GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

ICS 27.180

CCS F 19

GB/T 42855-2023

Technical Requirements of Fueling Protocols for Hydrogen Fuel Cell Vehicles

氢燃料电池车辆加注协议技术要求

Issued on: August 6, 2023 **Implemented on: December 1, 2023**

Issued by: State Administration for Market Regulation;

Standardization Administration of the People's Republic of China.

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Technical Requirements of Fueling Protocols for Hydrogen Fuel Cell Vehicles

1 Scope

This document specifies the basic requirements, general requirements, fueling boundary conditions, fueling process and fueling process control requirements for high-pressure hydrogen fueling protocols for hydrogen fuel cell vehicles.

This document is applicable to the fueling protocols for the hydrogen fueling facilities of hydrogen fuel cell vehicles. The fueling protocols for the hydrogen fueling facilities of hydrogen internal combustion engine vehicles, hydrogen energy ships, hydrogen energy tramcars, hydrogen energy aircrafts, hydrogen energy engineering vehicles, hydrogen energy power generation devices and hydrogen transportation vehicles, etc. may also take this document as a reference.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in this text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 31138 Hydrogen Dispensers

3 Terms and Definitions

The terms and definitions defined in GB/T 31138, and the following terms and definitions are applicable to this document.

3.1 fueling protocol

Fueling protocol refers to the operating boundary conditions and fueling strategies followed by the hydrogen fueling facilities for fueling hydrogen fuel cell vehicles.

3.2 mass capacity of onboard hydrogen storage system

Mass capacity of onboard hydrogen storage system refers to the total mass of hydrogen stored by the onboard hydrogen storage system when the hydrogen is at 15 °C and under the nominal working pressure.

3.3 dispenser pressure

Dispenser pressure refers to the hydrogen pressure in the hydrogen fueling pipeline within 1 m upstream of the hydrogen dispenser breakaway valve.

3.4 target pressure

Target pressure refers to the hydrogen pressure expected from the onboard hydrogen storage system at the end of fueling.

3.5 fuel delivery temperature

Fuel delivery temperature refers to the temperature of hydrogen in the hydrogen fueling pipeline within 1 m upstream of the hydrogen dispenser breakaway valve.

3.6 pre-cooling temperature of hydrogen

Pre-cooling temperature of hydrogen refers to the temperature of hydrogen in the hydrogen dispenser after passing through the pre-cooling heat exchanger.

3.7 average pressure ramp rate

Average pressure ramp rate refers to the average growth rate of pressure of the hydrogen dispenser from the beginning to the end of fueling.

3.8 cool soak

Cool soak refers to the circumstance where the temperatures of the hydrogen dispenser pipeline and the high-pressure hydrogen storage cylinder of the onboard hydrogen storage system are both lower than the ambient temperature.

3.9 hot soak

Hot soak refers to the circumstance where the temperatures of the hydrogen dispenser pipeline and the high-pressure hydrogen storage cylinder of the onboard hydrogen storage system are both higher than the ambient temperature.

3.10 fueling with communication

Fueling with communication refers to a fueling mode, in which, data is exchanged between the hydrogen dispenser and the onboard hydrogen storage system through wired or wireless modes during the fueling time.

3.11 fueling with non-communication

Fueling with non-communication refers to a fueling mode, in which, there is no data exchange between the hydrogen dispenser and the onboard hydrogen storage system, or the data exchange is invalid during the fueling time.

4 Basic Requirements

4.1 Composition of Fueling Protocol

The fueling protocol shall include requirements for fueling performance target, boundary conditions, fueling method, process control, fueling speed and target pressure, etc.

4.2 General Rules

4.2.1 The fueling protocol shall be formulated in combination with the hydrogen fueling method and fueling performance target. In accordance with the parameters, such as: hydrogen dispenser's ambient temperature adaptability, hydrogen temperature pre-cooling capacity, hydrogen supply capacity (pressure and flow), hydrogen pipeline pressure drop and heat exchange capacity, as well as the mass capacity of onboard hydrogen storage system (hereinafter referred to as "capacity of onboard hydrogen storage system"), type of hydrogen storage cylinder, initial temperature and initial pressure, etc., determine the fueling speed and target pressure, and match the corresponding process control requirements.

