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Regulations, Codes and Standards FOR FIRST RESPONDERS

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Hydrogen Energy – New Challenges

PRODUCTION	TRANSPORT	STORAGE	Applications Old: more than 50 years	Hazards
- Steam Reformer Old / P <10 bar - Electrolyzer Old / P <25 bar	- Gas Old P <300 bar / Type I & II New P<700 bar / Type III & IV - Liquid Old P <10 bar / T°: -253°C- - Pipe Old / P <100 bar	- Gas Old P <300 bar New / P <1100 bar - Liquid Old P <10 bar / T°: -253°C - Cryo-compress Old P <300 bar / T°: -100°C - Solid New P <10 bar / Magnesium	- Nuclear Power plant - Glass industry - Air Space - Chemistry industry - Agro industry	- Cylinder burst ⇒ Overpressure - Gas explosion ⇒overpressure & Thermals effects - Jet fire ⇒thermals effects

New challenges to consider now:

$$\mathbf{H_2Energy = H_2 + High\ Pressure + Public\ Area}$$

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Introduction – Standardization is coming

Cars	Buses	Forklifts
- P: 700 bar	- P: 350 bar	- P: 350 bar
- Volume V: 140 l	- Volume V: 640 to 960 l	- Volume V: 15 to 80 l
- On-board tanks: 2 type IV	- On-board tanks: 8 to 12 type III or IV	- On-board tank: 1 type II or III
- kg of H2: 5 – 7	- Kg of H2: 35 - 50	- Kg of H2: 0,5 to 2
- TPRD release : left rear	- TPRD release : up from the roof	- TPRD release : in the box

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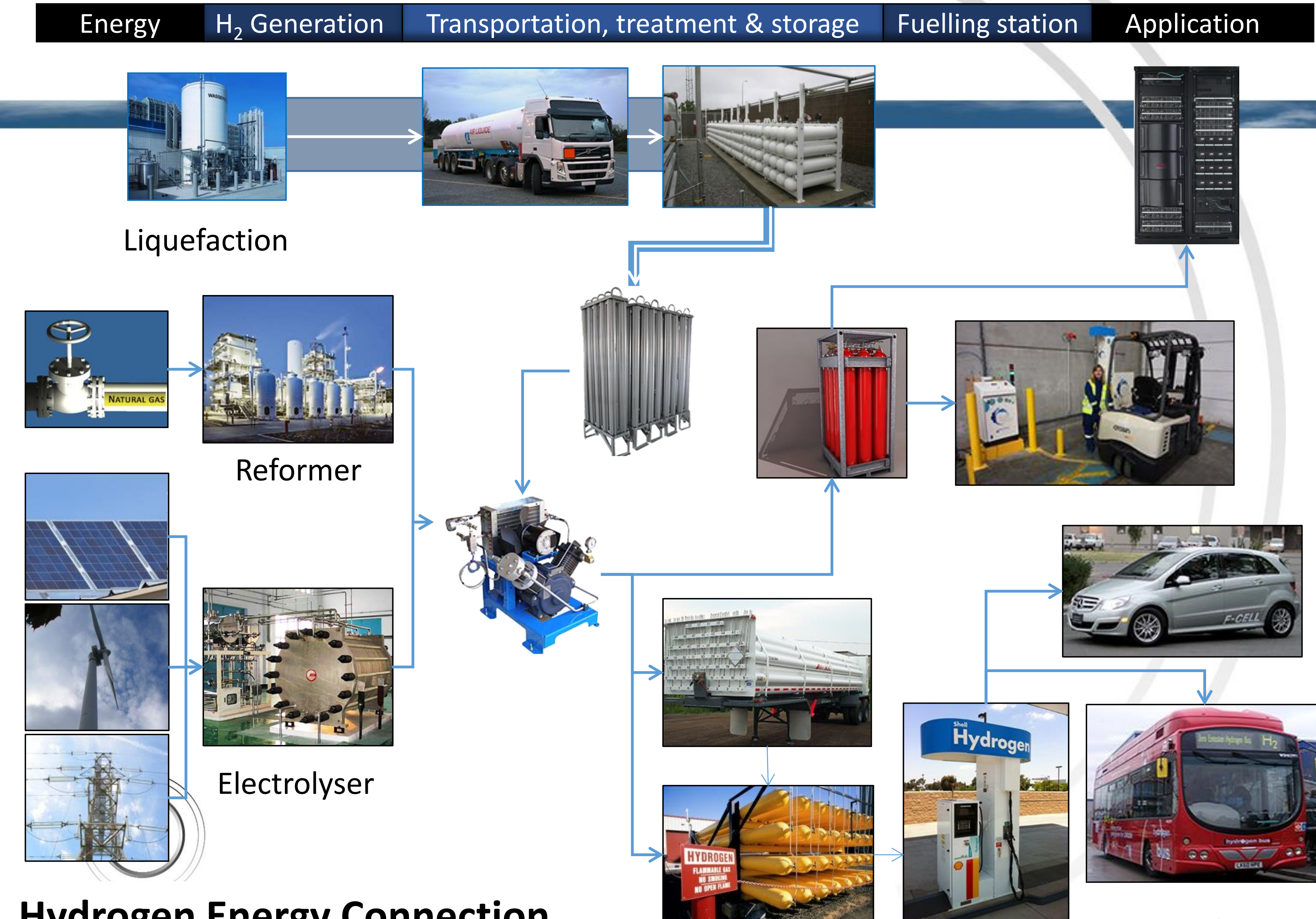

Hydrogen Energy Connection

Content

- **Regulations, Codes and Standards (RCS)**
  - introduction
  - short RCS list of fuel cell and hydrogen (FCH) standards
- **Hydrogen production, storage, transportation and distribution**
- **FCH applications - some examples**
  - hydrogen refueling stations (HRS)
  - stationary fuel cell power systems
  - fuel cell electric vehicles
- **Prescriptive and performance-based approach to hydrogen safety**
  - hydrogen properties(ISO/TR 15916:2015)
  - primary hazards (ISO/IEC Guide 51:2014)
  - fire safety engineering principles for buildings (BS 7974:2001)

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Regulations, Codes & Standards

Introduction

Short List

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What is RCS
- definitions from ISO/IEC Guide

- **Regulation:** Is a document providing binding legislative rules, that is adopted by an authority
- **Technical regulation:** Regulation that provides technical requirements, either directly or by referring to or incorporating the content of a standard
- **Code:** A set of guidelines set forth and enforced by a local government agency for the protection of public safety, health, etc.
- **Standard:** A document, established by consensus and approved by a recognized body, that provides for common and repeated use
- **International standard:** A standard that is adopted by an international standards' organization and made available to the public. Examples: ISO, IEC.

What is RCS
- general information

- The ISO and IEC work results in international agreements, which are published as international standards. These international standards are: voluntary, market driven and globally relevant.
- In Europe, the equivalent international bodies are CEN and CENELEC who work under agreements with ISO and IEC to avoid duplication of efforts.
- At this early stage of FCH technology, there are not too many published RCS available.
- Standards provide a set of technical requirements based on input of experts.

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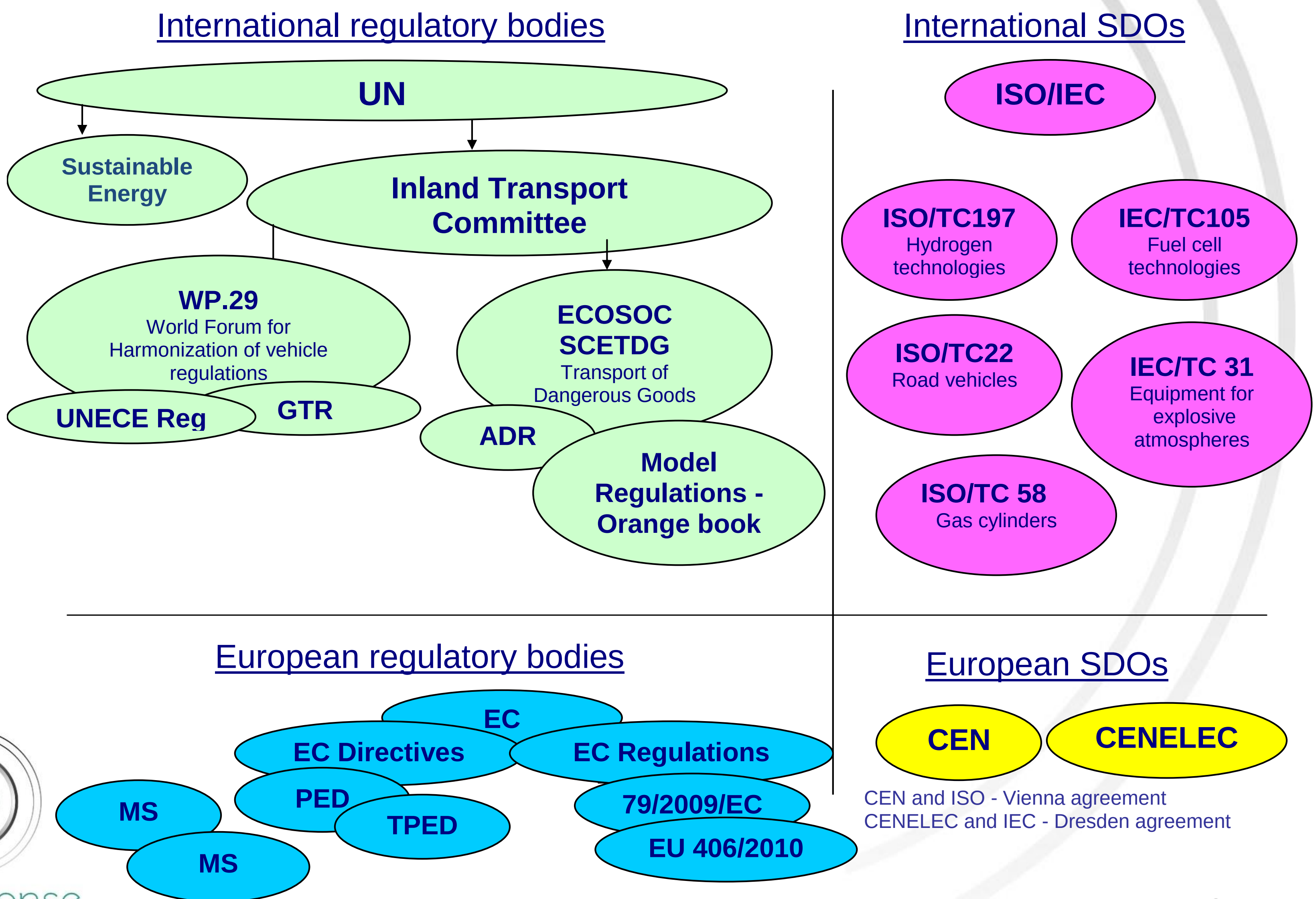
New Energy World JU
fuel cells & hydrogen for sustainability

