



**FUEL CELLS AND HYDROGEN**  
JOINT UNDERTAKING

# **Session 2: On-board storage - Safety considerations**

Online workshop on  
**Safe Storage of Compressed Gas Hydrogen**  
in road transport applications  
and related infrastructure

**Georg W. Mair, EHSP**

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# Tests as basis for safety in usage of storage systems

Workshop on Safe Storage of Hydrogen



- Burst testing (p@ambient T, hydraulic)
- Sustained loads (p@ambient T, hydraulic)
- Creep effects (p@accelerated T, hydraulic)
- Load cycles (p@accelerated T, hydraulic)
- Gaseous cycle tests
- Chemical exposure test (hydraulic)
- Flawed cylinder test (hydraulic)
- Boss strength test (mechanical)

**Each test implicates danger for the executing staff  
(electrical and mechanical energy, water jet, splinters,  
rupture, explosions, respirable filaments etc.)!**





# Operational conditions

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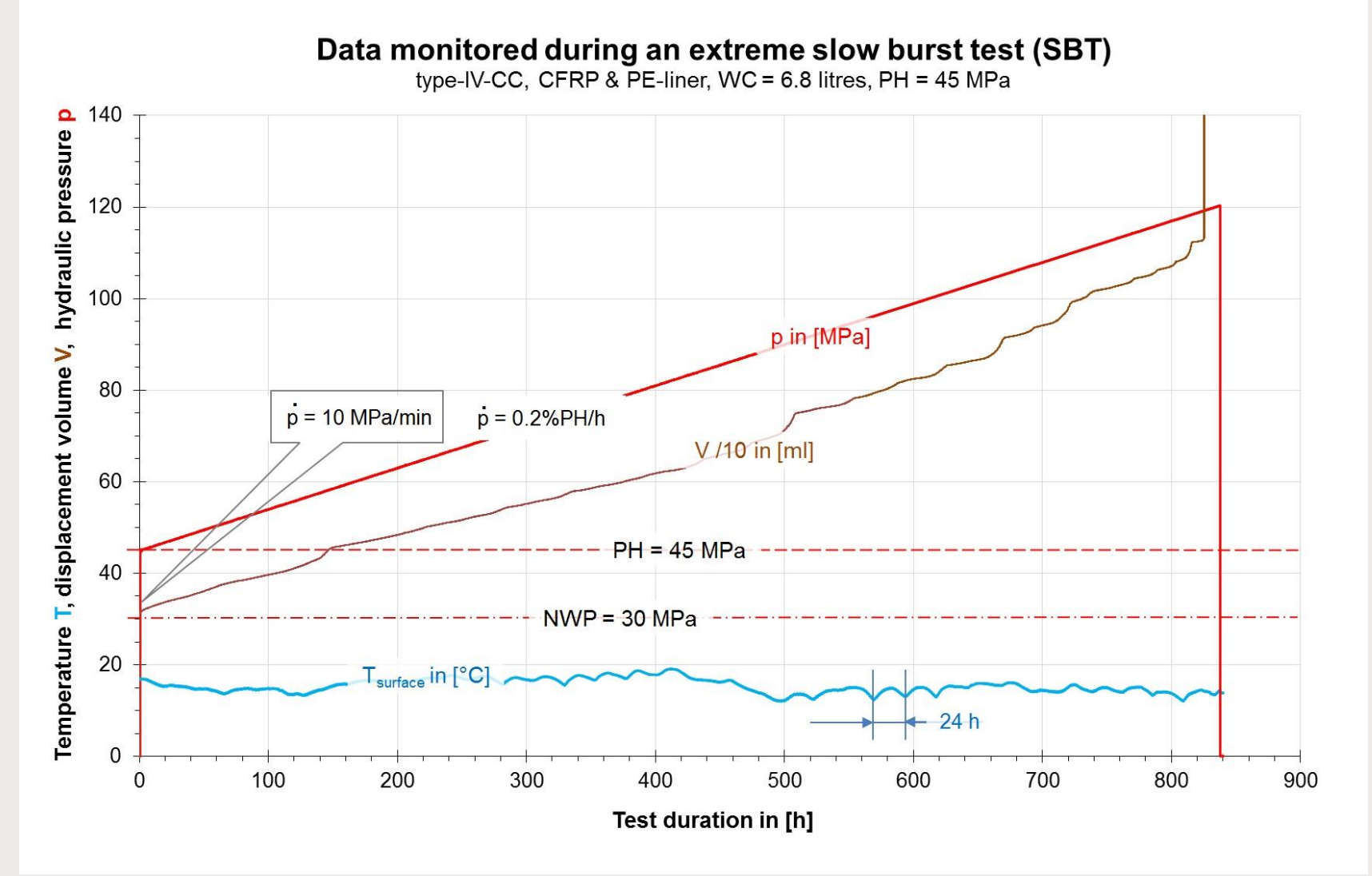
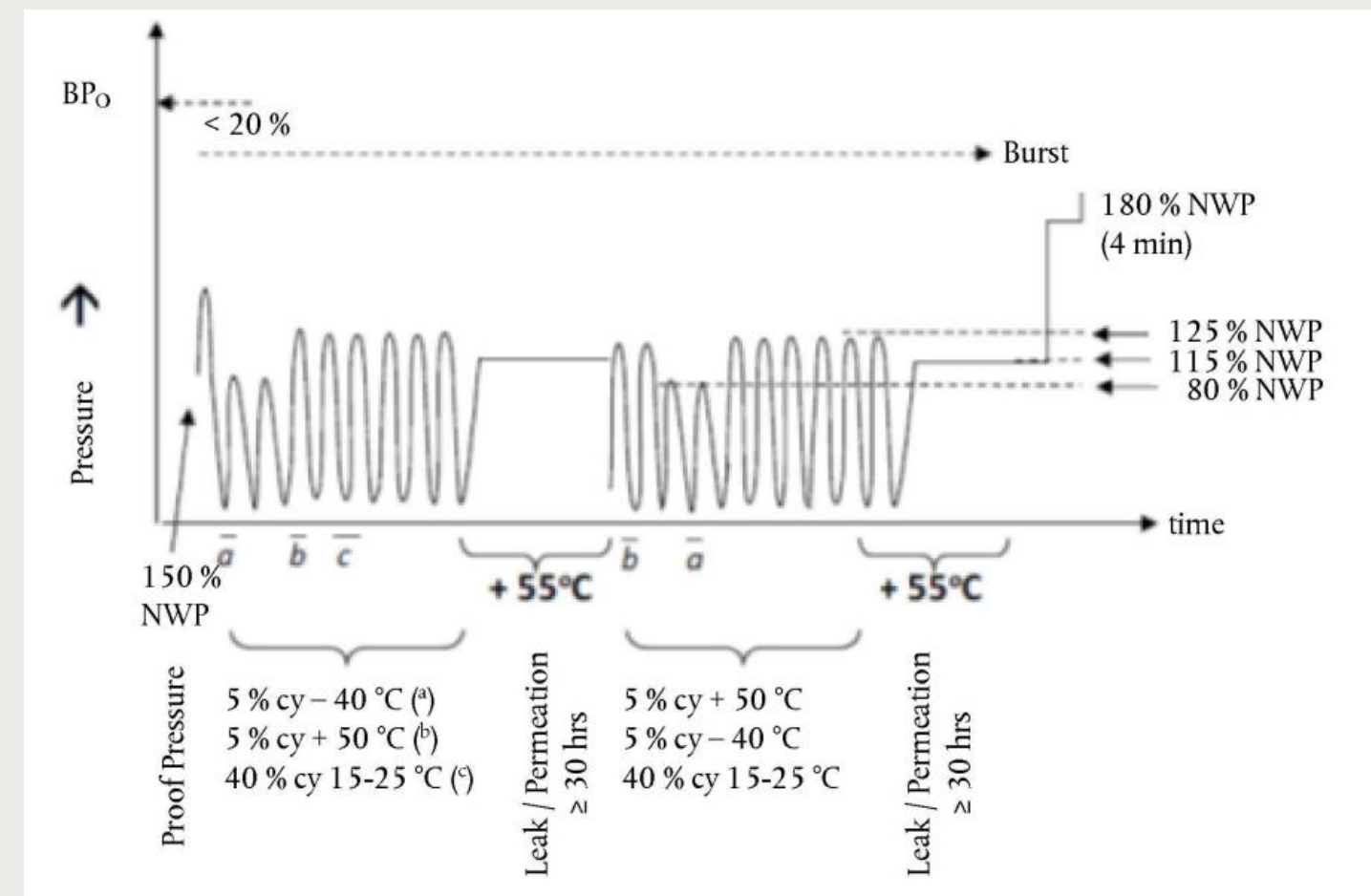
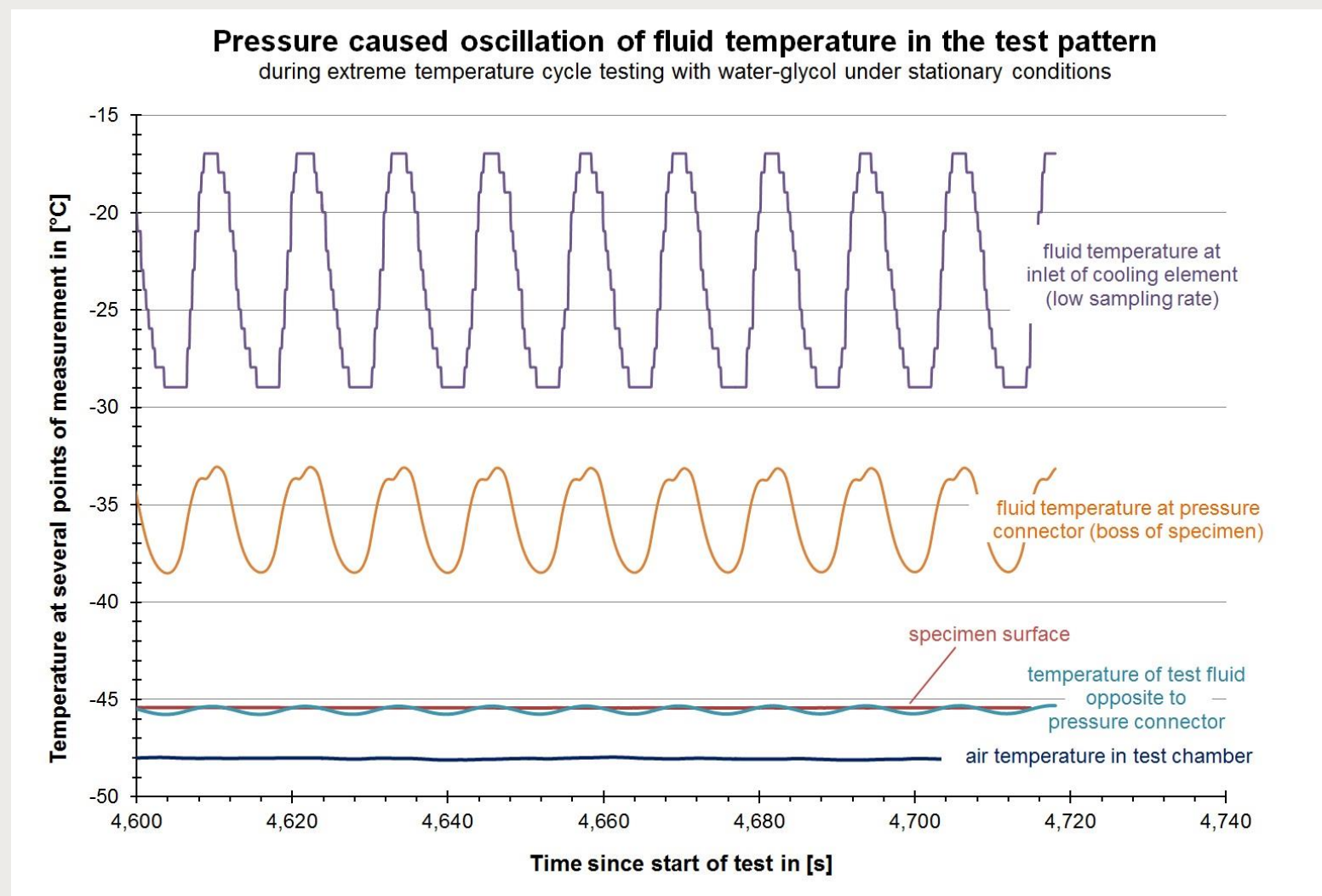
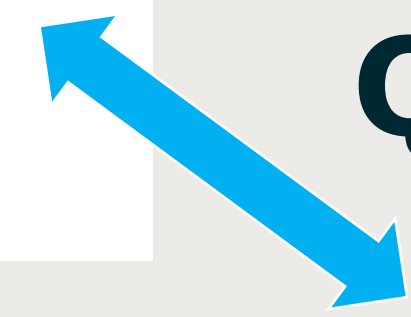
# Operational conditions

