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# CONSEQUENCES OF EXPOSING CRYOGENIC STORAGE VESSELS CONTAINING LIQUID HYDROGEN TO A FIRE LOAD

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# Sites & branches



Fabeckstraße  
branch



Adlershof branch



Lichterfelde headquarters



Test Site Technical Safety,  
BAM TTS

BAM is a senior scientific and technical federal institute with responsibility to Federal Ministry for Economic Affairs and Climate Action. (BMWK)

~ 1700 employees



Federal Ministry  
for Economic Affairs  
and Climate Action

# BAM Test Site Technical Safety (TTS)

An der Düne 44 | 15837 Baruth/Mark

total area of ~ 12 km<sup>2</sup>



Test area  
Hydrogen Safety

Legende  
legend

 Sammelplatz -  
Nutzung bei Gebäuderäumung  
Meeting points - use in building evacuation

 Standorte Defibrillatoren  
Locations of defibrillators

Haus 101, Eingangsbereich  
Haus 201, Flur neben Verbandskasten  
Haus 306, Flur neben Verbandskasten  
Haus 308, Eingang Beobachtungsbunker

Haus 412, Flur neben Verbandskasten  
Haus 433, Flur neben Verbandskasten  
Haus 445, Flur neben Verbandskasten  
Haus 601, Eingang Beobachtungsbunker

# Motivation: efficient transport und storage of Hydrogen in cryogenic state → SH2IFT Project

- LH2-carrier and stationary LH2-storage-vessels

- 2020/2022: 2500 m<sup>3</sup>



<https://global.kawasaki.com/en/stories/articles/vol18/>

future: up to 160.000 m<sup>3</sup>

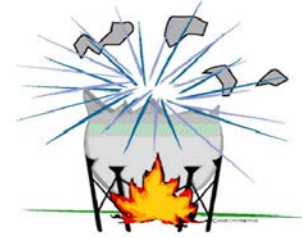


<https://energyresearch.ucf.edu/research/hydrogen/liquid-hydrogen-storage/>



<https://wiki.openstreetmap.org/wiki/File:Berlin-WasserstoffTankstelle-2007.jpg>

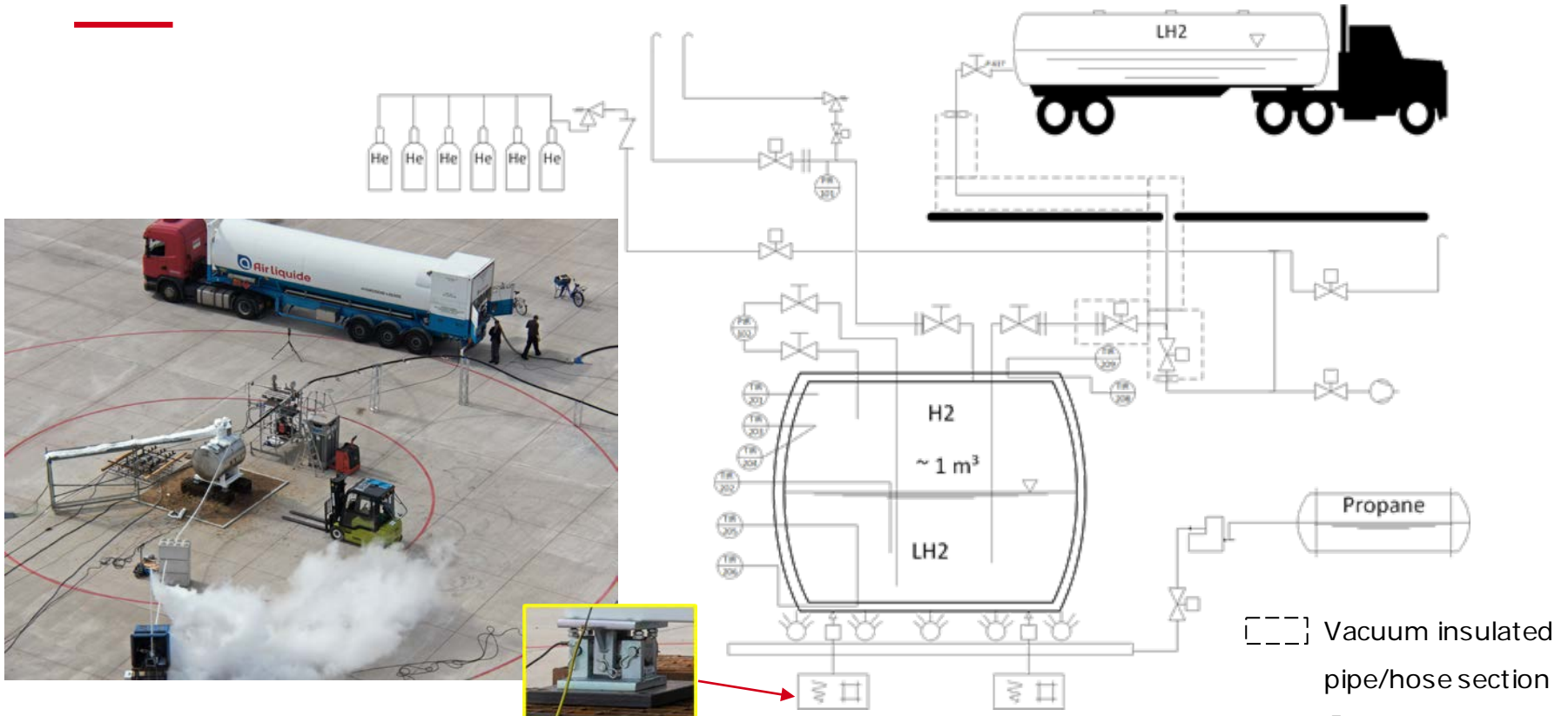
Boiling Liquid Expanding  
Vapour Explosion



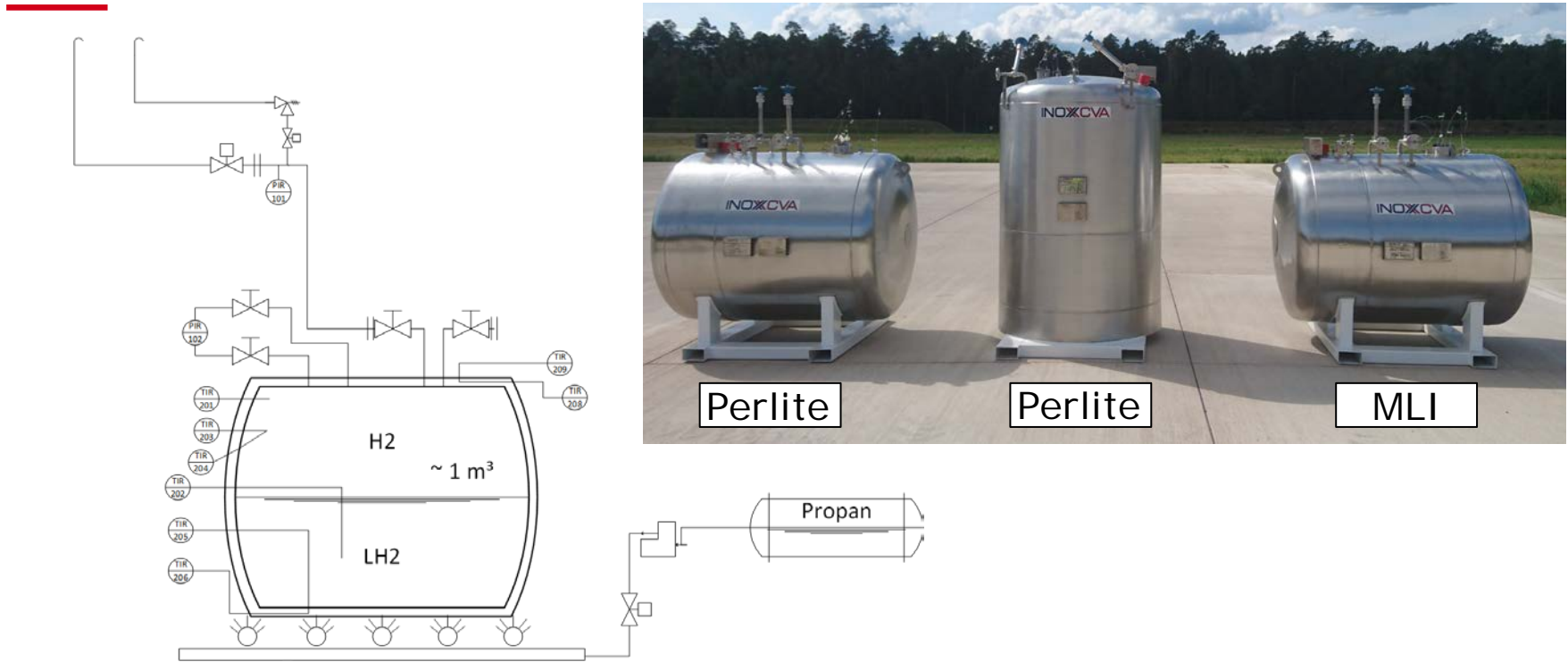
Rapid Phase Transition



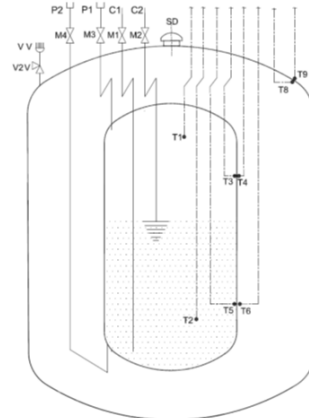
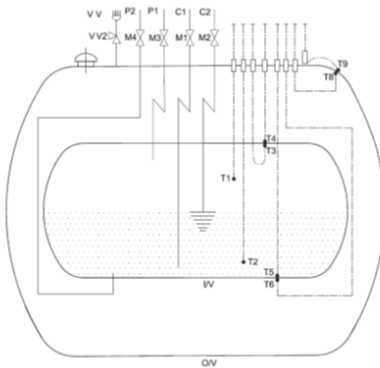
# Test Setup for „BLEVE“ experiments: Filling



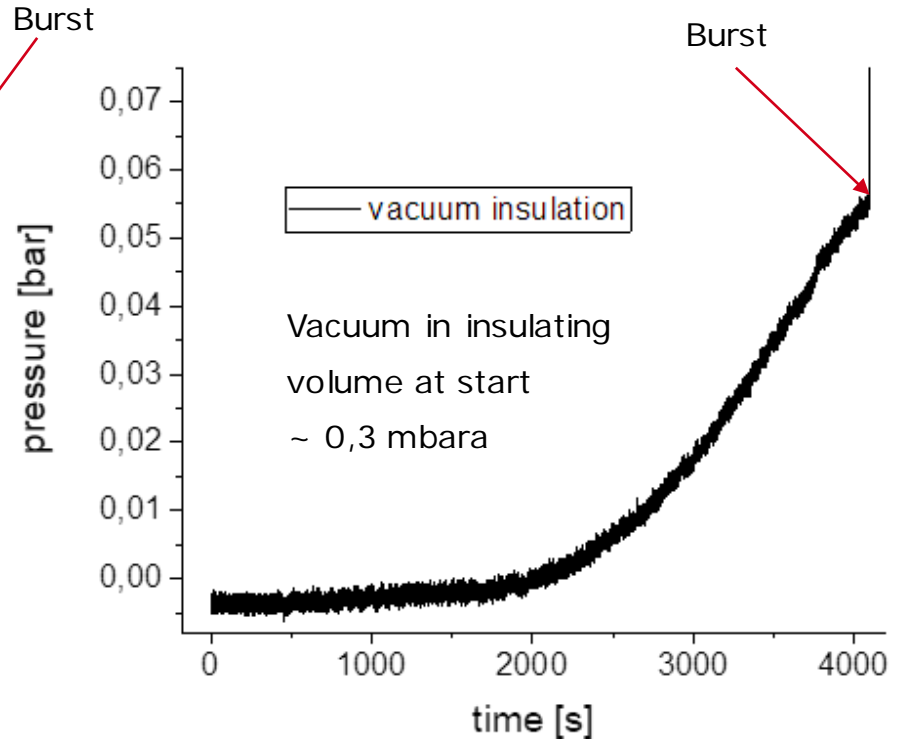
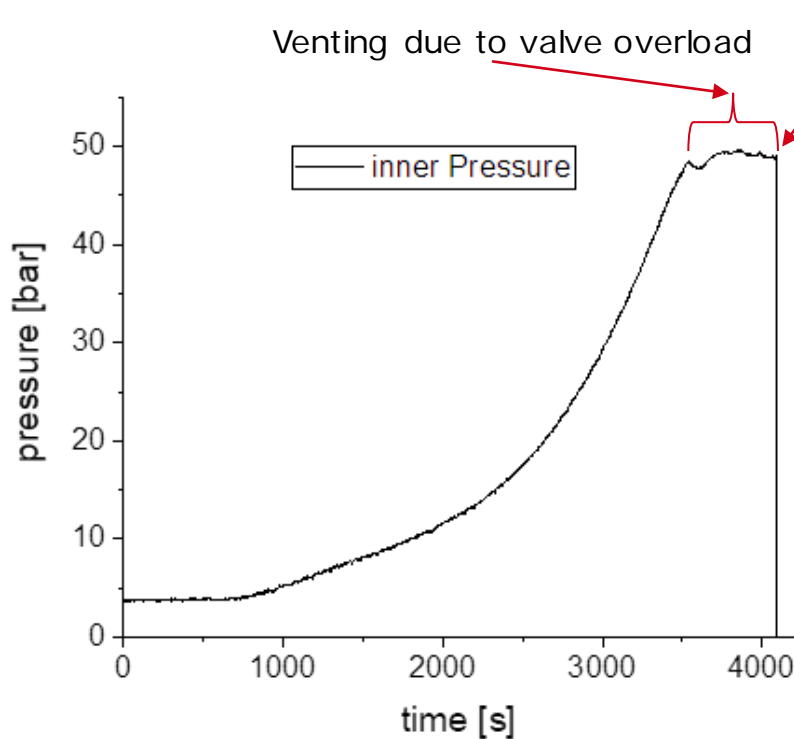
# Test Setup for „BLEVE“ experiments



# „BLEVE“ Experiments: Performing the tests



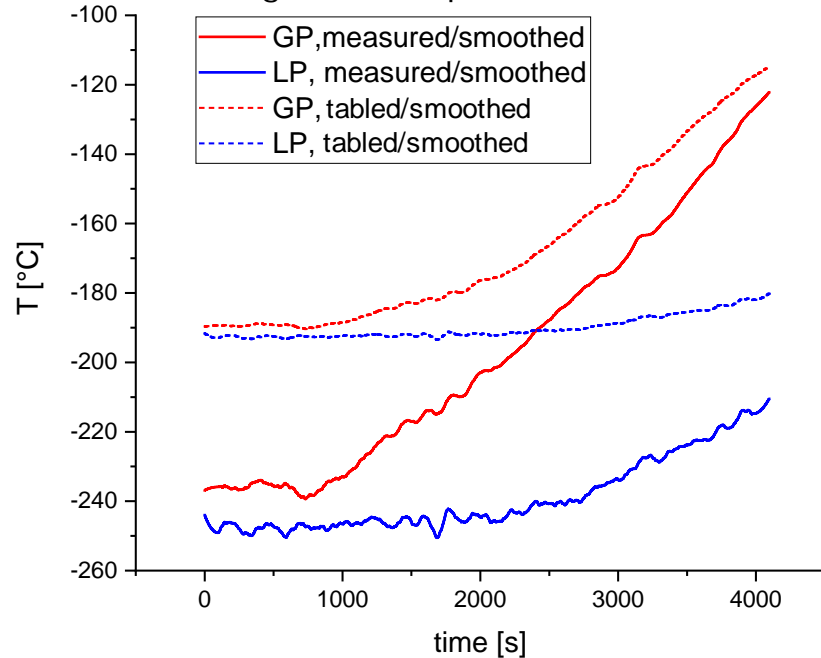
# Results of „BLEVE2“ test: internal Pressure readings



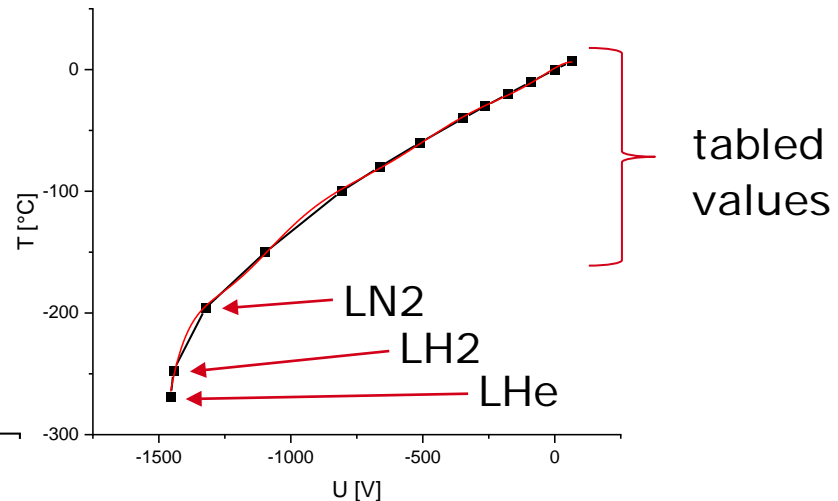


# Results „BLEVE2“ Experiment: temperature measurements

Conversion of thermoelectrical  
voltage into temperature



- Type K thermocouples were used with voltage amplifier
- Many signal conditioners give wrong values at these low temperatures



# Consequences of „BLEVE2“ Experiment: UAV - Video

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# Consequences of „BLEVE2“ Experiment: action cam - Video

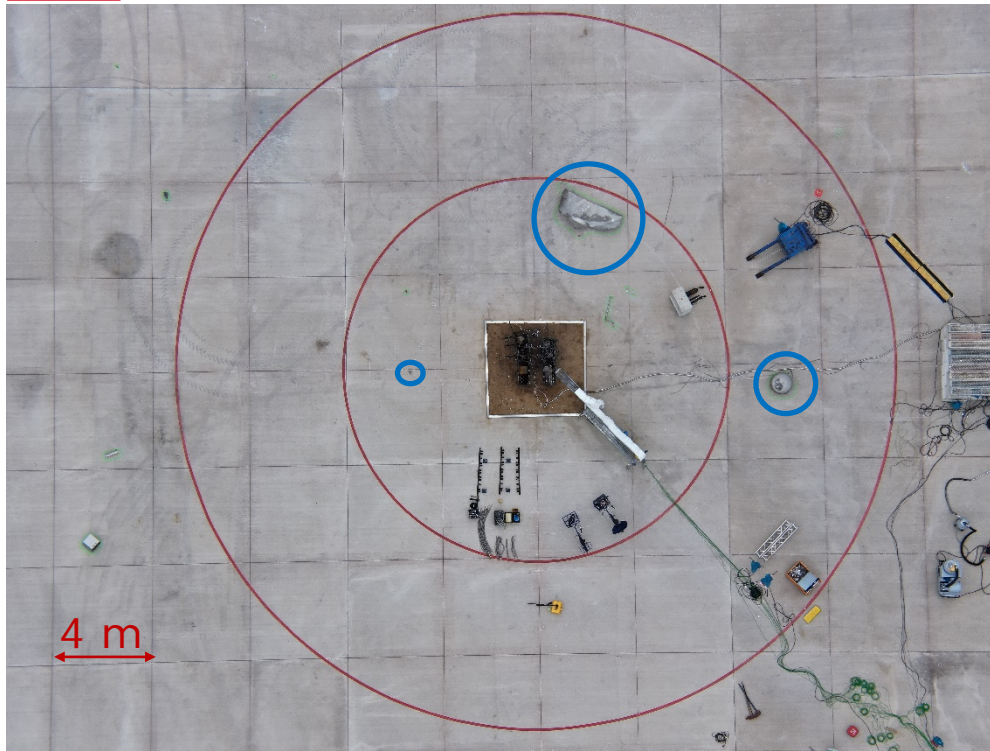
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# Consequences of „BLEVE2“ Experiment: throw of fragments

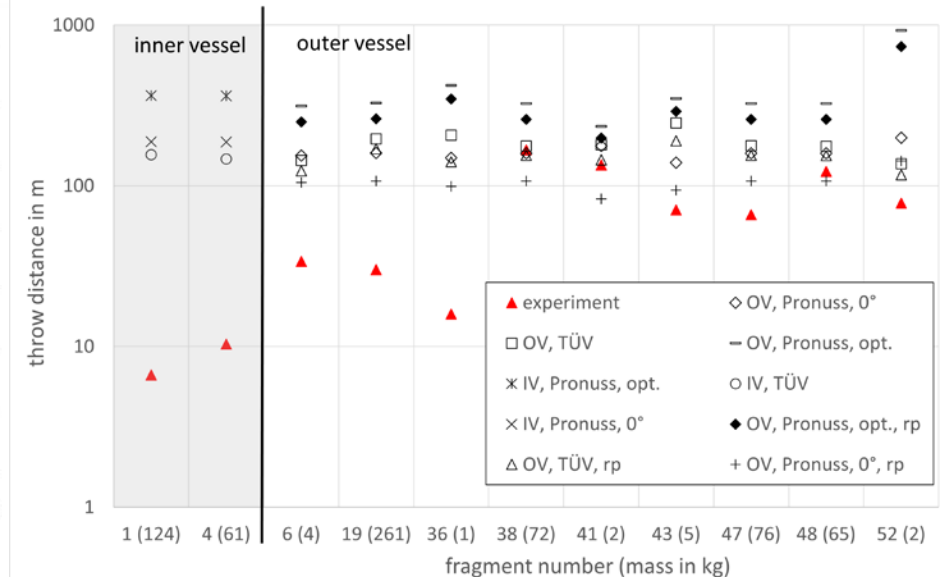
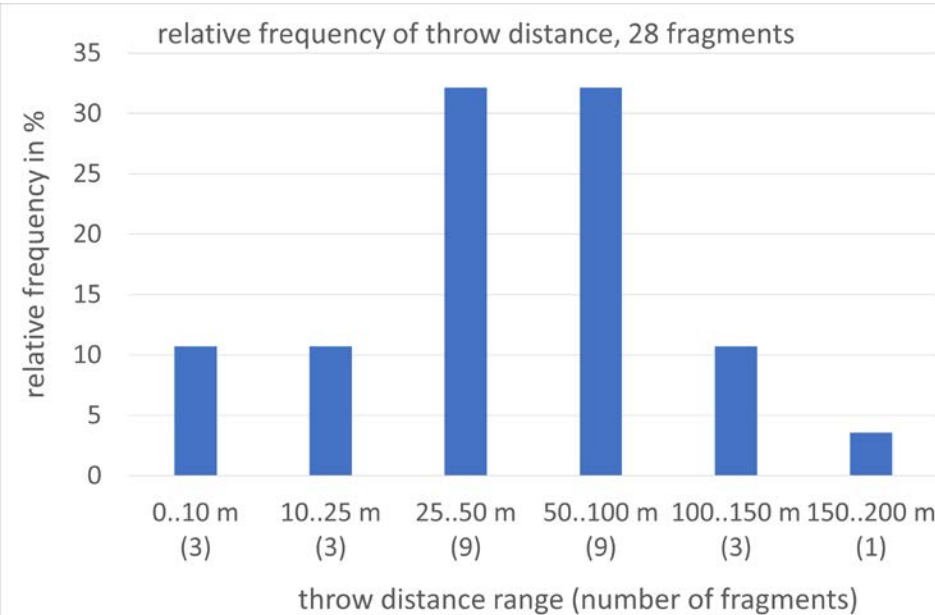


# Consequences of „BLEVE2“ Experiment: throw of fragments



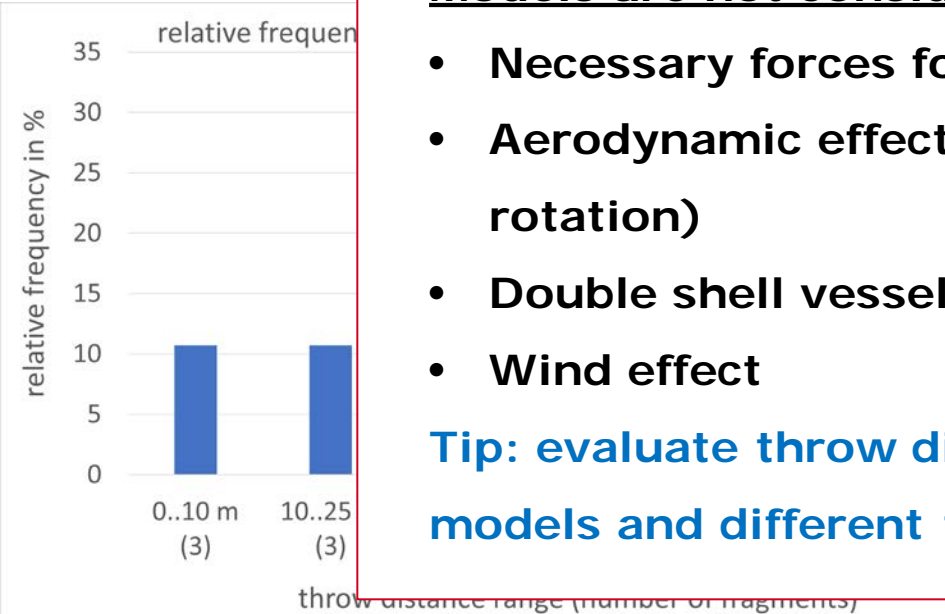
# Consequences of „BLEVE2“ Experiment: throw of fragments

comparison of experimental found throw distances against calculated values



# Consequences of „BLEVE2“ Experiment: throw of fragments

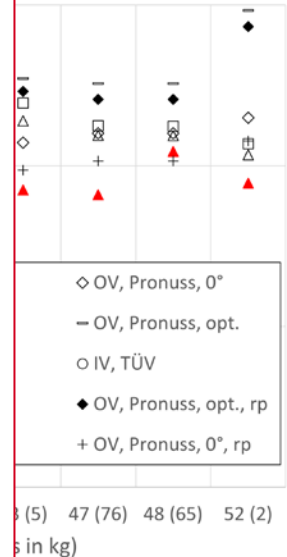
comparison of experimental found throw  
values



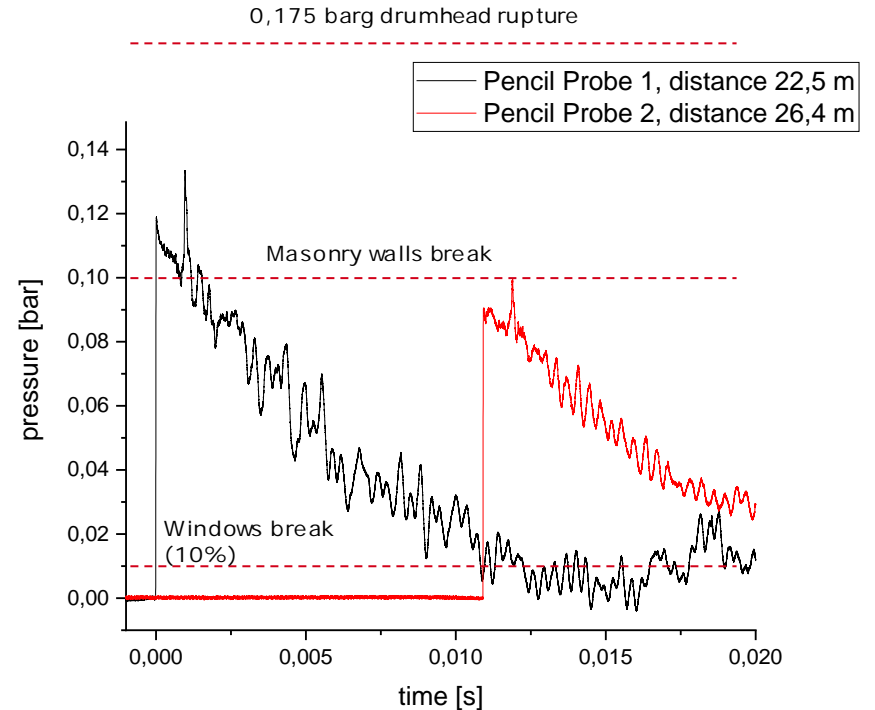
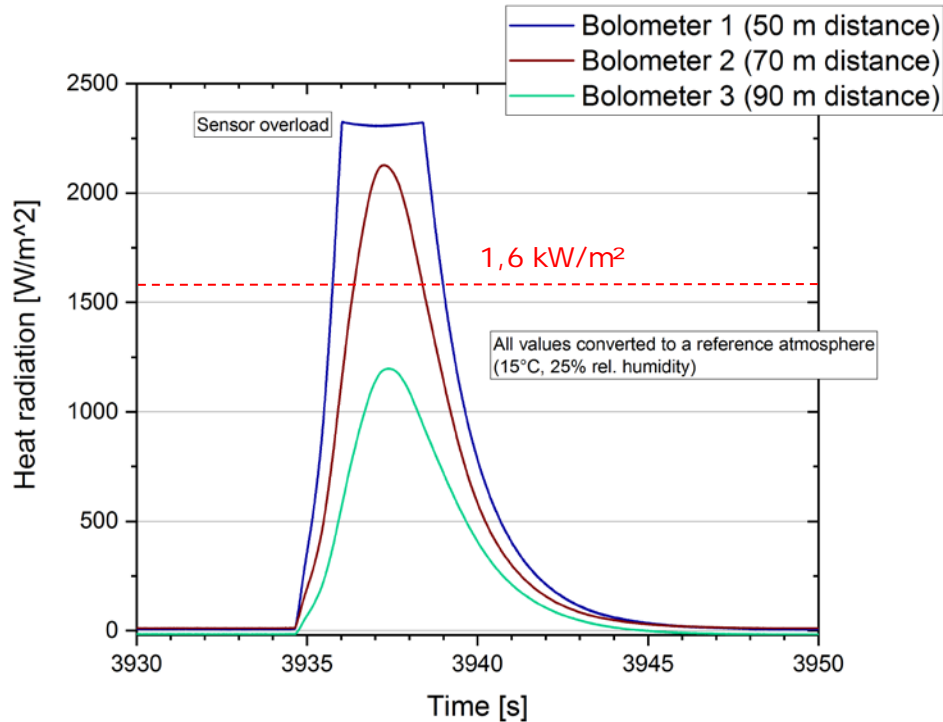
## Models are not considering:

- Necessary forces for material rupture
- Aerodynamic effects (Shape of the fragment, rotation)
- Double shell vessel (Multi-Layer-shells)
- Wind effect

**Tip: evaluate throw distances with different models and different fragment sizes**



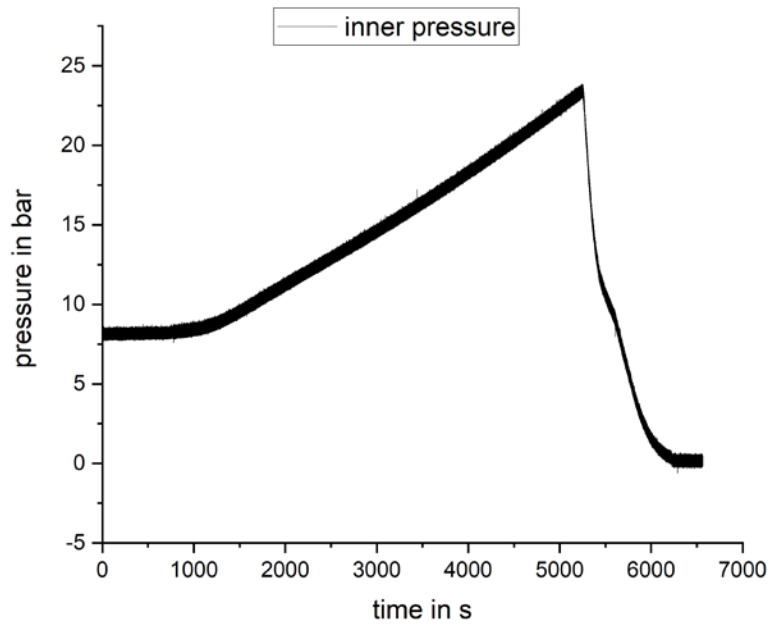
# Consequences of „BLEVE2“ Experiment: Heat radiation and Blast-pressure



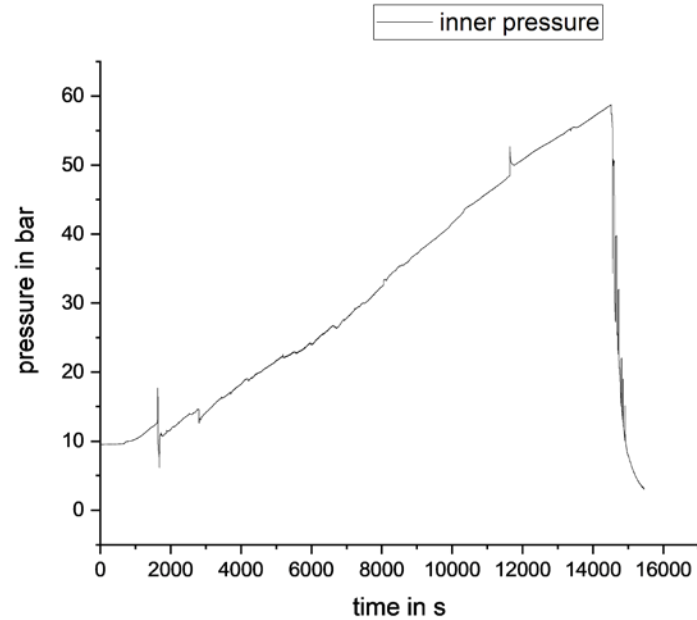


# “BLEVE1” and “BLEVE3”

## BLEVE1



## BLEVE3



# Results of „BLEVE“-Experiments



BLEVE 1



BLEVE 2



BLEVE 3

- One of the three tanks did burst (MLI, after 70 minutes)
- All tanks withstood the fire for more than one hour
- Initiating cause of failure is still an open question (leackage, MLI-decay...)



BLEVE 1



3D - Scan



BLEVE 3



3D - Scan

- Dismantling of unburst vessels (Q1/2024)
  - Examination of inner vessel deformation
  - Degradation of Perlite insulation (volume loss?)
  - Fixation and location of thermocouples
  - Measurement of wall thicknesses
- 
- Investigation of the behaviour of different insulation materials for cryogenic purposes under fire load (Perlite, MLI, glass beads) → ongoing BAM project

# Acknowledgement



Research was done within a joint project together with Gexcon to investigate the release of LH2 in a water-pool and the behaviour of LH2-cryo-tanks involved in a fire and possible consequences in case of an accidental burst.

The work was undertaken as part of the research project Safe Hydrogen fuel handling and Use for Efficient Implementation (SH2IFT)

