Activities for hydrogen readiness

4th European Conference - Hydrogen & P2X

Rian Holdstock and Ditte Bilgrav Bangsgaard

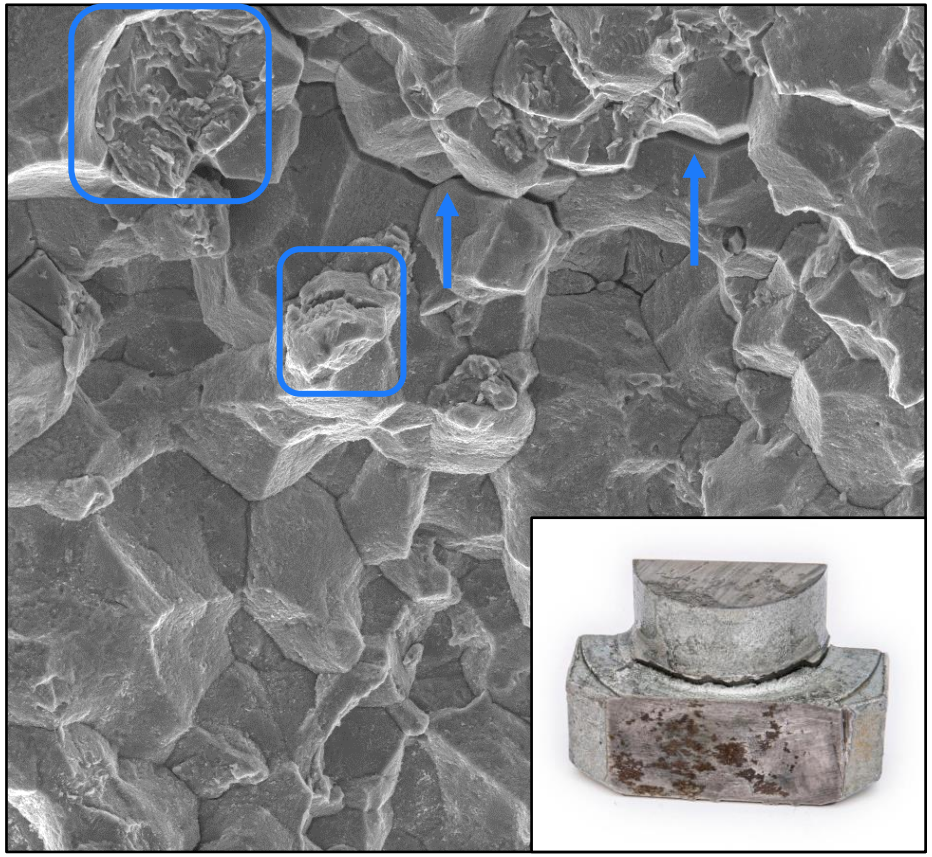
14 June, 2023

Theme

→ Materials and components

Background

Example of damage caused by hydrogen



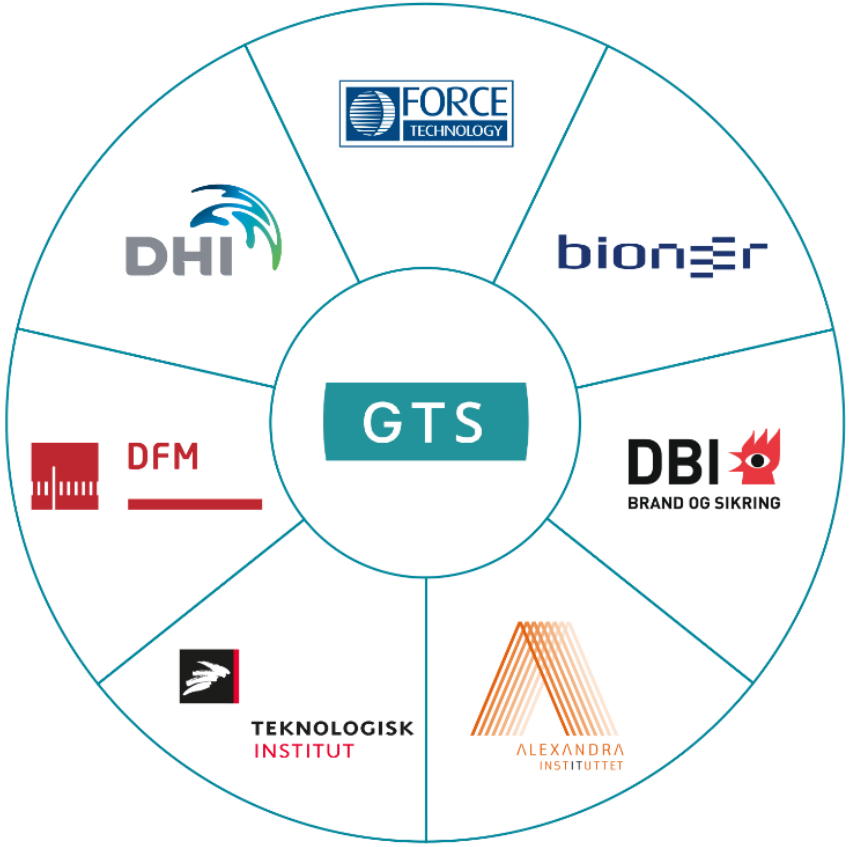
- This one shows mostly intergranular (brittle) fracture
- We also see some plastic deformation
- Several damage mechanisms have been proposed
  - → *Crack tip blunting/sharpening*
  - → *Increase/decrease in plastic deformation*
  - → *Fracture can be ductile, brittle … or both*

Contents

- Intro to FORCE Technology
- H_2 readiness
- Standardisation
- Activities to prepare for
- Example for valves
- Summary

Danish research and technology organisation

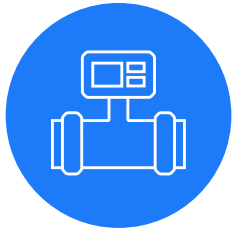
- 1 of 7
- A resource for industry, academia and public sector
- We develop, create and apply new knowledge
- We support around 30 000 businesses



