

**TRAINING AND  
EVENTS FROM**



# **Hydrogen Projects at the HSE Science and Research Centre**

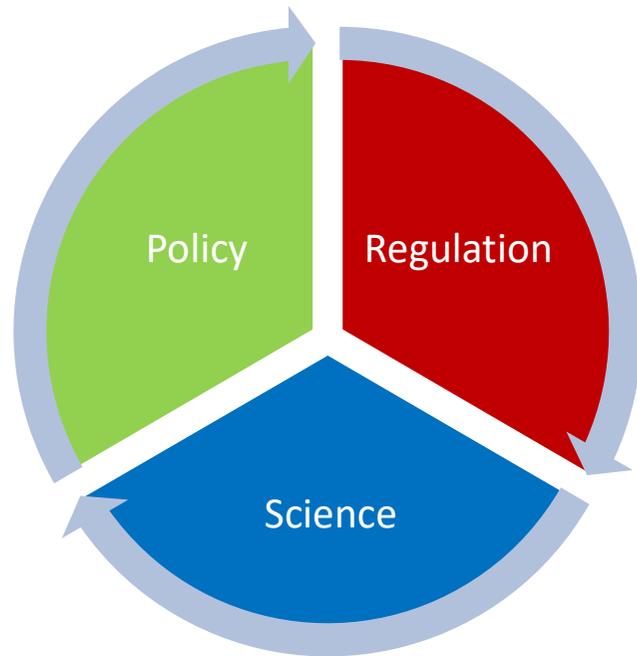
**Andrew Garrison, Sustainable Energy Safety Scientist**

**11<sup>th</sup> January 2024**

**Training and events** - built on our unrivalled expertise as Great Britain's health and safety regulator.

# HSE Science and Research Centre

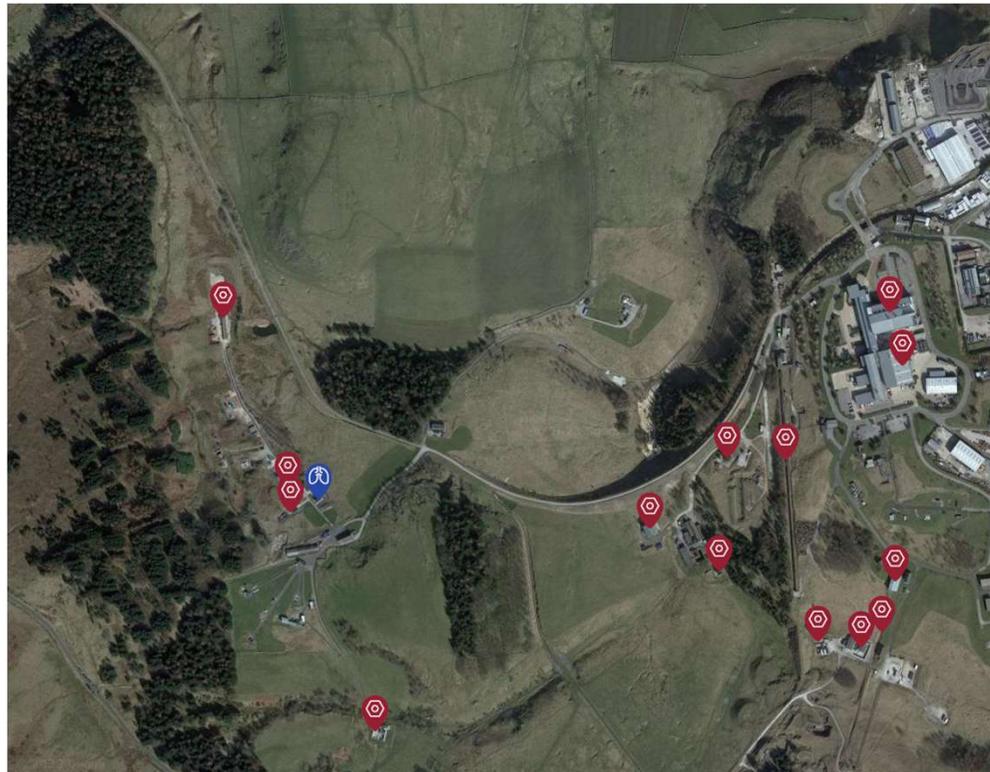
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# Overview of Work Within Explosive Atmospheres

