MAGNA STEYR

Automotive Hydrogen Storage Systems

STORHY – A European Integrated Project

Volker Strubel
IP Coordinator

October 10th, 2006

STORHY - General Project Information

"Hydrogen Storage Systems for Automotive Application"

Integrated Project n° 502667 within the EU FP6

Co-ordinator:	**MAGNA STEYR Fahrzeugtechnik AG & Co KG**
Time frame:	**2004 – 2008 (4,5 years)**
Official project start:	**March 1st, 2004**
Budget:	**€ 18.7 mio**
EU contribution:	**€ 10.7 mio**
Website:	**www.storhy.net**

34 partners from 13 European countries

(5 OEMs, 14 research institutes and 15 supplier companies)

STORHY - Vision

… to introduce *innovative* and *competitive* hydrogen storage solutions for cars and busses as quickly as possible

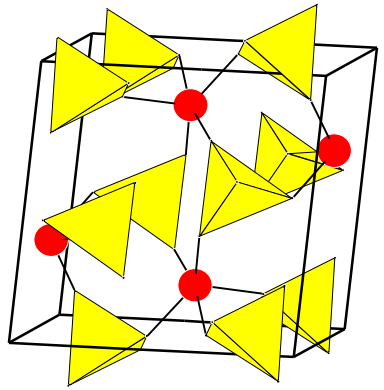
Gas:
700 bar Technologies

Source: Dynetek

Liquid:
Lightweight free form tank

Source: BMW Group

Solid:
Advanced Alanates



Source: FZK

Definition of Automotive Requirements

Excerpt only!

Mercedes Benz FC vehicle with CH2 tank

BMW ICE vehicle with LH2 tank

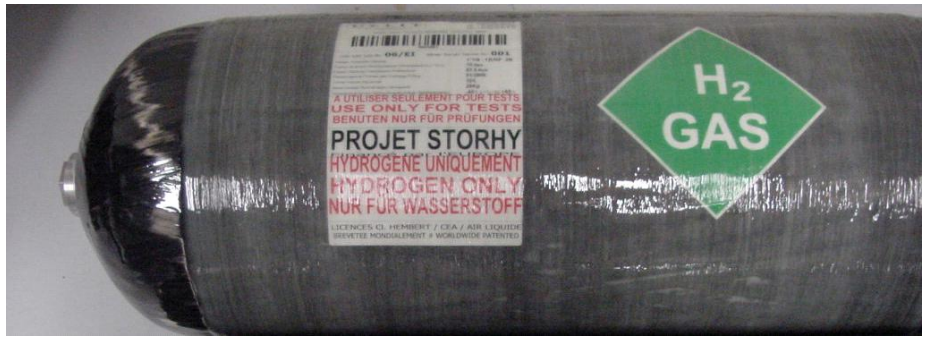
Parameter	Unit	StorHy Target 2010
Driving Range	km	600
Hydrogen Storage Mass	kg	6 - 10
System Gra. Energy Density	kWh/kg wt%	2.0 6
System Vol. Energy Density	kWh/l kg H_2/100l	1.5 4.5
Operating Temp.	°C	-40 to +85
Refuelling Rate	kg H_2/min	1.2
Delivery rate (max)	g H_2/sec	2.0 FC
Min. Pressure	bar	6
Permeation rate	H_2 Ncm^3/h per l internal volume	EIHP II 1
Loss of usable H_2 (boil-off)	g/h per stored kg H_2	1

MAGNA STEYR

Advanced C-H_2-Pressure Vessel

STORHY

700 bar Type IV vessels



January 06

"32 L" @ 700 bar

Liner : Nylon Patented (rotomolded)

Composite : "Basic Design"

- **Internal volume : 34 L (37 L @ 700 bar)**
- **Weight : 28 kg**
- **Gravimetric capacity : 5,3 % w**