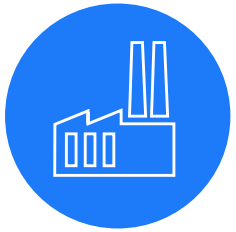
FORCE Technology

Power-to-X services

Materials



Metrology



Emissions

Pressure Equipment

Inspection

Welding

Risk Management

We can help …

Starting definitions

Compatibility

General conditions

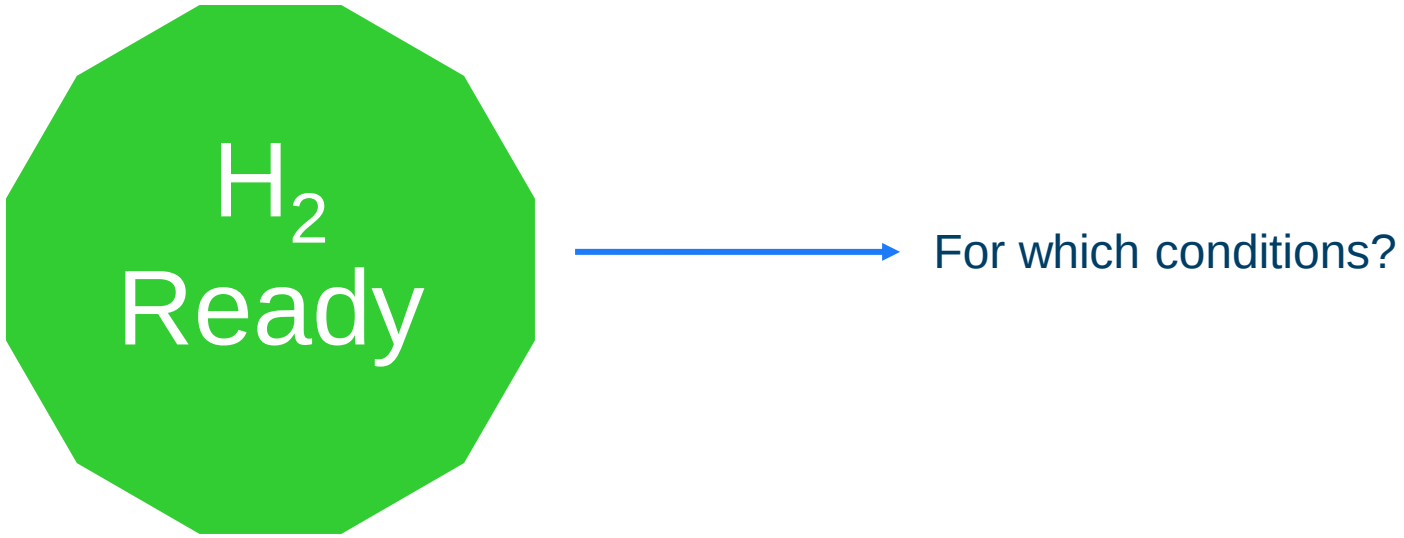
i.e., materials

Suitability

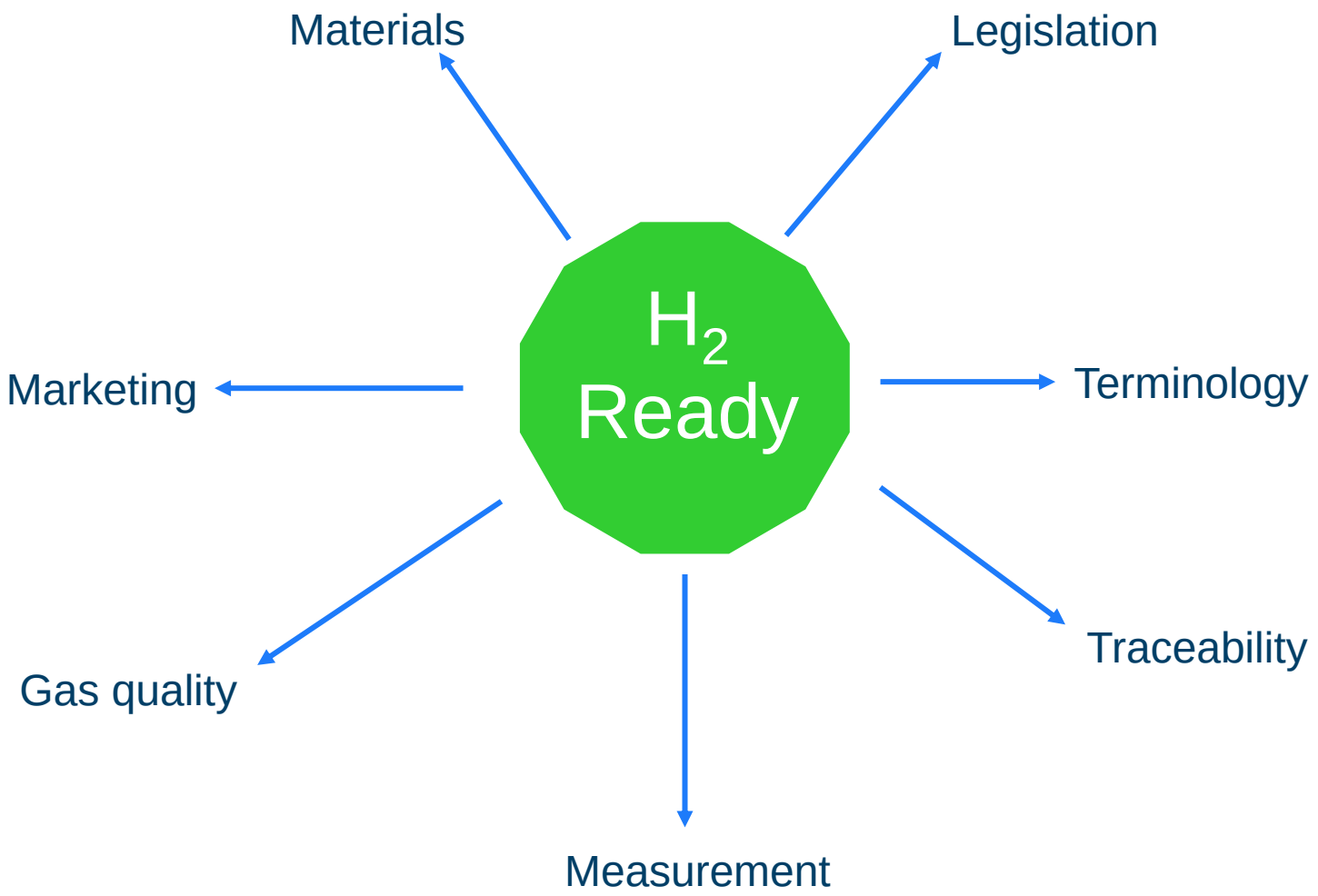
Specific conditions

i.e., components

Hydrogen readiness



Readiness is influenced by several factors

