
Risk management strategy for hydrogen economy projects

Dr Gordon Newsholme

Process safety corporate topic group

Presentation overview

- Understanding the regulatory framework
 - Who is the Regulator?
 - Important pieces of legislation
- Hazards of hydrogen
- Developing a risk management strategy
- Practical approaches to risk reduction
- Sources of advice and guidance

Regulation of workplaces etc



-
- Industrial premises, factories, hospitals, schools, universities, LA premises **HSE**
 - Commercial/retail **LAs**
 - Domestic (fuel gases) **HSE**
 - Road vehicles **VOSA/DfT**
 - Ships/boats **M&CGA/DfT**

Some important legislation



-
- Dangerous substances and explosive atmospheres regulations 2002 (DSEAR)
 - Gas safety (installation & use) regs 1998 (GSIUR)
 - Gas appliances (safety) regs 1995 (GASR)
 - Planning (hazardous substances) regs 1992
 - Control of Major Accident Hazards (COMAH) Regs
 - Health & Safety at Work etc Act 1974

Legislatively important quantities

- Planning(hazardous substances) regs 1992
>2 t hydrogen c24 000 sm³
- COMAH (lower tier)
5 – 49 t hydrogen
- COMAH (top tier)
>50 t hydrogen

Gas safety (installation & use) regs 1998



-
- Hydrogen only covered in domestic premises
 - Those carrying out work must be CORGI registered
 - Appliances defined (heating, lighting, cooking etc)
 - Equipment must be suitable

DSEAR



-
- The overarching legislation for flammable substances
 - Doesn't apply to GASR (GAD) gas appliances
 - Doesn't apply to ship/boats or vehicles
 - Doesn't apply in mines or quarries
 - Applies to FCs where electricity is the primary output

What does DSEAR require you to do?



- Assess and control the risks from dangerous substances
- Eliminate or reduce the risk from dangerous substances *so far as is reasonably practicable*

Remember also

ALARP

Notable hazards of Hydrogen



- Very wide flammable range
- Very low ignition energy
- Possibility of detonation
- Invisible flame
- Low viscosity
- Extremely diffusive
- Embrittlement of metals

Very wide flammable range



-
- Hydrogen is flammable in air from 4% to 75% v/v
 - The range is much wider than for other fuels:
 - Methane: 4% to 15%
 - Propane: 2% to 10%
 - Butane: 2% to 8%
 - Petrol: 1% to 8%
 - Hydrogen burns with an almost invisible flame

