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Gaseous hydrogen — Fuelling protocols for hydrogen-fuelled vehicles —

Part 1: Design and development process for fuelling protocols

PROOF/ÉPREUVE

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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 197, *Hydrogen technologies*.

A list of all parts in the ISO 19885 series can be found on the ISO website.

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

This document is intended to identify and describe requirements for the design and development of hydrogen dispenser fuelling protocols and address issues with current protocols with regard to their acceptance and thoroughness of verification as well as the safe implementation in dispenser systems.

This document is intended to coordinate with the ISO 19880 series with regard to road vehicles and, at the same time, address a more general need with the regard to fuelling a far broader range of vehicles. This document can help to address technical details of the fuelling process and will allow ISO 19880-1 to be streamlined and focus on basic requirements of the fuelling station.

This document is expected to be the first part in a series dealing with fuelling protocols for a broad range of vehicle applications.

Additionally, the requirements for the development process in this document are robust and can be considered for extension to other container-fuelling applications in the future.

Gaseous hydrogen — Fuelling protocols for hydrogen-fuelled vehicles —

Part 1: Design and development process for fuelling protocols

1 Scope

This document addresses the design and development of fuelling protocols for compressed hydrogen gas dispensing to vehicles with compressed hydrogen storage of fuel.

The document does not address dispensing of compressed hydrogen gas to vehicles with hydride-based hydrogen storage systems as well as the dispensing of liquefied or cryo-compressed hydrogen.

This document is intended to be used for a wide range of applications including, but not limited to, the following:

— light, medium, and heavy-duty road vehicles,

— motor bicycles and tricycles, carts, and trailers,

— off-road vehicles,

— fork-lift and other industrial trucks,

— rail locomotives and powered cars,

— airplanes and drones, and

— maritime ships, boats, and barges.

This document applies to a wide spectrum of development situations ranging from companies developing a fuelling protocol for their specific products or applications to standards development organizations (SDOs) developing a consensus-based fuelling protocol for a broad segment of the industrial or commercial market. Additionally, combinations between the two extremes are possible, where, for example, companies start design and development as a way of defining a proposal for new work by an SDO to complete development and publish the document as a consensus-based standard (including technical justification for compliance to this document).

This document defines requirements for the design and development of the fuelling protocols. These requirements can be integrated into the existing design and development processes to ensure that the fuelling protocol is fully verified and that the generated documentation is sufficient for the proper implementation and safe use of the fuelling protocols in dispensing systems for the targeted application.

In addition to addressing the design and development of fuelling protocols for general applications, Annex A provides specific requirements and information relative to fuelling protocols for road vehicles at public fuelling stations based on ISO 19880-1.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13849-2, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

ISO 17268, *Gaseous hydrogen land vehicle refuelling connection devices, 2020*

ISO 19880 (all parts), *Gaseous hydrogen — Fuelling stations*

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

ISO/SAE 21434, *Road vehicles — Cybersecurity engineering*

ISO 26262, *Road vehicles — Functional safety*

IEC 60204-1, *Safety of machinery - Electrical equipment of machines - Part 1: General requirements*

IEC 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61511, *Functional safety – Safety instrumented systems for the process industry sector*

IEC 62061, *Safety of machinery – Functional safety of safety-related electrical, electronic, and programmable electronic control systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19880-1 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
basic process control system
BPCS
system which responds to input signals from the process, its associated equipment, other programmable systems and/or an operator and generates output signals causing the process and its associated equipment to operate in the desired manner

Note 1 to entry: a *BPCS* does not perform any safety-instrumented functions with a claimed SIL ≥ 1.

[SOURCE: IEC 61511-1:2004, 3.2.3]

3.2
compressed hydrogen storage system
CHSS
system designed to store compressed hydrogen fuel for a hydrogen-fuelled road vehicle, 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

Note 1 to entry: The above definition is specific to hydrogen road vehicles where the CHSS has one (and only one) container with dedicated primary closures devices. See A.3.

Note 2 to entry: Hydrogen road vehicles typically have more than one CHSS. See *vehicle fuel system*.

Note 3 to entry: The CHSS can also include actuators, sensors, and electronics as deemed necessary by the vehicle manufacturer.

[SOURCE: ECE/TRANS/180/Add.13/Amend.1 UN GTR No. 13, UN Global Technical Regulation on Hydrogen and Fuel Cell Vehicles: 2023, 3.6]

3.3
container
pressure-bearing component on the road vehicle within the hydrogen storage system that stores the primary volume of hydrogen fuel in a single chamber or in multiple permanently interconnected chambers

Note 1 to entry: Cylinders and conformable containers are types of containers for road vehicles. See A.3.