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## Cyclic loading (focusing on metal)

## Quasi-static loading (focusing on CFRP)





# Accidental loads

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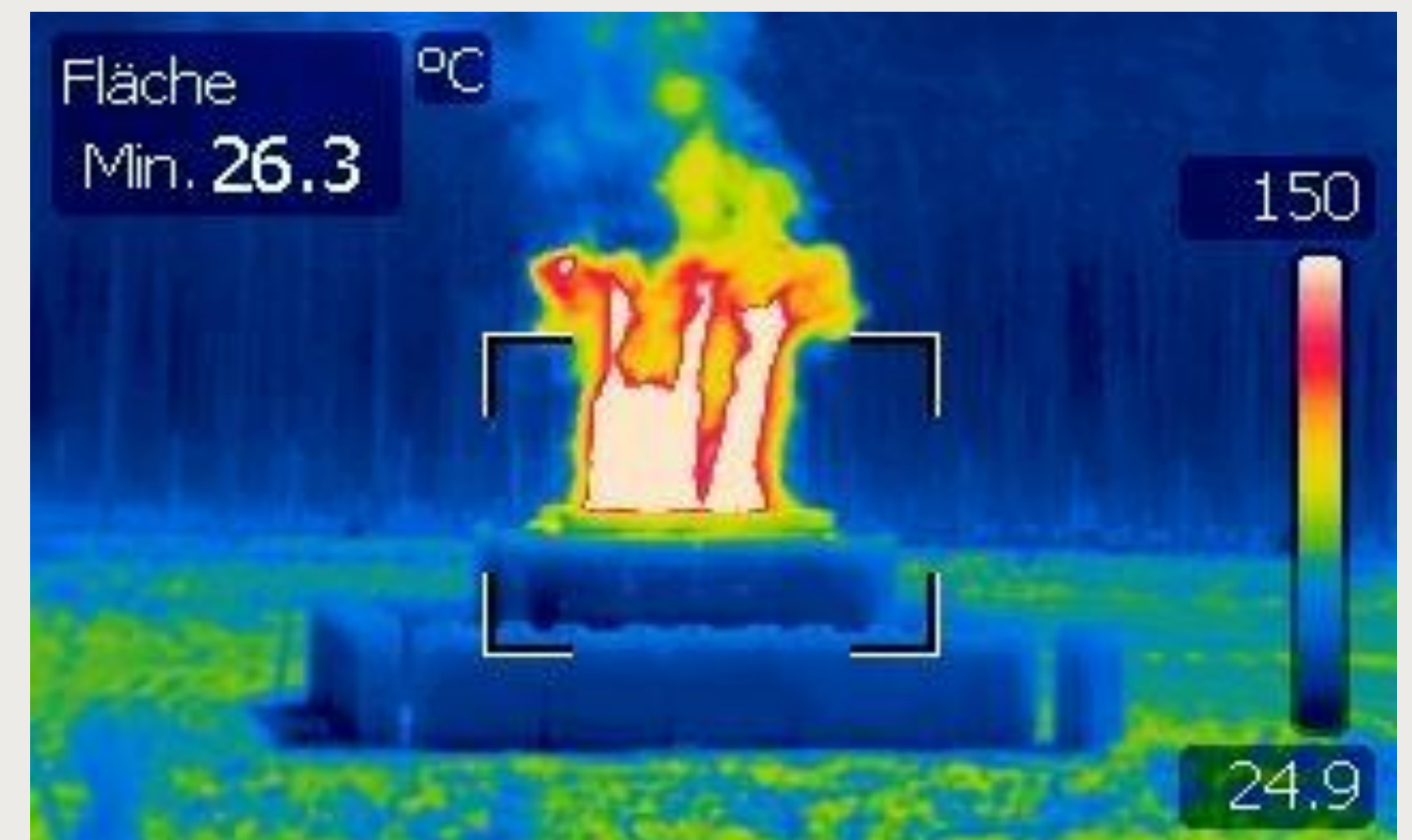
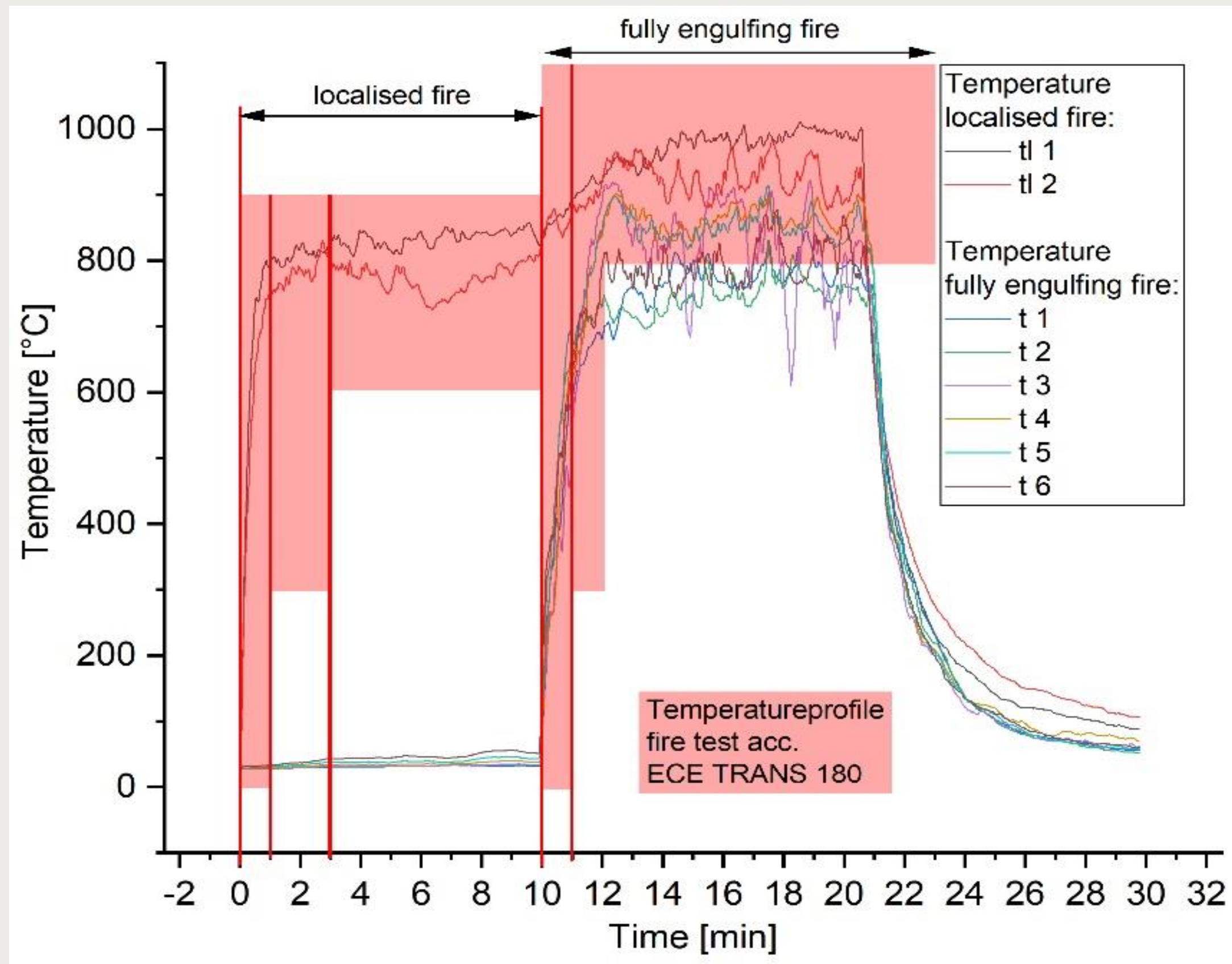