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- HyTunnel-CS
- PRESLHY
- MultHyFuel
- H21



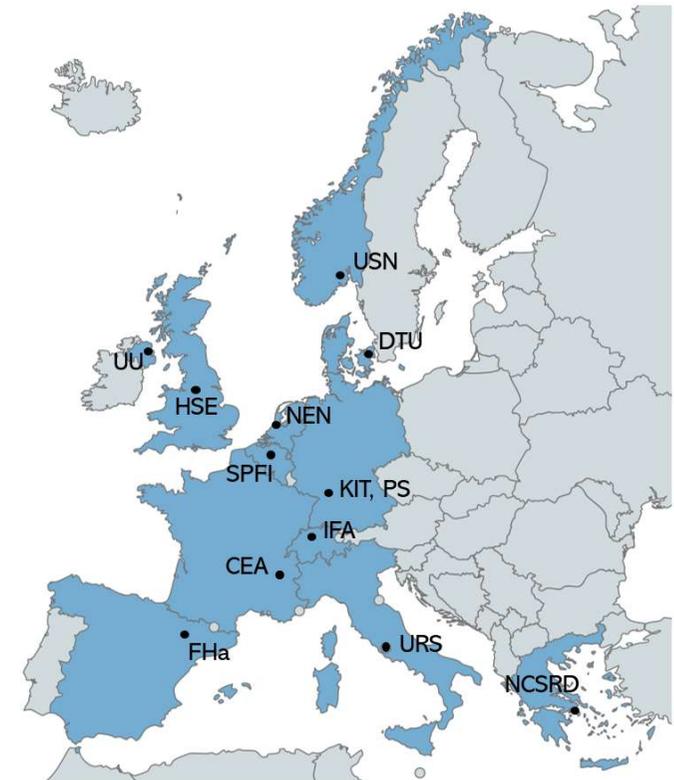
[solutions.hse.gov.uk/about-us/facilities](https://solutions.hse.gov.uk/about-us/facilities)

# HyTunnel-CS

## What is HyTunnel-CS?



- **Pre-normative research for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces**
- **13 Partners across 11 countries, comprising of:**
  - **Academia;**
  - **Emergency services;**
  - **Research institutions;**
  - **Standard development organisations.**
- **Ran from 2019 to 2023**



## 13 Partners



**PRESLHY**



## What is PRESLY?

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- **Pre-Normative Research for Safe use of Liquid Hydrogen**
- **9 Partners across Europe, comprising of:**
  - **Academia;**
  - **Emergency services;**
  - **Research institutions;**
  - **Standard development organisations.**
- **2016 to 2021**
- **Follow up work – ELVHYS (Ongoing)**
  - **Enhancing safety of Liquid and Vaporised Hydrogen transfer technologies in public areas for mobile applications**



# PRESLHY

## 9 Partners

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# MultHyFuel

# What is MultHyFuel?



- Development of best practice for Hydrogen Refuelling Stations (HRS).
- 10 Partners across Europe, comprising of:
  - Academia;
  - Emergency services;
  - Research institutions;
  - Standard development organisations.
- 2021 – Ongoing
- Leakage of hydrogen from fuelling dispenser in forecourts