4.2.2 The fueling protocol shall be selected in accordance with the fueling boundary conditions and fueling performance target that the hydrogen fueling facilities satisfy. During the fueling process, the fueling method specified in the fueling protocol shall be adopted. In accordance with the fueling conditions, select the appropriate fueling speed and target pressure, and carry out corresponding process control.

4.2.3 When the parameters required by the hydrogen fueling facilities, such as: fueling method, fueling performance target and boundary conditions change, the fueling protocol shall be re-formulated.

4.3 Fueling Speed

The fueling speed shall satisfy the requirement that the onboard hydrogen storage cylinders do not exceed the maximum allowable working temperature under the following conditions:

a) The hydrogen temperature is the maximum hydrogen temperature value allowed by the hydrogen pre-cooling temperature level;

b) The onboard hydrogen storage system only contains one hydrogen storage cylinder, and the capacity of the hydrogen storage cylinder is the capacity of the onboard hydrogen storage system;

c) The initial temperature of the onboard hydrogen storage cylinders is the hot soak temperature corresponding to the current ambient temperature;

d) The pressure drop of the pipeline is the maximum allowable value.

tightness inspection, initial pressure measurement and volume measurement of the onboard hydrogen storage system, etc. The main fueling process shall include fueling process control and fueling shutdown control. The fueling process detection shall cover hydrogen dispenser pressure and ambient temperature, hydrogen fueling flow rate and ambient temperature, etc. The specific procedures of fueling startup, fueling table selection, main fueling process and fueling process detection are shown in B.1 ~ B.4 in Appendix B.

7.1.2 Shutdown of fueling

The pressure of the hydrogen dispenser shall not be greater than the target pressure, ore the pressure of the hydrogen dispenser shall be set in accordance with the pressure difference between the hydrogen dispenser and the onboard hydrogen storage system, so as to ensure that the pressure of the onboard hydrogen storage system is not greater than the target pressure at the end of fueling.

NOTE: for an onboard hydrogen storage system with multiple hydrogen storage cylinders, it is considered that the hydrogen pressure in each hydrogen storage cylinder is always equal.

7.2 Fueling with Communication

7.2.1 Fueling process

The communication fueling process includes communication establishment, fueling startup, fueling table selection, main fueling process, fueling process detection, fuel delivery temperature level reduction and communication disconnected, etc. The requirements for fueling startup, fueling table selection, main fueling process and fueling process detection are consistent with fueling with non-communication, as shown in B.1 ~ B.4. When the hydrogen temperature exceeds the upper limit of the preset pre-cooling temperature level, the fuel delivery temperature level shall be adjusted, as shown in B.5.

7.2.2 Communication establishment

Before the hydrogen dispenser starts fueling, it shall be confirmed that effective communication has been established with the onboard hydrogen storage system, and the following conditions are satisfied:

a) The onboard hydrogen storage system does not send a termination signal;

b) The deviation between the volume of the onboard hydrogen storage system transmitted by communication and the volume of the onboard hydrogen storage system measured by the hydrogen dispenser does not exceed ± 15%;

c) The deviation between the initial pressure of the onboard hydrogen storage system transmitted by communication and the initial pressure of the onboard hydrogen storage system measured by the hydrogen dispenser is within the measurement and calculation error range.

7.2.3 Communication disconnection

When the hydrogen dispenser cannot obtain the data signal of the onboard hydrogen storage system or does not comply with the requirements specified in 7.2.2, if it satisfies the conditions of fueling with non-communication, the fueling shall be continued in accordance with the procedures of fueling with non-communication, and shall comply with the following requirements; otherwise, the hydrogen dispenser shall stop fueling within 3 s.

a) The fueling speed set by the procedures of fueling with non-communication is equal to the fueling speed set by the procedures of fueling with communication before switching;

b) The target pressure set by the procedures of fueling with non-communication is re-determined in accordance with the pressure of the onboard hydrogen storage system when switching to the procedures of fueling with non-communication.