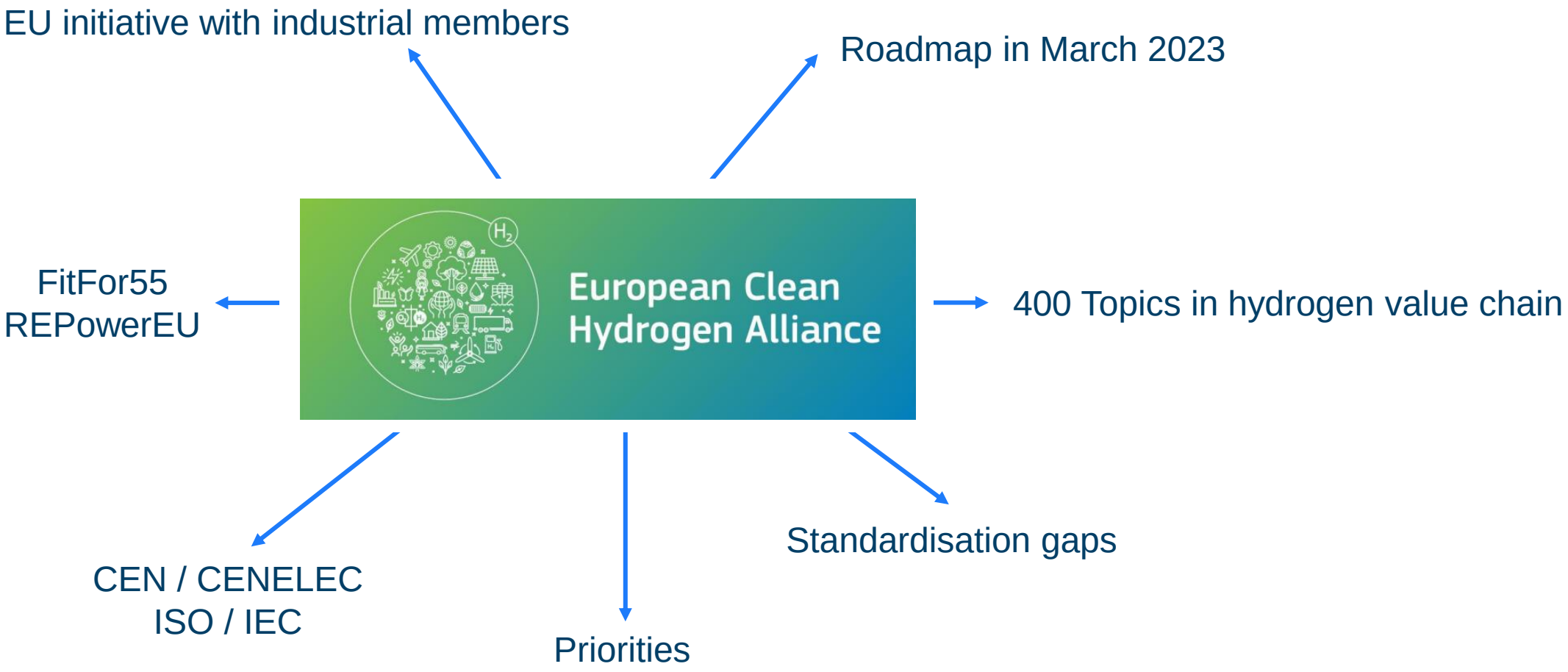


Work in progress

H_2 Ready

Standardisation

Recent developments



Priorities

Materials, Explosion, Leakage, Components

Horizontal aspects	details
terminology / definitions	collection of relevant topics
sustainability and origin	guarantee of origin (chain of custody)
	emissions / GHG
gas quality aspects	purity
	gas families / test gases
	quality measurement
safety aspects	material compatibility
	potential explosive atmosphere
	leakage