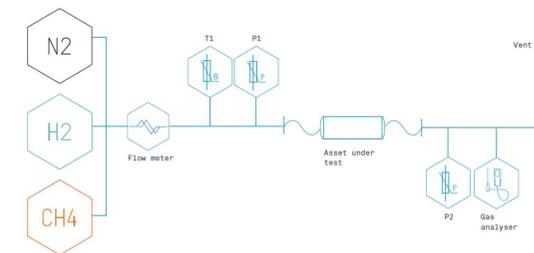
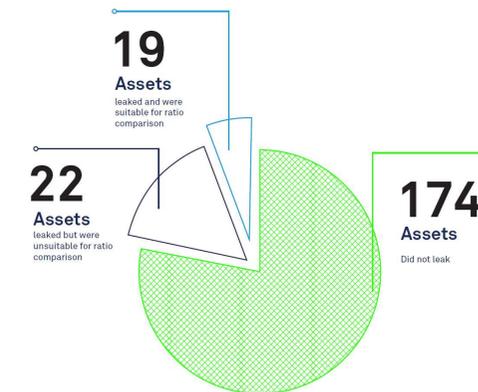


**H21**

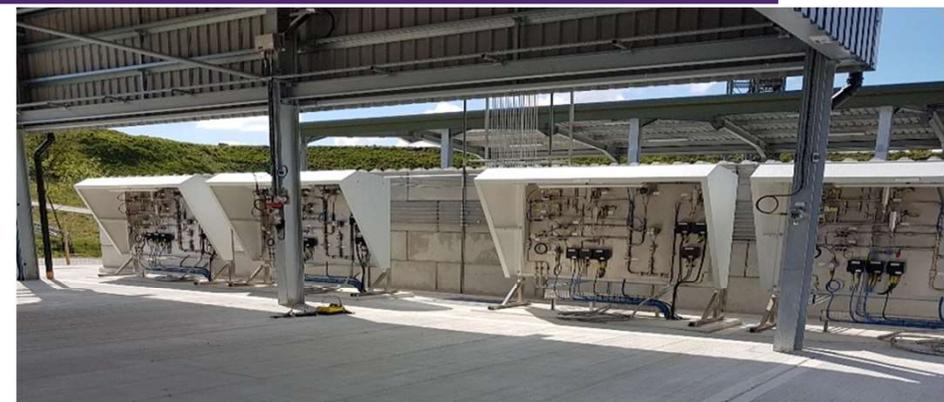
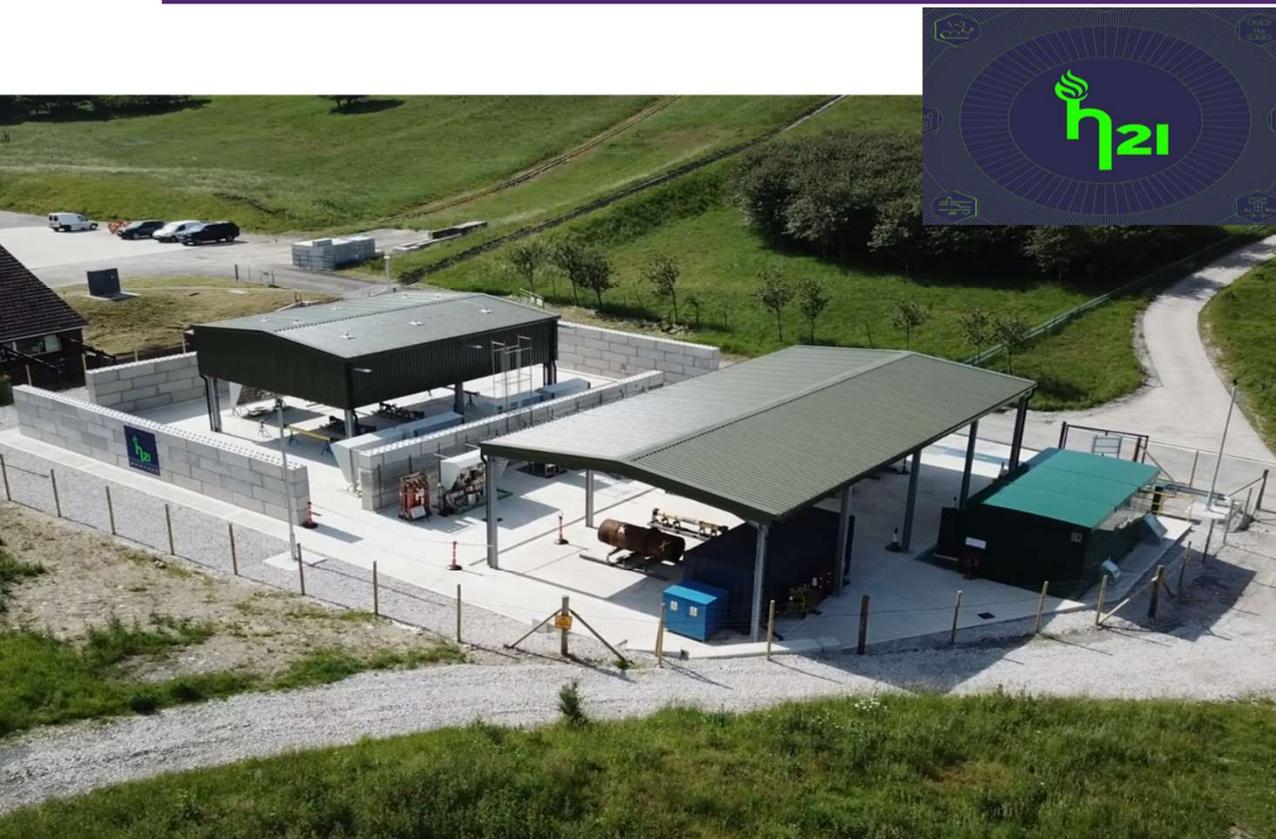