[SOURCE: ECE/TRANS/180/Add.13/Amend.1 UN GTR No. 13, UN Global Technical Regulation on Hydrogen and Fuel Cell Vehicles: 2023, 3.8]

3.4
control system
system which responds to input signals from the process and/or from an operator and generates output signals causing the process to operate in the desired manner

3.5
data
design characteristics and limits, process measurements (such as temperature, pressure, and flow), and associated calculated parameters of the interconnected dispensing system and vehicle fuel system during the fuelling process

Note 1 to entry: Calculated parameters can be based on, for example, interpolations of data tables such as fuelling tables for containers as well as formulas or equations involving other data.

3.5.1
dynamic data
data (3.5) such as temperature and pressure measurements, and associated calculated parameters that are expected to change value with time during the fuelling process

3.5.2
static data
data (3.5) such as design characteristics and limits and associated calculated parameters that are expected to remain constant with time during the fuelling process

3.6
dispenser
equipment in the dispensing system, including the dispenser cabinet(s) and support structure, that is physically located in the fuelling area

Note 1 to entry: The hydrogen dispenser typically includes the fuelling assembly, required temperature and pressure instrumentation, filters, and the user interface to conduct vehicle fuelling.

Note 2 to entry: The manufacturer of the hydrogen dispenser can include additional equipment in the dispenser, including all equipment in the dispensing system.

3.7
dispensing system
system downstream of the hydrogen supply system comprising all equipment necessary to carry out the vehicle fuelling operation, through which the compressed hydrogen is supplied to the vehicle

3.8
fuelling envelope
required design space for the fuelling protocol that captures extreme combinations of hydrogen fuelling and storage systems on vehicles to be fuelled, the ambient and operating conditions of the vehicle during operation and dispensing, and the capabilities and limitations of the vehicle fuel system and dispensing systems

3.9
fuelling protocol
technical descriptions, instructions, or constructs that define how the dispensing of compressed gaseous hydrogen to storage systems on vehicles is to be conducted

Note 1 to entry: The *fuelling protocol* serves as the basis for defining control strategies and algorithms for implementation in the *BPCS* (3.1) hardware and software of the dispensing control system

Note 2 to entry: *Fuelling protocols* can range from simple descriptions that can be performed in hardware to complex programmable control functions using prescribed values, tables, and/or reduced-order models as well as conventional process controls such as feedforward-feedback and predictor-corrector control functions.

3.10
fuelling station
hydrogen fuelling station
hydrogen refuelling station
HRS
facility for the dispensing of compressed hydrogen vehicle fuel, including the supply of hydrogen, and hydrogen compression, storage, and dispensing systems

3.11
hydrogen service level
HSL
pressure level in MPa used to characterize the hydrogen service of the dispensing system based on the NWP of the vehicle

Note 1 to entry: See ISO 19880-1:2020, Annex E for application of pressure terminology to hydrogen dispensing systems and vehicles.

3.12
maximum allowable working pressure
MAWP
maximum pressure permissible in a system at the temperature specified

Note 1 to entry: The maximum allowable working pressure can also be defined as the design pressure, the maximum allowable operating pressure, the maximum permissible working pressure, or the maximum allowable pressure for the rating of pressure vessels and equipment manufactured in accordance with national pressure vessel codes.

Note 2 to entry: See ISO 19880-1:2020, Annex E for discussion of pressure terminology and its application to dispensing systems and fuelling stations in general. Pressures are understood to be gauge unless otherwise specifically indicated in this document.

3.13
maximum developed pressure
MDP
highest pressure achieved during infrequent, short-term excursions above MAWP during fault management

Note 1 to entry: See ISO 19880-1:2020, Annex E for a discussion of pressure terminology and its application to dispensing systems and fuelling stations in general. Pressures are understood to be gauge unless otherwise specifically indicated in this document.

3.14
maximum fuelling pressure
MFP
maximum pressure expected during a normal (fault-free) vehicle fuelling

Note 1 to entry: Per GTR#13, the maximum fuelling pressure is 125 % NWP for road vehicles.

Note 2 to entry: See ISO 19880-1:2020, Annex E for a discussion of pressure terminology and its application to dispensing systems and fuelling stations in general. Pressures are understood to be gauge unless otherwise specifically indicated in this document.

3.15
maximum operating pressure
MOP
highest pressure that is expected for a component or system during normal operation including anticipated transients

Note 1 to entry: In the case of the *dispensing system* (3.7), the MOP is equivalent to the *maximum fuelling pressure* (3.14) of the vehicle.

