

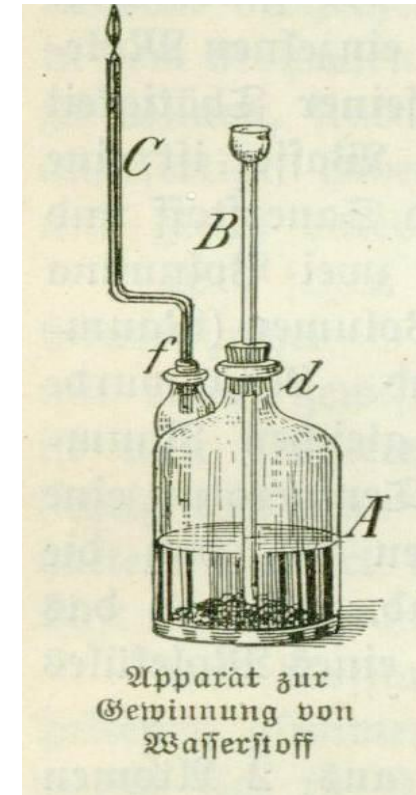
Hydrogen – Controls on Transport

European Industrial Gases Association

July 2nd 2021

Hydrogen – Some History

- 1671 Robert Boyle discovered combustible gas when metals react with acids
- 1766 Henry Cavendish recognized this as being a discrete substance
- 1783 Antoine Lavoisier named the gas "flammable air" and later hydrogen (Greek hydro = water and genes = creator)
- 1898 James Dewar hydrogen liquefied



Hydrogen has been around a long time !!

Hydrogen Properties

- Chemical Name (and symbol) Hydrogen (H but usually H₂)
- Most abundant substance in the Universe
- Gaseous hydrogen fourteen times lighter than air and fifty seven times lighter than petrol vapour
- Liquid hydrogen temperature $-252.87\text{ }^{\circ}\text{C}$
- Flammability range in air between 4% and 75%
- Burns with an almost invisible flame

- Electrolysis
 - Using electricity to separate water into hydrogen and oxygen
- Reforming
 - Reaction between methane and water to produce gas that contains hydrogen
- Other methods being considered such as photosynthesis

Most hydrogen is produced and used on chemical plants, and relatively small percentage is transported by road/rail



- Metal processing
- Hydrogenation oils for food
- Refining
- Electronics
- Analytical carrier gas
- Cooling generators in power plants and.....
- Transport