International and European RCS bodies



European Commitment to RCS

- In 2014, a Directive for the deployment of alternate fuels infrastructure was published:
  - 2014/94/EU Alternate Fuels Infrastructure directive (AFID)
- In 2009, The EXPRESS report Standardization *for a competitive and innovative Europe: a vision for 2020»* http://ec.europa.eu/enterprise/express recommended that:
  - CEN and CENELEC support international standards (ISO/IEC) wherever possible unless the need is uniquely European.
  - Where a European standard is needed, consideration be given from the outset to its potential future contribution to international standardization.
- CEN has a Vienna agreement with ISO
- CENELEC has a Dresden agreement with IEC
- Strategic Coordination in Europe of RCS for alternate fuels is being planned by:
  - CEN/CENELEC/SFEM/HEWG and FCH JU/Hydrogen Europe

United Nations

- **World Forum for Harmonization of Vehicle Regulations (WP.29)**
  - Working on revision of GTR:2013 for hydrogen and fuel cell vehicles
  - Working on the revision of the UN ECE Regulations applicable to electric power train (UNECE R100) and Hydrogen and fuel cell vehicles (UNECE R134)
- **ECOSOC Sub-Committee of Experts on the Transport of Dangerous Goods**
  - Working on the development of UN Recommendations on the Transport of Dangerous Goods (Orange Book) (e.g. UN 3468: Hydrogen in a metal hydride storage system)
  - Working on the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)

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WTO/TBT

(159 members)

- The World trade Organization (WTO) has established a strategic partnership with ISO and IEC, the International Standards Development Organizations
  - **ISO** – International Organization for Standardization - 162 members
  - **IEC** – International Electro-technical Commission - 84 members
- The WTO recognizes the important contribution that international standards make towards the removal of Technical Barriers to Trade (TBT)

For Color document

- ISO and IEC work results in international agreements, which are published as **International Standards**. These international standards are:
  - Based on the principle of consensus
    - Standards provide a set of requirements set up by experts.
    - Standards do not articulate a safety approach.
    - FCH technologies are at an early stage so few standards are available.

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Regulations, Codes & Standards

Introduction

Short List

International Standards Short list

- **UN ECE World Forum for Harmonization of Vehicle Regulations (WP.29)**
  - GTR:2013 for hydrogen fuelled vehicles
- **UN ECOSOC Sub-Committee of Experts on the Transport of Dangerous Goods**
  - Orange Book and ADR:2015
- **79/2009/EC Regulation** on Type Approval of hydrogen-powered motor vehicles.
- **EU 406/2010 implementing the above regulation**
  - **97/23/EC** Directive on the approximation of the laws of the Member States concerning pressure equipment (PED)
  - **2010/35/EU** Directive on transportable pressure equipment (TPED)

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International Standards Short list

- **BS 7974:2001** Application of fire safety engineering principles to the design of buildings. Code of practice
- **EN 60079-10-1:2015** Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres.
- **ISO/TR 15916:2015** Basic considerations for the safety of hydrogen systems.
- **ISO 26142:2010** Hydrogen detection apparatus – Stationary applications

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International Standards Short list

ISO 22734-1:2008 Hydrogen generators using water electrolysis process – Part 1: Industrial and commercial applications.
ISO 22734-2:2011 Hydrogen generators using water electrolysis process – Part 2: Residential applications
ISO 16110-1:2007 Hydrogen generators using fuel processing technologies – Part 1: Safety
ISO 16110-2:2010 Hydrogen generators using fuel processing technologies – Part 2: Test methods for performance
ISO/TS 20100:2008 Gaseous hydrogen - fuelling stations (Note: This standard has been withdrawn.)
ISO/TS 19880 -1:2016 Gaseous hydrogen - fuelling stations- Part 1: General Requirements
ISO/TS 15869:2009 Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks

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International Standards Short list

- **IEC 62282-3-100:2012** Fuel cell technologies – Stationary fuel cell power systems - Safety
- **IEC 62282-3-200:2015** Fuel cell technologies – Stationary fuel cell power systems – Performance test methods
- **IEC 62282-3-201:2013** Fuel cell technologies – Stationary fuel cell power systems - Performance test methods for <u>small</u> systems
- **IEC 62282-3-300:2012** Fuel cell technologies – Stationary fuel cell power systems – Installation
- **IEC 62282-4-101:2014** Fuel cell technologies – Fuel cell power systems for propulsion other than road vehicles and auxiliary power units - Safety of electrically powered industrial trucks
- **IEC 62282-5-1:2012** Fuel cell technologies – Portable fuel cell power systems – Safety

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Hydrogen production, storage, transportation and distribution

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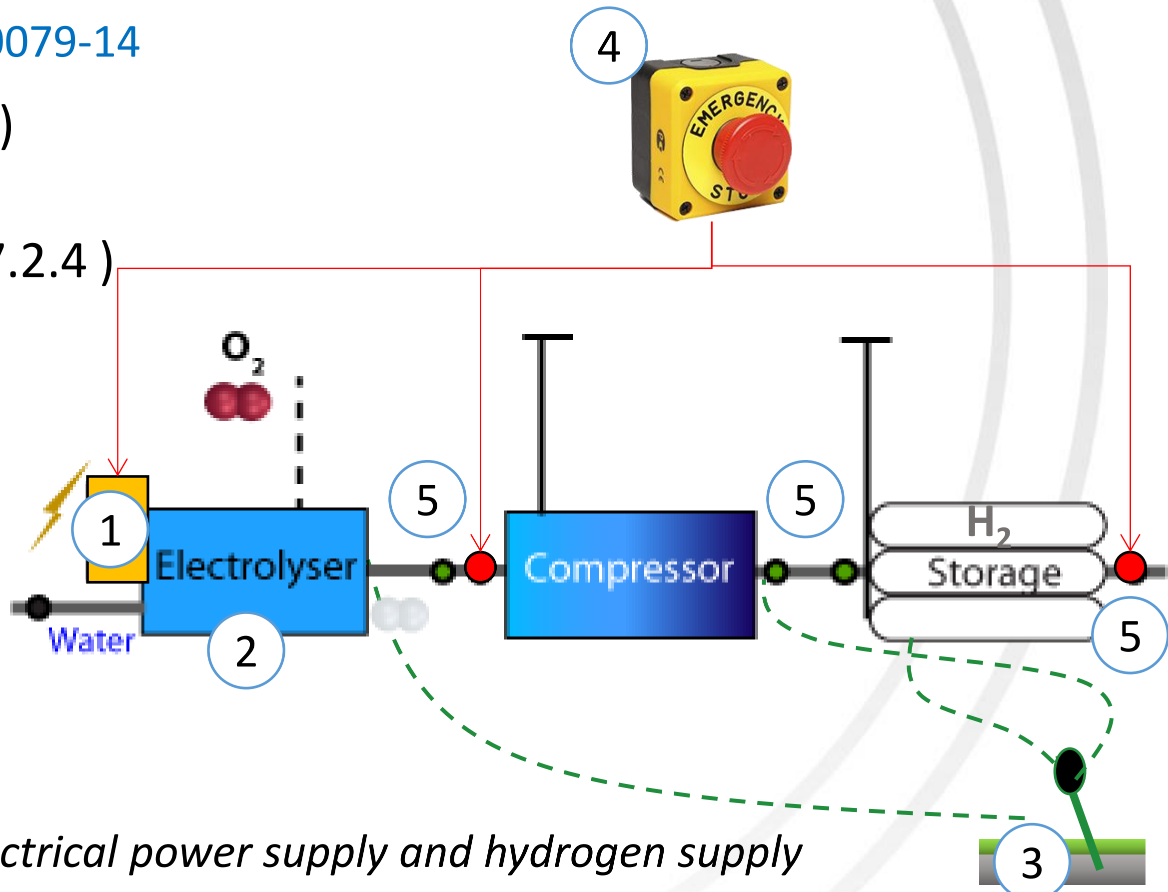
ISO 22734 - Hydrogen generators using water electrolysis process

(summary of requirements)

1. Electrical **components** IEC 60079-0
2. Electrical **installations** IEC 60079-14
3. Grounding & Bonding (cl 6.2.2)
   IEC 60204-1
4. ESD (emergency shut down) (cl 7.2.4)
   IEC 60204-1 & ISO 13850
5. Shutoff valves(cl 5.4.9)
   ASOV (automatic)
   MSOV (manual)



Note: The ESD

- *Shuts off electrical power supply and hydrogen supply*
- *Closes all the automatic shut off valves in the hydrogen system*
- *Shuts down the hydrogen system*

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ISO 22734 -Hydrogen generators using water electrolysis process

(summary of requirements)

6. Classification of hazardous areas IEC 60079-10 Explosive atmospheres *Part 10*
7. PRV's Rupture disk or spring loaded VENTS (cl 5.4.7)
   ISO 41261-2 / 41261-1 or ISO 16528-1
8. H2 detectors (cl 6.1.9)
   IEC 60079-29-1&2 and ISO 26142 Hydrogen detection apparatus
9. Enclosure IEC 60529 Environment class IP22 / ISO 1182 Fire resistance

10. Oxygen Venting (cl 11.6)
11. Compressor IEC 60034-1
12. Purification ISO 14687
    H2 rate, P, T & Quality

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ISO 22734 -Hydrogen generators using water electrolysis process (summary of requirements)

13. Ventilation openings (cl 5.3.6)
14. Fans & ventilators (cl 5.7)
15. Heat transfer system (cl 5.8)
16. Piping ISO 16258-1 or ISO 15649
17. Cylinders & tubes for stationary storage ISO/CD 19884

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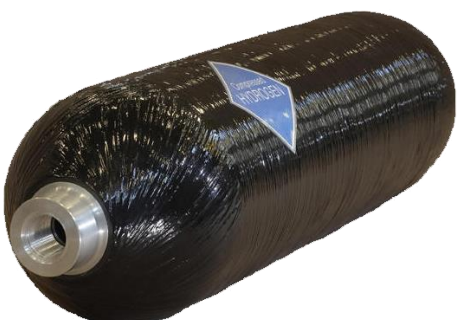
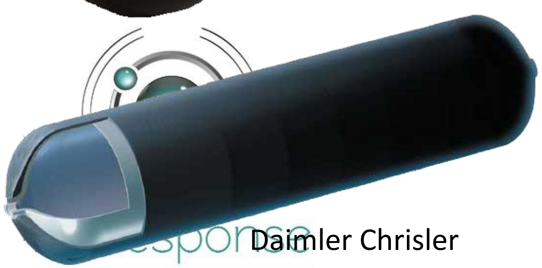
ISO 22734 -Hydrogen generators using water electrolysis process (summary of requirements)

Built-in Pressure Storage Cylinders (cl 5.4.1)

Hydrogen	
Aluminium	ISO 7866
Steel	ISO 9809-1
Composite	ISO 11119-1
Fully wrapped	ISO 11119-2 & 3
Vessels	ISO 16528-1 or equiv