# What is H21? Outcomes of Phase 1a

- Converting the gas grid from natural gas to 100% hydrogen
- What is the ratio of hydrogen to natural gas volumetric leak rates? Between 1.2 and 2.9
- Do any assets leak hydrogen but not natural gas? No
- What trends are shown in the results? Leakage ratio increases with pressure
- Full reports available at <https://h21.green>



# H21 – Natural Gas to Hydrogen Grid Conversion



## H21 – Testing Pictures



Installed 1870 and didn't leak



# **Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)**

# Key Elements of DSEAR

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## Risk Assessment

- Failure Frequencies
- Consequence Analysis

## Hazardous Area Classification

- Ignition Source Control

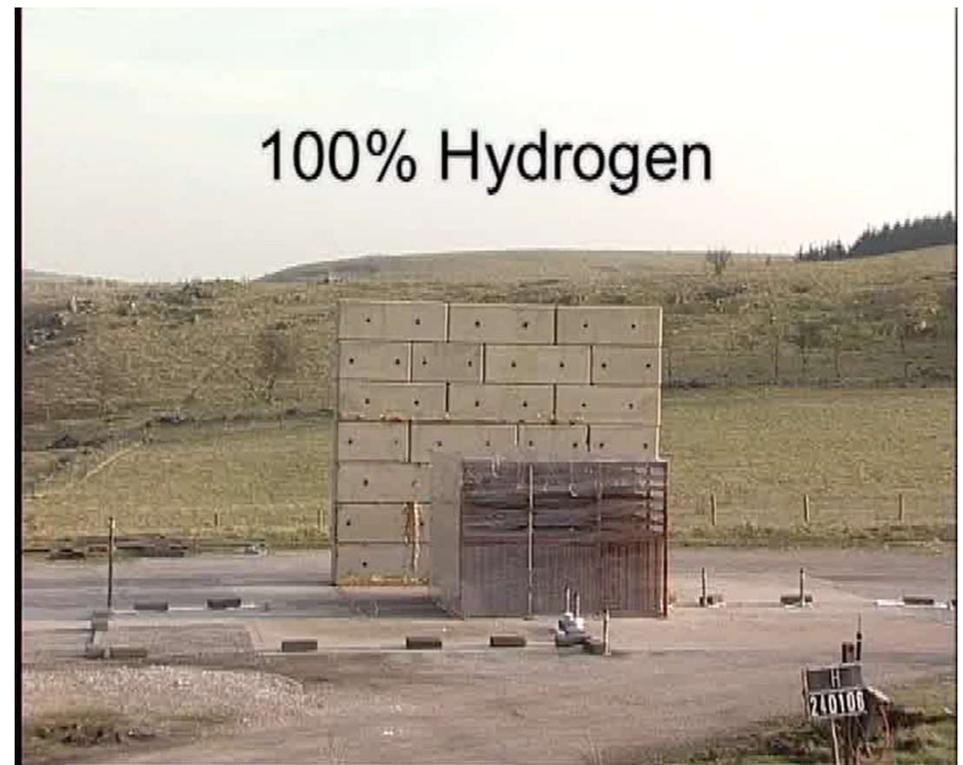
## Emergency Response

- Information and Training

- **H21**: no change in leak frequency.
- **HyTunnel, HyPresly, Multi-HyFuel**: dispersion, consequence data.
- **NaturalHyL**: Congestion and Detonation data.
- **IGEM/SR/25** H2 Supplement
- **MECHEX** HSL Tests, Mechanical Ignition

## Tendency to Detonate (NATURALHY)

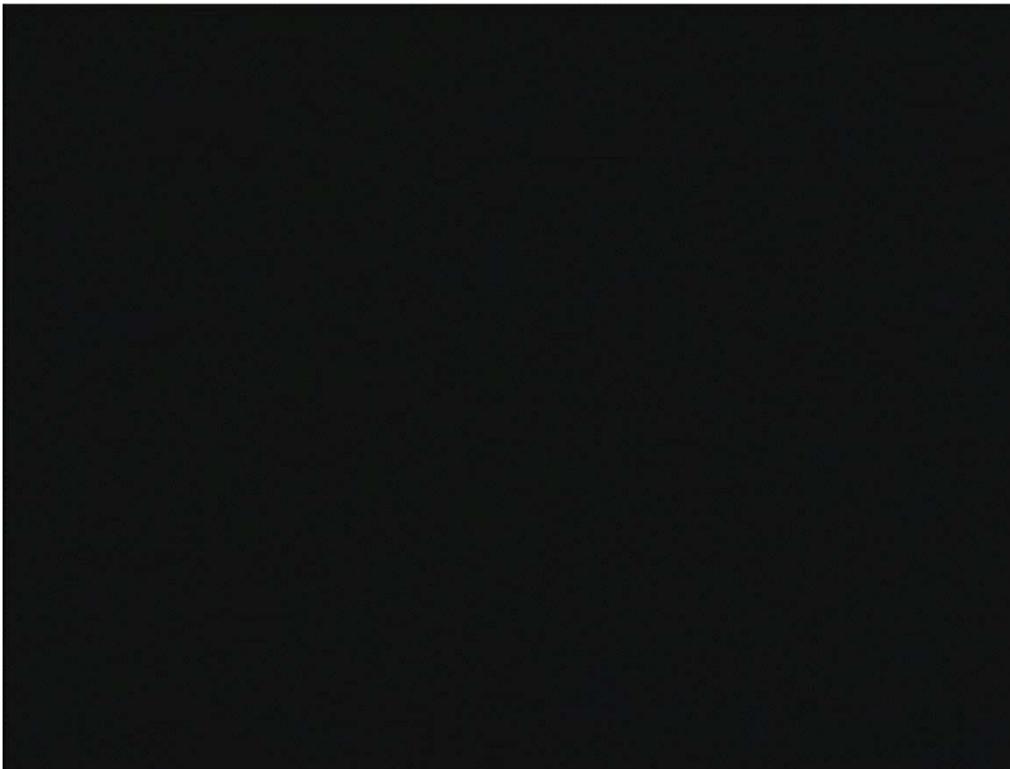
Vapour cloud explosions from the ignition of methane/hydrogen/air mixtures in a congested region. Royle, M, Shirvill, L.C & Roberts, T.A



