
**Gaseous hydrogen — Thermally
activated pressure relief devices for
compressed hydrogen vehicle fuel
containers**

*Hydrogène gazeux — Dispositifs limiteurs de pression thermiquement
activés pour les conteneurs de carburant de véhicules à hydrogène
comprimé*

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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.

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 documents 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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*.

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.

Introduction

The purpose of this document is to promote the implementation of hydrogen powered land vehicles through the creation of performance based testing requirements for thermally activated pressure relief devices for compressed hydrogen fuel containers. The successful commercialization of hydrogen land vehicle technologies requires standards pertaining to fueling stations, vehicle fuel system components and the global homologation of standards requirements for technologies with the same end use. This will allow manufacturers to achieve economies of scale in production through the ability to manufacture one product for global use.

This document is based on the CSA Standard ANSI/CSA HPRD 1-2013.

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Gaseous hydrogen — Thermally activated pressure relief devices for compressed hydrogen vehicle fuel containers

1 Scope

This document establishes minimum requirements for pressure relief devices intended for use on hydrogen fuelled vehicle fuel containers that comply with ISO 19881, IEC 62282-4-101, ANSI HGV 2, CSA B51 Part 2, EC79/EU406, SAE J2579, or the UN GTR No. 13.

The scope of this document is limited to thermally activated pressure relief devices installed on fuel containers used with fuel cell grade hydrogen according to SAE J2719 or ISO 14687 for fuel cell land vehicles, and Grade A or better hydrogen according to ISO 14687 for internal combustion engine land vehicles. This document also contains requirements for thermally activated pressure relief devices acceptable for use on-board light duty vehicles, heavy duty vehicles and industrial powered trucks such as forklifts and other material handling vehicles, as it pertains to UN GTR No. 13.

Pressure relief devices designed to comply with this document are intended to be used with high quality hydrogen fuel such as fuel complying with SAE J2719 or ISO 14687 Type 1 Grade D.

Pressure relief devices can be of any design or manufacturing method that meets the requirements of this document.

This document does not apply to reseating, resealing or pressure activated devices.

Documents which apply to hydrogen fuel vehicles and hydrogen fuel subsystems include IEC 62282-4-101, SAE J2578 and SAE J2579.

<https://standards.iteh.ai/catalog/standards/sist/2aab98f1-dcf4-4634-8957-ec9d3cf7-recommended>
[Annex A](#) presents an informative record of recommended fuel container, fuel storage subsystem and vehicle level requirements. The statements in [Annex A](#) are intended as recommendations for consideration of inclusion by the organizations and committees developing standards on these subsystem and vehicle level standards.

[Annex B](#) presents a rationale for the design qualification tests in this document.

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 1431-1, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing*

ISO 6270-2, *Paints and varnishes — Determination of resistance to humidity — Part 2: Condensation (in-cabinet exposure with heated water reservoir)*

ISO 14687¹⁾, *Hydrogen fuel quality — Product specification*

ISO 19881, *Gaseous hydrogen — Land vehicle fuel containers*

ASTM D1149, *Standard Test Method for Rubber Deterioration-Surface Ozone Cracking in a Chamber*

ASTM D1193-06(R2011), *Standard Specification for Reagent Water*

1) To be published. Current stage 40.60

CSA ANSI HGV 2, *Compressed hydrogen gas vehicle fuel containers*

CSA B51-14, *Boiler, Pressure Vessel, and Pressure Piping Code*

EC79 (EU406), *Type-approval of hydrogen-powered motor vehicles*

SAE J2579:2013, *Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles*

SAE J2719, *Hydrogen Fuel Quality for Fuel Cell Vehicles*

UN GTR No. 13, *UN Global Technical Regulation on Hydrogen and Fuel Cell Vehicles*

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

flow capacity

<pressure relief device> capacity in volume per unit time at specified conditions

3.2

fusible material

metal, alloy, or other material capable of being melted by heat where the melting is integral to the function of the *pressure relief device* (3.6)

3.3

manufacturer's specified activation temperature

temperature, as specified by the pressure relief device manufacturer, at which the *pressure relief device* (3.6) is designed to release pressure

3.4

manufacturer's specified nominal working pressure

highest settled pressure at a uniform gas temperature of 15 °C of the container or container assembly with which the *pressure relief device* (3.6) may be used, as specified by the pressure relief device manufacturer

3.5

normal cubic centimeters

Ncc

dry gas that occupies a volume of 1 cm³ at a temperature of 273,15 K (0 °C) and an absolute pressure of 101,325 kPa

3.6

pressure relief device

device that, when activated under specified performance conditions, is used to vent the container contents

Note 1 to entry: Reseating and resealing devices are not addressed by this document.

