



Resistance of materials to LH2 impinging jets and fires

I. Dinkov, Ferraro Porcel de Peralta, A. Friedrich, T. Jordan, N. Kotchourko, M. Kuznetsov, D. Schelb, E. Torres de Ritter, A. Vesper

ELVHYS Dissemination Conference, Brussels, Belgium

E. Torres de Ritter (KIT)

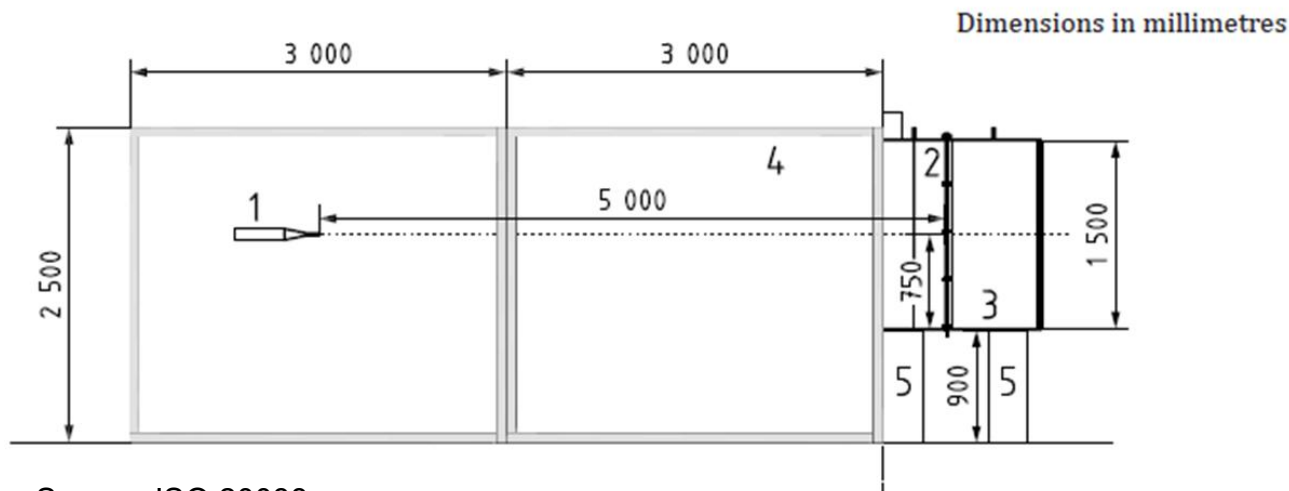
16-17.09.2026



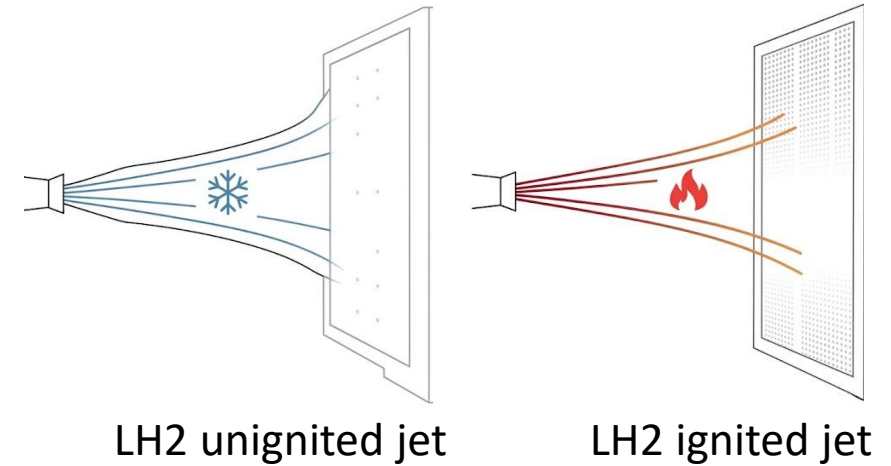
ELVHYS project No. 101101381 is supported by the Clean Hydrogen Partnership and its members. UK participants in Horizon Europe Project ELVHYS are supported by UKRI grant numbers 10063519 (University of Ulster) and 10070592 (Health and Safety Executive)

KIT Experimental Tasks 4.3.1, 4.3.2 & 4.4

- ❑ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials
- The **primary goal** of this investigation is to understand material behavior during pressurized liquid hydrogen (LH2) release incidents to establish safety measures, prevent escalation, and mitigate failure consequences.

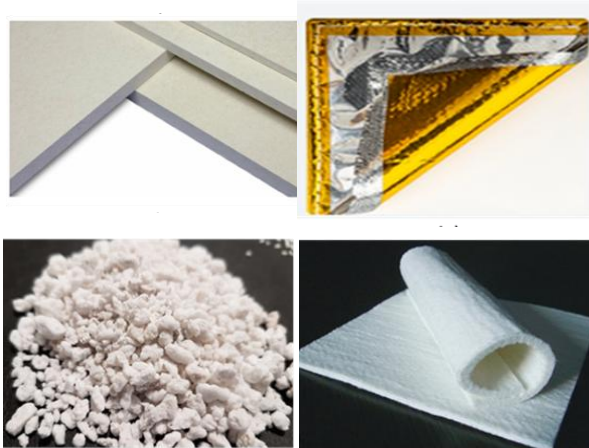


Source: ISO 20088



KIT Experimental Tasks 4.3.1, 4.3.2 & 4.4

❑ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials



- **Materials:** MLI (20&40), perlite (cryogenic use), fire protecting wall, aerogel (fibers)
- **Measurements:** BOS technique, thermocouples, silicon diodes, video camera, thermo-vision camera (FLIR), pressure sensors.
- The **main findings** to be figured out: Resistance of materials to cryogenic LH2 jet. & to ignited LH2 jet fire. Possibility to extrapolate normed test protocol.
- **Material characterization** by loss of stability, isolation property or mechanical failure (cracking, critical deformation). Post experiment structural analysis could be done in a lab (collaboration with FFB).

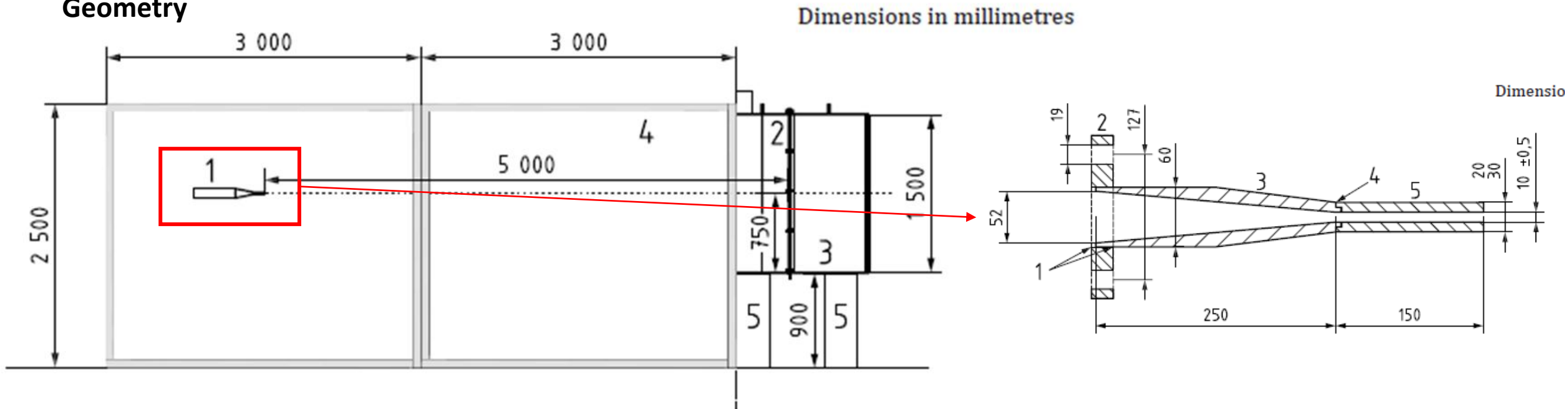
Material	Dimensions (mm)				Properties		
	Height	Length	Thickness	Distance to target	R-value (m ² K/W)	Density (kg/m ³)	(Apparent) Thermal Conductivity
Dry wall - 10 mm	1005	1005	10	500	0.03125**	1150 +- 50 **	0.32 **
Aerogel - 10 mm	1005	1005	10	500	0.890*	920*	0.011*
MLI*****	920	920	10	1000	Not reported	Not reported	0.029 ***
Perlite	*	*	*	*	*	65****	0.045****
* Yet to be tested							