	odorisation
components / equipment	valves

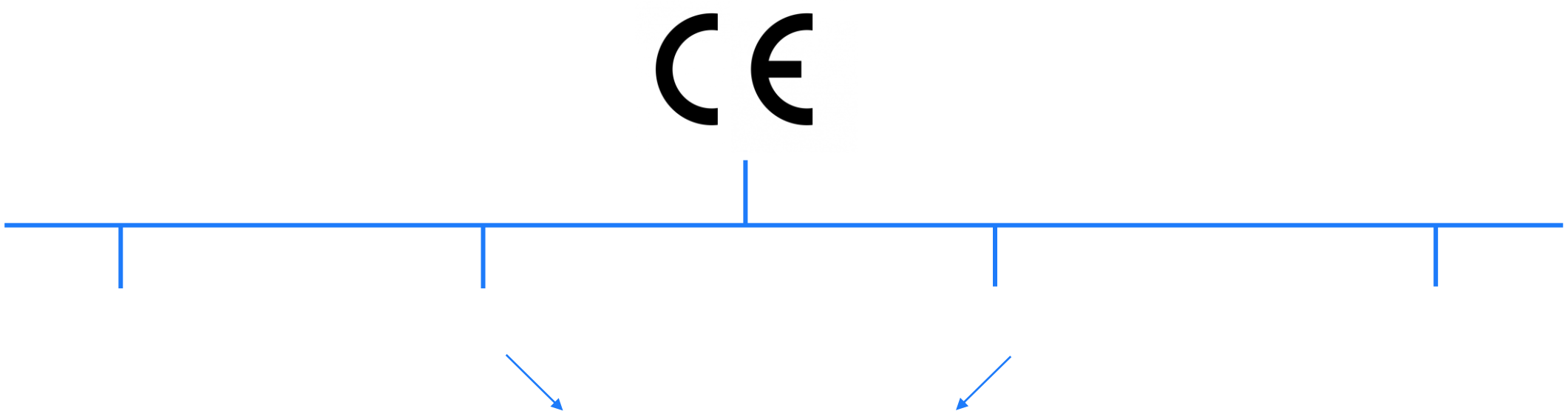
Horizontal aspects	details
	pipes
	seals
installation	bunkering
	refueling
	storage
energy / hydrogen carrier	liquid hydrogen
	gaseous hydrogen
	other carriers
	LOHC
	LIHC - Liquid Inorganic Hydrogen Carrier & HydroSil
	KBH_4 and other solid H_2 carriers
	metal hydride (e.g. iron pellets)
	ammonia
	methanol
	HHO
metrology	measurement (e.g. quality and volume)
	efficiency
	certification

