydrogen shut-off system

The fuel system and its control shall provide a means to close the main hydrogen shut-off valve and thereby prevent unwanted discharge of hydrogen or other hazards arising from single-point failures, as per ISO 23273-1.

#### 5.3 Location and installation of components

All components and interconnecting piping and wiring shall be securely mounted or supported in the vehicle to minimize damage and prevent leakage and/or malfunction.

Components shall be located within the vehicle to reduce the possibility of accidental damage, unless the components are adequately protected and no part of the component lies outside of the protective structure.

Fuel pipes shall be located and protected in such a way that no damage can be caused by vehicle vibrations under normal operational conditions as specified by the vehicle manufacturer.

#### 5.4 Discharges

The vehicle design for all fuel system exhausts, purges, vents and other discharges that occur during normal operation of the vehicle shall prevent hydrogen-related hazardous conditions. All normal operating modes including start, run, stop and off (parked) should be considered in these requirements.

Discharges into all vehicle compartments under normal operation and single failure conditions shall not lead to any hazardous conditions.

In areas of contemplated use such as outdoors, mechanically ventilated buildings and structures and non-mechanically ventilated residential garages legal requirements shall be met. Normal discharges from the vehicle to the outside shall be non-flammable.

NOTE Guidance relative to evaluating vehicles for commonly contemplated situations such as driving outdoors, idling the vehicle in commercial buildings, and parking in a residential garage is provided in SAE J2578.

Discharges from the PRD shall be vented to the outside of the vehicle, and shall be protected as well as all associated piping and outlet, such that functionality is not compromised due to flow restrictions.

The release of hydrogen from traction batteries shall not lead to any hazardous conditions.

### 6 Test methods for determining flammability around the vehicle from fuel discharges

Tests shall be performed according to applicable national or International Standards or legal requirements. Otherwise test methods shall be specified by the vehicle manufacturer.

### 7 Complementary or alternative approach to verify hydrogen-related safety requirements

#### 7.1 General

Complementarily to the requirements in Clause 5, protection for persons and the environment inside and outside the vehicle against hydrogen-related hazards may be achieved by the following procedure. This procedure may also be applied instead of the requirements in Clause 5, resulting in requirements more specific to the conditions of a given fuel cell vehicle design.

NOTE Such approach is applied to vehicle electronic systems in several ECE Regulations (R13, R79).



## 7.2 Hydrogen-related components and systems

Components and systems containing and/or carrying and/or processing hydrogen shall be specified by the vehicle manufacturer unless legal requirements apply.

## 7.3 Integration of the hydrogen-related components and systems into the FCV

### 7.3.1 Normal (fault-free) hydrogen related conditions of the vehicle

The vehicle manufacturer shall establish a process that, under normal (fault-free) conditions of the hydrogen-related components and systems, no hazard for persons in or in the vicinity of the FCV in normal environmental and operational conditions can occur.

### 7.3.2 Hydrogen-related fault conditions of the vehicle

A hazard analysis in relation to hydrogen shall be performed considering primarily the interface between the components and systems, as established during assembly into the vehicle. This analysis may use an FMEA (failure mode and effect analysis), an FTA (fault tree analysis) or another appropriate method, and shall determine potential single hardware and software failures or conditions which could form a hazard for persons in or around the vicinity of the vehicle.

Based on this analysis, a description shall be provided of the hardware and software measures enacted to prevent or limit failures or conditions to non-hazardous levels for persons, i.e. such that the fundamental safety requirements and criteria expressed in this part of ISO 23273 are met (safety concept).

## 7.4 Verification of the safety concept

The vehicle manufacturer shall define and perform an appropriate combination of necessary analyses and tests that are required to sufficiently demonstrate that the alternative concept provides protection against potential hazards that is equivalent to the means provided in this part of ISO 23273.

## 8 Fuelling requirements

### 8.1 General

Vehicle movement by its own propulsion system should be prevented when the vehicle is being refuelled.

NOTE 1 For guidance on design of fuel systems, see also SAE J2578.

NOTE 2 Safety for persons during refuelling at a hydrogen filling station has mainly been provided by appropriate measures regarding safety related design and operation of the station, including the interface between pump/nozzle and vehicle/receptacle (see also 8.2).

### 8.2 Fuelling inlet

See ISO 17268 for nozzle and receptacle requirements. Nozzle and receptacle shall be provided with a cap to prevent invasion of dust, liquid, contaminants, etc.

The fuelling location on the vehicle shall be designed so as to prevent the accumulation of flammable gases and the ingress of foreign material. It shall be placed in an appropriate position to ensure safe operation. The side of the vehicle is preferable.

Measures against electrostatic discharges of the vehicle at the receptacle should be taken.

The receptacle shall be able to withstand a minimum of 670 N of loading in any direction without its gas tightness being affected (e.g. in the case of a refuelling hose breakaway).

## Bibliography

- [1] SAE J2578, *Recommended practice for general fuel cell vehicle safety*
- [2] United Nations ECE R13, *Uniform provisions concerning the approval of vehicles of categories M, N, and O with regard to braking*
- [3] United Nations ECE R79, *Uniform provisions concerning the approval of vehicles with regard to steering equipment*

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