KIT Experimental Task 4.4

❑ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

Determination of the resistance to cryogenic spill of insulation materials –EN ISO 200882: 2020

Geometry



KIT Experimental Task 4.4

□ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

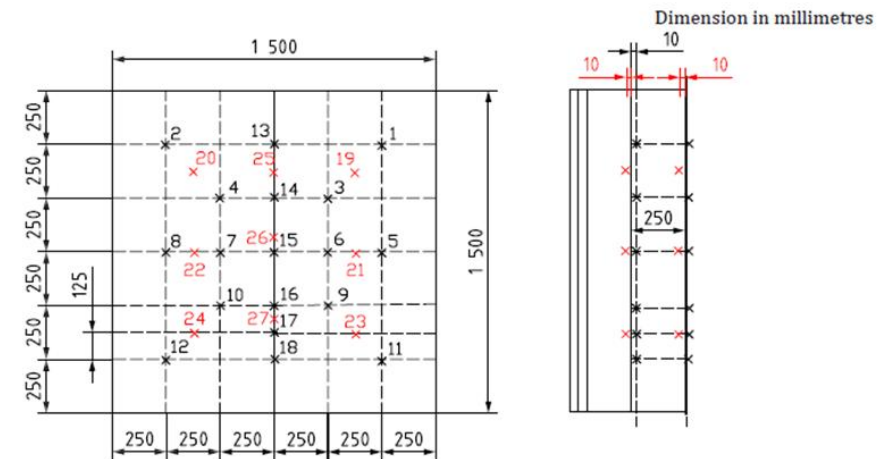
Determination of the resistance to cryogenic spill of insulation materials –EN ISO 200882: 2020

Parameters and measurements

- Temperature in the insulation specimen and in nozzle
- Pressure in nozzle (8 bar)
 - Pressure in our tank maximum-> 6 bar
- Exposure time to impingement (15 min)
 - Inventory constraint
- Liquid N2
 - Liquid H2 in our case

1/5 Geometry 1 = Geometry 2

$d_{\text{nozzleH2}} = 0,002 \text{ m}$ (proposal)



Key

- 1 thermocouples 13 to 18
- 2 thermocouples 1 to 12

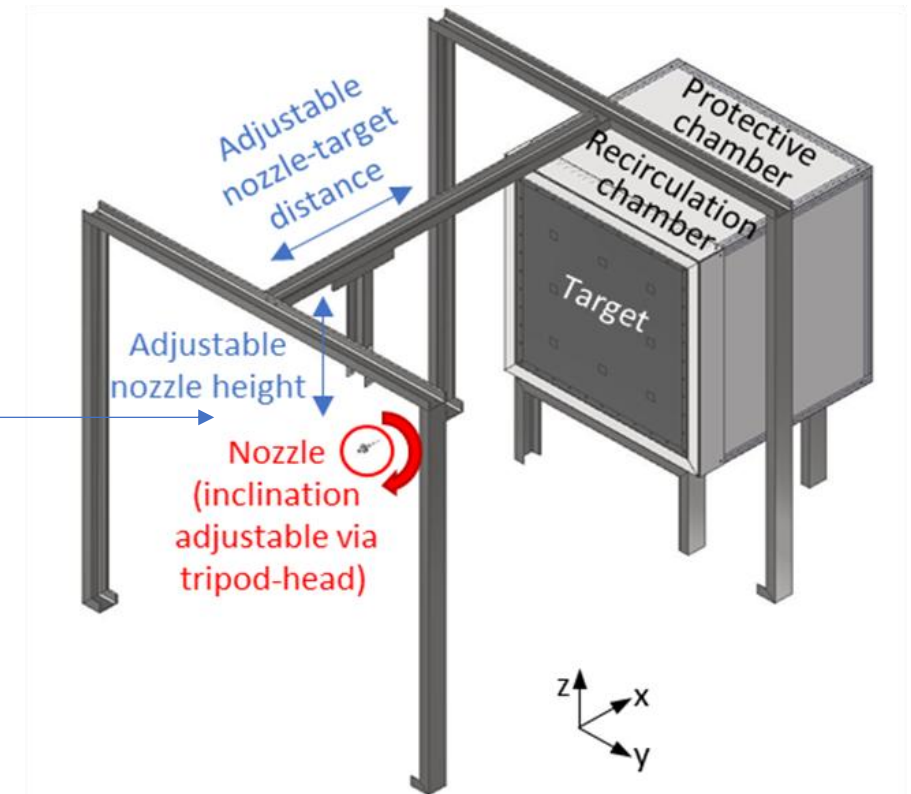
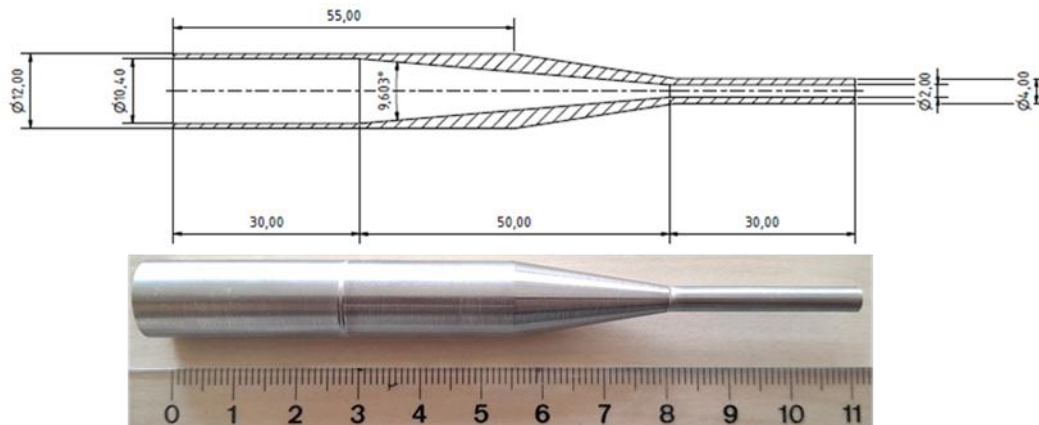
NOTE Thermocouple locations for specimen. Red thermocouples are in front of the box whereas the black marks are in relation to thermocouples in the steel.