# Accidental load “fire”

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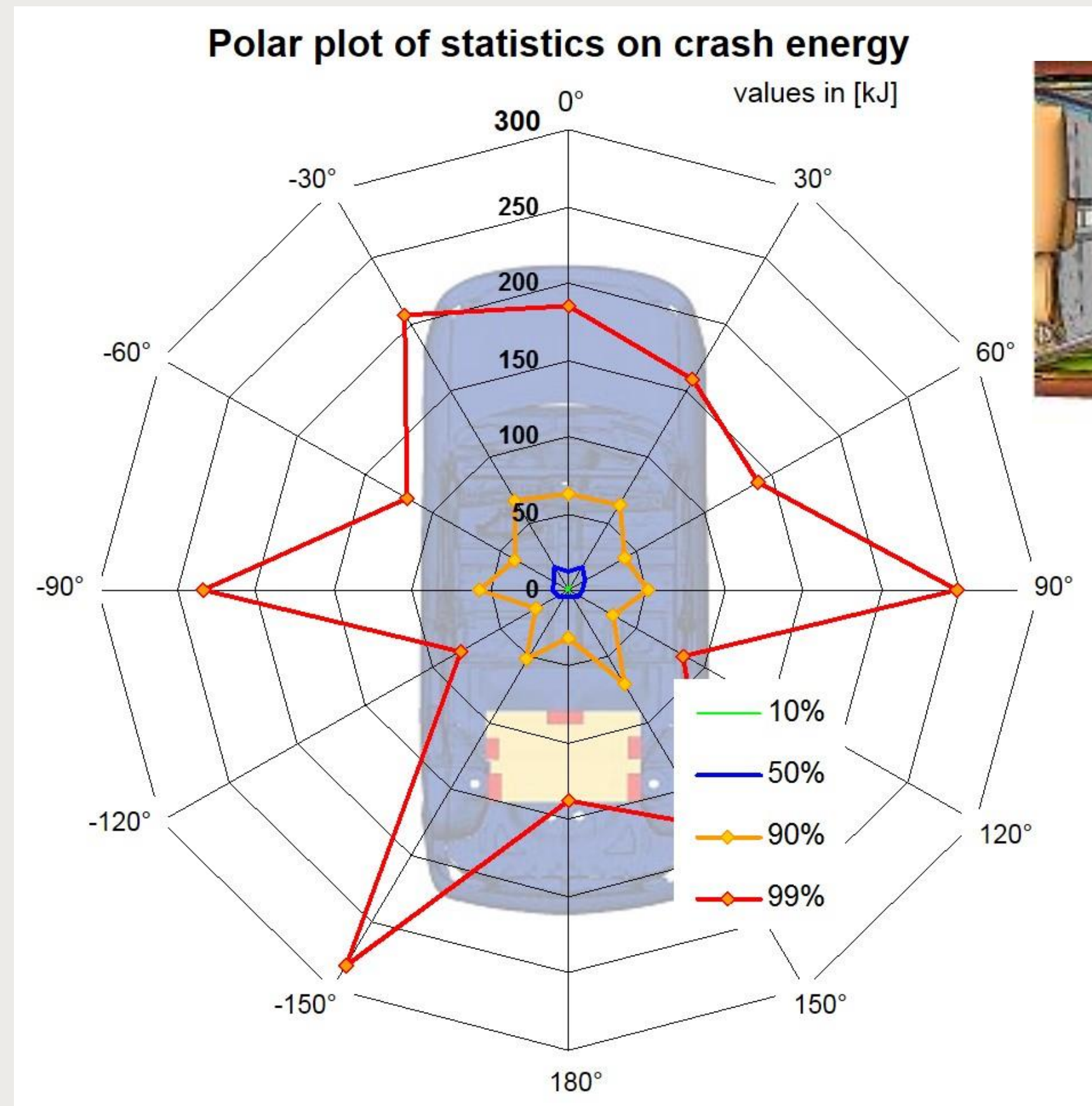
*Green H<sub>2</sub> as combustible material instead of LPG?*





