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Hydrogen Fueling in FCEV: A Study

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ABSTRACT

Hydrogen fueling stands as a pivotal element in the widespread adoption and success of Fuel Cell Electric Vehicles (FCEVs). This study delves into the critical factors essential for the efficient fueling of FCEVs, addressing parameters such as adherence to hydrogen storage system limits, acceptable fueling rates, and driving range satisfying customer expectations. The paper outlines the typical procedures and conditions involved in hydrogen fueling, including pressure and temperature requirements. Fast-fill stations, commonly operating within the range of 350 to 700 bar, cater to mainstream fueling demands, while home and fleet stations may operate at lower pressures, around 200 to 350 bar. Temperature variations, both ambient and chilled, further influence fueling efficiency, with the latter enhancing hydrogen density and storage capacity. Storage conditions, encompassing both vehicle and station infrastructure, are meticulously designed to accommodate a spectrum of pressures and temperatures. Moreover, adherence to established standards such as ISO 14687 and ISO 19880 ensures quality and safety across fueling operations. The paper also highlights SAE standards governing hydrogen coupling, gas quality, and vehicle-tostation communication protocols, emphasizing the role of interoperability and industry standards in advancing hydrogen fueling technology. Ultimately, by elucidating the intricate dynamics of hydrogen fueling, this study contributes to the ongoing evolution of FCEV infrastructure, fostering a sustainable and resilient transportation ecosystem.

Keywords: Hydrogen surface vehicles, FCEV, FCV, Hydrogen Fuelling, Temperature and pressure limits, communication data.

INTRODUCTION

Fuel Cell Electric Vehicles (FCEVs) represent a promising pathway toward achieving sustainable and zero-emission transportation. Central to their viability is the infrastructure supporting hydrogen fueling, which plays a pivotal role in the widespread adoption and success of FCEVs. In this study, we delve into the intricate dynamics of hydrogen fueling for FCEVs, elucidating key factors that contribute to its efficacy and reliability. Successful hydrogen fueling hinges upon several critical factors that must be meticulously addressed. Firstly, fueling operations must operate within the constraints of the vehicle's hydrogen storage system, ensuring compatibility and safety. Additionally, the fueling rate and resulting driving range must meet the expectations and requirements of customers, fostering confidence and acceptance in FCEV technology. Crucially, the fueling process should mirror the convenience and speed of conventional refueling methods, minimizing disruption and inconvenience for users. Hydrogen fueling for vehicles typically involves compressing gaseous hydrogen to specific pressures and storing it within the vehicle's fuel tank. The exact pressure and temperature conditions vary depending on the technology employed and prevailing standards. Fast-fill stations, commonly operating at pressures ranging from 350 to 700 bar, cater to mainstream fueling demands, while home and fleet stations may operate at lower pressures to accommodate different usage scenarios. Temperature considerations further influence fueling efficiency, with ambient conditions generally preferred, although chilled hydrogen may be employed to enhance storage capacity. Amidst these considerations, adherence to established standards and regulations is paramount. International bodies such as the International Organization for Standardization (ISO) and the Society of Automotive Engineers (SAE) provide comprehensive guidelines on fueling conditions, ensuring uniformity and safety across the hydrogen fueling infrastructure. Moreover, effective communication between FCEVs and hydrogen fueling stations is essential for orchestrating a safe and efficient fueling process. The exchange of information, encompassing vehicle identification, tank parameters, fueling protocol negotiation, safety data, and error handling, is facilitated through standardized protocols outlined by organizations such as SAE.Automobile manufacturers such as Honda, Toyota, and Hyundai have started to manufacture fuel cell vehicles (FCVs) with hydrogen as fuel. These FCVs are currently available in North America, Asia, and Europe, and have primarily been bought by early adopters (Manoharan, Yogesh, et al) As technology and standards continue to evolve, it is imperative to remain abreast of the latest developments and guidelines to ensure the seamless integration and optimization of hydrogen fueling infrastructure. By elucidating the intricacies of hydrogen fueling for FCEVs, this study seeks to contribute to the ongoing advancement and maturation of sustainable transportation solutions.

LITERATURE REVIEW

Hydrogen fuelling process

When a vehicle operator activates the dispenser, hydrogen flows from the storage tanks to the dispenser and through the nozzle into the vehicle in a closed system. Initial safety checks ensure the integrity of the system before fueling starts. During the fill, the dispenser is designed to pause periodically for several seconds to conduct additional integrity checks, according to code and/or fuel protocol, and then resume filling.

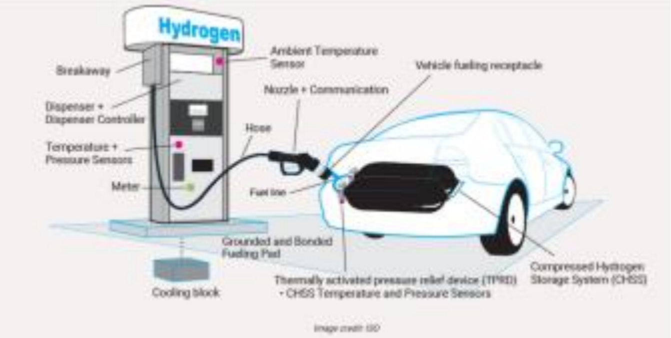

Image credit: ISO

Figure 1: Fuel System between Hydrogen Station and FCEV

Most vehicles have a standardized communication system that sends parameters from the vehicle's fuel storage system to the dispenser, which are used to calculate the pressure to stop the fill at a "full" tank. A Fuel Cell Electric Vehicle can fill up in less than five minutes.

Guidelines and Considerations for Hydrogen Fueling in Vehicles

Hydrogen fueling for vehicles typically involves compressing gaseous hydrogen to a certain pressure and storing it in the vehicle's fuel tank. The temperature and pressure conditions for hydrogen fueling depend on the specific technology and standards in use, but there are some general guidelines.

[1]. Pressure:
  A. Fast-Fill Stations: Common fast-fill stations typically provide hydrogen at pressures ranging from 350 to 700 bar (5,000 to 10,000 psi). The exact pressure may depend on the vehicle and the station infrastructure.
  B. Home and Fleet Stations: Stations for home or fleet use might operate at lower pressures, around 200 to 350 bar (3,000 to 5,000 psi).
  C. Low-Pressure Stations: Some early fuel cell vehicles operate at even lower pressures, but this is less common.

[2]. Temperature:
  A. Ambient Temperature: Hydrogen fueling is most effective at ambient temperatures. However, the specific temperature range can vary. Generally, it is between 0 and 40 degrees Celsius (32 to 104 degrees Fahrenheit).
  B. Chilled Hydrogen: Some fueling stations may provide chilled hydrogen to increase the density of hydrogen molecules, allowing more hydrogen to be stored in the vehicle's tank. Chilled hydrogen can be dispensed at temperatures as low as -40 degrees Celsius (-40 degrees Fahrenheit).

[3]. Storage Conditions:
  A. Vehicle Storage: The on-board storage of hydrogen in the vehicle is designed to handle a range of temperatures and pressures. Composite materials are often used for the construction of high-pressure hydrogen storage tanks.

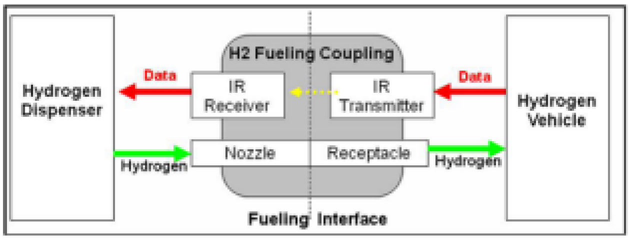

Figure 2: Overall Gaseous Hydrogen Fueling System

  B. Station Storage: Hydrogen at fueling stations is typically stored in large tanks at high pressures. The station infrastructure includes compressors to pressurize the hydrogen for dispensing.

[4]. Standards and Regulations:
  A. ISO Standards: International standards such as ISO 14687 for hydrogen fuel quality and ISO 19880 for hydrogen fueling stations provide guidelines on fueling conditions.
  B. SAE Standards: The Society of Automotive Engineers (SAE) has developed standards such as SAE J2601 for hydrogen fueling protocols.

It's crucial to note that these are general guidelines, and actual conditions may vary based on regional standards, technological advancements, and specific vehicle and station requirements. Always refer to the relevant standards and guidelines in your region for accurate and up-to-date information. Additionally, advancements in hydrogen fueling technology and infrastructure may lead to changes in

Hydrogen Station-to-Vehicle Communication

The overall hydrogen fueling system consists of a dispenser, Hydrogen Surface Vehicles (HSV), and hydrogen fueling coupling. The nozzle and receptacle mechanically couples the hydrogen fueling system (dispenser) and the HSV, and allows hydrogen gas to flow between them. The interface between the two is defined as the fueling interface. The data is transmitted from the IR transmitter on the HSV to the IR (infrared) receiver on the dispenser.

Communication between Fuel Cell Electric Vehicles (FCEVs) and hydrogen fueling stations is crucial for ensuring a safe and efficient fueling process. The information exchanged typically includes details about the vehicle's hydrogen storage system and its capacity. The Society of Automotive Engineers (SAE) has established standards for communication protocols during hydrogen fueling. SAE J2601, in particular, outlines some of the communication requirements. Here are some key pieces of information that may be exchanged:

[1]. Vehicle Identification:
The FCEV may provide identification information to the fueling station to ensure that it is compatible with the station's protocols.

[2]. Tank Volume, Pressure and Temperature:
The FCEV communicates the tank volume, current pressure and temperature of its hydrogen storage tank to the fueling station. This information helps the station adjust the dispensing parameters for optimal fueling.

[3]. Fueling Protocol and Speed:
The FCEV and the fueling station negotiate the fueling protocol, including the dispensing pressure and temperature. The vehicle may request a specific fueling speed based on its design and specifications.

[4]. Fueling Progress:
The FCEV and the fueling station exchange information on the progress of the fueling process. This includes data on the amount of hydrogen dispensed and the remaining fueling time.

[5]. Safety Information:
The FCEV may provide safety-related information to the fueling station, such as the status of safety systems and sensors within the vehicle.

[6]. Authentication and Authorization:
The fueling station may request and verify the FCEV's authentication and authorization credentials before initiating the fueling process.

[7]. Error Handling:
In the event of any issues or errors during the fueling process, the FCEV and the fueling station exchange information to manage the situation safely

It's important to note that the specific details of communication may depend on the standards adopted by the fueling station and the FCEV manufacturer. SAE J2601 provides guidelines for interoperability, but variations may exist. As technology and standards evolve, it's recommended to refer to the latest versions of relevant standards and protocols for the most accurate and up-to-date information on the communication between FCEVs and hydrogen fueling stations. Additionally, proprietary systems developed by manufacturers may have specific communication protocols that go beyond industry standards.

CONCLUSION

In conclusion, this article underscores the pivotal role of standardized fueling protocols in advancing the use of hydrogen as a clean energy source for Fuel Cell Electric Vehicles (FCEV). Emphasizing safety, efficiency, and interoperability, the study provides comprehensive insights into fueling process, standards, and operational considerations, offering valuable guidance for stakeholders in the evolving landscape of hydrogen-powered transportation.

Data format According to SAE J2799 / J2601

Variable	Unit	Format
Protocol Identifier	N/A	|ID=SAE_J2799|
IRDI Software Version Number	N/A	|VN=##.##|
Tank Volume	Liter	|TV=####.#|
Receptacle Type	N/A	|RT=H##|
Fill Command	N/A	|FC=Dyna|
Measured Pressure	MPa	|MP=###.#|
Measured Temperature	Kelvin	|MT=###.#|
Optional Data	0-74 characters not including "|"	|OD=ASDEFINEDINJ2601|

Figure 3: Data Format

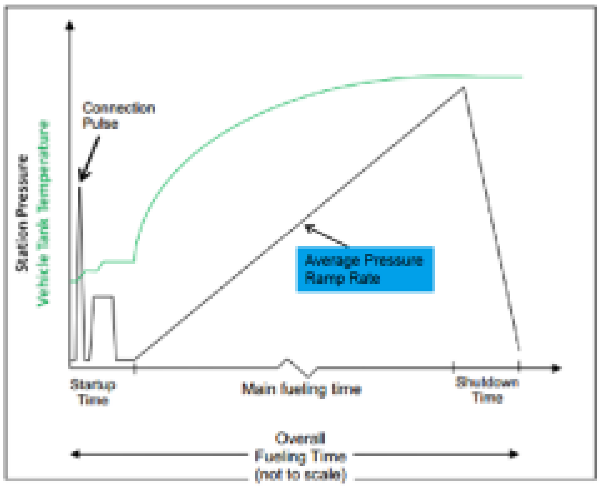

Figure 4: H2 Fuelling temperature and pressure curve

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