Oxygen	
Steel	ISO 9809-1&2 &3
	ISO 4706





Daimler Chrisler

cl 5.4.3.2 Separation of O_2 & H_2 cylinders

H_2

D_{min}: 3 m

Or …

O_2

…non-combustible partition w 60 m firing rate ISO 834-1

Area classification

As per:

→ IEC 60079-10-1 *Electrical apparatus for explosive gas atmospheres — Part 10-1: Classification of hazardous areas*

→ Three (3) Zones (cl 4.3)

→ based on the frequency of occurrence and duration of an explosive gas atmosphere

Zone	Context	Occurence	
		Frequency	Duration
0	All	Frequently	• Continuous • Long Period
1	Normal operation	Occasionally	• Short period
2	Normal operation	Not likely	• Short period

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Hydrogen Transportation and Distribution

UN regulation: ADR

EC Directive: 2010/35/EU
Transportable Pressure
Equipment (TPED)

Air Liquide


Praxair

Liquid


Praxair

Gaseous

ISO 17519 Gas cylinders Refillable permanently mounted composite tubes for transportation
(450 -10 000 l)

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FCH Applications

- Hydrogen refuelling stations
- Stationary FC power system
- FC Electric Vehicle

FCH Applications

- Hydrogen refuelling stations
- Stationary FC power system
- FC Electric Vehicle

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Typical fueling stations

1. On-site production (Electrolysis – Reforming)
2. Gaseous delivered – Compressor-purifier / Gaseous buffer Storage / Dispenser
3. Liquid delivered / Liquid storage (ISO 21009-1) / Cryogenic pump (ISO 24990) / Evaporation unit / Gaseous buffer storage / Dispenser


UC Irvine 3rd gen HRS

bmw-wasserstoff-7er


Liquid Air – Swarm Project Birmingham

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Gaseous hydrogen – fuelling station

Electrical grounding of delivery vehicles **prior** to hose connection (cl 5.1.2)

Tube trailer (cl 5.2.1)

- Not located near occupied building or any potential hazard
- Accessibility to tractors and firefighting services at all time
- Minimum clearance 1 m on all sides


Ceekay.com

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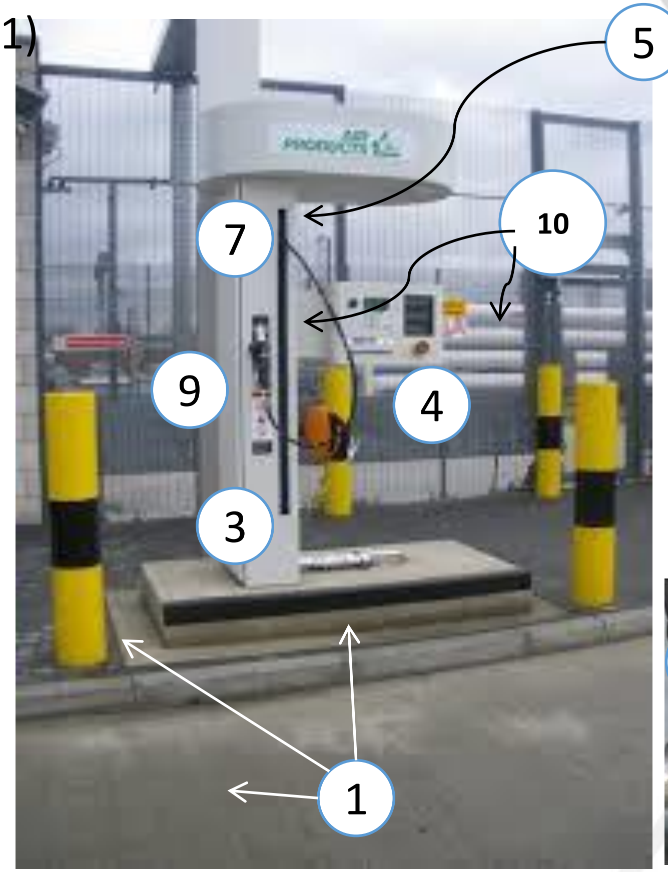
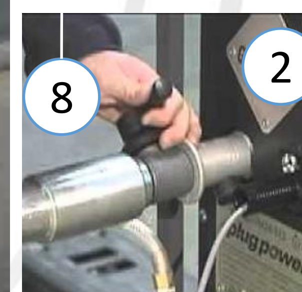
Gaseous hydrogen – fuelling station

1. Location and protection of dispenser (cl 11.1)
2. Nozzle & receptacle at good ground connection before connection
3. Non combustible – antistatic materials
4. ESD (cl 11.8.3)
5. Hose break-away device (cl 11.5)
6. End of fill control (cl 11.7.2)
7. Excess flow control (cl 11.8.2) in case of fuelling hose rupture
8. PRD to prevent over pressure in vehicle storage (cl 11.8.1)
9. Impact sensors at dispenser
10. PRD for all pressurized gaseous systems (cl 16.3) ISO 16528-1



Air Liquide



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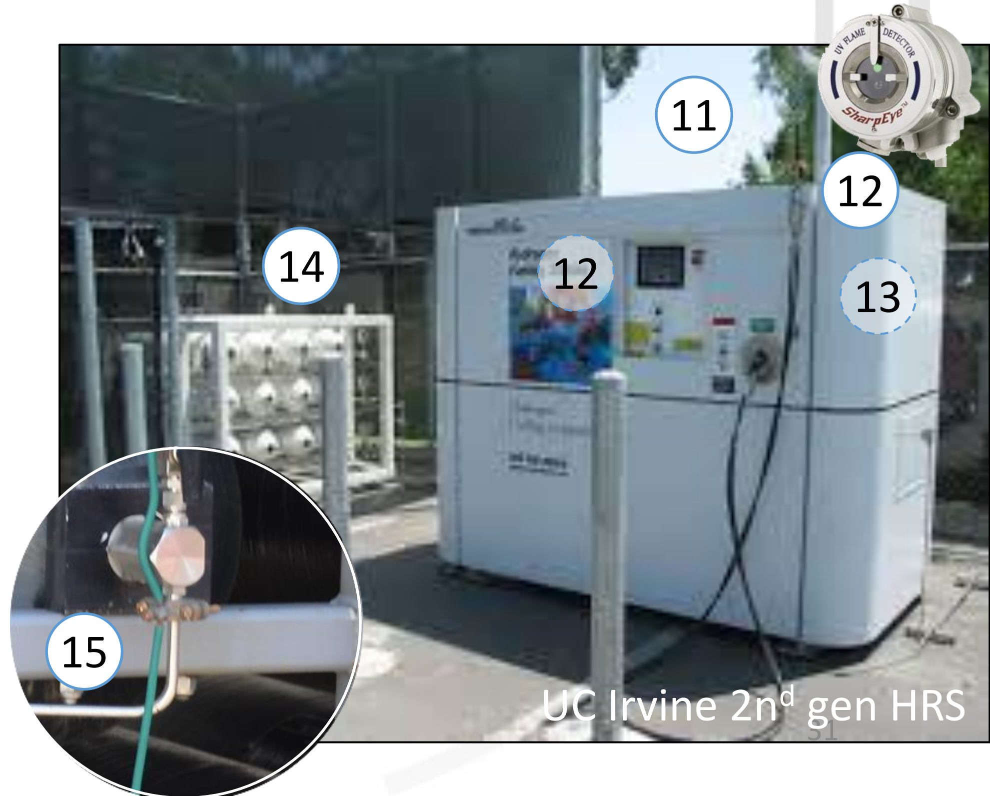
Gaseous hydrogen – fuelling station

11. Gaseous vents & venting to safe location (cl 17)
    - Separate vent for high and low pressure
    - Including PRD'S vents
12. Fire detection system (UV sensors) for hydrogen-free fire and detection of other fire hazards (cl 20.2)
13. H2 gas detectors

14. Tanks and associated piping & flanges grounding & bounding (cl 16.5)
    IEC 60204-1
15. Lightning protection (cl 21.2) – major structure bounded directly to ground

    IEC 62305



UC Irvine 2nd gen HRS

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Gaseous hydrogen – fuelling station

Nozzle main characteristics

- Safe flow connection
- Closed loop design
  - No leaks
- Incorporated Pressure Control
  - Pressure Relief Valve
  - Vent line connection (not all)
  - Tank filling limiting device
- Integrated Flow Control
- Dissipate static electricity by design

35 MPA 70 MPa

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Gaseous hydrogen – fuelling station

Indoor refuelling

of Forklifts

Air Liquide

Plug Power

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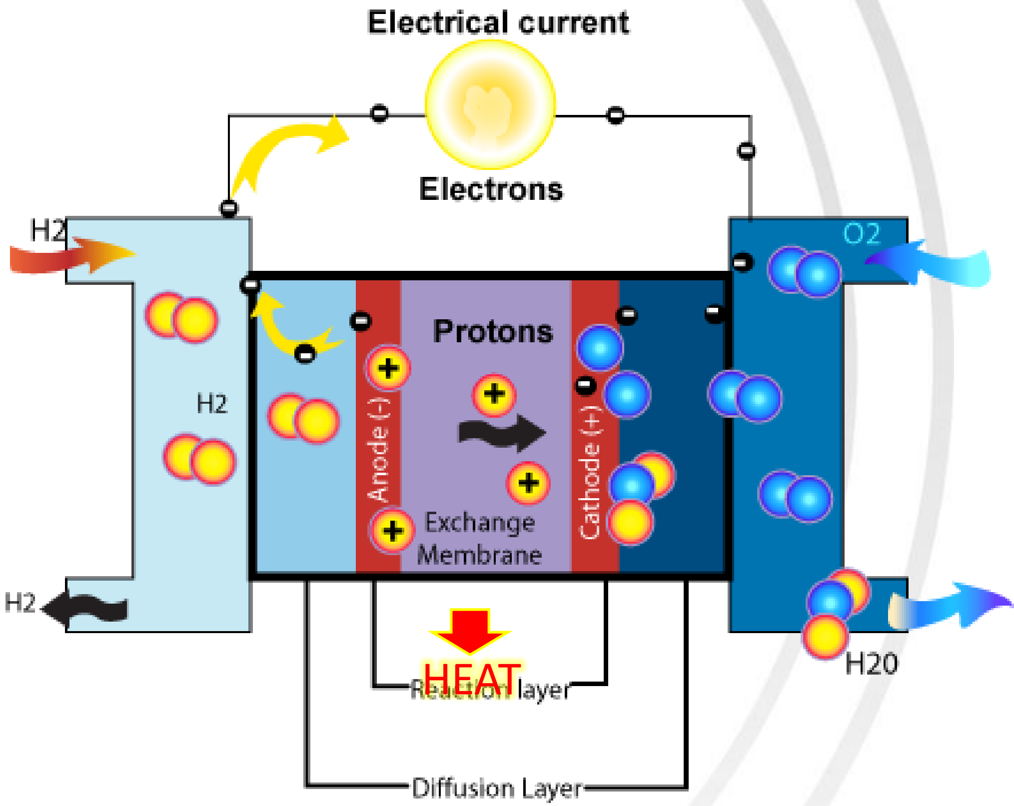
FCH Applications