Note 2 to entry: See ISO 19880-1:2020, Annex E for discussion of pressure terminology and its application to dispensing systems and fuelling stations in general. Pressures are understood to be gauge unless otherwise specifically indicated in this document.

3.16
nominal working pressure
NWP
pressure within a hydrogen storage container(s) in the vehicle fuel system at 100 % SOC at a gas temperature of 15 °C

Note 1 to entry: For road vehicles, this is typically 35 MPa or 70 MPa.

Note 2 to entry: See ISO 19880-1:2020, Annex E for discussion of pressure terminology and the correspondence between vehicle terminology and dispensing systems. Pressures are understood to be gauge unless otherwise specifically indicated in this document.

Note 3 to entry: Also known as “settled pressure” in ISO 10286.

Note 4 to entry: [SOURCE: ISO 19880-1:2020, 3.51, modified to replace “*CHSS*” for road vehicles with the more general term “hydrogen storage container(s) in the *vehicle fuel system*”.]

3.17
non-comm fuelling
fuelling that is conducted without communications between the vehicle and the dispensing control system

Note 1 to entry: *Non-comm fuelling* is equivalent to a *UCDC* (3.25) of 0.

3.18
non-public fuelling station
fuelling station that does not sell or dispense gaseous hydrogen to the general public

EXAMPLE Private or municipal vehicle fleet operation

[SOURCE: ISO 19880-1:2020, 3.52]

3.19
physics-based model
representation of the governing laws of nature such as the equation of state for compressed hydrogen gas and the conservation of mass, momentum and energy as applied in thermodynamics, fluid mechanics and heat and mass transfer equations

Note 1 to entry: Physics-based models can be empirically adjusted to improve accuracy within the range of interest.

3.20
public fuelling station
fuelling station that sells gaseous hydrogen to the public

Note 1 to entry: [SOURCE: 19880-1:2020, 3.62, modified - the text “general public” has been changed to "public"]

3.21
risk assessment
determination of quantitative or qualitative value of risk related to a specific situation and a recognised threat

Note 1 to entry: See ISO 19880-1 for a discussion of the risk assessment process as well as examples of threats and hazards.

Note 2 to entry: A recognized threat is also referred to as a hazard.

[SOURCE: 19880-1:2020, 3.66, modified - text from the definition moved to Note 2 to entry.]

3.22
safety function
function to be implemented by a safety-instrumented system that is intended to achieve or maintain a safe state for the process with respect to a specific hazardous situation

Note 1 to entry: See ISO 19880-1 for a discussion of safety-instrumented systems and their application to dispensing systems and fuelling stations in general.

[SOURCE: 19880-1:2020, 3.71, modified - Note 1 to entry has been replaced.]

3.23
standards development organization
SDO
industry- or sector-based standards organization that develops and publishes industry specific standards

Note 1 to entry: In some cases, international industry-based SDOs can have direct liaisons with international standards organizations. SDOs are differentiated from standards setting organizations (SSOs) in that SDOs may be accredited to develop standards using open and transparent processes.

Note 2 to entry: In the European Union, only standards created by CEN, CENELEC, and ETSI are recognized as European standards, and member states are required to notify the European Commission and each other about all the draft technical regulations. These rules were laid down in Directive 2015/1535/EU with the goal of providing transparency and control with regard to technical regulations.

[SOURCE: 19880-1:2020, 3.77]

3.24
state of charge
SOC
density (or mass) ratio of compressed hydrogen in the vehicle fuel system between the actual condition and the capacity at NWP when the system is equilibrated at 15 °C

Note 1 to entry: SOC is typically expressed as a percentage. See ISO 19880-1:2020, 3.78 for details related to the calculation process.

[SOURCE: 19880-1:2020, 3.78, modified - replaced *CHSS* (3.2) for road vehicles with the more general term "*vehicle fuel system"* (3.27) and Notes 1 to 4 to entry have been removed.]

3.25
use classification of data communicated
UCDC
numerical ranking of data communicated between the vehicle and the dispensing systems based on its use within the fuelling protocol as supported by risk assessment for the following four levels of UCDC:

0) No *data* (3.5) is communicated (e.g., *non-comm fuelling* (3.17));

1) The *data* communicated is not used for safety functions but is available for *data* collection and, if countermeasures are provided to mitigate risks (if any) resulting from faults, can also be used to improve the performance of the basic process control for fuelling protocol;

2) Communicated *static data* (3.5.2) is used for safety functions (in addition to the allowed usages for static and *dynamic data* (3.5.1) defined for UCDC of 1);

3) *Static* and *dynamic data* is used for dynamic control within the protocol or safety functions.