Methods for qualifying materials for hydrogen use

H2 Forum Lausitz

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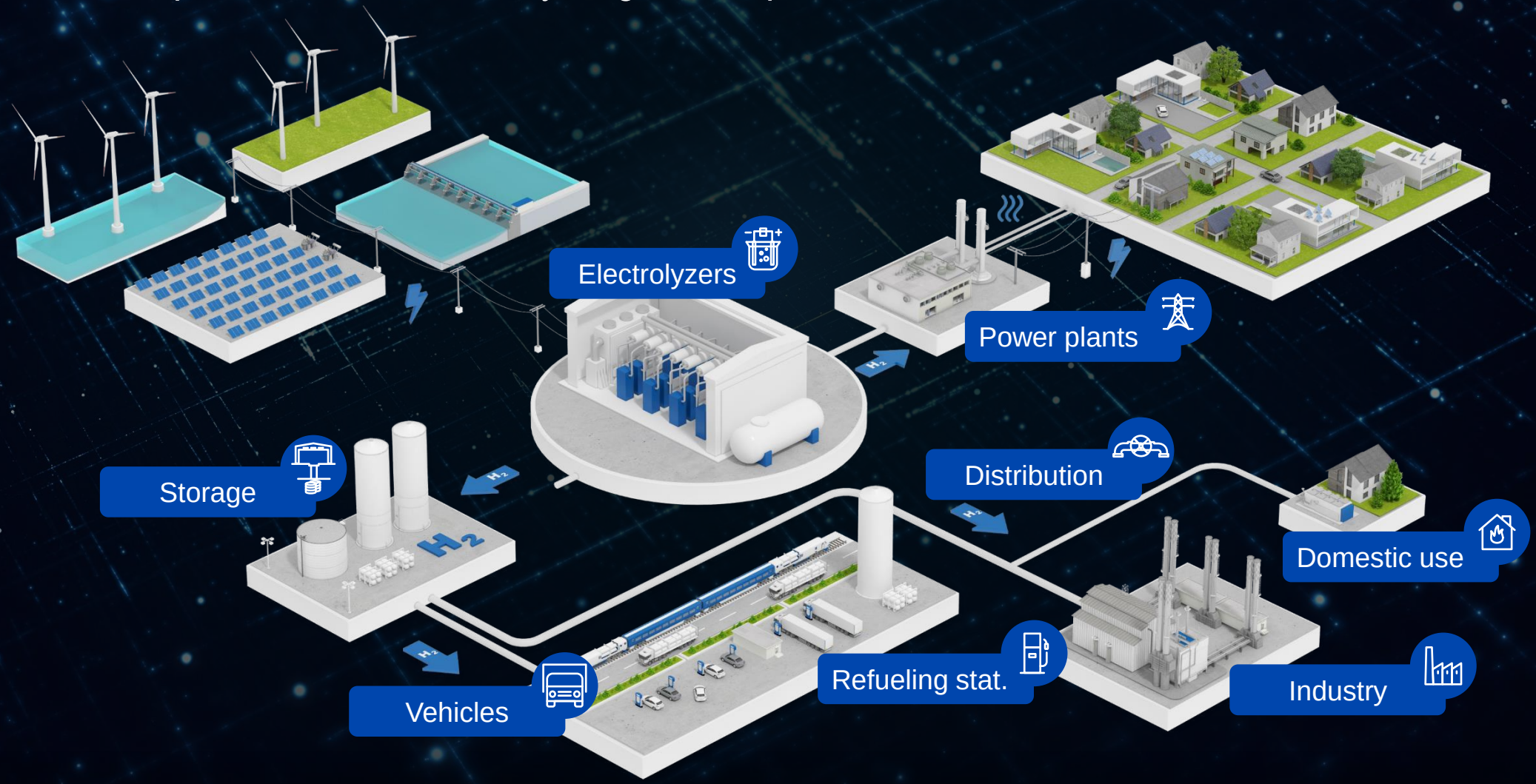
Mehr Wert.
Mehr Vertrauen.

Our energy system will be based on hydrogen –

so materials & components need to be hydrogen compatible



Ways to approve the hydrogen compatibility of materials

- Qualification by documentation, literature review
- Lifetime testing on component level
- Material testing according to norms & standards

Plastic materials

Qualification by documentation & literature review?

SAE J2579

Whitelist for metallic materials, but not for plastics

ASME B31.12

Generally very detailed, but not for specific materials

ISO/TR 15916

Referencing other standards for materials qualification

Sandia Techn. Refer. 8100

Investigation on some standard materials, but general

TÜV SÜD standard P003

Focus on metals, plastics may be adressed in future versions

→ *Excellent literature resources available*

→ *However: Explicit qualification of plastic materials harldy possible*

Metallic materials

Qualification by documentation & literature review?

SAE J2579

Whitelist for metallic materials, with footnotes

DVGW guidelines

Several DVGW sheets give detailed information

ISO/TR 15916

Information on general H2 compatibility of material groups

ASME B31.12

Very detailed information

Sandia publications

Several high-quality R&D based publications

TÜV SÜD standard P003

Focus on metals, plastics may be adressed in next version

- *Qualification by documentation thinkable*
- *But: Actual material composition (3.1 certificate) & use case to be considered!*

Hydrogen compatibility of materials

Qualification by testing – it sounds easy, but it‘s not

Pressure Equipment Directive 2014/68/EU

„[Materials] shall be be sufficiently chemically resistant to the fluid contained in the pressure equipment; the chemical and physical properties necessary for operational safety shall not be significantly affected within the scheduled lifetime of the equipment”.

DVGW G491, Annex O

„[Materials] shall be suitable for hydrogen and hydrogen-rich fuel gases“.

406/2010/EU, Annex 3, Part 4

„Non-metallic materials: Hydrogen compatibility shall be demonstrated“.

?

Detailed requirements and procedures missing, but lots of influencing factors

- Pressure range
- Temperature range
- Environmental atmosphere
- Lifetime cycles
- Gas quality
- Others

Hydrogen compatibility of materials

Qualification by testing – general approach

- Identification of relevant material properties
- Baseline measurement of material properties
- Aging / lifetime simulation
- Comparative measurement of material properties

Qualification by testing - plastic materials

Standard	ISO 17268 / SAE J2600	ISO 19880-3	CSA ANSI CHMC2	CSA ANSI CHMC2	Individual methods (example)
Intended application	*Mobility*	*Stationary*	*General*	*General*	*Individual discussion*
Material group	*Elastomers*	*Elastomers*	*Elastomers*	*Thermoplasts*	*Elastomers & thermoplasts*
Test samples	*Material samples*	*Components (valves)*	*Material samples*	*Material samples*	*Components (valves)*
Relevant criteria	*Swelling, shrinking weight loss*	*Leakage*	*Swelling, shrinking weight loss*	*Permeation, tensile str., hardness*	*Robustness, leakage, permeation*
Measuring method	*Weight & volume measurement*	*Leakage testing*	*Weight & volume measurement*	*Permeation, tensile, hardness testing*	*Lifetime test for >= 2x intended lifetime*
Aging parameters	*168h static H2 exposure*	*70h static H2 exposure*	*Static & cyclic H2 exposure*	*Static & cyclic H2 exposure*	
Rating	*pass/fail*	*pass / fail*	*0-10 points*	*0-10 points*	*pass/fail*

Qualification by testing - metallic materials

Standard	ISO 11114-4, method A	CSA ANSI CHMC1	CSA ANSI CHMC1	Individual methods (example 1)	Individual methods (example 2)
Intended application	*Pressure vessels*	*General*	*General*	*Individual*	*Individual*
Test samples	*Burst discs*	*Tensile probes*	*Fatigue probes*	*Tensile probes*	*Components (e.g. valves)*
Relevant criteria	*Burst pressure*	*Relative notch tensile strength*	*Stress amplitude*	*Tensile & yield strength*	*Pressure & cycle robustness*
Measuring method	*Comparative burst tests with H2 & He*	*SSRT*	*Fatigue cycling*	*Tensile testing*	*Lifetime test for >=2x intended lifetime*
Aging parameters	*Gas exposure during test*	*Gas exposure during test*	*Gas exposure during test*	*168 h static H2 exposure*	
Rating	*Calculated embrittlement index*	*pass/fail*	*Safety factor calculation*	*>= 94% strength retained*	*pass/fail*

Conclusion

- Hydrogen is becoming relevant for more and more parts of our energy system.
- Material qualification is crucial for ensuring safe operation over the whole product lifetime.
- The single gold standard for qualifying materials has not yet evolved (and probably won‘t ever).
- Qualifying plastic materials without testing is hardly possible.
- Qualifying metallic materials without testing is thinkable, but dependent on several factors.
- Testing provides a safe and cost-efficient way for qualifying materials and increasing trust

Contact

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