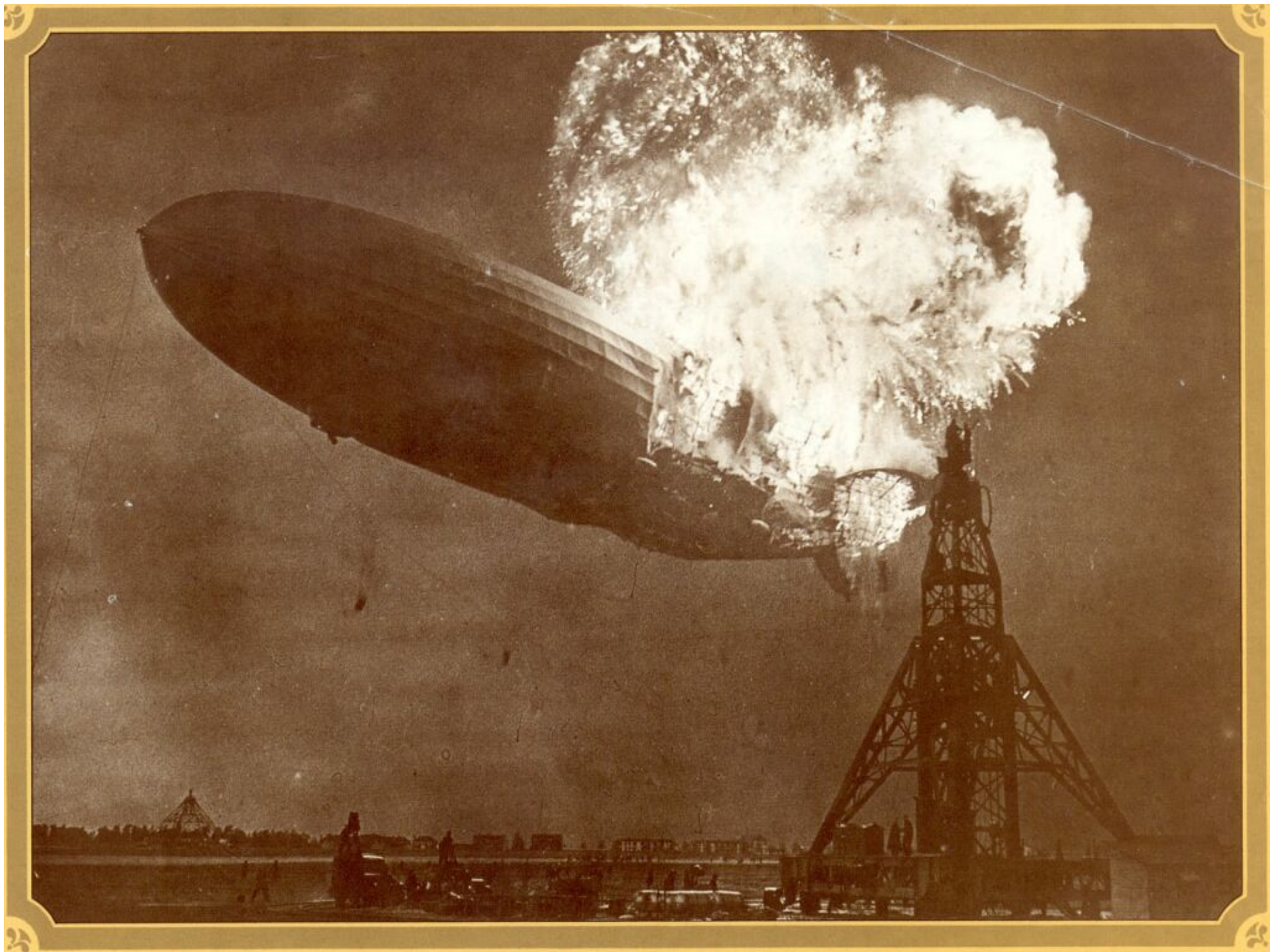
Very low ignition energy

- Hydrogen/air mixtures ignite extremely easily
- At stoichiometric ratios only 0.02 mJ required

compare methane 0.30 mJ

petrol 0.25 mJ

- Almost any spark may cause ignition
- Mobile phones are a potential ignition source



Practical approaches to risk management

Risk management strategy



- Recognise, understand and prioritize the hazards
- Identify those scenarios that generate the **big** risks
- Demonstrate you have a plan to manage the risks
- Show your plan follows a suitable hierarchy
- Don't forget the boring, old fashioned risks!

DSEAR risk control hierarchy



-
- Substitute
 - Control the risk
 - Reduce inventory
 - Avoid/control releases
 - Prevent flammable atmospheres forming
 - Avoid ignition sources
 - Mitigate the risk
 - Reduce the number of people at risk
 - Provide explosion relief, suppression or containment

Reducing the risk from hydrogen



- Replace hydrogen with a lower hazard material
- Reduce the inventory
- Avoid the formation of flammable mixtures
- Avoid sources of ignition
- Ensure the security of the installation
- Suppress the explosion or mitigate its effects

Avoiding flammable mixtures



- Containment
- Location
- Ventilation

Containment

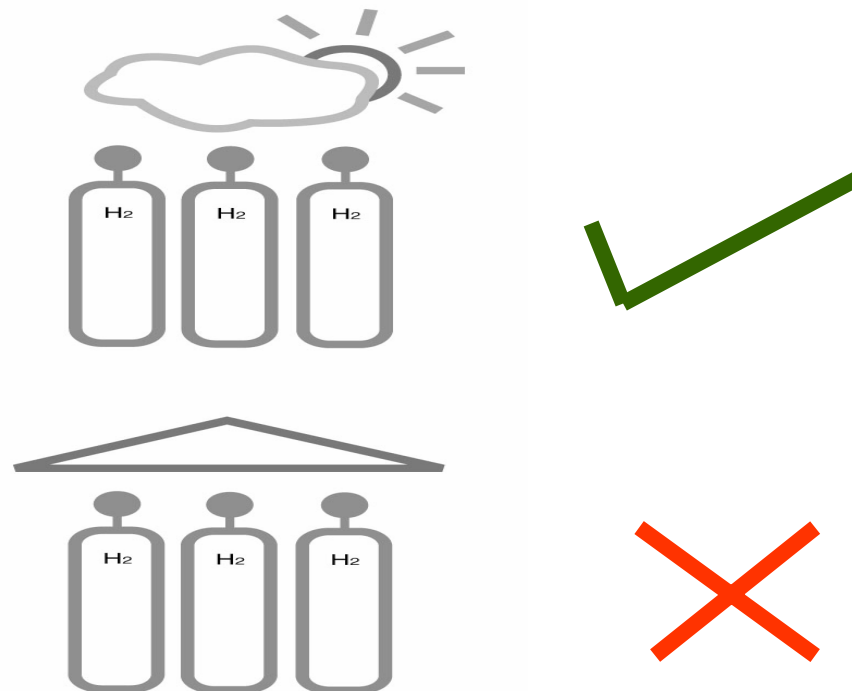


-
- Design and construct to an appropriate code
 - Use suitable materials
 - Minimise the number of joints
 - Use welded or brazed joints when practicable
 - Minimise the use of threaded or flanged joints
 - Avoid compression joints
 - Leak test in an appropriate manner