FORCE TECHNOLOGY

Standardisation

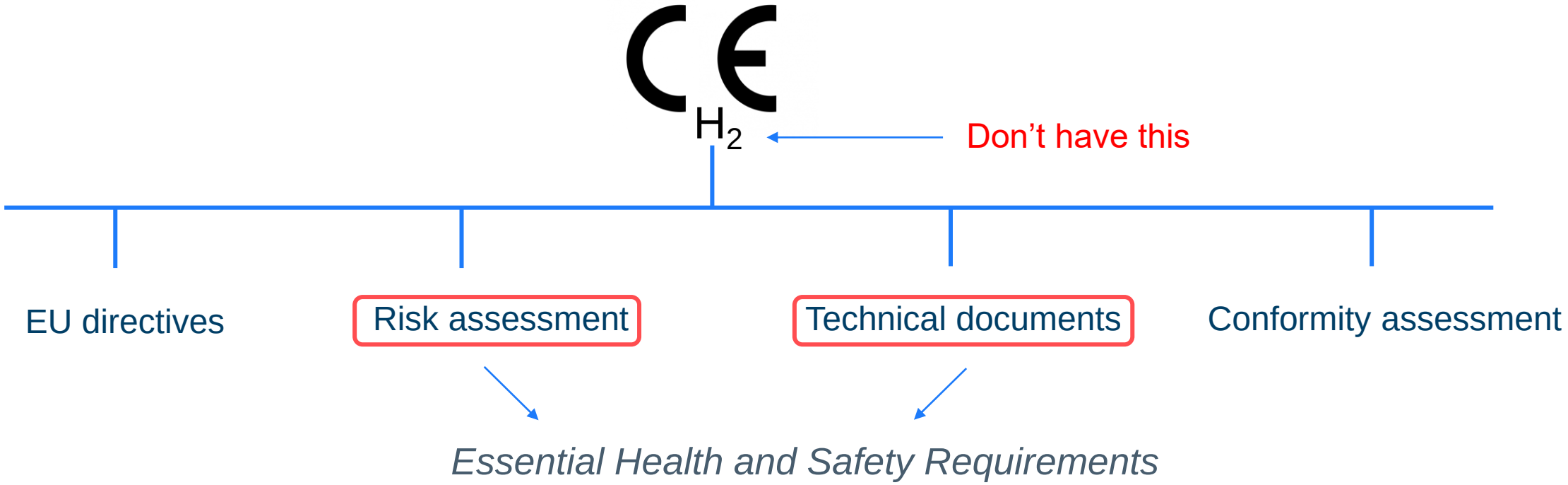
- Ongoing process
- Will take several years
- What can we do until then?

Inspiration from EU technical regulations

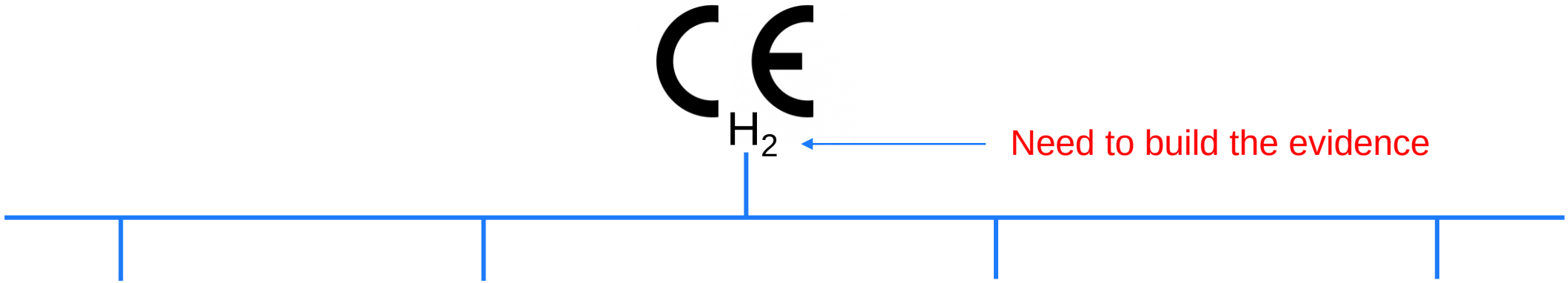


Essential Health and Safety Requirements + Conformity Assessment

Inspiration from EU technical regulations



Process



EU directives

- *PED*
- *ATEX*
- *Machinery Directive*
- *LVD …*

Risk assessment

- *Big hazards*
- *Find the gaps*
- *Define test activities*

Technical documents

- *Harmonised standards*
- *State of the art*
- *Best engineering practice*
- *Operational history*
- *H_2 gas as test medium*

Conformity assessment

- *Specific conditions*
- *2%, 5%, 20%, 100%*
- *Pressure, temperature*
- *Gas purity*
- *Leakage*