C-H_2 Filling Technology

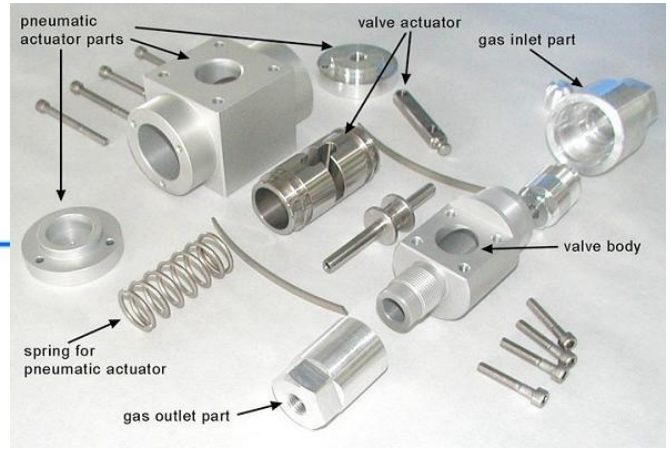
700 bar Filling Technology

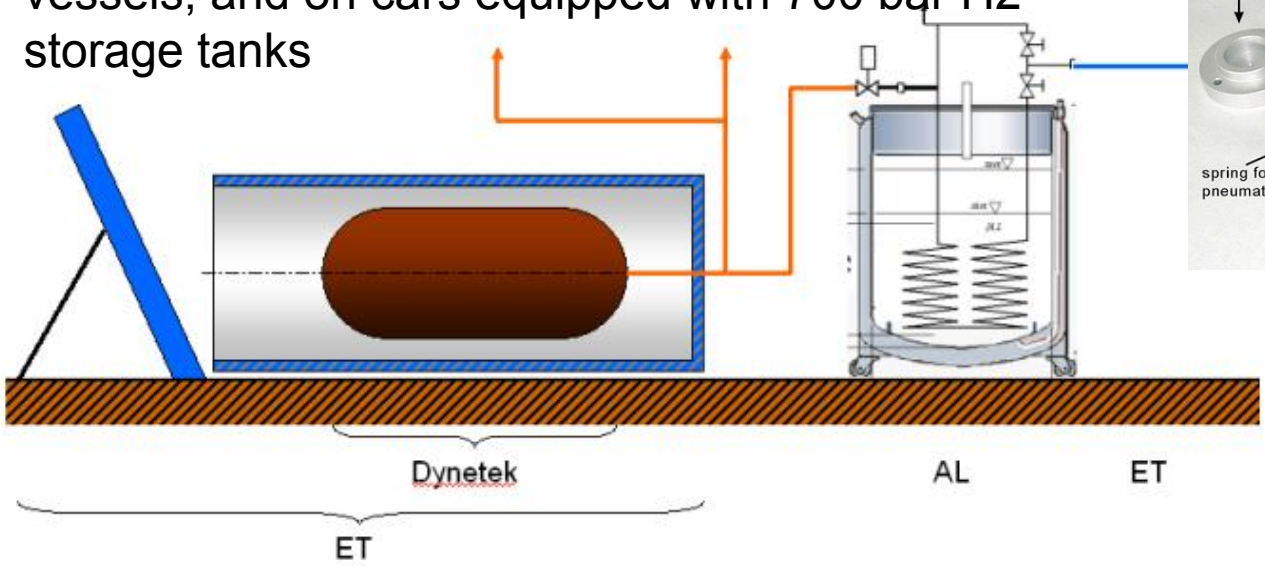
Filling procedure of 700 bar H2 pressure vessels

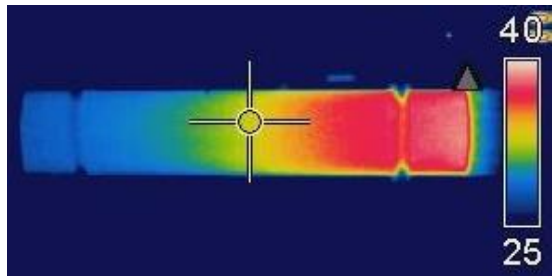
Breakaway system and **high pressure linear valve**

Understanding **heating effects during fast filling**, and evaluating **"warm"** and **"cold" filling** methods

Validation at fueling stations on new pressure vessels, and on cars equipped with 700 bar H2 storage tanks





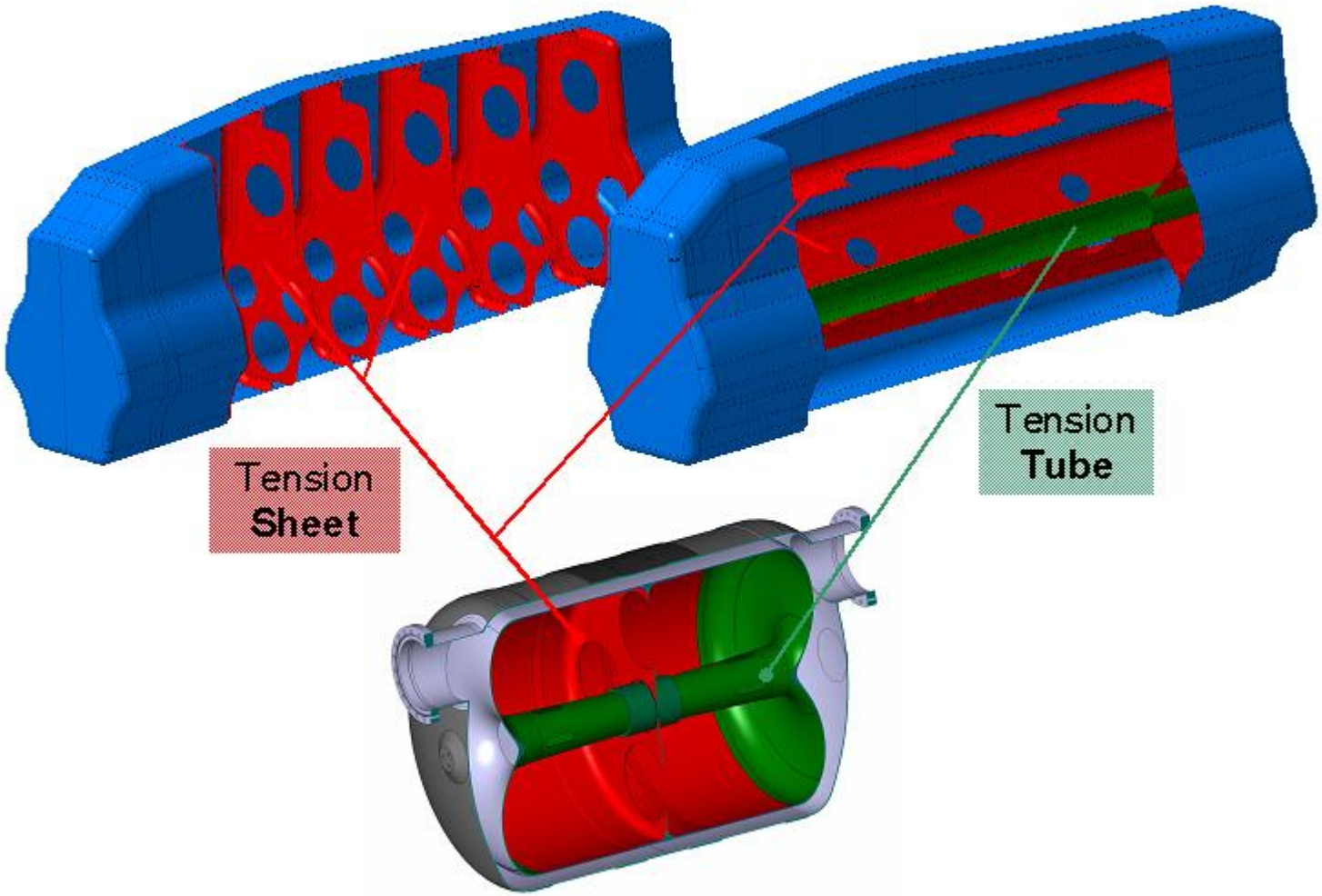


Design of Cryogenic Tanks

Design Process of Cylindrical and Free Form Tank appyling the same Design Elements

Free-Form

Cylindrical



MAGNA STEYR

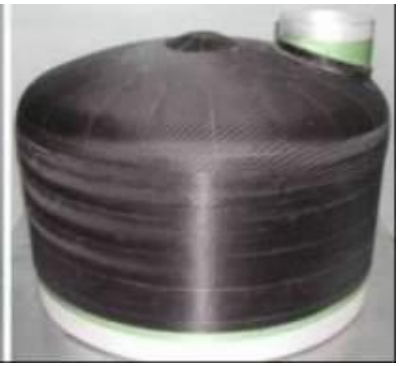
Manufacturing of Cryogenic Tanks

STORHY

Prototypes Tanks

Manufacturing & pre-assembly:



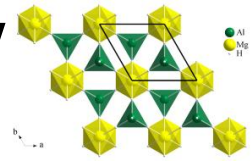



Flexible pipe:


SP Solid: Major Milesstones

2004 | 2005 | 2006 | 2007 | 2008

Definition of requirements

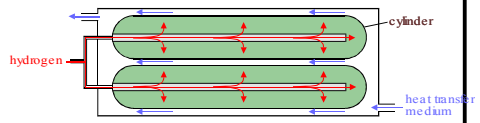


Na/Mg AlH_4 synthesized

500 g Alanate tank

8kg material Bread Board Tank

Simulations and heat management aspects of 5kgH2 tank



Identifying new mixed alanates

Kinetic and thermodynamic characterization of the Na/Mg AlH_4

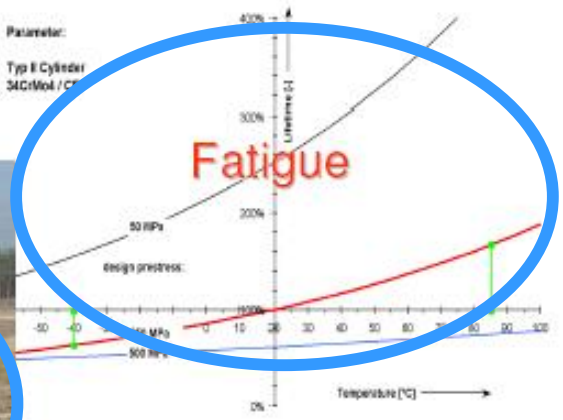
8 kg Material tank Specifications

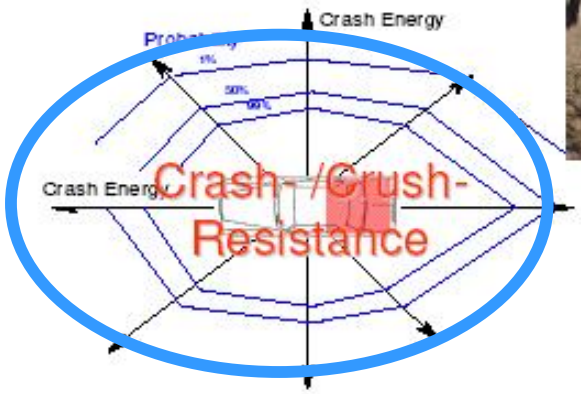
Safety tests

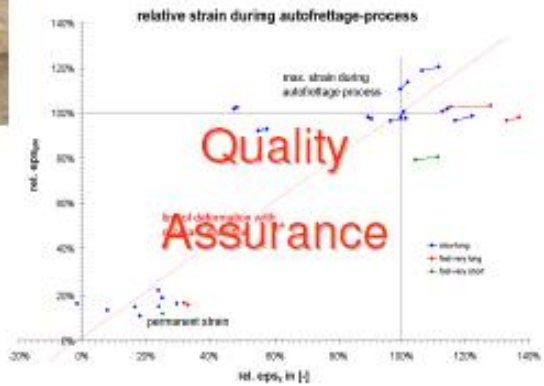
Start of Project

END

Safety Aspects

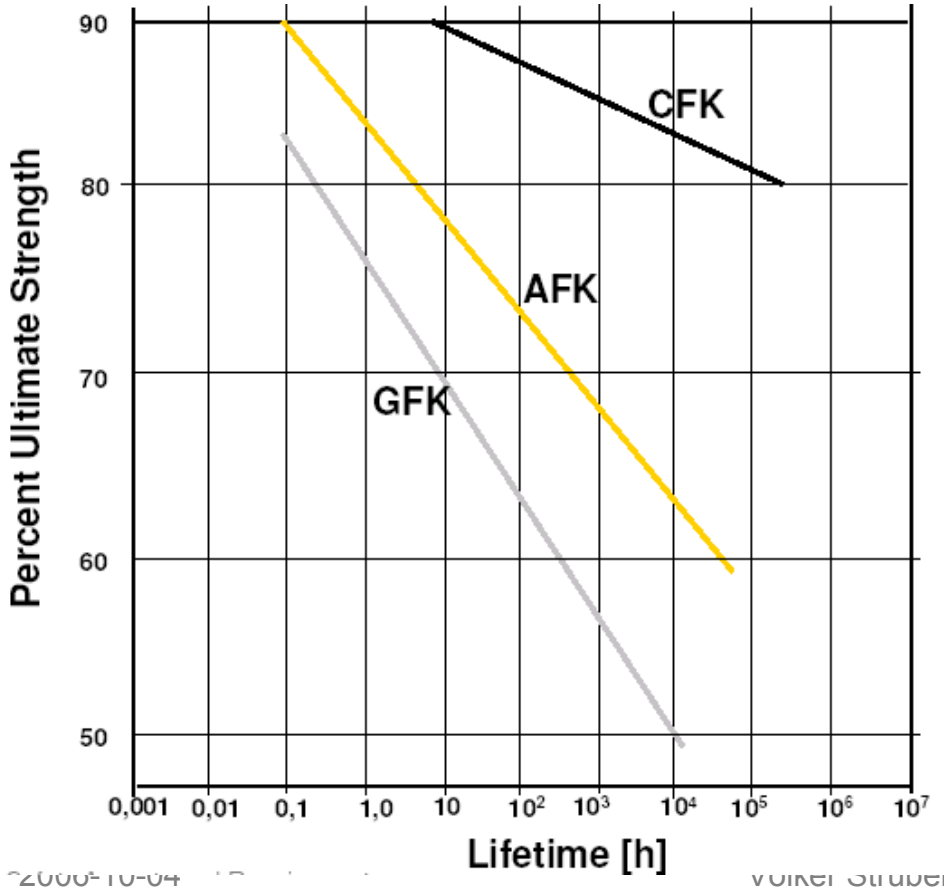






Stress Ratio Factors

Long term properties of different composite materials

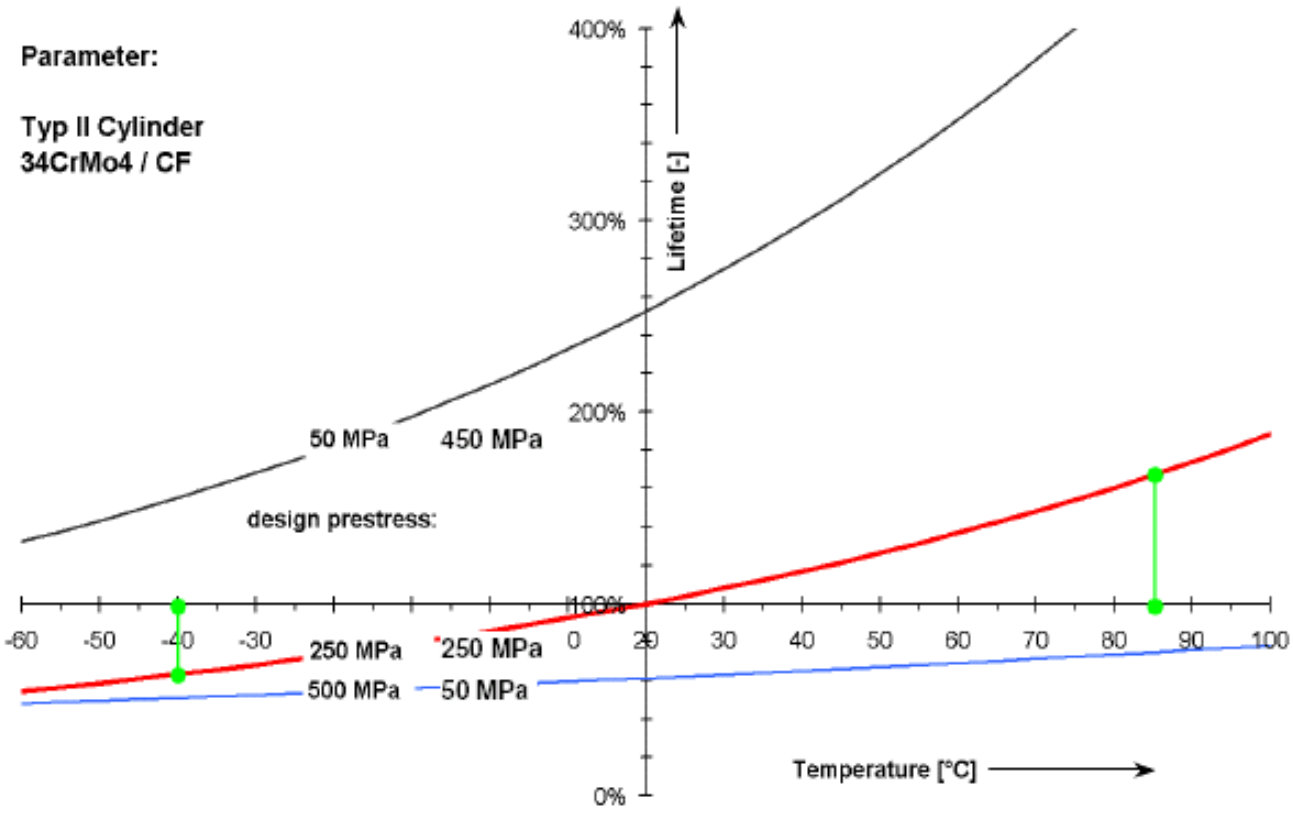


CF: 2,35

Material data: 1980 –1990

Status quo?

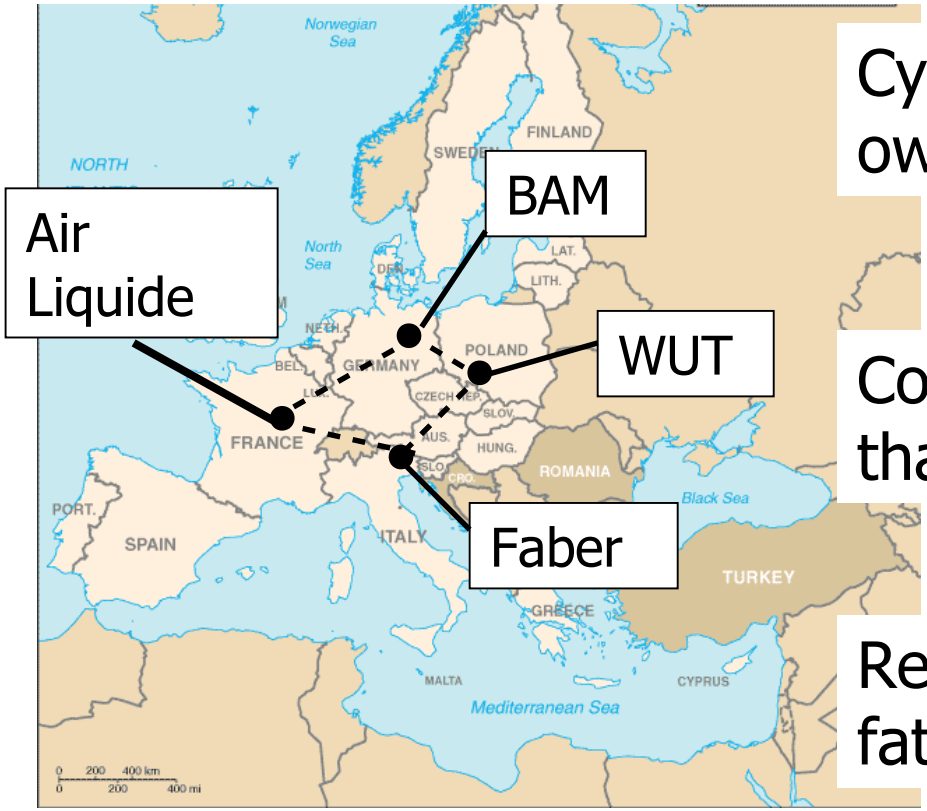
Metal Liner: Fatique Behaviour



- Temperature influence on the fatique behaviour
- 3x 5000 cycles required?

Interlaboratory Tests

Round robin: Pressure cycling tests



Cycling equipments have their own characteristics

Comparison of the precision that may be achieved

Reproducibility of hydraulic fatigue results

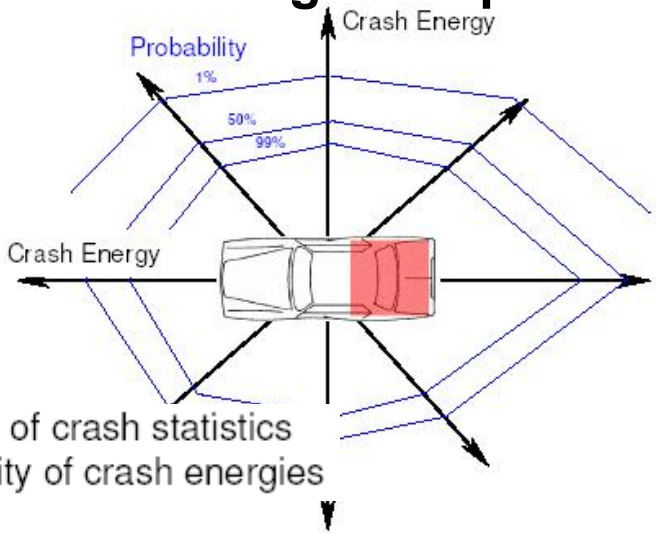
Crash Resistance

The drop test according the current draft (UN-ECE WP 29) for hydrogen vehicles does not cover the real accident scenario.

The crash energy has not been considered!

The drop test covers only
handling accidents
during installation and inspection.

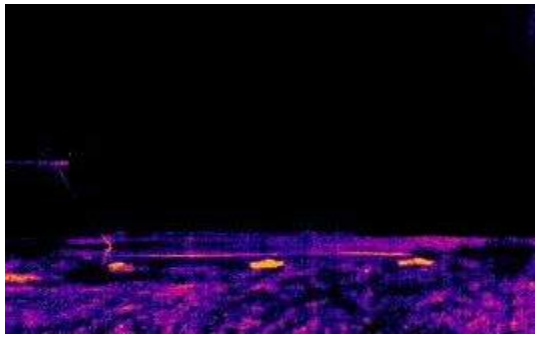
Analysis of real crash energies required



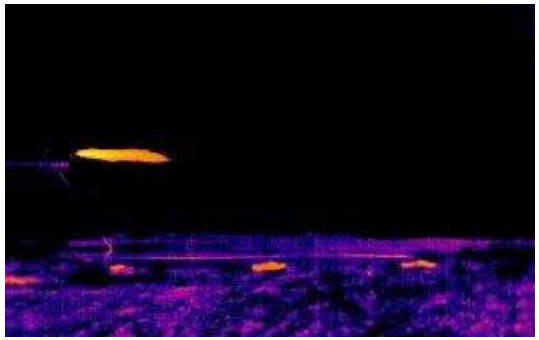
Polar diagram: Analysis of crash statistics concerning the probability of crash energies

Chemical safety experience of Alanate powders

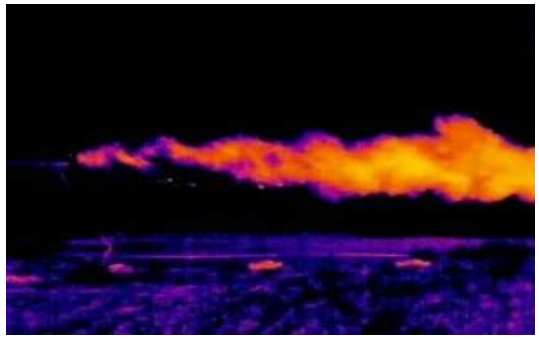
t=0 ms



t=30 ms



t=320 ms



Probabilistic Approach

StorHy-Systems are primarily designed to cover the standards and not a certain level of reliability.
Improvement of e. g. the hydrogen storage technology is possible by a probabilistic design and approval in order:

- ⇨ to achieve a lower weight,
- ⇨ to achieve a decrease of material consumption,
- ⇨ to achieve a cheaper manufacturing process….

…at a safety level which is on no account lower than today.

MAGNA STEYR

Thank you for your patience

STORHY