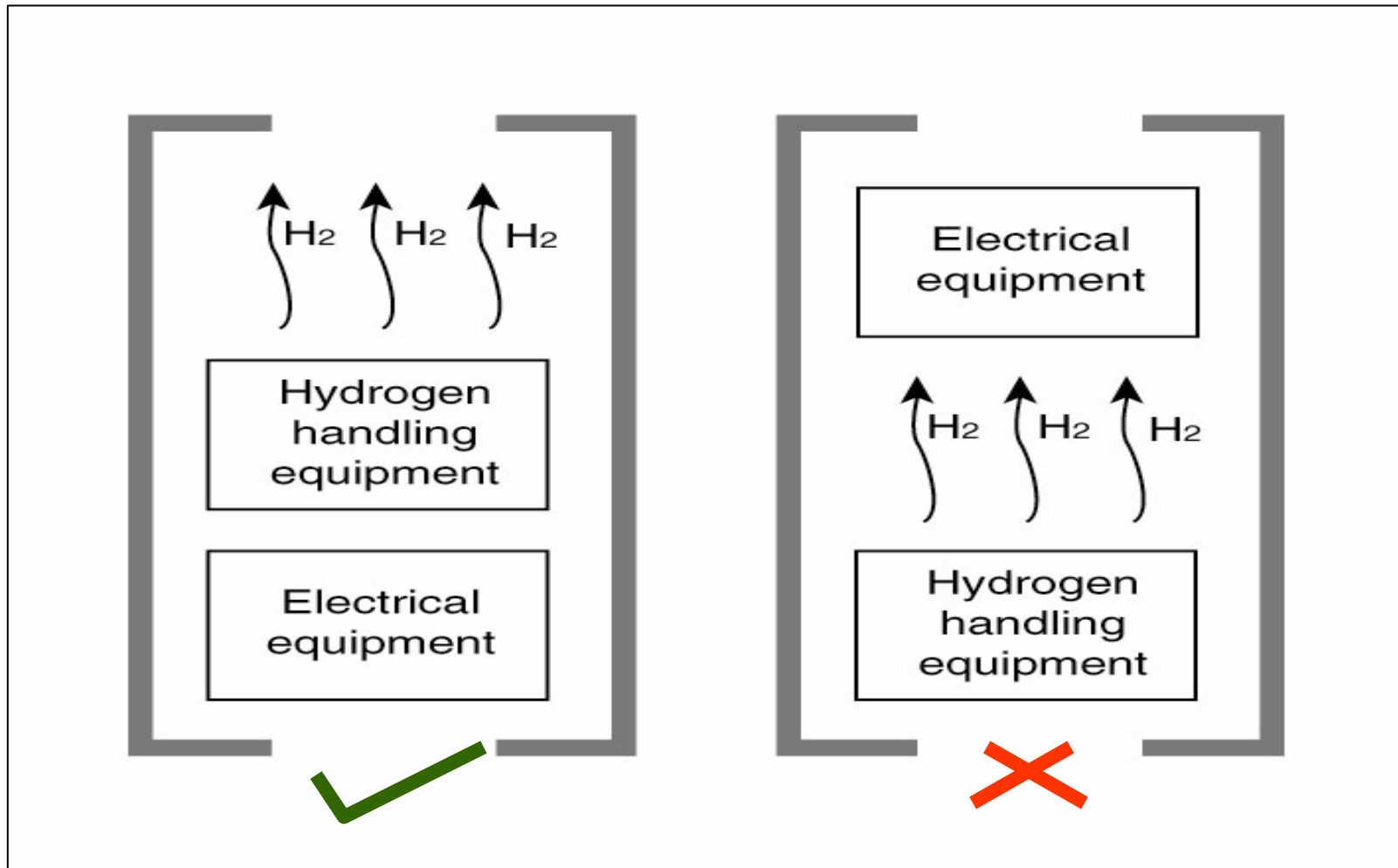
Location



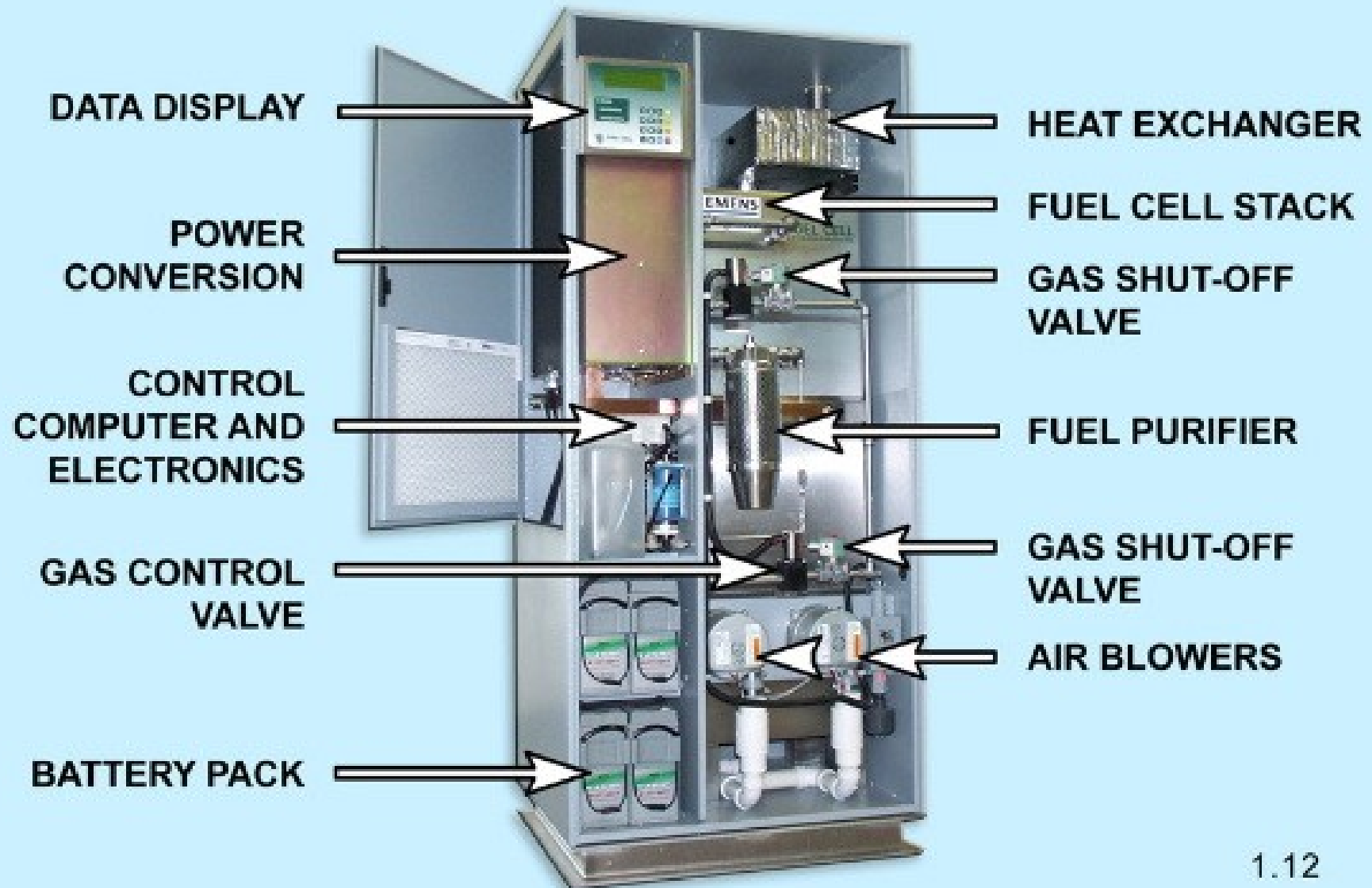
- Locate H₂ storage/handling equipment outside
- Beware of ceilings, covers, canopies and roofs