KIT Experimental Task 4.4

❑ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall, insulation) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

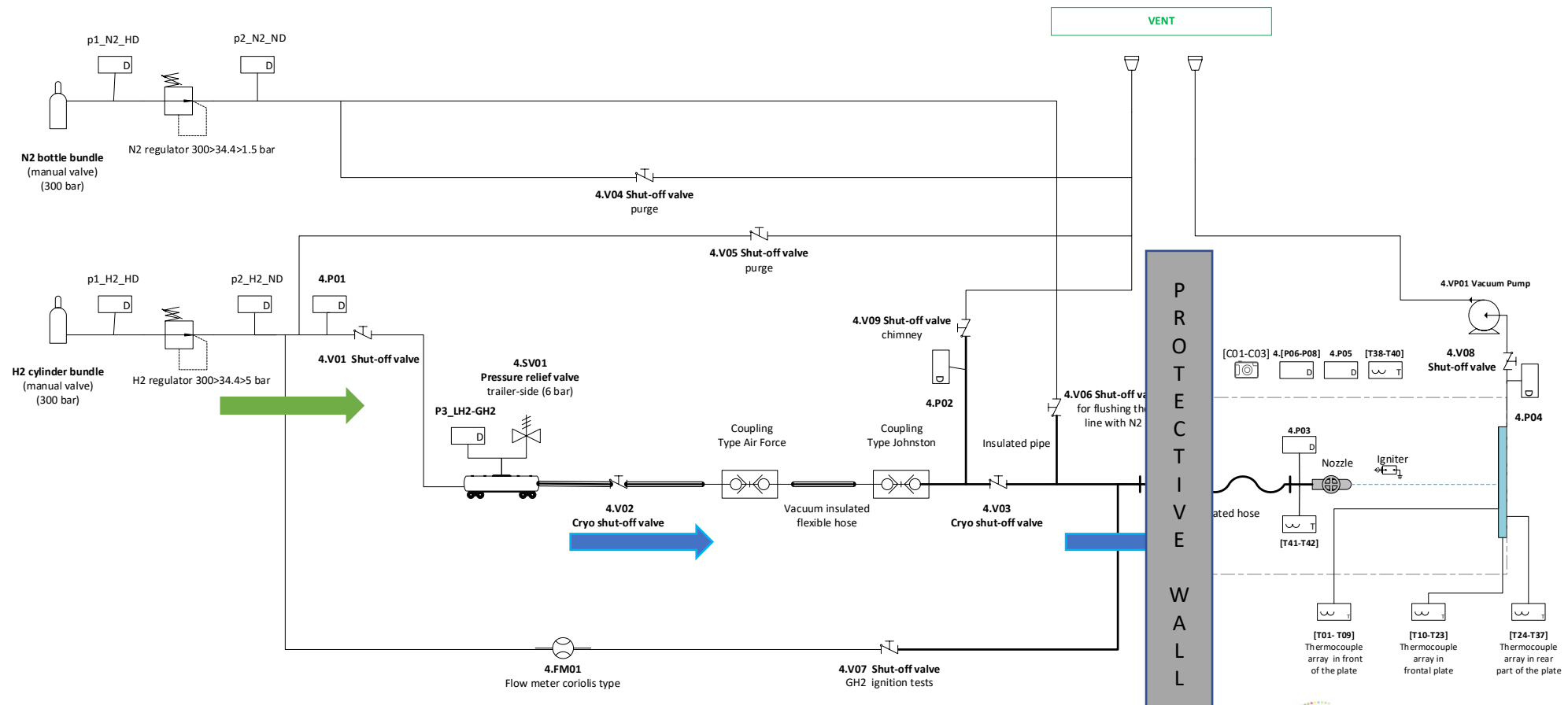
1/5 Geometry 1 = Geometry 2

$d_{\text{nozzleH2}} = 0,002 \text{ m}$ (proposal)



KIT Experimental Task 4.4

□ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials



KIT Experimental Task 4.4

Observations

- Insulated pipes with 2 to 3 layers of Armaflex (expanded foam) and aluminum
- Vacuum insulated hoses
- Pre cooling with LN2



Spark



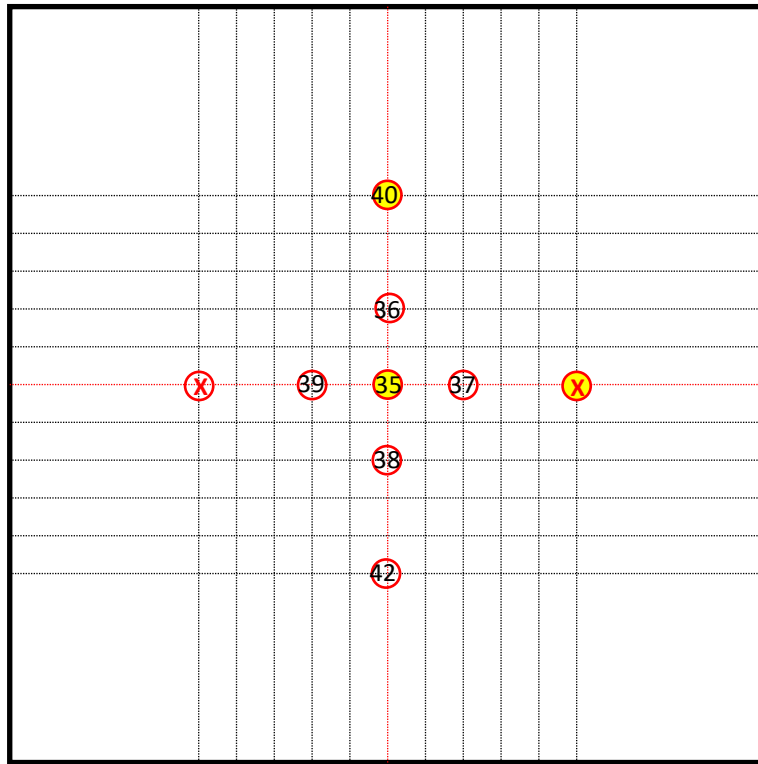
Nozzle



KIT Experimental Task 4.4

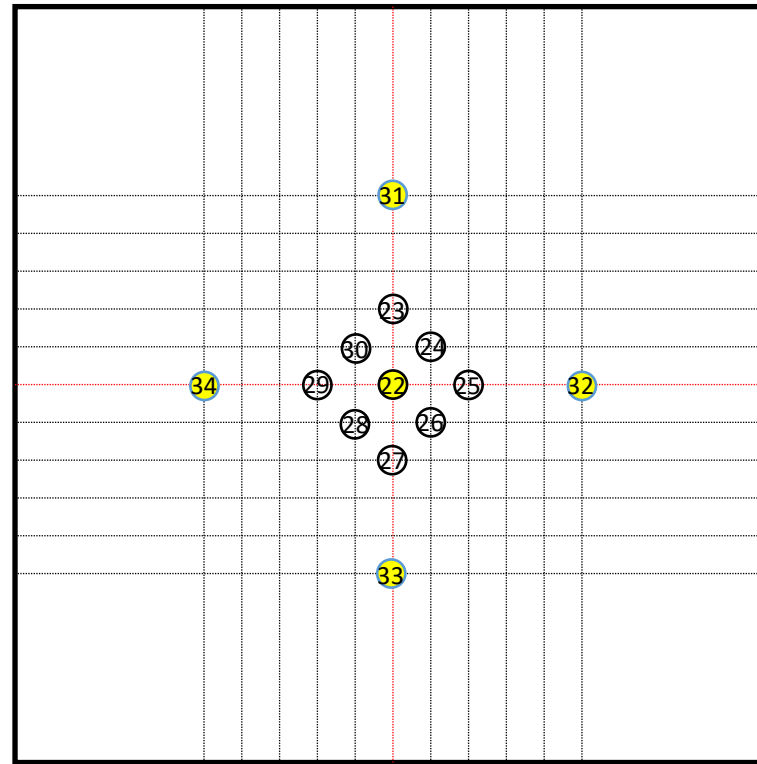
□ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