Evolution of Transport for Hydrogen

UN 1049 HYDROGEN COMPRESSED



High pressure, up to 700 bar, composite pressure receptacles

UN 1966 HYDROGEN REFRIGERATED LIQUID



Low temperature, vacuum insulated tanks

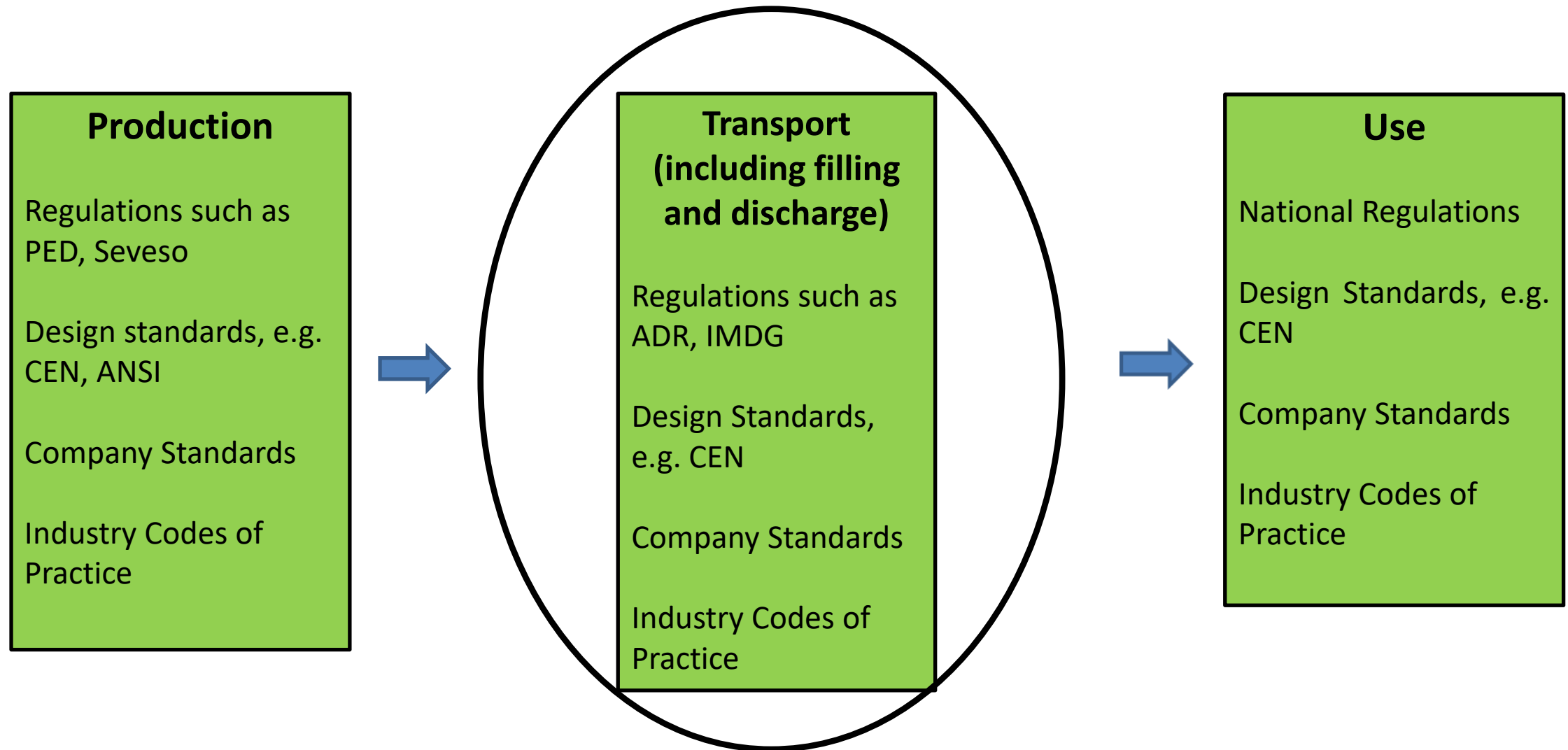
Liquid hydrogen fueling station Type CP90



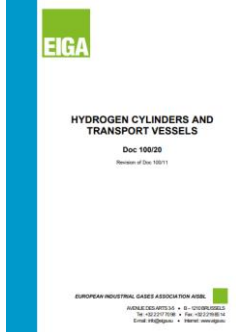
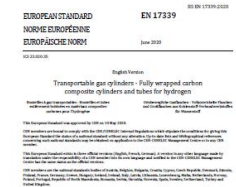
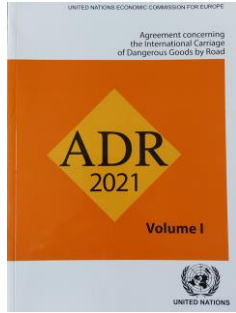
Performance

- Footprint: **6.10 x 3.40m**
- Capacity: **Up to 50kg/hr.**
- Bulk storage capacity: **400kg LH₂**
- MAWP: **100 MPa**
- Energy consumption (total): **45kW**
- Specific energy consumption:
1.2 kWh/kg H₂ → Energy saving of ~ 70%¹
- Boil-off: **4 kg/day, utilized for stand-by cooling**
- Refueling protocol: **SAE J2601-A70 and CEP**
- Refueling performance: **6 FCEV cars/hr.**
- Consequent development for installations at existing gasoline/ diesel retail stations, based on joint workshops with oil companies Shell, Total, OMV

¹ Compared to a conventional piston compressor



Transport Safety – Hydrogen Distribution



Transport (including filling and discharge)

Regulations such as ADR, IMDG

Design Standards, e.g. CEN

Company Standards

Industry Codes of Practice



Measured Safety Performance by Companies and EIGA

Companies report and record safety performance and EIGA recognises safety performance

EIGA Members have been transporting hydrogen for over 100 years

Transport Safety – Hydrogen Distribution

- Examples of initiatives in transport safety for EIGA Members include:
 - Vehicle developments
 - Dashcams to monitor external environment
 - Monitoring vehicle driving performance
 - Cameras to monitor blind spots
 - Drivers
 - Non ADR training topics delivered by Smartphone app, e.g. Procedures, specific safety topics, (e.g. Winter is coming, be aware of your surroundings)
 - Well being, physical and mental
 - Recognising “doing it right”
 - EIGA Publications
 - Transport Safety Information Sheets – www.eiga.eu