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Section on Prevention in the Chemical Industry
Section on Machine and System Safety

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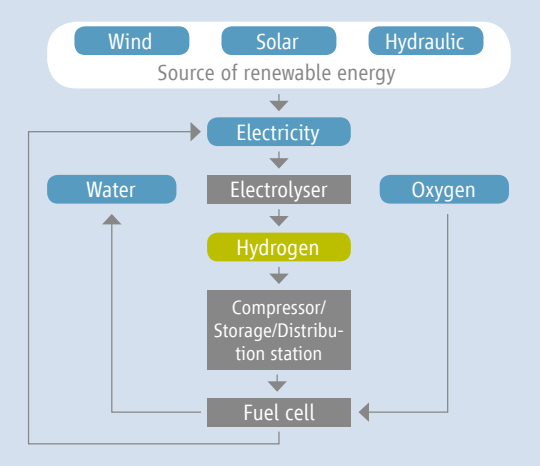
Factsheet on Explosion Protection

Hydrogen production and use in fuel cells

001

Introduction

At a time when renewable energy sources are being sought, hydrogen appears to be one such essential source. This new "energy carrier" is promising, particularly because it can be part of a virtuous circle, as illustrated by the diagram below.



Hydrogen characteristics

- Hydrogen (H_2) is the smallest existing molecule
- Under normal conditions, it is a colorless, odorless and tasteless gas
- It is the lightest of gases, it spreads rapidly in the atmosphere, is extremely flammable and, combined with air, it forms an explosive atmosphere
- The flame is almost invisible and very hot (2045 °C)

Properties Hydrogen	
Flammable limits	4 – 75 Vol.-%
Minimum ignition energy	0.02 mJ
Auto-ignition temperature	585 °C
Density relative to air	0.07
Gas/vapor classification (ISO/IEC DIS 80079-20-1)	II C

Production of hydrogen

- Hydrogen cannot be recovered directly from nature
- Two main production methods: water electrolysis or methane reforming

Storage of hydrogen

Three main forms of storage

- Under pressure (200 – 900 bar)
- In liquid form (–253 °C, 1 liter of liquid equals 844 liters of gas at 15 °C and 1013 mbar)
- In solid form (as metal hydrides, extremely violent reaction with water, can auto-ignite in air)

Main risks

- Originating from hydrogen:
- fire/explosion, material incompatibility
- Originating from the entire system:
- pressure, cold temperature, electricity

Main preventive and protective measures when using hydrogen

Technical measures

- Materials for the entire system must be suitable for hydrogen
- Pipeline network protected against shocks, welded connections
- Earthed installations
- Permanent ventilation
- Gas detectors (atmosphere surveillance, leak detection …) coupled with measures to secure the installation (10 % LEL: stopping the installation; 25 % LEL: measures to secure and purge the installation, evacuation)
- Pipeline network: purge and nitrogen inerting system
- Manual or automatic fire extinction system (fire extinguishers, fire hose, water curtain …)
- General emergency stop (easily accessible from a safe place)

Worksite design
- Dedicated area, separated from other plants/facilities, exhaust openings under the ceiling
- Pressure storage tanks outside

Organisational measures
- Identification (plant, pipes …) and safety signs
- Classification of ATEX zones
- Operations on the installation
  (1) Work Permit System including metrological clearance
  (2) Separation of material and energy flows, securing the installation (by logout/tagout for example)
  (3) Rules applicable to hot work
- Employee training

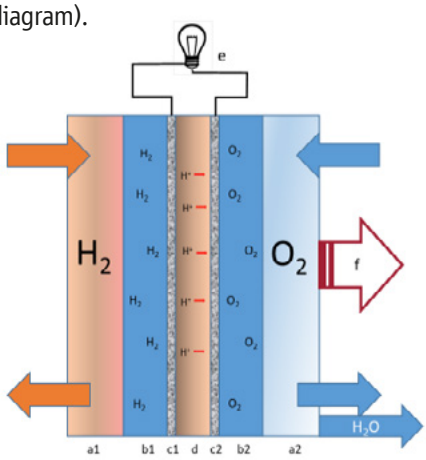
Fuel cells

Fuel cells, particularly hydrogen fuel cells, are often presented as an interesting alternative to conventional methods for producing electricity. Applications are expanding and are increasingly present on the market as a temporary solution or as a permanent source of energy for forklift trucks, vehicles, heating installations, etc. Power plants also intend to acquire fuel cells in order to store energy using hydrogen.

How does it work?

Fuel cells are comprised of two electrodes, one of which is in contact with hydrogen (H_2) and the other with oxygen (from air; O_2). The electrochemical reaction produces water, heat and electricity (see diagram).

a1, a2 gas supply
b1, b2 diffusion controlled area
c1 anode
d proton exchange membrane
c2 cathode
e electrical loads
f heat release



Specific preventive and protective measures at each process stage

Power station (production and / or storage) and network
- Sufficiently large distance to the distribution station
- Fire protection of surrounding buildings and facilities/installations

Distribution station
- Sufficiently large distance to the power station
- Hold-to-run system during filling
- Pipeline purging with nitrogen (between storage and distribution) after filling
- Emergency stop that can be activated from a safe area

Fuel cell (on a vehicle etc.)
- Protection of the tank against shocks
- An explosive atmosphere is regularly formed when hydrogen is used to remove the water that forms on the fuel cell membrane (particularly in proton exchange membrane fuel cells); the position of the water vent should be optimised in particular
- Controls (pressure, temperature, water level …)

Further literature

Background information on hydrogen technologies is given in, e. g.:

» www.nrel.gov/docs/fy15osti/60948.pdf
» https://www.hydrogen.energy.gov

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