Let the buoyancy of H₂ work for you



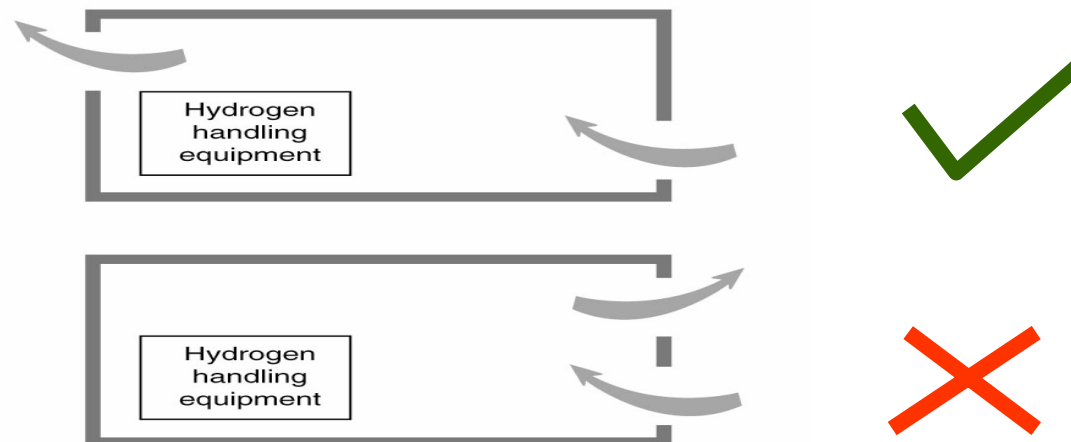
A FUEL CELL SYSTEM



Ventilation



- Estimate maximum foreseeable leak rate
- Provide adequate high and low level ventilation
- Use CFD for complex ventilation requirements



Avoiding sources of ignition



-
- Carry out a hazardous area classification
 - Try to locate electrics in non-hazardous zones
 - Use appropriate electrics in hazardous zones
 - Control hot work, smoking, mobile phones etc
 - Use bonding, earthing and anti-static clothing
 - Consider protection against lightning

Security and access control



- Provisions should be appropriate to location
- Perception of Regulator likely to exceed true risk
- “Precautionary principle” expectation likely