In front of test material



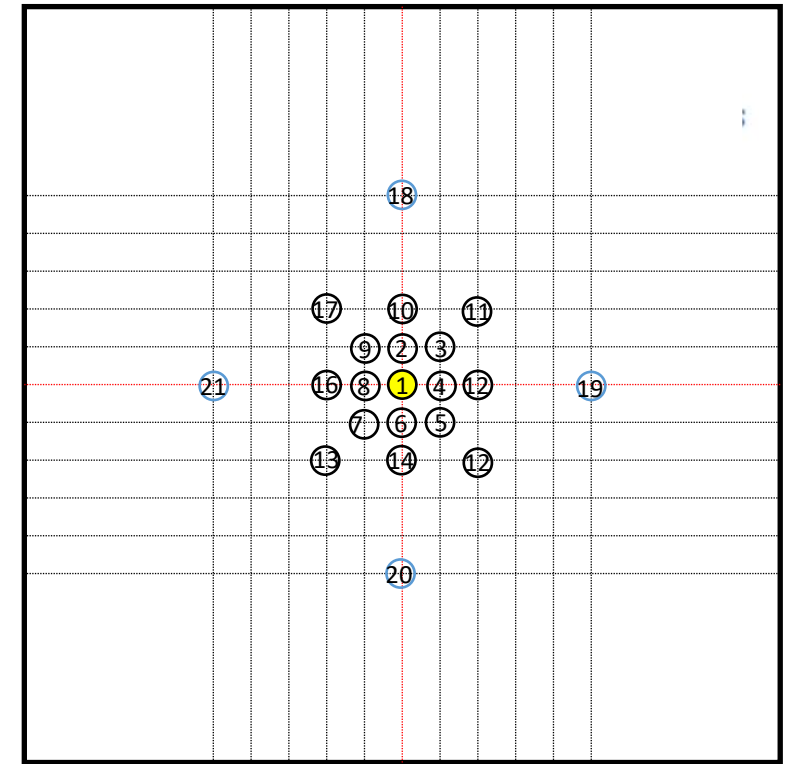
9 - 2 (X)

Front wall view from outside



9 + 4

Back wall view from inside



17 + 4

9

SD diodes sensing in yellow coloured circles together with thermocouples

KIT Experimental Task 4.4

□ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

In front of test material



9 – 2 (X)

Front wall view from outside



9 + 4

Back wall view from inside



17 + 4

SD diodes sensing in yellow coloured circles together with thermocouples

KIT Experimental Task 4.4

❑ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall, insulation) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

MATRIX

Activities	Week
Unignited 3 targets	Without target, Dry wall, Aerogel , MLI 40
Ignited 3 targets	Dry wall, Aerogel , MLI 40

All experiments conducted with 3,7 bar(g) and in principle LH2 (plato)

We would try to test perlite after final conference if possible

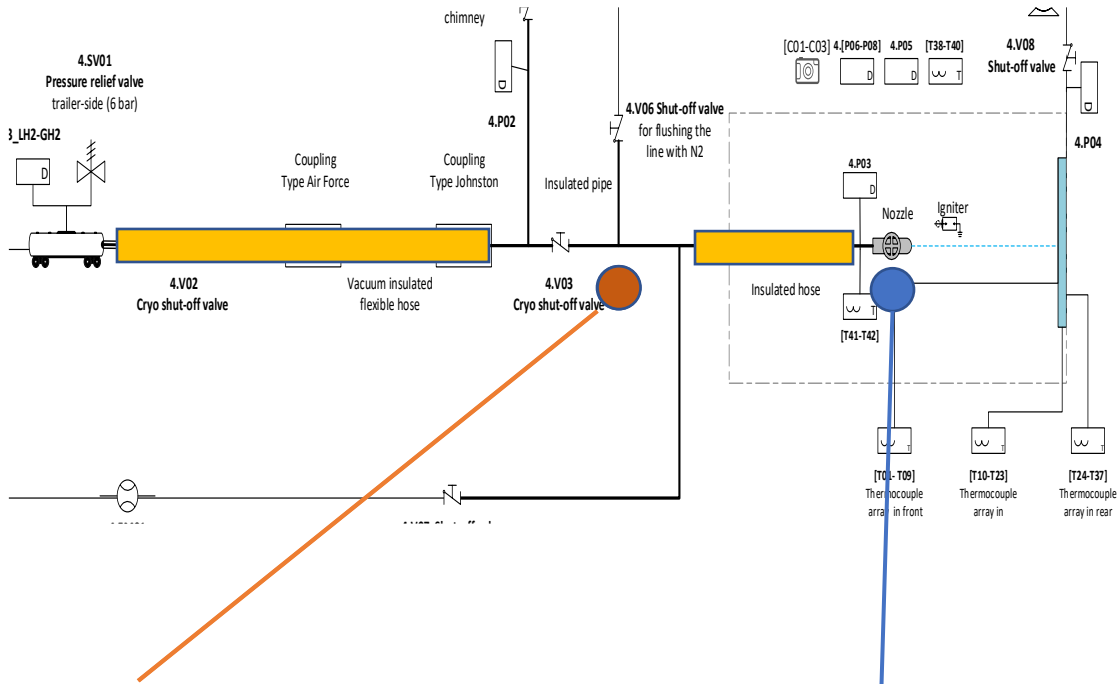
Material	Ignition	Distance (mm)	Back Panel		Front Panel		Max Heat Flux(W/cm2)
			MinT(K)	MaxT(K)	MinT(K)	MaxT(K)	
Dry wall - 10 mm	NO	1000	274,9	299,1	187,5	300,5	-
Dry wall - 10 mm	NO	500	249,0	295,4	146,2	296,4	-
Dry wall - 10 mm	YES	500	290,2	359,7	259,2	1694,6	0,13
Aerogel - 10 mm	NO	500	288,1	300,0	174,1	290,0	-
Aerogel - 10 mm	YES	500	Lost data	Lost data	Lost data	Lost data	0,18
MLI	NO	1000	289,7	303,2	215,6	299,9	-
MLI	YES	1000	270,5	1507,4	134,0	1653,9	0,78