General requirements

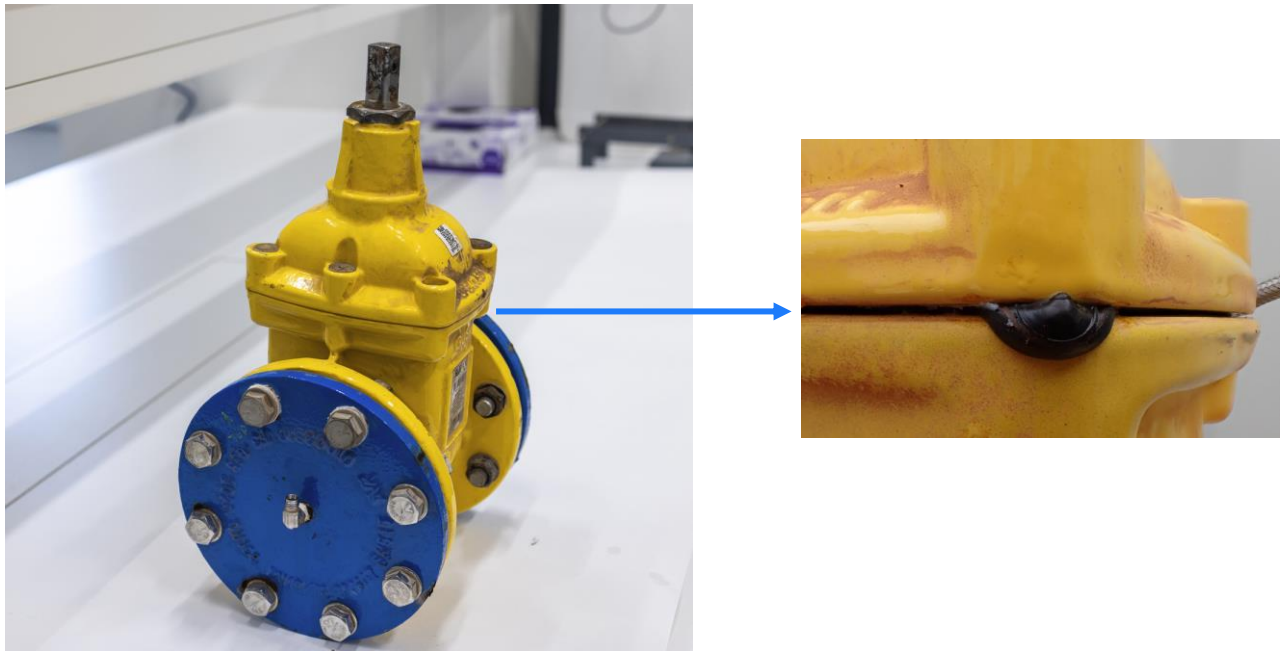
- No leaks
- No embrittlement
- No ignition sources
- No influence on measurement
- Considers future operational conditions

Activities for valves

- General material compatibility
- Fracture mechanics and fatigue
- Pressure cycling
- Temperature fluctuations
- Internal and external leakage
- Permeation
- Rapid decompression
- Ignition sources

Example – pressure and cyclic testing in H_2

Power-to-X services



- Modification of existing industry standards
- Pressurised hydrogen environment
- To document suitability for certain conditions
- Also included extreme conditions
- Image shows 10 x design pressure (extreme)

Example – fracture mechanical testing in H_2

Power-to-X services

- Existing industry standards can be used
- Long term exposure test
- High pressure H_2 gas
- Sample has crack and will be in tension
- Final examination under scanning electron microscope
- Provides plane strain fracture resistance of test material

Summary

- General materials compatibility
- Risk assessment
- Select (test) methods to fill the gaps
- Gather technical documents
- Conformity assessment
- A few steps closer to standardisation

Rian Holdstock
FORCE Technology

Tel.: +45 42 62 76 12
rih@forcetechnology.com

Ditte Bilgrav Bangsgaard
FORCE Technology

Tel.: +45 42 62 76 74
dbk@forcetechnology.com

Follow us on: