Testing and Approval of Hydrogen Systems for Automotive and Industrial Applications

12th German-Japanese Economic Forum

Dr.-Ing. Stefan Behrning, TÜV Rheinland Group

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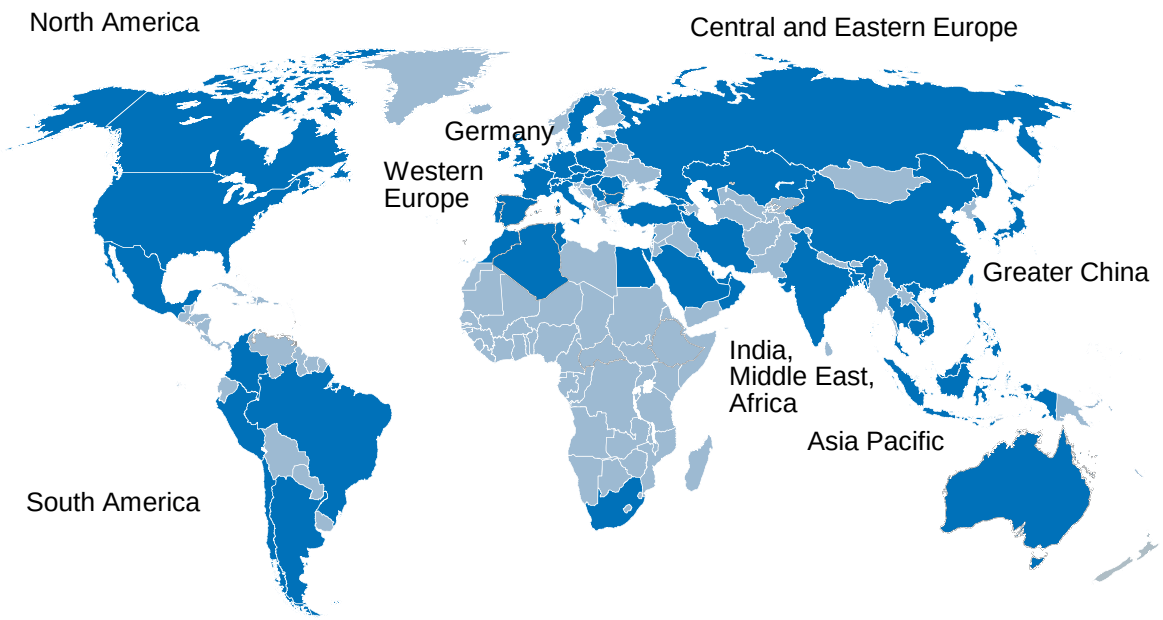
TÜV Rheinland: A Global Player

8 Regions

500 Locations

>200 Laboratories

GERMAN AT HEART – GLOBAL IN MIND.



20,000	employees worldwide
11,400	employees outside Germany
16,432	km are there between the HQ in Cologne and our office in Melbourne, Victoria, Australia
2,625	meter above 0 is the highest situated office: Bogotá, Colombia
9.5	Millions vehicles are periodically reinspected every year
50,000	certificates are issued annually

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TÜV Rheinland: The „alternative drives“-TÜV

Milestones

1872

Founded as an association for testing steam boilers

1904

First periodical inspection of vehicles

1994

First Fuel Cell Vehicle approval

1994

First CNG Bus (MAN)

2003

Fuel Cell Bus (Mercedes)

2003

Second generation Fuel Cell Vehicles

2004

Second Generation Fuel Cell Bus (various OEM)

2004

CNG Passenger Car

2006

Bus with H2 combustion engine

2017

Series Fuel Cell Vehicle

Source: Daimler, MAN, Volkswagen

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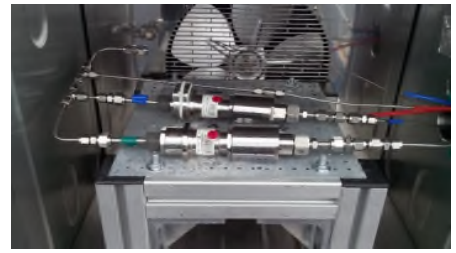
TÜV Rheinland: Competence Center alternative Fuels

Since 1994, the Competence Center for Alternative Fuels is focused on gaseous fuels applications (LPG, CNG, H2) as well as other alternative propulsion systems (e-drives) covering:

- advising
- inspection / testing
- certification / type approval
- training

for automotive and industrial (fueling stations, ADR, etc.) applications.



NGVA Europe membership; partnership in various standardization working groups

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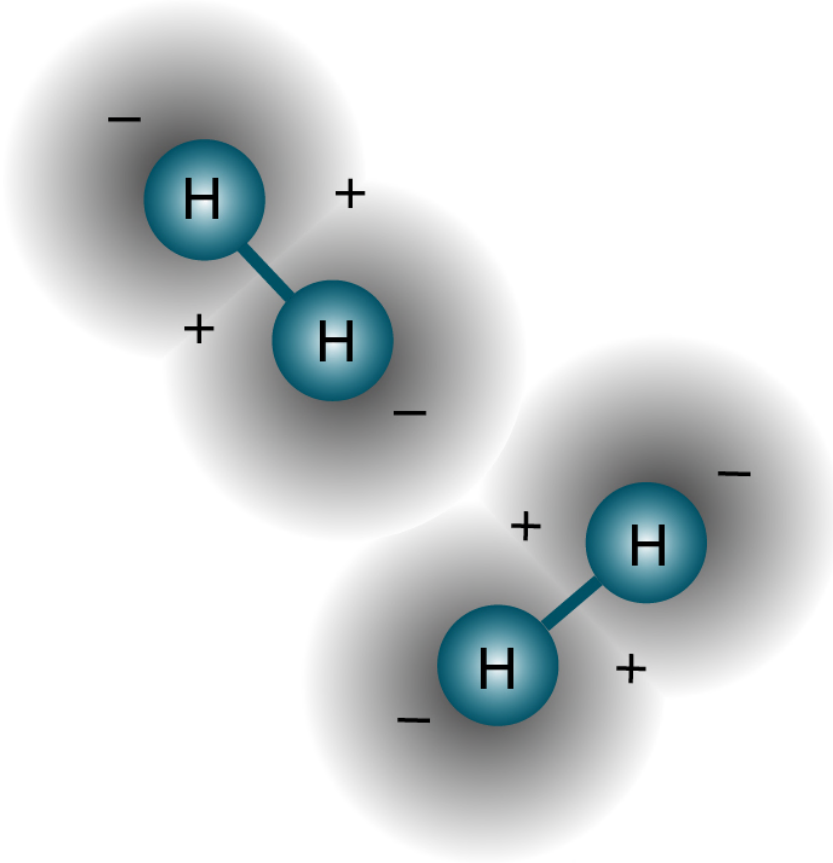
Basics

Physics and Chemistry

H_2

- two „Hydrogenium“ atoms result in a Hydrogen molecule, atoms are not stable
- gaseous (storage @ 35 MPa (350 bar) or 70 MPa (700 bar))
- liquid at -253°C



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Basics

Physics and Chemistry

- non-toxic
- odorless
- unflavored
- invisible
- invisible, barely perceptible flame
- burns at 2,200 °C, hardly any radiation
- lighter than air (ca. 14,4 times)
- embrittling
- non-corrosive
- non-carcinogenic
- Tboil = -253 °C
- energy: 33,33 kWh/kg (3,0 kWh/Nm^3) up to 39,41 kWh/kg (3,5 kWh/Nm^3)

  => 1 kg (H2) = 2.1 kg (CNG) = 3.9 l (Gasoline) = 3.3 l (Diesel)
- ignition energy in air: E = 0,02 mJ
- at 29 Vol.-% (stoichiometric ratio with pure O_2), T= 3,000 °C

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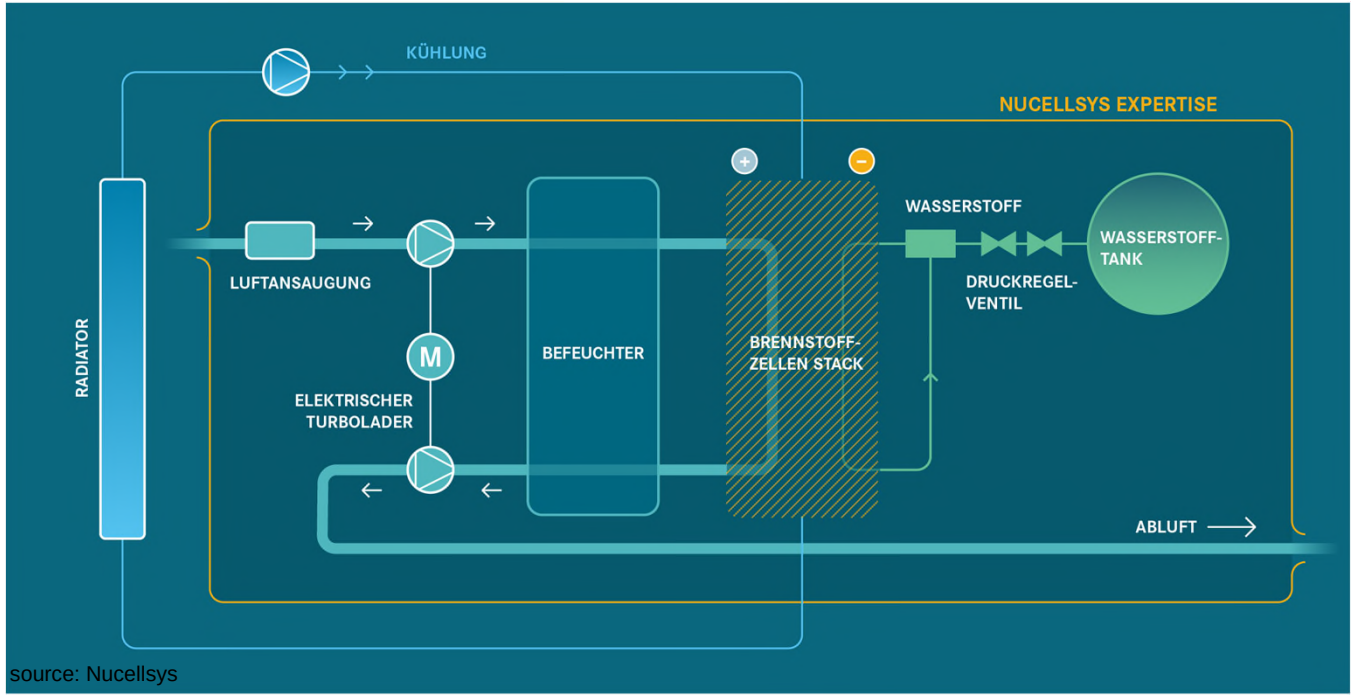
Fuel Cell Technology of Vehicles

Fuel Cell System

- ecological, no pollutant emissions
- w/o vibrations, no moveable parts
- quiet, low-noise fan only
- efficient (efficiency 60-67%)
- modular (=scalable power)
- excellent partial load performance: almost no losses when operated between 50% und 100%



source: Nucellsys

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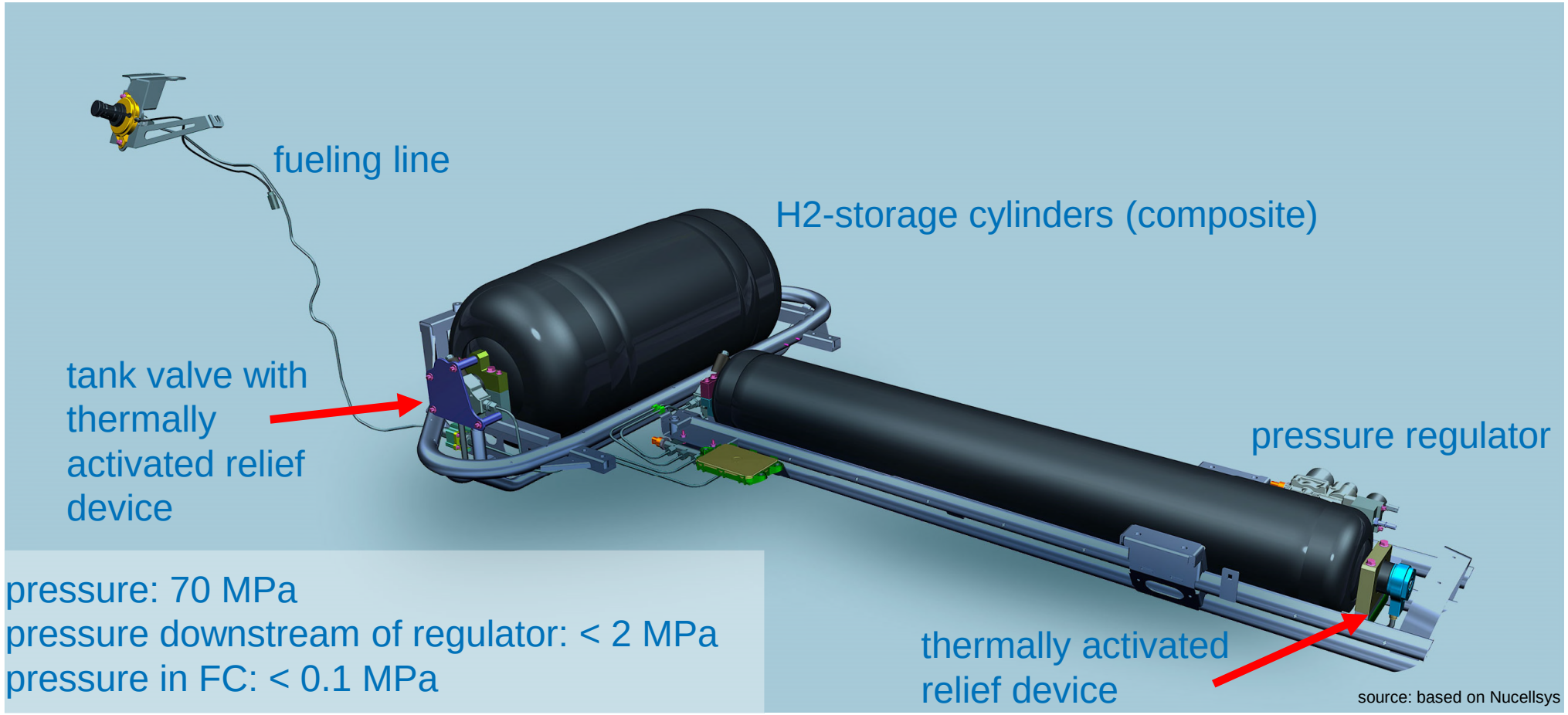
Fuel Cell Technology of Vehicles

Fuel Cell and Gas System



pressure: 70 MPa
pressure downstream of regulator: < 2 MPa
pressure in FC: < 0.1 MPa