- Hydrogen refuelling stations
- Stationary FC power system
- FC Electric Vehicle

Plug Power Oldenburg Valliant

Fuel Cell Module – How a fuel cell works

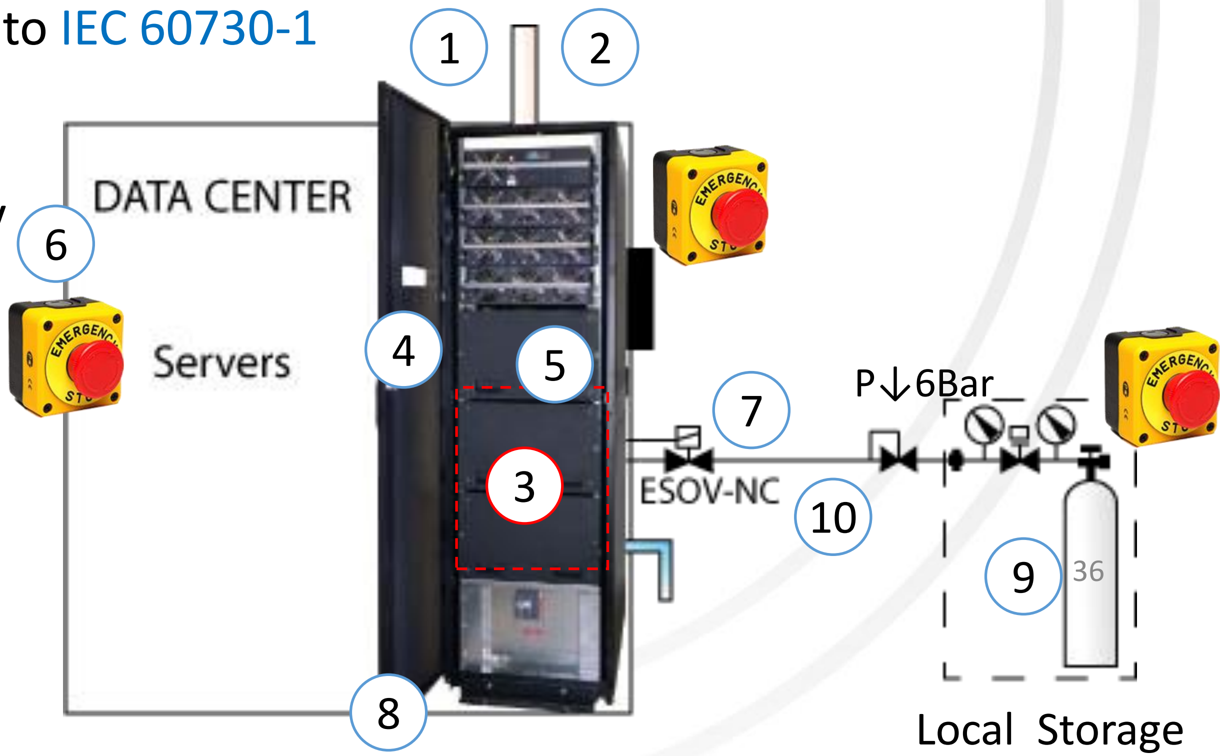
1. Basic structure: A fuel cell is composed of an anode, a cathode and an electrolyte membrane.
2. Inputs: Hydrogen is passed through the anode while oxygen is through the cathode.
3. Principle: At the anode, the hydrogen molecules are split into electrons and protons.
4. Outputs:
   - These electrons are driven from anode to cathode through a circuit generating electric current and heat.
   - At the cathode the protons, electrons and oxygen combine to produce water molecules.



Electrolyte: polymer membrane (PEM)

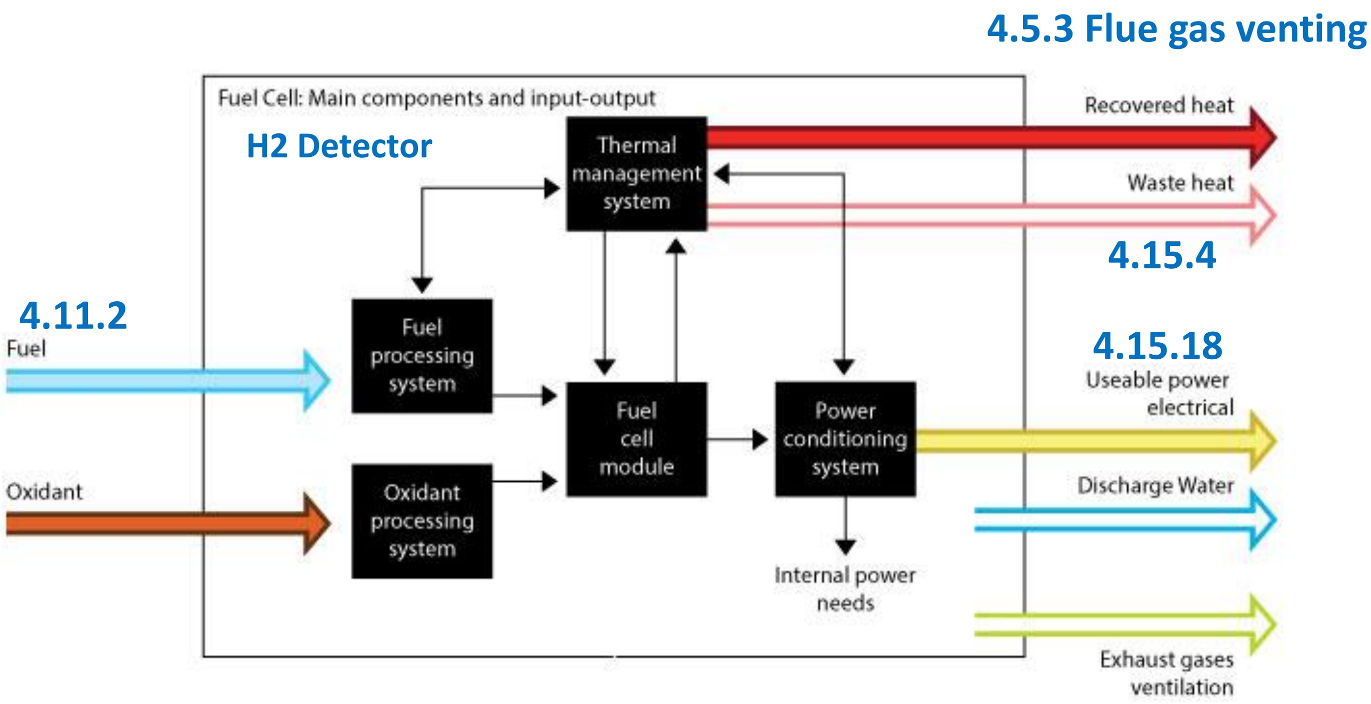
FC power system

1. Purging (cl 4.2.8)
2. Flue gas venting (cl 4.5.3)
3. Fuel compartment (cl 4.6.1)
4. EMC (electromagnetic compatibility - cl 4.8) IEC 61000-3-2/3/4/5/11; IEC 61000-6-1/2/3/4;
5. Automatic electric & electronic Control System (cl 4.9.2) residential, commercial and light industrial conform to IEC 60730-1
6. ESD (cl 4.9.2.3.1) ISO 13850
7. Valves (cl 4.11) min: 2 ASOV
8. Cabinet (cl 4.13)
9. If Metal hydride ISO 16111
10. Piping system ISO 15649



Cabinet Gas detector
- Keep [H_2] under 25% LFL
- Interlocked with ASOV'S
- FC shut down

Main fuel cell components



Fuel Cell corresponds to the reverse electrolysis process.
The graphic shows the main constituents of a fuel cell, though,
It requires many auxiliary services, such as removing waste heat, discharging water, etc

4.4.11 Allowable temperature IEC 62282 -3 -100 Ed.1.0

Part	Temperature rise * °C
External enclosures, except handles held in normal use	60
Surfaces of handle, knobs, grips and similar parts which are held for short periods only in normal use: • of metal	35
• of porcelain	45
• of moulded material (plastic), rubber or wood	50

Note 1: Maximum surface temperature rises above ambient of external surfaces that may be contacted by people during operation without PPE. Values ref. in table 3 of IEC 60335-1:2010

* Based on ambient temperature of 25°C.

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Fuel Cell can be seen on many applications

Source :Ballard

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FCH Applications

- Hydrogen refuelling stations
- Stationary FC power system
- FC Electric Vehicle

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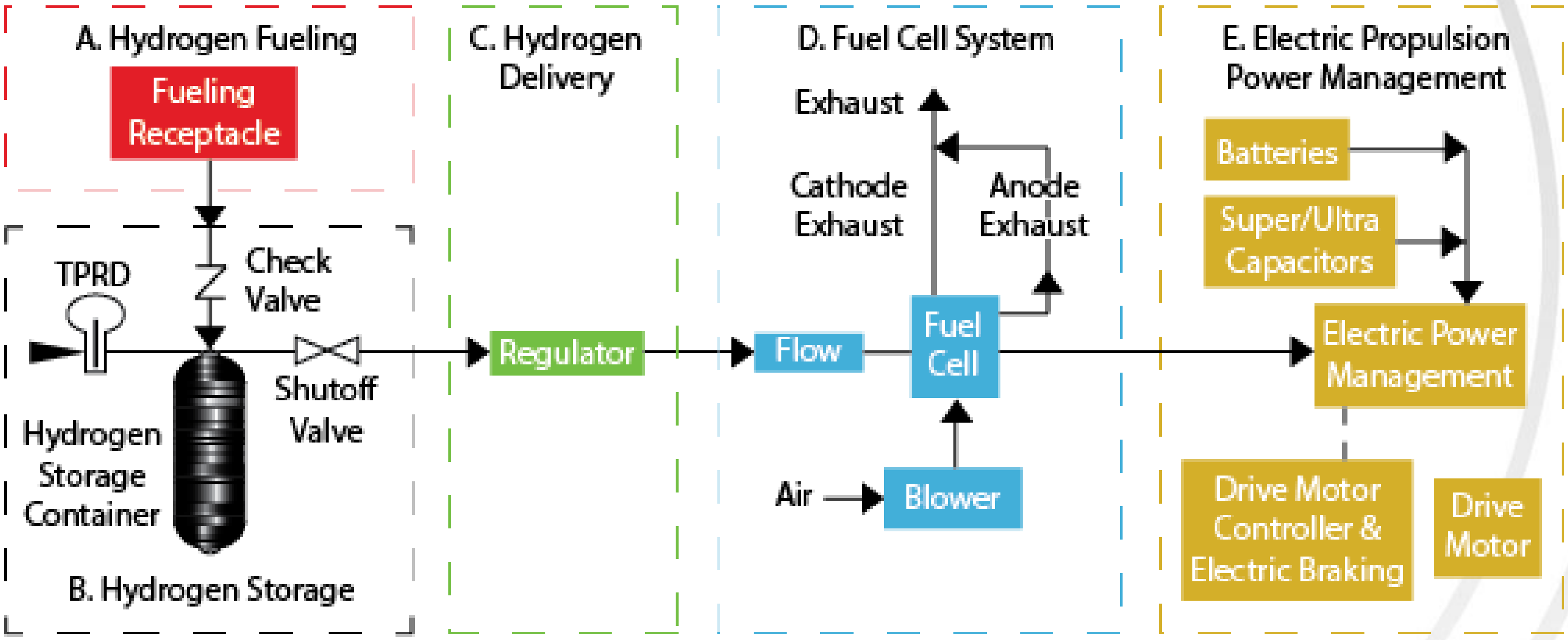
FCEV - Systems



Source: ECE/TRANS/WP.29/2013/41

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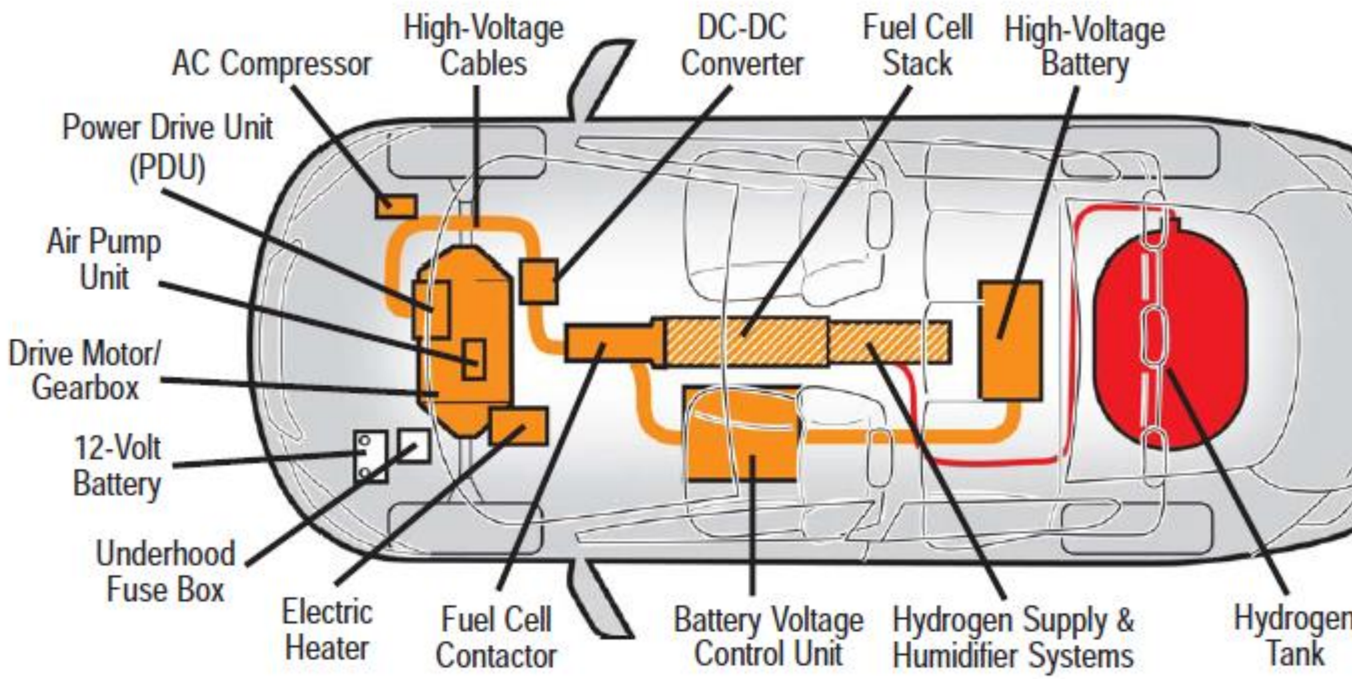
FCEV- Honda FX Clarity case

- component location: top view



Honda Clarity ER Guide C

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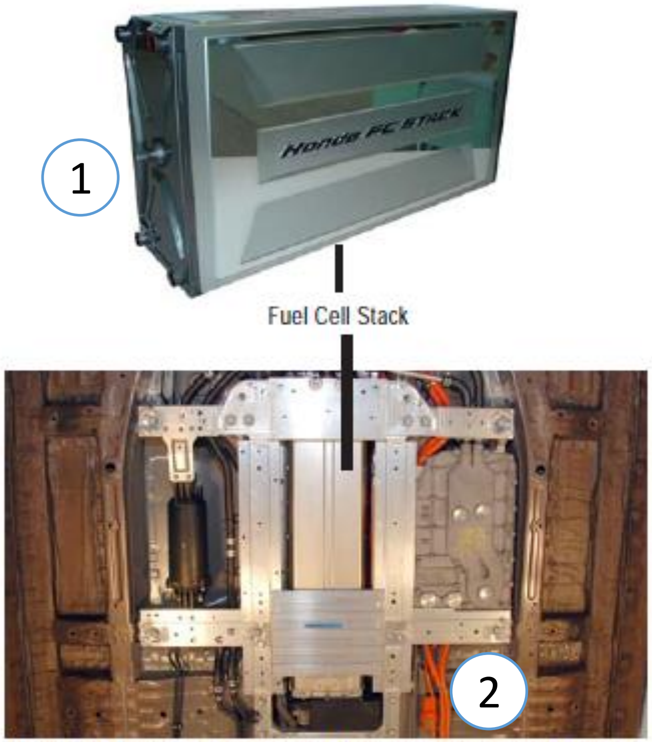
FCEV- Honda FX Clarity case

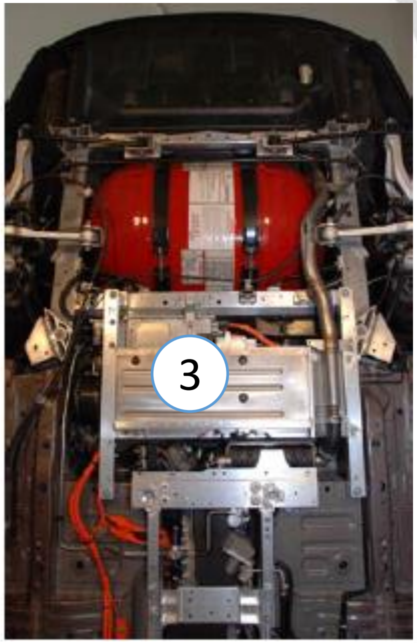
1. Fuel cell stack: main power source
   - mixture of air and onboard hydrogen produces electricity
   - by-products: heat & water
2. High voltage cable
   - HV cable is orange as for hybrid vehicles,
   - located inside or behind high voltage component
   - protected by orange covers



The fuel cell stack is well protected in the lower center of the vehicle, shown here with the underbody covers removed.

FCEV- Honda FX Clarity case

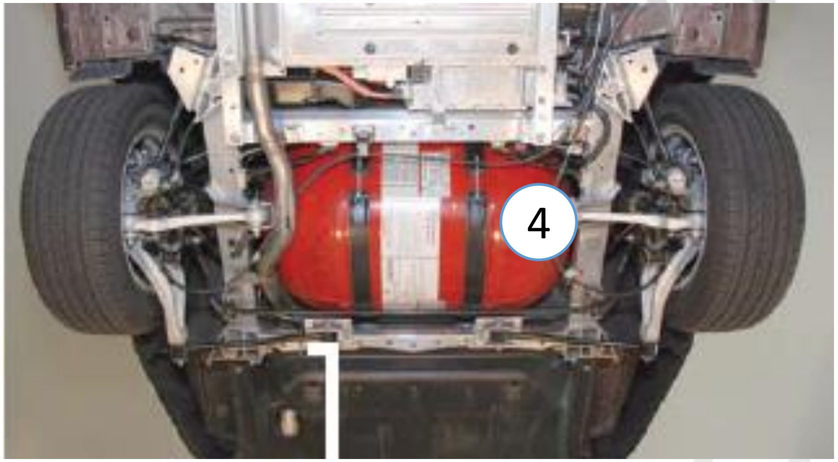
3. Lithium-ion High voltage battery (288 V DC)
   - located under the back seat

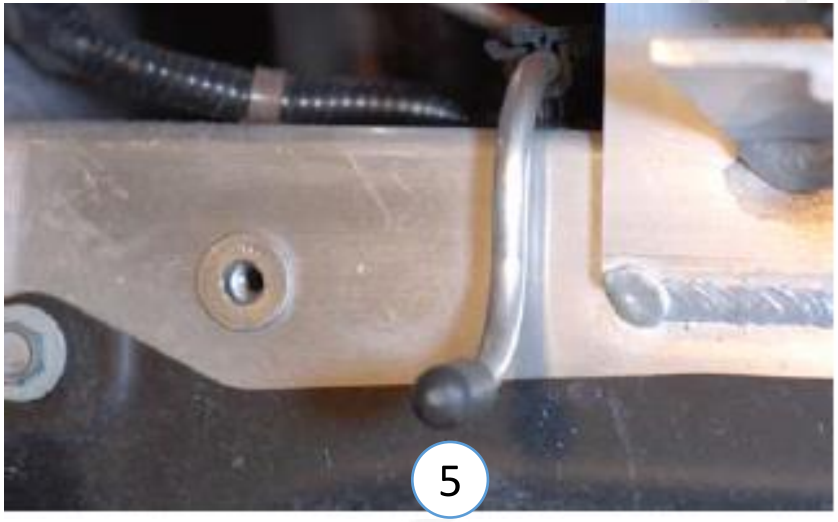


FCEV- Honda FX Clarity case

4. Hydrogen Tank contains a solenoid valve with three safety valves to:
    - prevent backflow while refuelling
    - stop hydrogen flow when signalled by the controller
    - release pressure (TPRD) when temperature > 108°C

5. If TPRD opens, hydrogen flows out through relief line under the trunk, passenger side.
    - if tank is full: 5 minutes to empty





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FCEV- Honda FX Clarity case

6. Hydrogen detectors
   - several detectors used throughout vehicle
   - if hazardous leak is detected the detector shuts down hydrogen flow from tank

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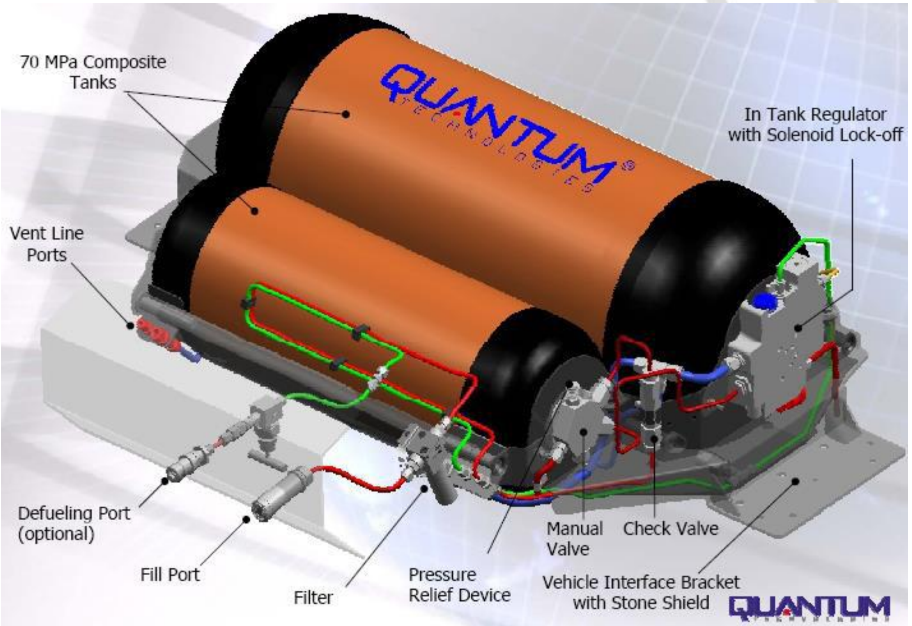
FCEV – Land vehicle fuel tank ISO/DIS 15869:2009

4.0 Categories

H: hydrogen storage

M: hydrogen blend storage



Nominal working pressure

At 15°C, can be 25, 35 or 70 Mpa

Type of service

A: on board light duty four wheel passenger road vehicle

B: on board heavy duty road vehicles (e.g.: buses, trucks)

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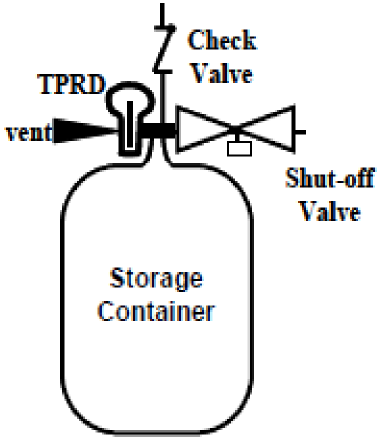
FCEV – Land vehicle fuel tank ISO/DIS 15869: 2009

1. Protection from fire effects (5.7)
   - Use of Non-reclosing TPRD (temperature activated pressure relief device)
   - Non-reclosing PPRD (pressure activated pressure relief device) only used in parallel with TPRD
   - TPRD opening must be independent from PPRD opening
   - Cannot be isolated from storage tank
   - Protection can be supplemented by thermal insulation

2. Some of these requirements are also covered in the GTR 2013.

Typical components:

- container/vessel
- check valve
- shut-off valve
- thermally activated pressure release device (**TPRD**)



FCEV – Land vehicle fuel tank ISO/DIS 15869: 2009

Hydrogen tank testing

- Hydrostatic **burst test**

  Tank bursting pressure≥ 2 x Working Pressure

- Ambient **pressure cycling test**

  fuel tanks must resist at least to 11,250 fill cycles (= 15-years).

- **Penetration** test

  tank must not rupture when an armour piercing bullet or impactor with a diameter of 7.62 mm or greater fully penetrates its wall.

- **Leak-before-break**

  fuel tank shall fail by leakage or exceeding the number of filling cycles

- **Bonfire** test, the fuel tank…
  - must vent through the non-reclosing TPRD;
  - shall not fail when exposed to a large and controlled fire of 20 minutes duration.

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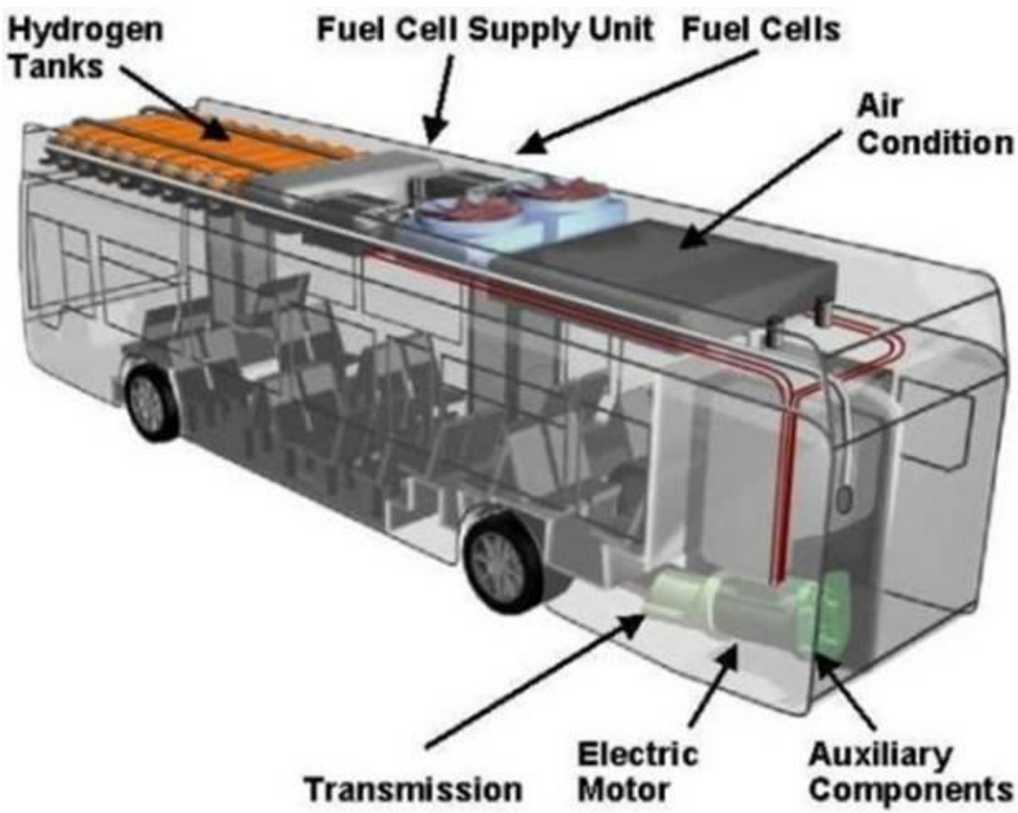
FCEV- Buses

- Location of FCEV components specific to each construction
  - storage on top
  - electrical system (FC, inverters, etc.) at the back
  - cooling (fuel cell & passenger) on top
  - battery pack: behind front wheels



Iceland New Energy

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FCEV- Buses

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Association Française pour l'Hydrogène et les Piles à Combustible

Mercedes

Mercedes

Fuel cell e mobility

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Prescriptive and performance-based approach to Hydrogen safety

- Hydrogen properties
- Primary hazards
- Fire safety engineering for buildings

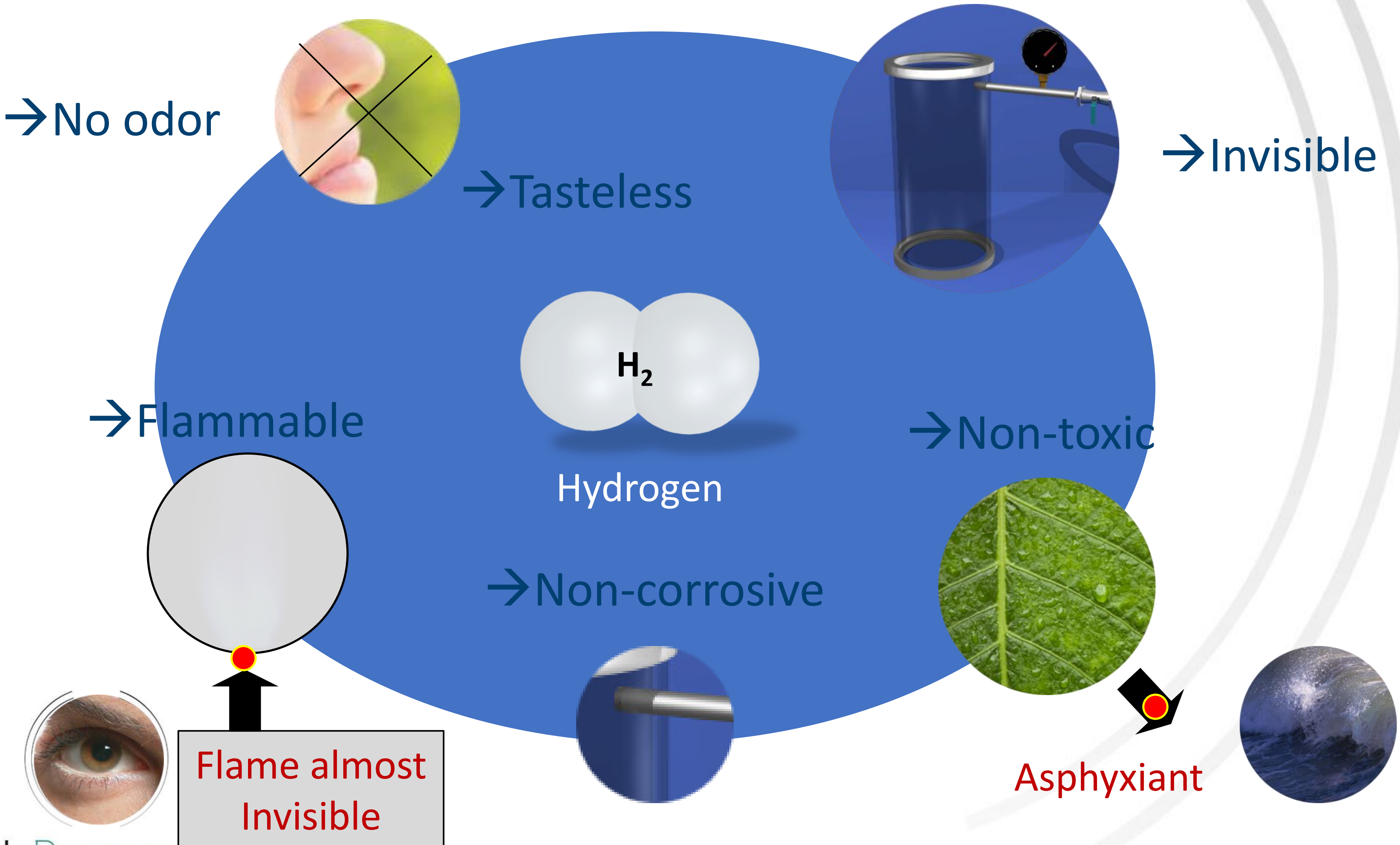
Prescriptive and performance-based approach to hydrogen safety

- Hydrogen properties
  - Primary hazards
  - Fire safety engineering for buildings

ISO/TS 15916:2015

Basic considerations for the safety of hydrogen systems

Gaseous Hydrogen Properties



Gaseous Hydrogen Properties

Name	Formula	Density	HHV[1] (MJ/kg)	HHV[1] (MJ/m^3)	Auto-Ignition °C	MIE[2] (mJ)
Hydrogen	H_2	0,069	141,8	11,8	585	0,017
Methanol	CH_3OH	-	22,7	-	385	0,174
Methane	CH_4	0,56	55,5	35,6	537	0,274
Propane	C_3H_8	1,53	50,4	92,6	450	0,24
Gasoline* (n-octane)	C_8H_{18}	-	47,3	-	215	0,25
Acetylene	C_2H_2	0,9	50,2	53,4	300	0,017

- Smallest and lightest molecule
  - Lighter than air
  - High diffusivity and buoyancy = mixes easily with air and rises rapidly
  - Low viscosity = tendency to leak
  - Low density = gas stored at high pressure

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[1] **High Heating Value** (m^3 at Normal T & P)

[2] **Minimum Ignition Energy** Stoichiometric mix with air at NP, 25° C,

Liquid Hydrogen Properties

- Lighter than water
- Transparent with a light blue tinge
- Low boiling point at atmospheric pressure

Air will condense on uninsulated component!

	Boiling point °C	K
O_2	-183,15	90,0
N_2	-195,85	77,3
H_2	-252,85	20,3

- 1 m^3 of $H_{2\text{ -liquid}}$ = **845** m^3 of $H_{2\text{ -gaseous}}$
- Extremely fast expansion

=

Fast pressure rise,

when confined!

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Prescriptive and performance-based approach to Hydrogen safety

- Hydrogen properties
- **Primary hazards**
- Fire safety engineering for buildings

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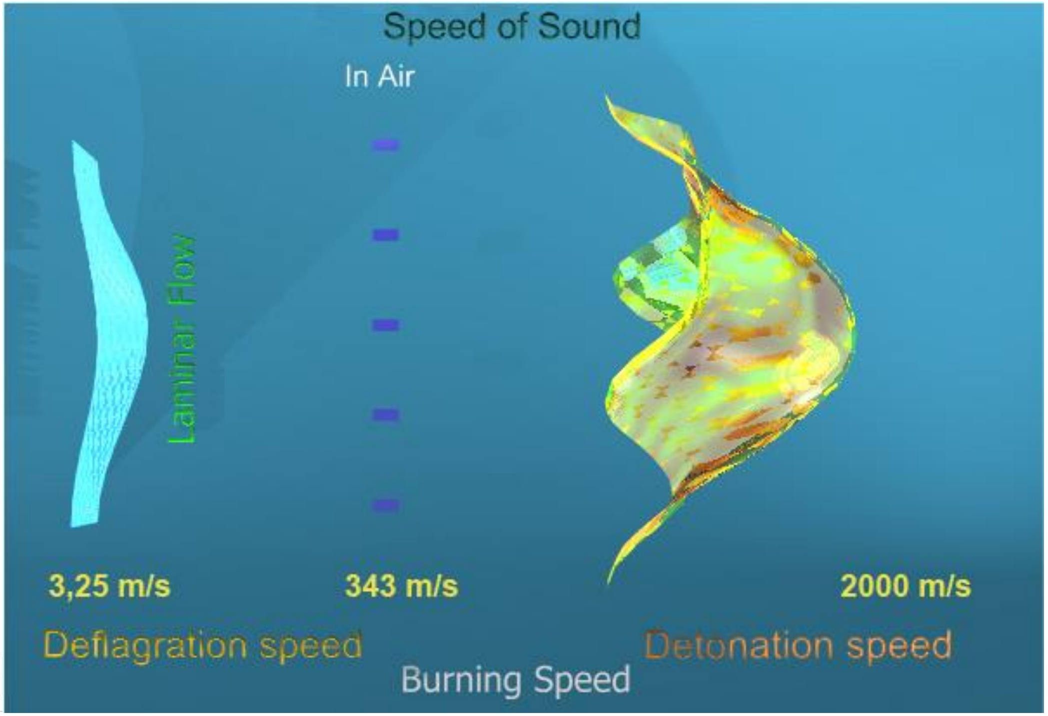
Primary Hazard #1

1. Combustion

- Fire
- Explosion



- Safety considerations…
  - Prevent the formation of hydrogen-Oxidizer mixtures
  - Leak detection
  - Ventilation
  - Flame detectors

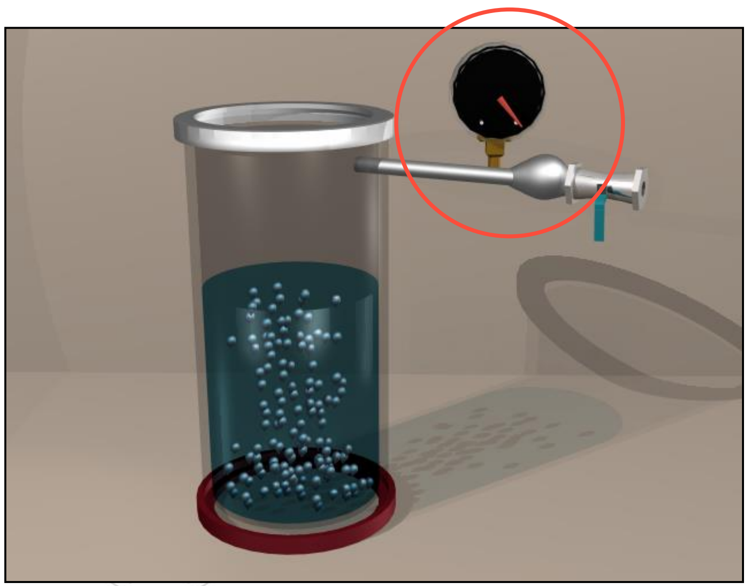
  - Eliminate ignition sources
  - Bonding
  - Grounding

  - Avoid confinement
    - Within the system
    - Outside the system

Primary Hazard #2

2. Pressure

- Gaseous hydrogen: High pressure storage (40-340 Bar)
- Liquid hydrogen: Quick increase of volume (845) resulting from the liquid to gas phase change



○ Safety considerations

- Proper design and material selection
  - Vessels & components
  - Piping, joints & connections
- Adequate Pressure Relief Devices
  - Location
  - Sizing
- Proper insulation of liquid hydrogen storage containers and piping

Primary Hazards #3

3. **Low temperature**
   - Liquid hydrogen temperature
     - Decrease in material ductility
     - Material shrinkage
     - Air will condense on uninsulated component, providing an oxygen-enriched condensate that will increase the flammability and oxidation of materials

- Safety considerations
  - Proper material selection
  - Account for the shrinkage of materials in design
  - No use of organic material including bituminous road underneath uninsulated pipes and components

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Primary Hazard #4

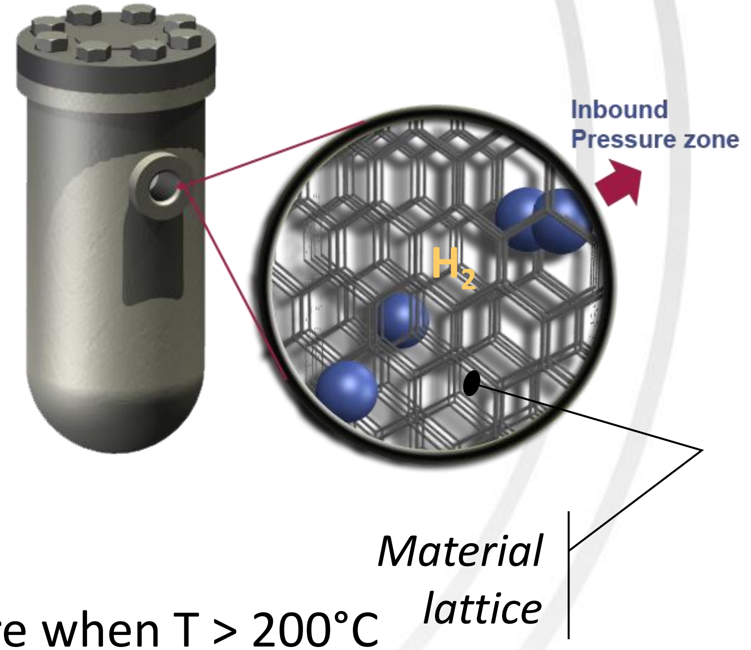
4. Embrittlement

- Loss of structural strength caused by permeation of hydrogen through containment material lattice

Hydrogen is the smallest element of all.

1. Dissociated hydrogen (H) migrates through material matrix
2. Recombination into H_2 induces internal pressure
3. Material loses tensile strength & ductility

…until it cracks open



- Degradation of steel microstructure when T > 200°C

Safety considerations

- Proper design and material selection

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Primary Hazard #5

5. Exposure

- Cold burns
  - Due to direct skin contact with liquid or cold gaseous hydrogen
- High temperature burns
  - Flame **almost invisible** in artificial or day light
  - Low IR = low heat radiation emission → **cannot sense flame proximity**
- UV-exposure burns
  - Large amount of UV emission = sunburn
- Asphyxiation
  - Enclosed space due to oxygen depletion

o Safety considerations

Wear appropriate protective clothing and protective equipment !

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Prescriptive and performance-based approach to Hydrogen safety

- Hydrogen properties
- Primary hazards
- Fire safety engineering for buildings

BS 7974:2001 – Structure and publication

The code of practice for fire safety engineering principles applied to building designs covering safety of a building and its occupants.

PD 7974-0	PD 7974-1 (Sub-system 1)	PD 7974-2 (Sub-system 2)	PD 7974-3 (Sub-system 3)	PD 7974-4 (Sub-system 4)	PD 7974-5 (Sub-system 5)	PD 7974-6 (Sub-system 6)	PD 7974-7
Guide to design framework and fire safety engineering procedures	Initiation and development of fire within the enclosure of origin	Spread of smoke and toxic gases within and beyond the enclosure of origin	Structural response and fire spread beyond the enclosure of origin	Detection of fire and activation of fire protection systems	Fire service intervention	Evacuation	Probabalistic risk assessment
Design approach QDR Comparison with criteria Reporting and presentation	Design approach Acceptance criteria Analysis Data References	Design approach Acceptance criteria Analysis Data References	Design approach Acceptance criteria Analysis Data References	Design approach Acceptance criteria Analysis Data References	Design approach Acceptance criteria Analysis Data References	Design approach Acceptance criteria Analysis Data References	Design approach Acceptance criteria Analysis Data References

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Figure 1 Structure of the code of practice and the published documents

BS 7974 –0 Guide to design framework

Design framework is based on five systemic factors that affect fire safety.

