# Hydrogen Technologies in Refueling Station Facilities



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Because of emissions from burning fossil fuels there is an increase in carbon dioxide and global warming. We are moving to greener solutions in different areas and that directly impacts the worldwide transportation system.

Globally, 1.4 billion vehicles were produced until 2021 and by 2035 this number is expected grow up to 1.8 billion. Companies and consumers are looking for green solutions.

Hydrogen use as a fuel for vehicles is already a reality in 2022. But there are many other aspects to be considered in determining how green of a fuel it is. The cost of production is the first thing that comes to mind but the type of source is an important topic to consider as well.

Production of hydrogen is classified with many different colors: for example Grey, Blue, Turquoise and Green.

What basically differs between them is the process and the source, which will be detailed on this document.

Governments around the globe will need to commit to the zero emission vehicles transition where not only hydrogen but also electrical cars will become more popular.

After the COP26 (UN Climate Change Conference in Glasgow) that happened in UK in November 2021, several governments agreed to pursue the zero emission vehicle transition. As an example the US government signed the Infrastructure Law to help move the country into a clean energy transmission.

# Hydrogen Source Types

Hydrogen can be produced from a variety of sources. The most common form still comes from fossil fuels. As countries move to a renewable source they can take advantage of the benefits of producing green hydrogen. Below are listed examples of the different colors of hydrogen which are directly connected to the sources.



# **Grey Hydrogen**

Process: SMR (Steam Methane Reforming) or gasification Source: Methane or coal



# **Blue Hydrogen**

Process: SMR or gasification with carbon capture (85~95%) Source: Methane or coal



Turquoise Hydrogen

Process: Pyrolysis Source: Methane



**Green Hydrogen** Process: Electrolysis Source: Renewable electricity (\*)

(\*) There are other green hydrogen production methods which may include: hydrogen extraction from reformed biogas and hydrogen extraction from waste.

# Hydrogen Station – Delivery to Fueling Process Flow

A typical hydrogen station contains multiple components including: low pressure storage, compressor, heat exchanger, dry cooler, low, medium and high pressure, 4 way valve, hydrogen cooler (down to -40) and a hydrogen dispenser. The below picture illustrates this typical hydrogen fueling system:

### Hydrogen Refueling Fuel Cell Electric vehicles (FCEV) H<sub>2</sub> dispenser Η, Low pressure storage Compressor H, H<sub>2</sub> cooler 4 way valve H, Heat exchanger \*\*\* ØΦ Cooling system H, to get H<sub>2</sub> to -40° \$\$) \$\$) \$\$) \$\$) Delivery storage high pressure Dry cooler ⊗ 🕺 4 way valve DELIVERY STORAGE COMPRESSION PRE COOLING HIGH PRESSURE PIPING

# What are the hazards associated with hydrogen refueling?

# **Hydrogen specifics**

Improper refueling, embrittlement of metallic parts, high pressure, low temperature, hose rupture, breakaway operation

# **Hazardous Locations**

Explosion of a gas cloud, spark ignition, thermal ignition, area classification

# **Functional Safety**

Unintended operation of a critical safety function, leak detection, e-stop, process flow

# **Other hazards**

Risk of Fire, Electric Shock and Casualty

# United States Standards and Codes addressing the hazards

For the United States market the standards addressing the different hazards cover the following areas: hydrogen, hazardous locations, functional safety and ordinary locations – fire, shock and casualty. The table below demonstrates the various standards and its markets.



# **United States Markets**

### Hydrogen specific

- ANSI/CSA HGV Series
- SAE J2600, "Compressed Hydrogen Surface Vehicle Fueling Connection Devices"
- SAE J2601, "Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles"
- UL 2249, "Outline of Investigation for Hydrogen Fuel Dispensing Systems"
- SAE J2799, 70MPa Compressed Hydrogen Surface Vehicle Refueling Connection Device and Optional Vehicle to Station Communication
- USA National Institute of Standards and Technology (NIST) Office of Weights and Measures, Hydrogen Gas -Measuring Devices

### **Hazardous Locations**

- UL 60079 Series
- UL 1203
- UL121201
- UL 913
- NFPA 497

### **Functional Safety**

- UL 1998
- UL991
- IEC 61508 Series
- IEC 61511-1, "Functional Safety Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Application Programming Requirements"

### Ordinary Locations – Fire, Shock and Casualty:

- UL 50E, "Enclosures for Electrical Equipment, Environmental Considerations"
- Part I of UL 508, "Industrial Control Equipment"
- UL 508A, "Industrial Control Panels"
- UL 1238, "Control Equipment for Use with Flammable Liquid Dispensing Devices"
- UL 1995, "Heating and Cooling Equipment"
- UL 61800-5-1, "Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy"
- ANSI/UL508C, "Power Conversion Equipment"
- UL991, "Test for Safety-Related Controls Employing Solid-State Devices"

# International Standards addressing the hazardous

For International market the standards addressing the different hazards cover the following areas: hydrogen, hazardous locations, functional safety and ordinary locations – fire, shock and casualty. The table below demonstrates the various standards and its markets.



# **International Markets**

#### Hydrogen specific

- ISO TS 20100, Gaseous Hydrogen Service Stations
- ISO 17268 Gaseous Hydrogen Land Vehicle Refueling Connection Devices
- ISO 19880-1 Gaseous hydrogen Fuelling stations Part 1: General requirements
- ISO 19880-2 Gaseous Hydrogen Fueling Station Dispensers
- ISO 19880-3 Gaseous hydrogen Fuelling stations Part 3:Valves
- ISO 19880-5 Gaseous hydrogen Fuelling stations
  Part 5: Dispenser hoses and hose assemblies First edition
- ISO 19880-6 Gaseous Hydrogen Fueling Station Fittings
- ISO 19880-8 Gaseous Hydrogen Fueling Station Part 8: Hydrogen Quality Control

## Hazardous Locations

- IEC 60079 Series
- IEC 60079-10-1, "Classification of Areas Explosive Gas Atmospheres"

### Functional Safety

- IEC 61508 Series
- IEC 61511-1, "Functional Safety Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Application Programming Requirements"

### **IECEx System**

- Proposed H2 Dispenser program based on IEC60079-46 and references to ISO 19880 standard series
- CoPC Ex011 for Hydrogen Safety A hydrogen dispensing system may be constructed with the following USA standards:
  - Dispenser: HGV 4.1
  - Hose: HGV 4.2
  - Hydrogen fueling parameter evaluation: HGV 4-3
  - Gaseous hydrogen Fuelling stations Valves: HGV 4.4
  - Compressor guidelines: HGV 4-8
  - Hydrogen fuelling stations: HGV 4.9
  - Fittings: HGV 4.10
  - Compressed hydrogen surface vehicle connection devices: SAE J2600
- Breakaway: HGV 4.4, Manual valves: HGV 4.6 and Automatic valves: HGV 4.7 were incorporated into Gaseous hydrogen — Fuelling stations Valves: HGV 4.4.



# What are the safety certifications available and how UL can support?

The certification solutions can be summarized in two levels:

- Component level certification
- System level certification

UL offers the following types of certifications:

#### Certificate

Third party attestation related to products, processes, systems or persons. This is a broad term that covers various service offerings that are provided by NRTLs.

#### Listed

Defined in the codes as "Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose."

#### **Recognition or Recognized Component**

Components or materials that are evaluated and intended for use in a complete product or system, because

incomplete in construction features or testing. These components are intended only for end-use products that may be eligible for certification.

#### **Limited Production Certification**

A process where a single unit or a limited quantity of production undergoes the full construction review, testing evaluation, and then a certification decision is made. This results in the witnessing the application of a Certification Mark after the inspection of each piece of equipment.

# For component or system level certification, UL has a solution to address different demand and customer needs.

#### **Field Evaluation**

Assistance for an Authority Having Jurisdiction (AHJ) in the process of determining "acceptance" of a product leading to "approval" of the installation. Limited to the jobsite installation. The evaluation process consists of documentation review, limited testing, and inspection of the equipment.

# Hydrogen Fuel Dispensing System Certification

According to CSA/ANSI HGV 4.1 Standard for hydrogendispensing systems - 5.12.2 Risk assessment the manufacturer of the HFS shall conduct a safety review that shall include the review of the safety analyses of supplied systems and equipment.

The safety analyses may include a Hazardous Operations Review (HAZOP), or an FMEA, or equivalent risk assessment intended to identify failures that have significant consequences affecting the fueling station operation.

Risk assessments are also required in NFPA 2, Hydrogen Technologies Code, and HGV 4.9, Hydrogen Fueling Stations. The system certification plan will depend on a review of the risk assessments in these standards. UL 2249 standard was developed by UL experts to cover siteassembled and modular gaseous hydrogen fueling stations (HFS) intended to dispense hydrogen to hydrogen fuel vehicles for automotive applications.

The systems may include electronic controls and software to compress, store, cool and transfer the hydrogen from the station storage and/or compressor systems to the vehicle fuel tank. The system may include modular delivery, compression, storage and dispensing equipment that is intended to operate in conjunction as a system.





# Other Hydrogen Related Service Offerings

#### **Fuel Cell Module Certification Offerings**

- UL 2262 Outline for Fuel Cell Modules for Use in Portable and Stationary Equipment
- IEC 62282-2-100 Fuel cell technologies Part 2-100: Fuel cell modules – Safety (Cert)

#### **Industrial Truck Fuel Cell Certifications**

- UL 2267 Fuel Cell Power Systems for Installation in Industrial Electric Trucks
- IEC 62282-4-101 Fuel cell technologies Part 4-101: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) – Safety of electrically powered industrial trucks

#### **Stationary Fuel Cell Certification Offerings**

- ANSI CSA FC1 Fuel Cell Technologies Part 3-100: Stationary Fuel Cell Power Systems
- IEC 62282-3-100 Fuel Cell Technologies Part 3-100: Stationary Fuel Cell Power Systems

#### Hydrogen Generators

- UL 2264A Outline for Water Electrolysis Type Hydrogen Generators
- UL 2264B Outline for Hydrogen Generators Using Water Reaction
- UL 2264D Outline for Portable Water Electrolysis Type Hydrogen Generators
- UL/CSA FC4 (Under development)

#### Engine Generators Fueled by Hydrogen and Hydrogen Blends

- UL 2200 (CRD) Stationary Engine Generator Assemblies
- ANSI/CSA America FC 3 Portable Fuel Cell Power Systems

### **Energy Storage Systems and Equipment**

• UL 9540 Energy Storage Systems and Equipment

#### **Other Hydrogen Component Standards**

- UL 147 Hand-Held Torches For Fuel Gases
- UL 252 Compressed Gas Regulators
- UL 252A Compressed Gas Regulator Accessories
- UL 404 Gauges, Indicating Pressure, for Compressed Gas Service
- UL 429 Electrically Operated Valves Currently allows some leakage.
- UL 1357 Outline for Oxygen-Fuel Gas Combination Flash Arrester and Backpressure Check Valves
- UL 1358 Outline for Compressed Gas Check Valves and Hose Couplers
- UL 1477 Outline for Compressed Gas Shutoff Valves



# Regulatory Assessment Services for Industrial Systems | UL Solutions

# A curated regulatory mapping

- The Regulatory Assessment Service for Industrial Hydrogen Systems collects publicly available and authoritative information about technical regulations that impact safety, health and the environment, resulting in the creation of Technical Regulations and Standards (TRS) reports specific to the client's system and destination markets. This report also identifies the mandatory requirements to those critical parts of the product and system.
- The TRS report allows clients to develop a regulatory strategy for timely and cost-efficient market entry, including requirements for sustaining the regulatory compliance into operations and product and system retirement.

Learn more at <u>UL.com/services/solutions/hazardous-locations</u>.



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