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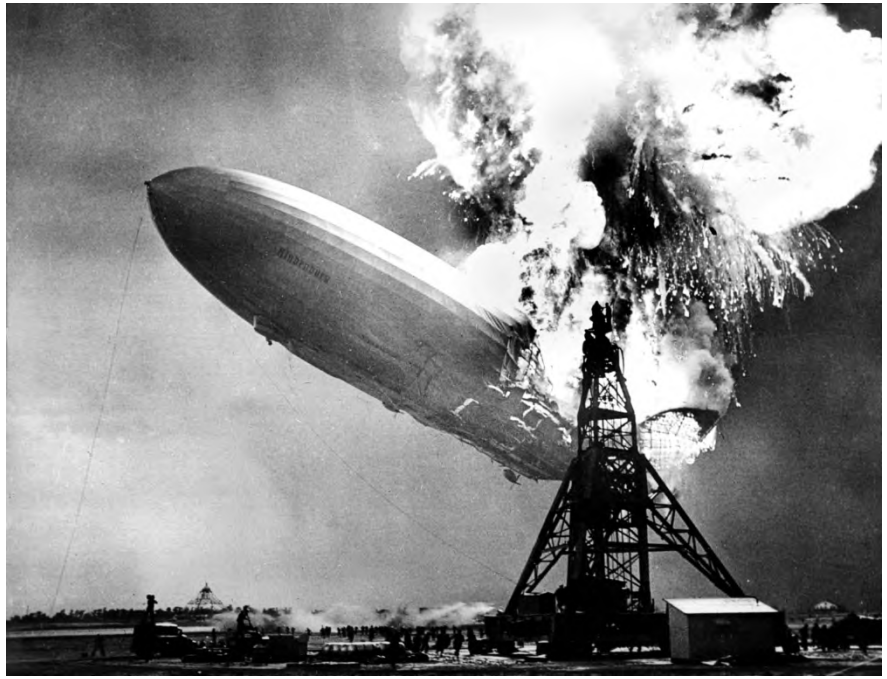
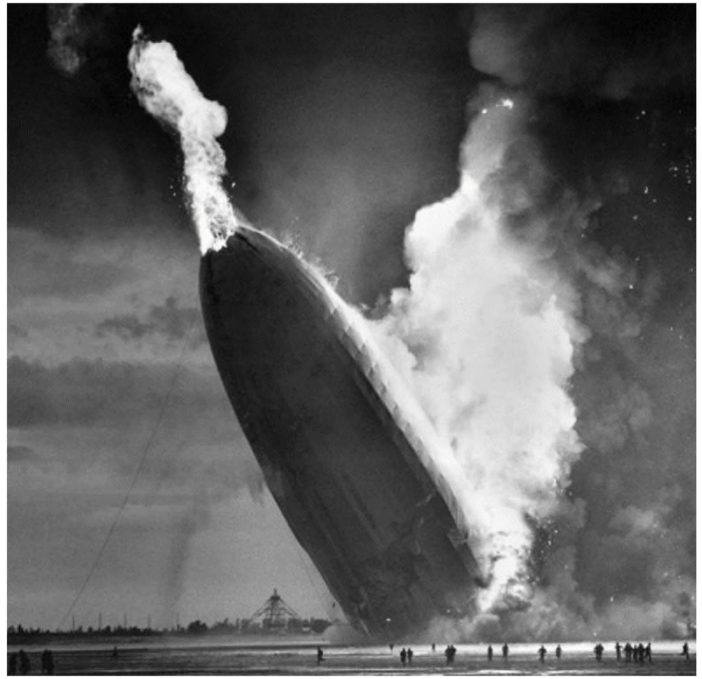
Safety

The Hydrogen Fairy Tale





Zeppelin Hindenburg catastrophy
Lakehurst, New Jersey, USA
May 6th, 1937

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Safety

European and International Regulations

EU
Regulation (EC) 79/2009 and ECE R134 for testing and approval of H2-components and whole vehicles

North America
Standards HGV2, HGV3.1 und HPRD1 for testing of H2-components, whole vehicles are covered by FMVSS, NFPA

Japan
HPGS Act und JARI S001/002 for testing and approval of H2-components and whole vehicles

World (including the countries of above)
GTR13 for testing of H2-components and whole vehicles

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Safety

Examples for Cylinder Tests

DROP TEST AT 45°

DROP TEST VERTICALLY

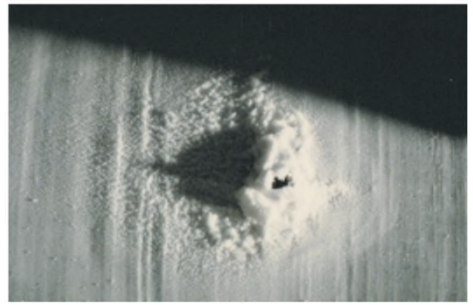
DROP TEST HORIZONTALLY

FRONTAL CRASH TEST 6.6 G FOR BUS

HYDRAULIC BURST TEST

PRESSURE CYCLING

BONFIRE TESTING



GUN FIRE TESTING BULLET 7.62 MM

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Safety

… and Lakehurst again?!?

That‘s how it should be…

… but not like this!

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Conclusion

Fuel Cell Vehicles

- are smart electric vehilces,
- show no pollutant emissions,
- have no range issue,
- are safe and
- deserve a sporting chance!

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Questions?

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