KIT Experimental Task 4.4

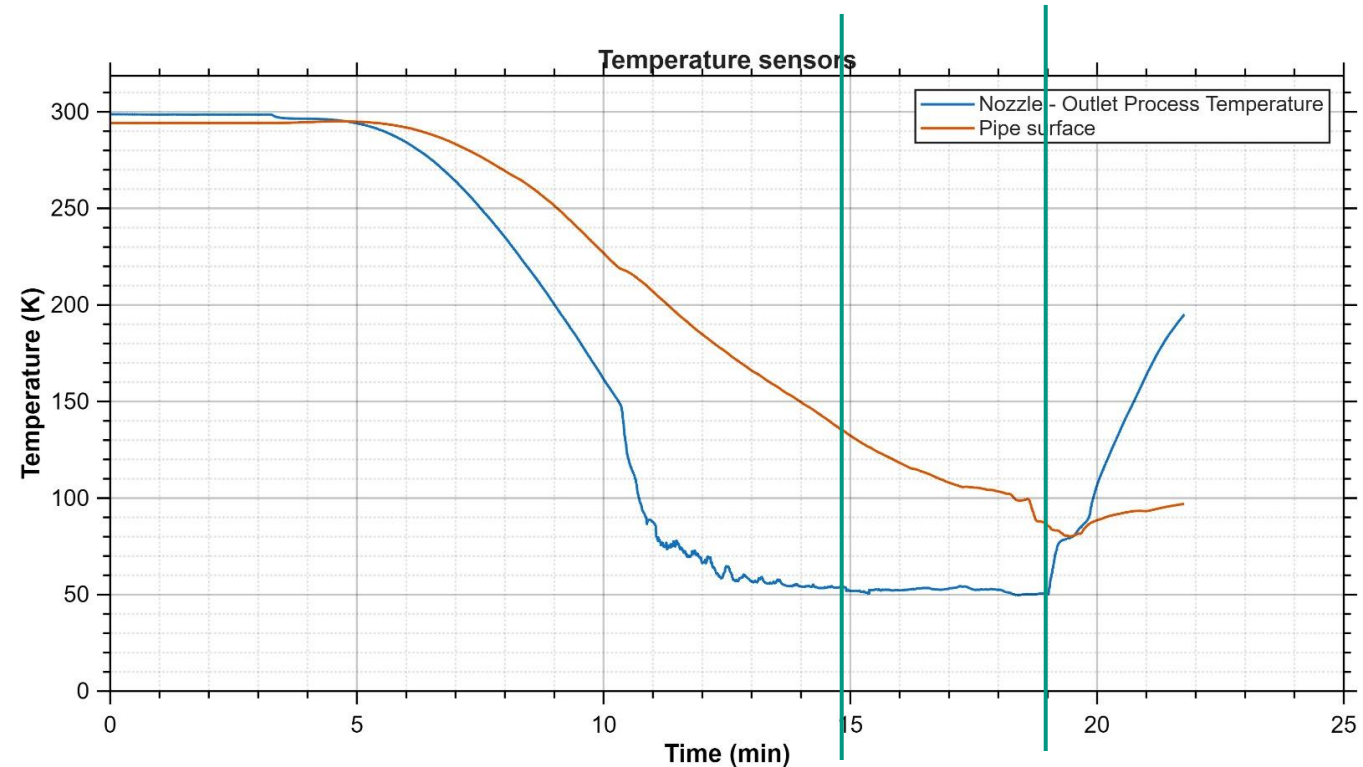
❑ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

Temperature ignited and unignited



Upstream SD on
external pipe
surface

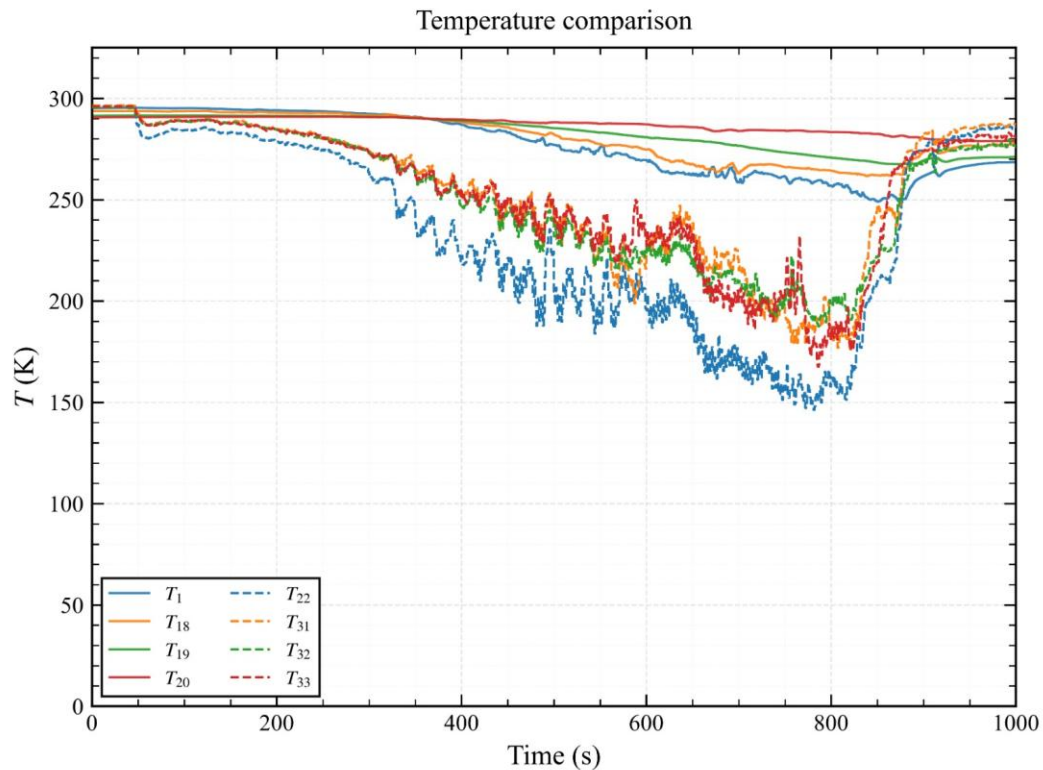
SD on external surface
of the tip of the nozzle