Energy content of gas similar in both cases

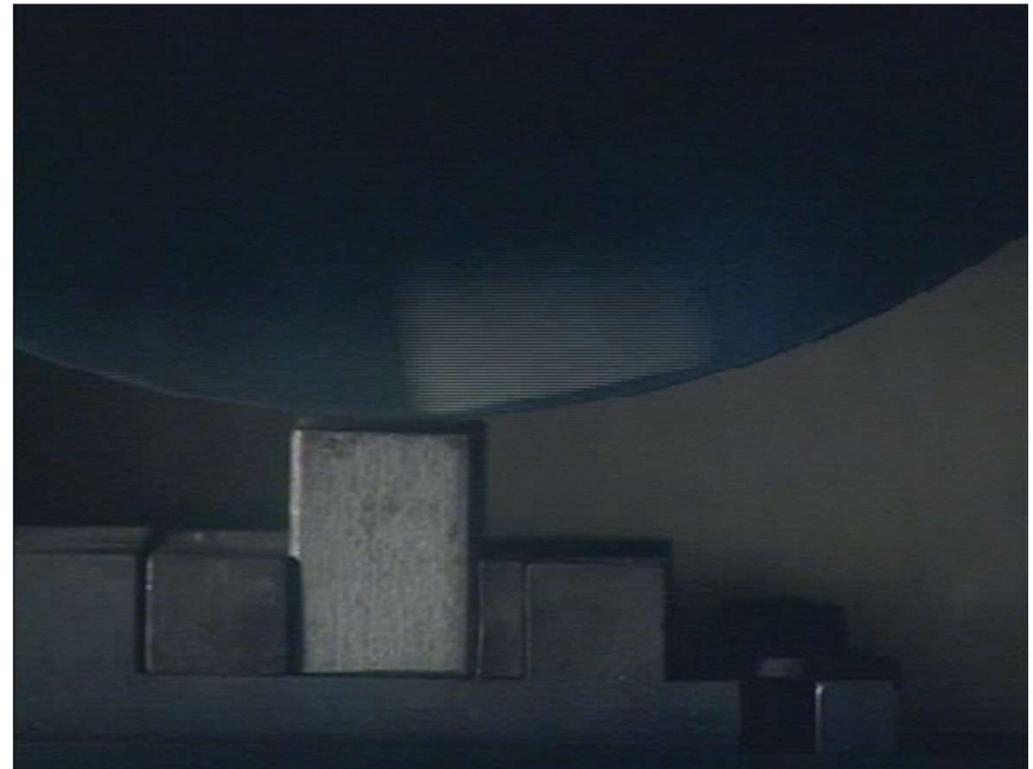
## Ignition by Hot Surfaces

Data from MECHEX tests at HSL, for stainless steel on stainless steel (ref. IChemE Symposium Series No.150, 2004)



7% Methane, speed 20 m/s, load 3525 N

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15% Hydrogen, speed 5 m/s, load 1225 N

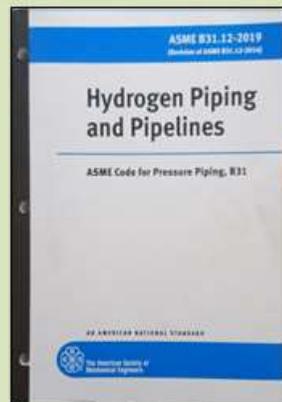
## EN1127 – Explosion prevention and protection