3.7

thermally activated pressure relief device

TPRD

pressure relief device (3.6) activated by temperature

4 Service conditions

4.1 General

Fuel containers may accidentally be exposed to fire or elevated temperature. These conditions may act to increase the contained pressure or to degrade the structural materials, depending on the container type and materials of construction. A pressure relief device provides a means to vent the fuel container under these conditions.

A specific pressure relief device may not be suitable for all container types, sizes or installations. Fuel container or installation standards may require that a pressure relief device be tested in conjunction with other components.

CGA S1.1 states: "relief devices may not prevent burst of a cylinder under all conditions of fire exposure. When the heat transferred to the cylinder is localized, intensive, and remote to the relief device, or when the fire builds rapidly, such as in an explosion, and is of very high intensity, the cylinder can weaken sufficiently to rupture before the relief device operates, or while it is operating".

The following service conditions are representative of what can be seen in an automotive service. These service conditions are provided as a basis for the design, manufacture, inspection and testing of pressure relief devices which are used in compressed hydrogen vehicle fuel containers.

4.2 Design service life

The design service life of the pressure relief device shall be specified by the pressure relief device manufacturer.

4.3 Nominal working pressure

This document applies to pressure relief devices that have a nominal working pressure, as specified by the manufacturer, of 25 MPa, 35 MPa, 50 MPa or 70 MPa at 15 °C, hereinafter referred to in this document as the following:

- a) "H25" — 25 MPa;
- b) "H35" — 35 MPa;
- c) "H50" — 50 MPa;
- d) "H70" — 70 MPa.

Other nominal working pressures for hydrogen gas besides those defined are allowed if the required qualification test requirements of this document are met.

4.4 Durability test cycles

The design pressure cycles for pressure relief devices shall be between not more than 10 % of the manufacturer's specified nominal working pressure and not less than 150 % of the manufacturer's specified nominal working pressure for ten cycles and between not more than 10 % of the manufacturer's specified nominal working pressure and not less than 125 % of the manufacturer's specified nominal working pressure for 14 990 cycles.

NOTE The maximum pressure under the condition of fueling station dispenser fault management is 150 % of the vehicle nominal working pressure, as defined in: SAE J2760, SAE J2579:2013, Appendix A and CSA HGV 4.1.

4.5 Temperature range

The pressure relief device shall be designed to maintain pressure integrity from –40 °C to 85 °C.

5 Quality assurance

Quality system programs shall be established and operated to demonstrate that pressure relief devices are produced in accordance with the qualified design.

6 General requirements

6.1 Material requirements

Materials normally in contact with hydrogen shall be determined to be acceptable in hydrogen service, with the consideration of hydrogen embrittlement and hydrogen accelerated fatigue. The performance tests cannot guarantee that all cases and conditions of the hydrogen service are validated, so it is still incumbent on the designer/builder to carefully screen materials of construction for their intended use. The materials and design shall be such that there is no significant change in the functioning of the device, deformation or mechanical change in the device, and no harmful corrosion, deformation or deterioration of the materials when subject to the service conditions given in [Clause 4](#).

NOTE 1 Material performance data and/or acceptance criteria in hydrogen environments can be found in the ISO 11114 series, the Sandia National Laboratory Technical Reference for Hydrogen Compatibility of Materials, ANSI/AIAA G-095, ANSI/CSA CHMC 1, ASME B31.12, SAE J2579:2013, Appendix B or in equivalent national requirements.

NOTE 2 Some fusible alloys can contain heavy metals that can be considered environmentally unacceptable by some customers and which can be prohibited by some jurisdictions.

Non-metallic materials normally in contact with hydrogen shall be verified to be acceptable in the hydrogen service. Consideration shall be given to the fact that hydrogen diffuses through these materials more easily than through metals; therefore the suitability of materials shall be verified. Non-metallic materials shall retain their mechanical stability with respect to strength (fatigue properties, endurance limit, creep strength) when exposed to the full range of service conditions and lifetime as specified by the container manufacturer. Materials shall be sufficiently resistant to the chemical and physical action of the fluids that they contain and to environmental degradation. The chemical and physical properties necessary for operational safety shall not be significantly affected within the scheduled lifetime of the equipment unless a replacement is foreseen; specifically, when selecting materials and manufacturing methods, due account shall be taken of the material's corrosion and wear resistance, electrical conductivity, impact strength, aging resistance, the effects of temperature variations, the effects arising when materials are put together (for example, galvanic corrosion), the effects of ultraviolet radiation, and to the degradation effects of hydrogen on the mechanical performance of a material.

6.2 Design requirements

The design shall be such that, once activated, the device fully vents the contents of the fuel container. The design should minimize the possibility of external hazards (e.g. projectiles) resulting from the activation of the device. Any material released shall not interfere with the proper venting of the pressure relief device.

The pressure relief device shall be designed to address degradation from creep or plastic deformation. The design or manufacturing process should account for the effects of material defects, particularly casting and shrinkage voids, which adversely impact the robustness of the design.

6.3 Flow capacity

The flow capacity shall be indicated in the manufacturer's published literature and verified by the flow capacity test under [7.13](#).

The adequacy of the flow capacity of pressure relief devices for a given application shall be demonstrated by bonfire testing in accordance with ISO 19881, ANSI HGV 2, CSA B51 Part 2, EC79/EU406, SAE J2579, or the UN GTR No. 13 for fuel cell vehicles and by the minimization of the hazardous effects of the

pressure peaking phenomenon which can take place during high flow rate releases from small diameter vents in enclosed spaces.

6.4 Rework and repair

New pressure relief devices that do not meet the requirements of this document may be reworked or repaired as long as they satisfy the requirements of this document.

6.5 Failure modes and effects analysis (FMEA)

Design FMEA and Process FMEA shall be performed for pressure relief devices. The documents shall be made available for review by fuel container or vehicle manufacturers upon request. A verification of the existence of these documents satisfies the intent of this provision.

NOTE FMEA is a methodology used in the automotive industry to identify potentially hazardous failure modes of safety devices and recommend changes in design, manufacturing, inspection or testing which eliminate such failure modes or minimize their effects. FMEA is applied to both device design and to the manufacturing and assembly process to identify corrective actions that improve device reliability and safety. Available references include SAE J1739.

7 Design qualification testing

7.1 General

Design qualification testing shall be conducted on finished pressure relief devices that are representative of the normal production. Test reports shall be kept on file by the pressure relief device manufacturer and made available for review by fuel container manufacturers and end users upon request.

The design qualification testing required by this document shall, as appropriate and necessary, be supplemented by additional tests defined in “design controls” or “recommended action” in the Design FMEA.

Pressure relief devices representative of each design and design change shall be subjected to tests as prescribed in [Table 1](#). Designs which are sufficiently similar to an existing fully qualified design shall be permitted to be qualified through a reduced test program as defined in [Table 1](#). Design changes not falling within the guidelines in [Table 1](#) shall be qualified as original designs.

Any additional tests or requirements shall be performed in accordance with appropriate published standards or procedures, as available.

Unless stated otherwise, the tests specified herein shall be conducted at an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$.

Unless stated otherwise, the tests specified herein shall be conducted with the following tolerances on specified pressures and temperatures:

Pressures 2 MPa or less: $+0/-1\text{ MPa}$

Pressures 125 % NWP or greater: $+2\text{ MPa}/-0\text{ MPa}$

Temperatures $\pm 5\text{ °C}$

Hydrogen used for testing shall be high quality hydrogen fuel, such as fuel meeting the requirements of SAE J2719 or ISO 14687 Type 1 Grade D.

Table 1 — Test requirements for design and design changes

ISO 19882 Tests	Original design	Manufacturer's specified nominal working pressure	Manufacturer's specified activation temperature	Elastomeric seals	Orifice size	Body material	Surface coating	Inlet connection	Outlet connection
7.2 Pressure cycling	X	X	X	X		X		X	
7.3 Accelerated life	X	X	X	X		X			
7.4 Thermal cycling	X		X	X		X	X		
7.5 Accelerated cyclic corrosion	X			X		X	X		
7.6 Automotive fluid exposure	X	X				X	X		
7.7 Atmospheric exposure	X			External only					
7.8 Stress corrosion cracking resistance	X	X				X	X	X	
7.9 Impact due to drop & vibration	X	X	X			X		X	
7.10 Leakage	X	X	X	X		X	X	X	X
7.11 Bench top activation	X	X	X	X	X	X	X		
7.12 Flow capacity	X	X			X			X	X
7.13 High pressure activation and flow	X	X			X			X	X

NOTE "X" requires physical testing.