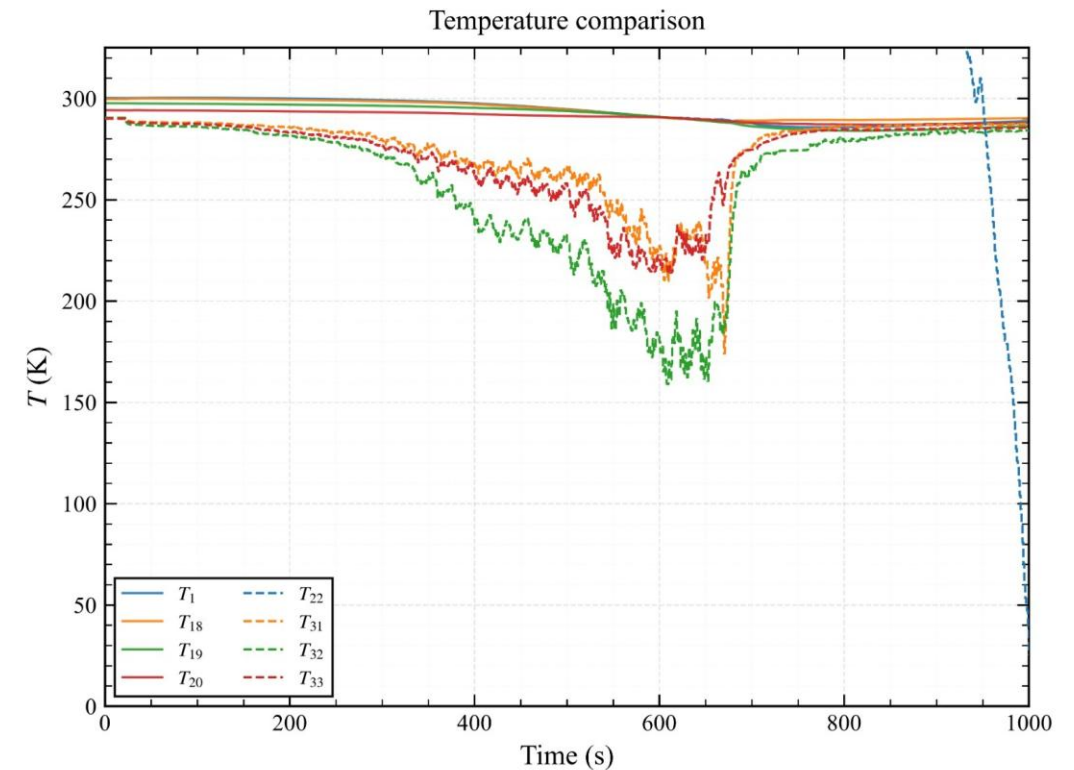
KIT Experimental Task 4.4

□ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

Temperature ignited and unignited



Dry wall dry wall 10 mm thickness
Unignited

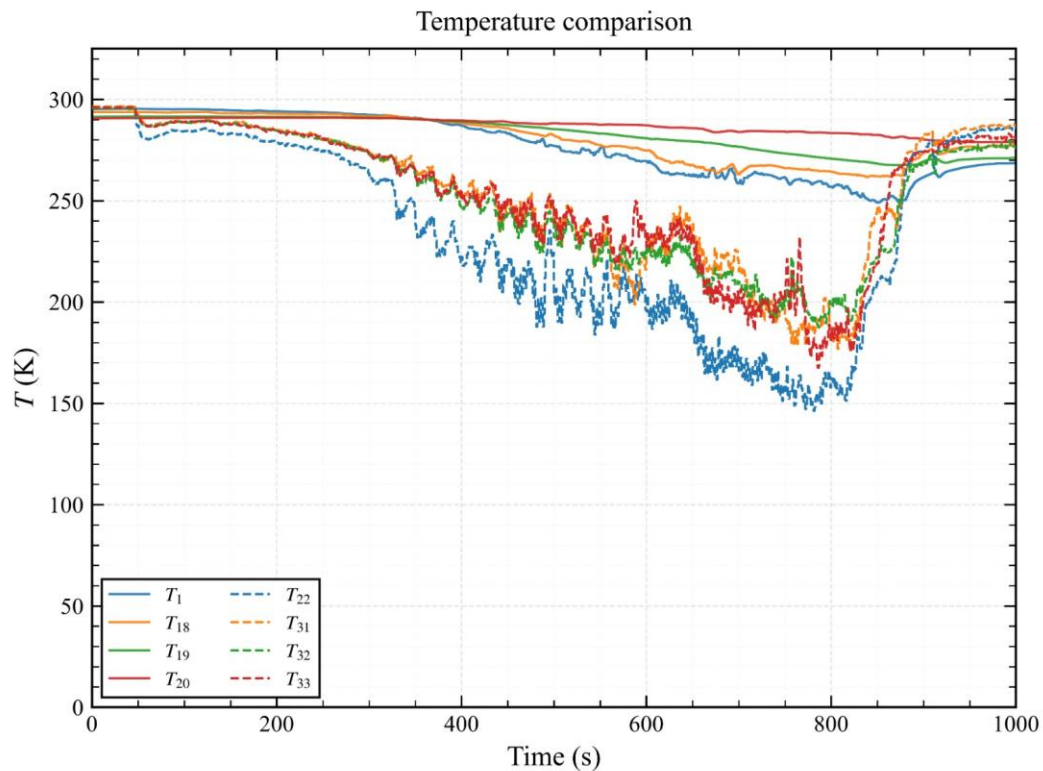


Aerogel 10 mm thickness Unignited

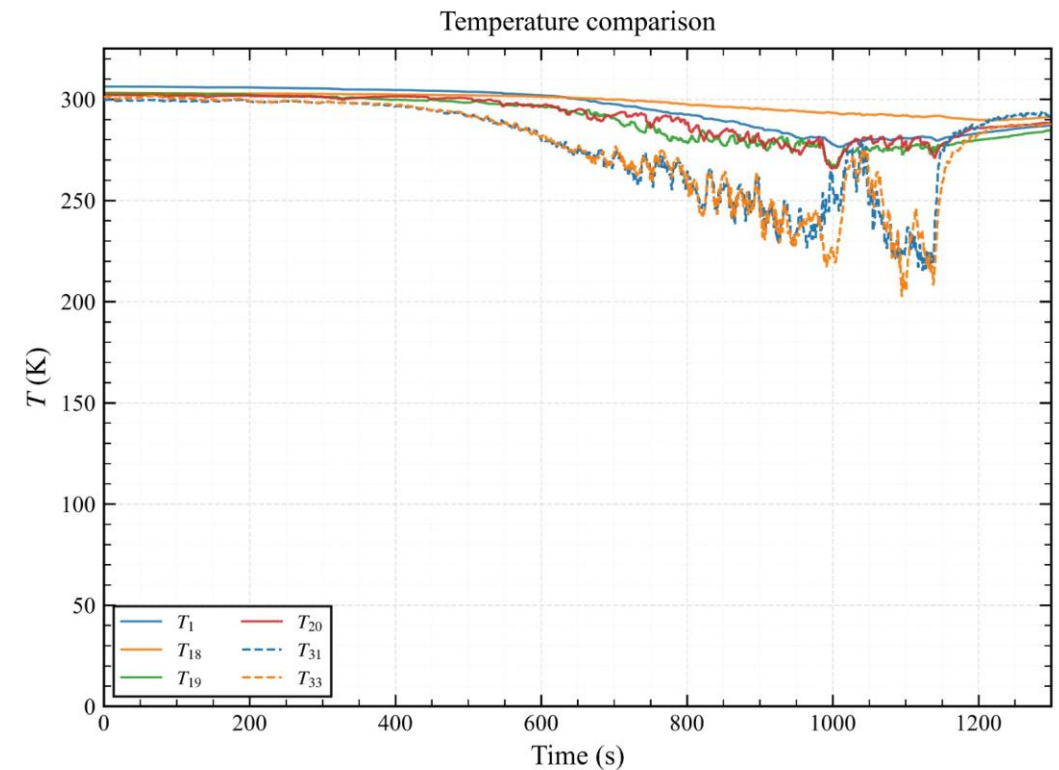
KIT Experimental Task 4.4

□ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

Temperature ignited and unignited



Dry wall dry wall 10 mm thickness
Unignited

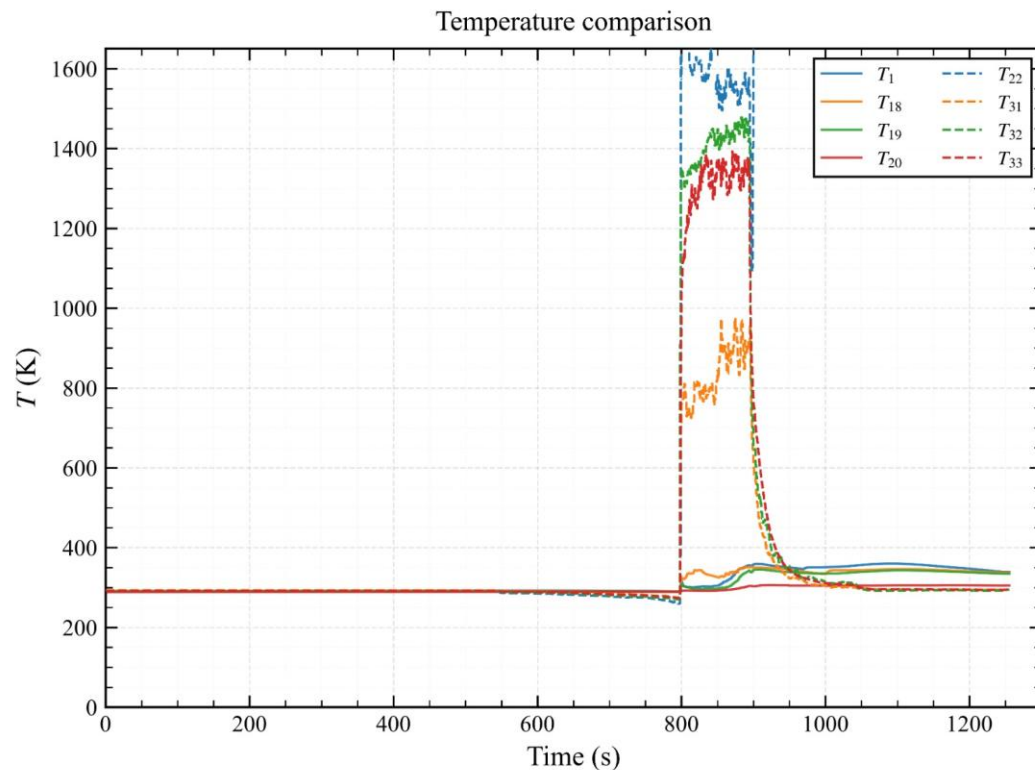


MLI 10 , 40 layers Unignited