7.2.4 Shutdown of fueling

The hydrogen dispenser shall adopt the real-time temperature of hydrogen in the onboard hydrogen storage system, the real-time pressure of the onboard hydrogen storage system and the fueling speed obtained through communication as the basis for determining the shutdown of fueling, so as to ensure that the fueling performance target requirements are satisfied at the end of fueling. In accordance with the method specified in GB/T 31138, calculate the fueling speed of the onboard hydrogen storage system.

8 Fueling Process Control

8.1 Basic Requirements

8.1.1 Ambient temperature

The accuracy and installation position of the temperature sensor for measuring ambient temperature shall comply with the requirements specified in GB/T 31138. During the fueling, the ambient temperature shall be not lower than –40 °C and not greater than 50 °C. If this temperature range is exceeded, it shall be handled in accordance with the ambient temperature over-limit requirements specified in GB/T 31138.

8.1.2 Hydrogen pre-cooling temperature

The accuracy and installation position of the temperature sensor for measuring hydrogen temperature shall comply with the requirements specified in GB/T 31138. The hydrogen temperature within 30 s after the startup of fueling shall satisfy the range required by the preset hydrogen pre-cooling temperature level. If this range is exceeded, fueling with non-communication shall be handled in accordance with the hydrogen pre-cooling temperature over-limit requirements specified in GB/T 31138. For fueling with communication, when the hydrogen temperature is lower than the lower temperature limit corresponding to the preset

The determination of the fueling parameters shall comply with the following requirements:

a) In accordance with the type of the flow regulating device of the hydrogen dispenser, select the fueling process control method, and adopt the pressure control method or the flow control method;

b) In accordance with the pressure rating of the hydrogen dispenser and the type of the hydrogen storage cylinder, select the corresponding fueling table;

c) In accordance with the ambient temperature, onboard hydrogen storage system capacity and initial pressure, and based on the selected fueling table, adopt the linear interpolation method to determine the fueling speed (average pressure ramp rate and flow rate) and target pressure. If the interpolation point is located in the "no fuel" area of the fueling table, the hydrogen dispenser shall not be fueled.

NOTE 1: see Appendix C for the recommended pressure ramp rate based on pressure control.

NOTE 2: see Appendix D for the recommended average flow rate based on flow control.

8.2 Pressure Control Method

Within the main fueling time range, the pressure of the hydrogen dispenser shall increase in accordance with the average pressure ramp rate of the target. Except for the first 15 s, within the effective fueling time of the main fueling process, if the pressure of the hydrogen dispenser is higher than the upper pressure limit or lower than the lower pressure limit of the hydrogen dispenser, hydrogen fueling shall be stopped within 3 s. The upper pressure limit of the hydrogen dispenser shall be calculated in accordance with Formula (1), and the lower pressure limit of the hydrogen dispenser shall be calculated in accordance with Formula (2).

$$p_{\text{dispenser}} = p_0 + \text{APRR}_{\text{target}} \times t_{\text{fueling}} + \Delta p_{\text{high}} \quad \cdots\cdots(1)$$

$$p_{\text{dispenser}} = p_0 + \text{APRR}_{\text{target}} \times t_{\text{fueling}} + \Delta p_{\text{low}} \quad \cdots\cdots(2)$$

Where,

$p_{\text{dispenser}}$---the pressure of the hydrogen dispenser, expressed in (MPa);

p_0---the initial pressure of the onboard hydrogen storage system, expressed in (MPa);

$\text{APRR}_{\text{target}}$---the average pressure ramp rate of the target, expressed in (MPa/min);

t_{fueling}---the total time from the startup of fueling to the shutdown of fueling (excluding non-fueling time), expressed in (min);

Δp_{high}---the upper limit of pressure tolerance (Δp_{high} = 7.0 MPa), expressed in (MPa);

Δp_{low}---the lower limit of pressure tolerance (Δp_{low} = 2.5 MPa), expressed in (MPa).

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