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5	Possible ignition sources .....
5.1	Hot surfaces .....
5.2	Flames and hot gases (including hot particles) .....
5.3	Mechanically generated sparks.....
5.4	Electrical apparatus.....
5.5	Stray electric currents, cathodic corrosion protection.....
5.6	Static electricity .....
5.7	Lightning.....
5.8	Radio frequency (RF) electromagnetic waves from $10^4$ Hz to $3 \times 10^{11}$ Hz ..
5.9	Electromagnetic waves from $3 \times 10^{11}$ Hz to $3 \times 10^{15}$ Hz.....
5.10	Ionizing radiation .....
5.11	Ultrasonics .....
5.12	Adiabatic compression and shock waves .....
5.13	Exothermic reactions, including self-ignition of dusts.....

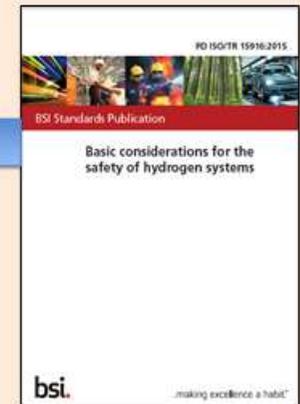
Annex A Non-sparking tools to be used in Zone 1 IIC and all Zone 0.

## Sources of Information on Material Compatibility



- **ASME B31.12; Hydrogen Piping and Pipelines**
  - Emphasis on new-build pipelines/ metals
  - Blends 10-100% H<sub>2</sub>; Pressures to 210 bar
  - Materials Classed as 'Acceptable' or 'Not acceptable'
  - Steel suitability up to X52 strength grade implied

- **PD ISO TR 15916: Basic considerations for the safety of hydrogen systems**
  - Safety considerations for gaseous and liquid H<sub>2</sub>
  - Appendix on materials suitability classification of materials; metals & polymers
  - Materials classed as 'Negligibly/ Slightly/ Severely/ Extremely embrittled'
  - Embrittlement susceptibility: Carbon steels 'in need of evaluation'



- **BS EN ISO 11114-2: Gas cylinders- Compatibility of cylinder and valve materials with gas contents: Non-metallic materials**
  - Covers a range of gas types, including 100% hydrogen
  - Covers 24 different polymer classes including: PE, PVC, PTFE, Nitrile rubber
  - Compatibility given as one of 13 classes including; *Acceptable; dangerous product release; ageing; permeation, swelling; mass loss*

## Summary of Codes and Standards for the Safe use of Hydrogen

Document Number	Description	Publisher	Publication Date
<b>BS ISO 26142:2010</b>	Hydrogen detection apparatus. Stationary applications.	BSI	30/06/2010
<b>PD ISO/TR 15916:2015</b>	Basic considerations for the safety of hydrogen systems.	BSI	31/12/2015
<b>BS ISO 11625:2007</b>	Gas cylinders — Safe handling	BSI	31/10/2007
<b>NFPA 2: 2020</b>	Hydrogen Technologies Core	NFPA	30/06/2020
<b>NFPA 55: 2020</b>	Compressed Gases and Cryogenic Fluids Code	NFPA	18/05/2020
<b>BCGA CP 39</b>	In-service requirements of pressure equipment	BCGA	Revision 2: 2017
<b>BCGA CP 44</b>	The storage of gas cylinders	BCGA	2016
<b>BCGA CP 46</b>	The storage of cryogenic flammable fluids	BCGA	2016
<b>EIGA Doc. 121/14</b>	Hydrogen pipeline systems	EIGA	2014
<b>EIGA Doc. 211/17</b>	Hydrogen vent systems for customer applications	EIGA	2017
<b>EIGA Doc. 23.07/18</b>	Hydrogen	EIGA	2018
<b>EIGA Doc. 06/19</b>	Safety in storage, handling and distribution of liquid hydrogen	EIGA	2019

Note: other codes and standards exist for related topics, such as cryogenic vessels, refuelling stations etc