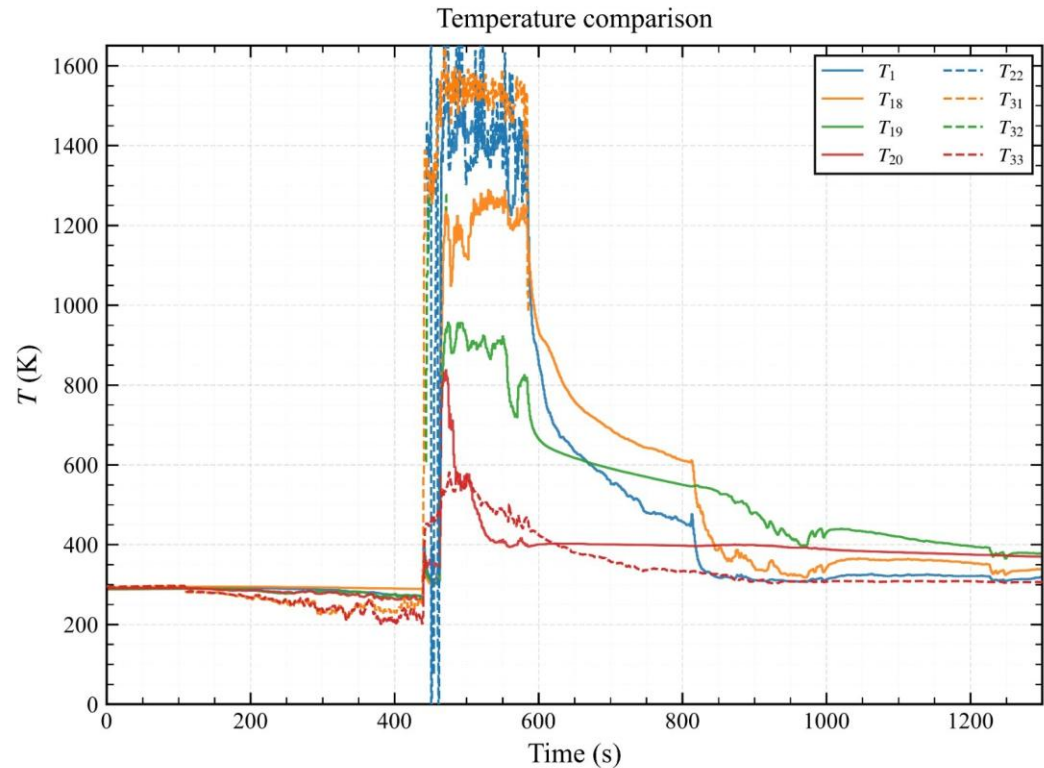
KIT Experimental Task 4.4

□ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

Temperature ignited and unignited



Dry wall dry wall 10 mm thickness
IGNITED



MLI 10 , 40 layers IGNITED

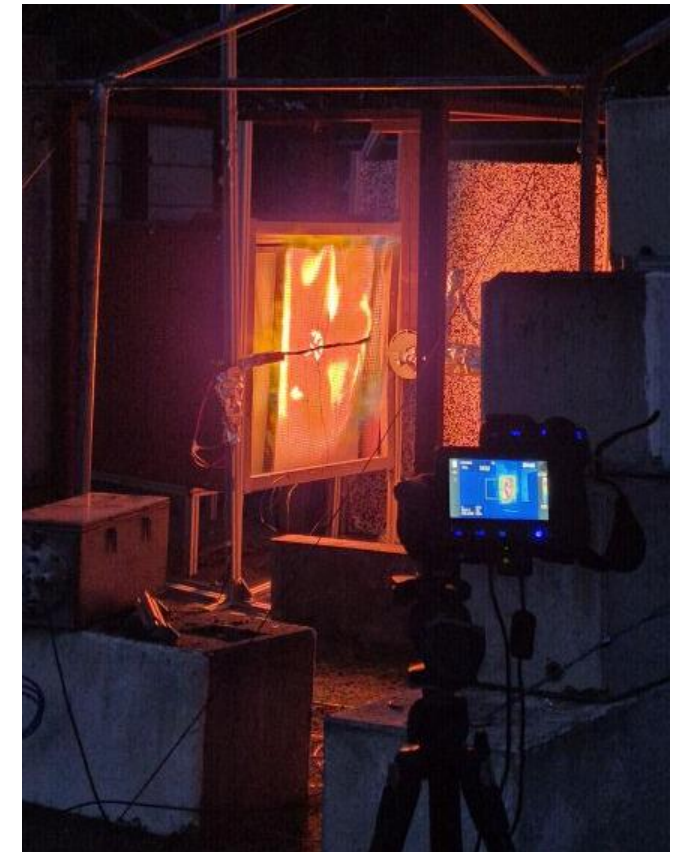
KIT Experimental Task 4.4

❑ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

Heat flux sensor FLIR camera COMPLETED



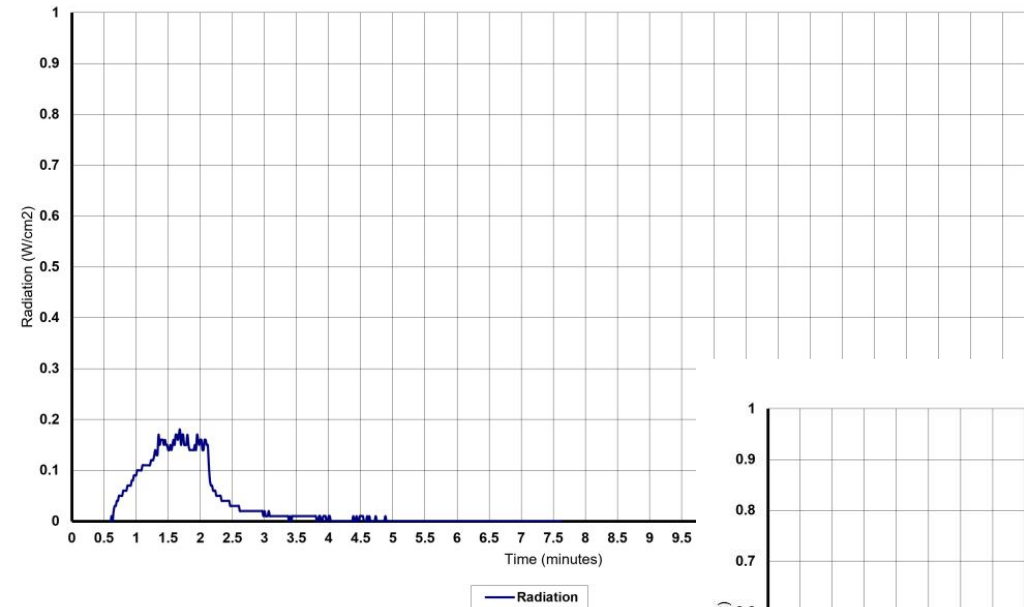
Hole with heat flux sensor
in the center of the height
of the target and right after
the plate