# Accidental load “crash” with high energy impact

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## Statistical analysis of impact energy

Data source: GIDAS

## Impact testing@700 bars



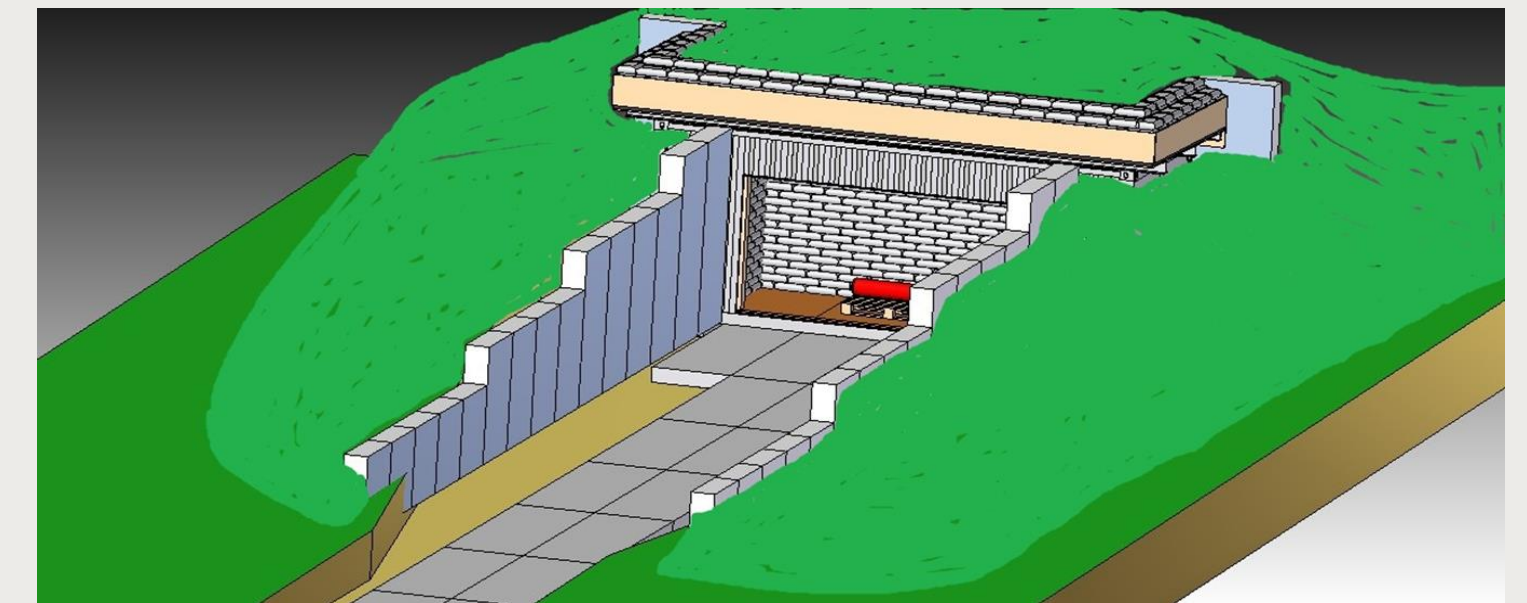


# Accidental load “impact” with high velocity impact

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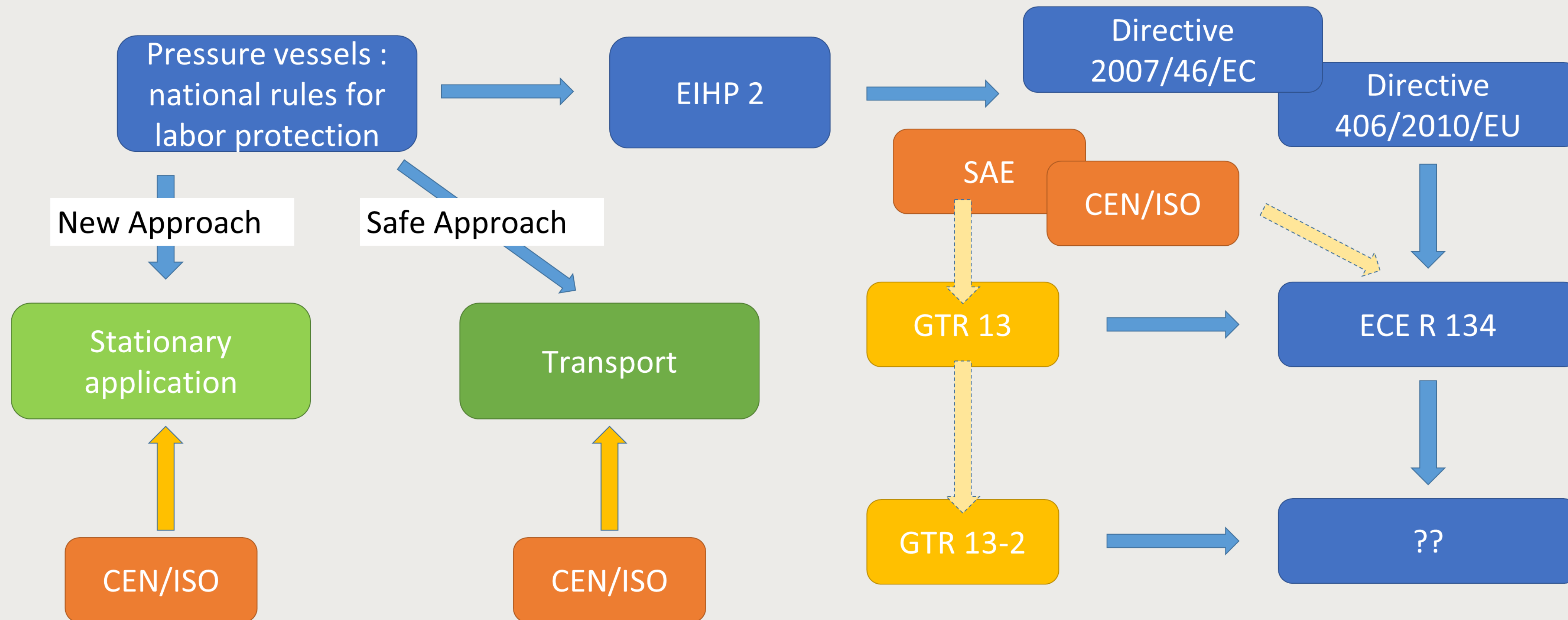
**Bullet testing is requested in some standards.**





# Diversity of design and test requirements (RCS)

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# Hydraulic test in ECE R 134

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## **5.1. Verification tests for baseline metrics**

5.1.1. Baseline initial burst pressure

5.1.2. Baseline initial pressure cycle life

## **5.2. Verification test for performance durability (sequential hydraulic tests)**

5.2.1. Proof pressure test

5.2.2. Drop (impact) test

5.2.3. Surface damage

5.2.4. Chemical exposure and ambient temp. pressure cycling tests

5.2.5. High temperature static pressure test

5.2.6. Extreme temperature pressure cycling

5.2.7. Residual proof pressure test

5.2.8. Residual strength burst test





# Gaseous tests and batch testing acc. ECE R 134

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## **5.3. Verification test for expected on-road performance (sequential pneumatic tests)**

5.3.1. Proof pressure test

5.3.2. Ambient and extreme temperature gas pressure cycling test (pneumatic)

5.3.3. Extreme temperature static gas pressure leak/permeation test (pneumatic)

5.3.4. Residual proof pressure test

5.3.5. Residual strength burst test (hydraulic)

## **9.3. ....production control of the containers for compressed storage**

9.3.1. Every container shall be ..... test pressure is  $\geq 150$  per cent of NWP.

9.3.2. batch testing ..... rupture pressure shall be at least  $BP_{min}$  and the average burst pressure recorded of the last 10 tests shall be at or above  $BP_0 - 10$  per cent.

9.3.2.2. Ambient temperature pressure cycling test in batch testing







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**Georg W. Mair**  
Member of EHSP  
Georg.Mair@BAM.de

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## For further information

[www.fch.europa.eu](http://www.fch.europa.eu)  
[www.hydrogeneurope.eu](http://www.hydrogeneurope.eu)  
[www.nerghy.eu](http://www.nerghy.eu)



@fch\_ju



Fch-ju@fch.europa.eu



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