Explosion mitigation



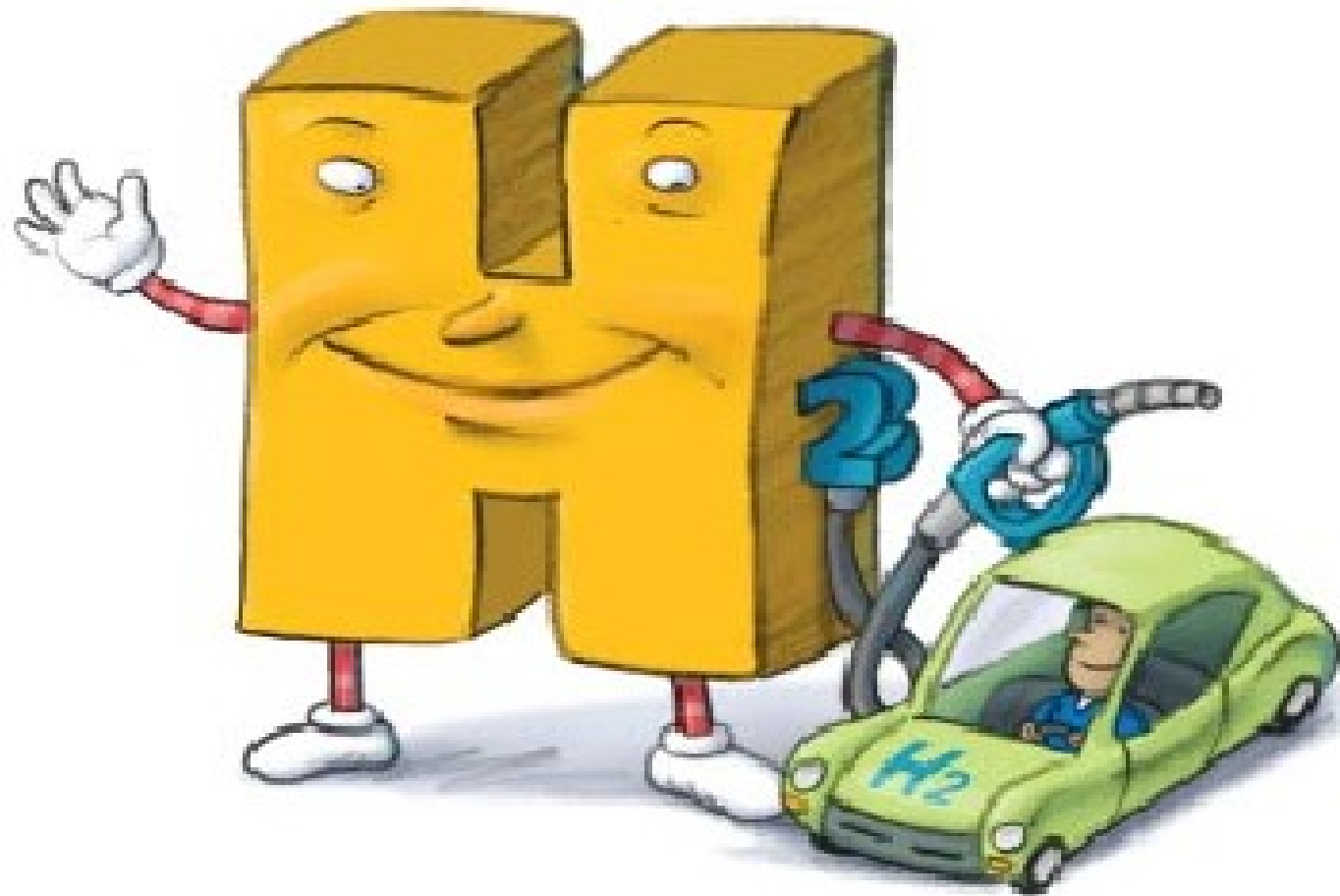
-
- Relief
 - Containment
 - Suppression

Information and guidance



-
- HSG 243; Fuel cells, understand the hazards, control the risks
 - European Industrial Gases Assoc. (IGC Doc 15/96)
 - NASA (Safety std for hydrogen & hydrogen systems)
 - ISO/DPAS 15916: Safety of hydrogen systems
 - NFPA 50A: Standard for gaseous hydrogen systems
 - ATEX (supply) Regs; SI192,1996
 - DSEAR ACOPs
 - BS EN 60079 Electrical app. for explosive gas atms

That's all folks!



Acknowledgements

- Jem Sullivan: hydrogen man cartoon
- Fuel Cells Canada: selected images