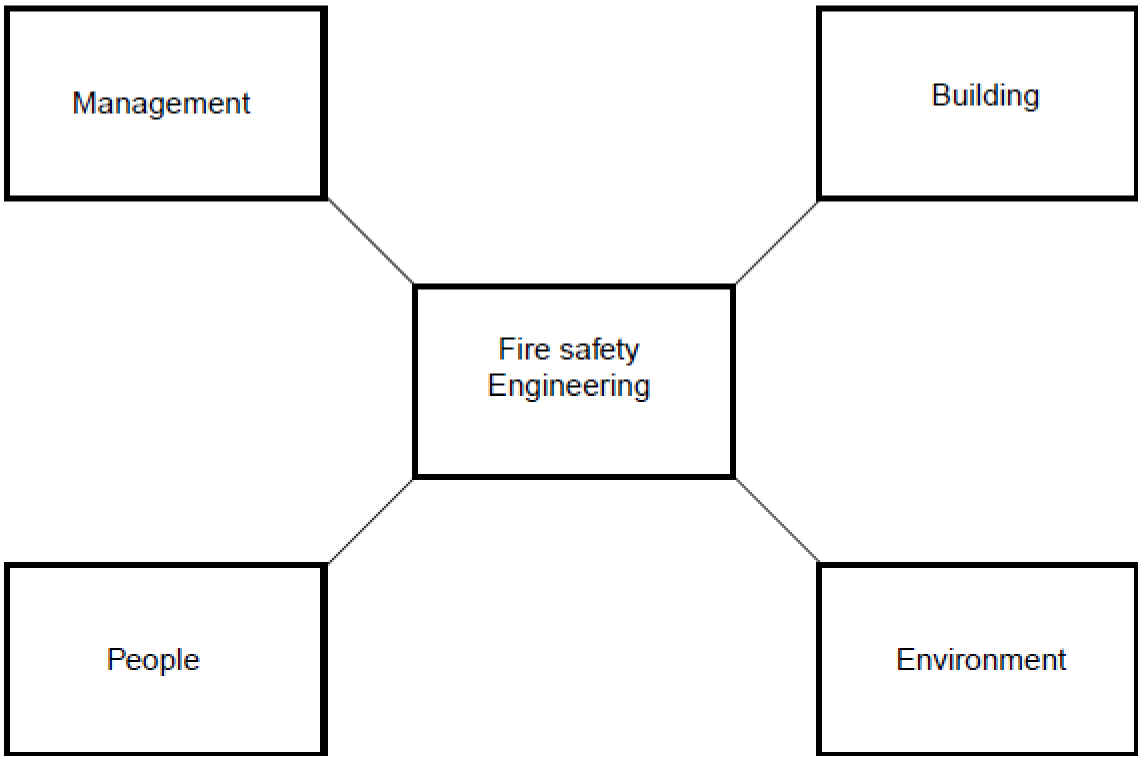

Figure 1 — Main factors involved in a fire safety engineering study

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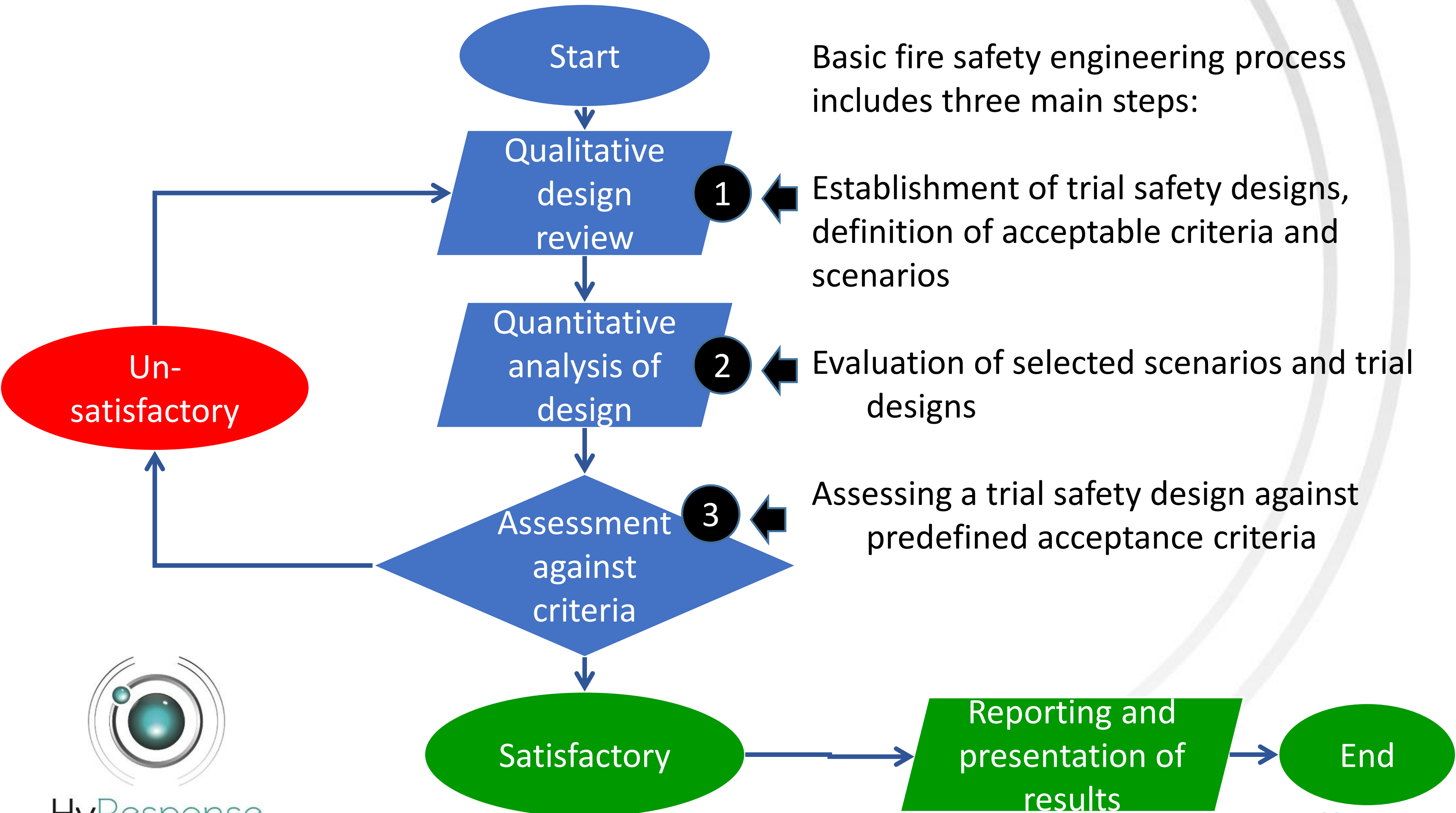
BS 7974 –0 Guide to design framework 1/2



BS 7974 – 7 Risk assessment

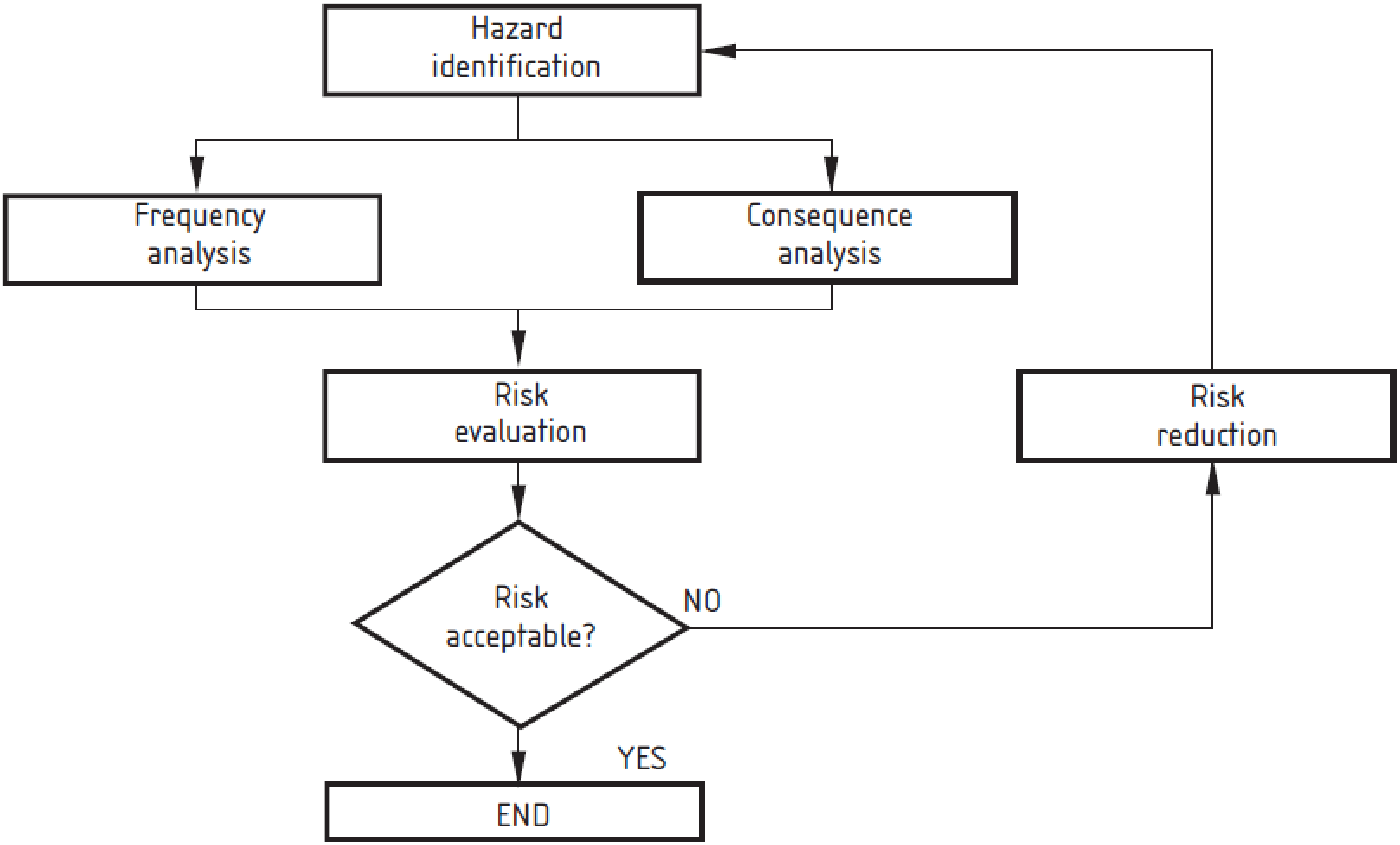


Figure 2 — General approach to probabilistic fire risk assessment

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Acronyms

- **AFID** Alternate Fuels Infrastructure Directive
- **ADR** European Agreement concerning the International Carriage of Dangerous Goods by Road
- **CEN** European Committee for Standardization
- **CENELEC** European Committee for Electrotechnical Standardization
- **FCH** Fuel Cell and Hydrogen
- **FCH JU** Fuel Cell and Hydrogen Joint Undertaking
- **GTR** Global Technical Regulation
- **HRS** Hydrogen Refuelling Station
- **IEC** International Electro-technical Commission
- **ISO** International Standards Organization
- **PED** Pressure Equipment Directive
- **RCS** Regulations, Codes and Standards
- **TBT** Technical Barriers to Trade
- **TPED** Transportable Pressure Equipment Directive
- **TPRD** Thermally Activated pressure Relief Devices
- **UNECE** United Nations Economic Commission for Europe
- **WP.29** World Forum for Harmonization of Vehicle Regulations
- **WTO** World Trade Organization

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