KIT Experimental Task 4.4

Heat flux sensor FLIR camera

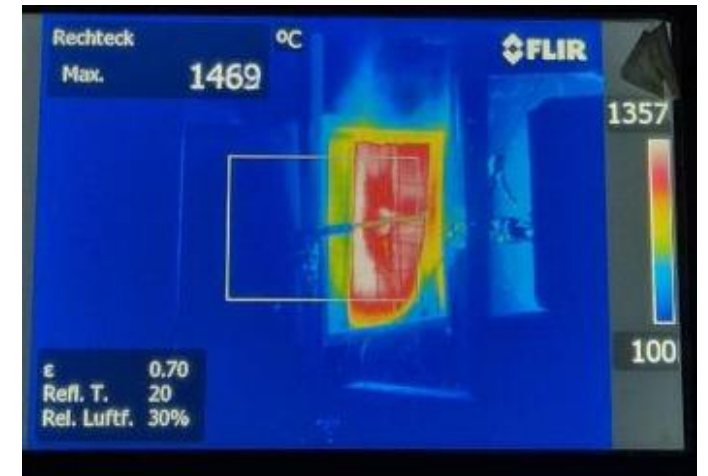
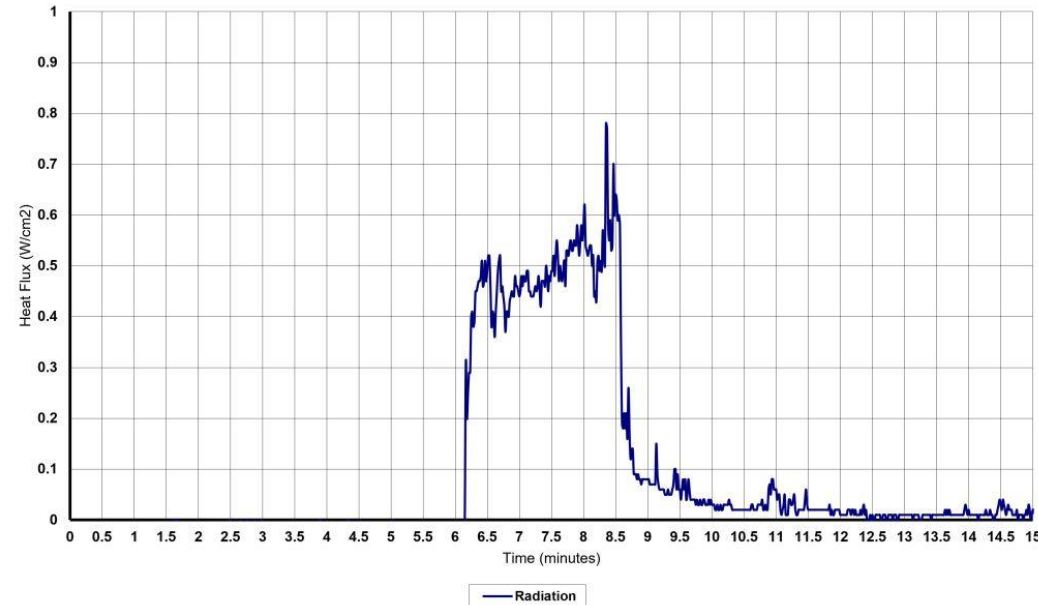
Radiation Aerogel Test 0,5 m



More heat flux is observed at 1 m

- Bigger burning surface
- The steady state of the burning flame seems to be achieved faster

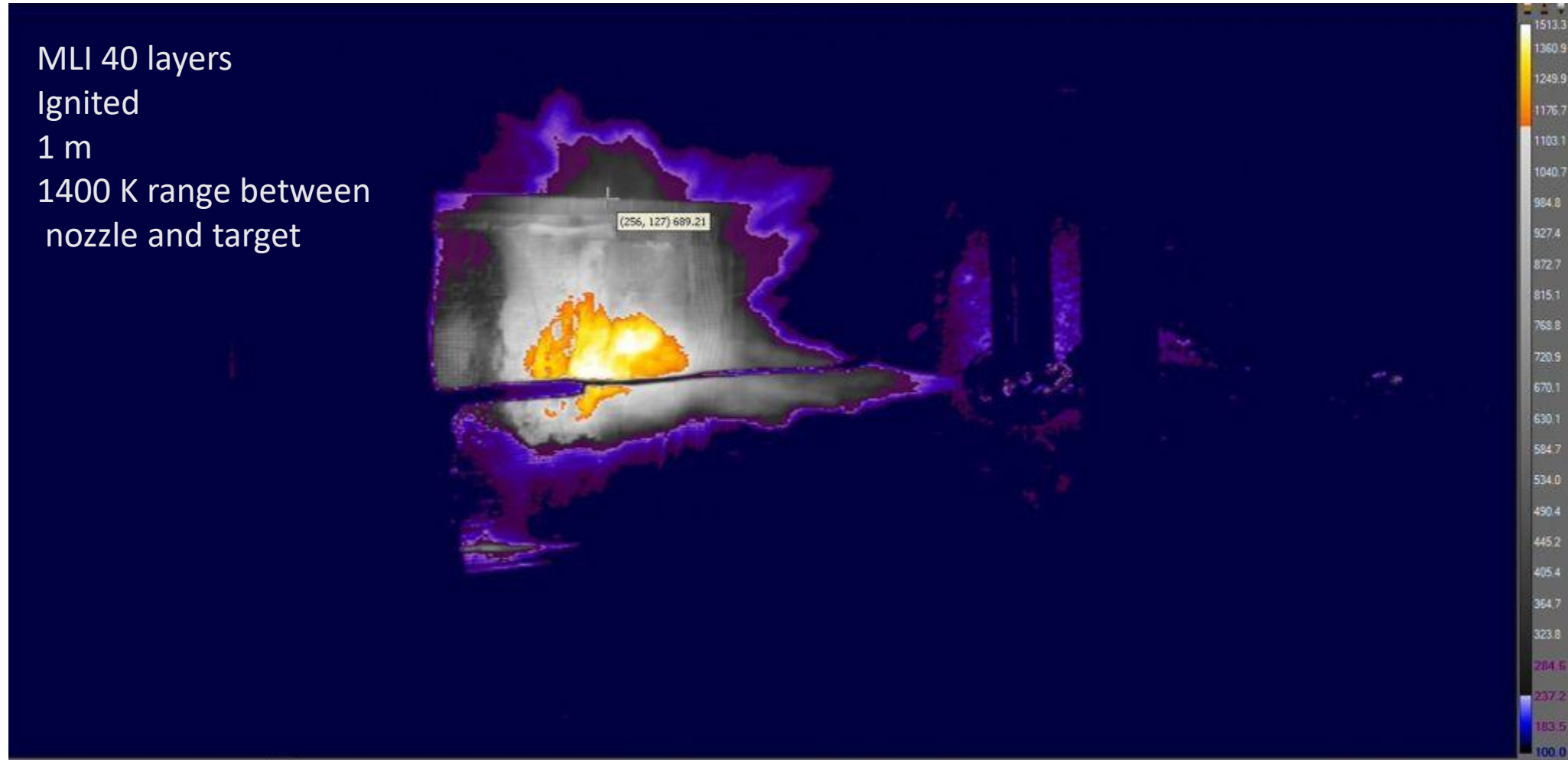
Radiation MLI Test 1m



KIT Experimental Task 4.4

Heat flux sensor FLIR camera

MLI 40 layers
Ignited
1 m
1400 K range between
nozzle and target



KIT Experimental Task 4.4

❑ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall,insultion) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

Web Cam

Was used to control overall phenomena

Target: MLI 40
1 m distance. Ignited



KIT Experimental Task 4.4

❑ Task 4.4 Material testing against unignited and ignited jet (MLI, glass spheres, perlite layers and fire protecting wall, insulation) according to **ISO 20088** (Lead partner: KIT). Resistance of materials

Web Cam

Was used to control overall phenomena

Target: Aerogel
0,5 m distance. Ignited



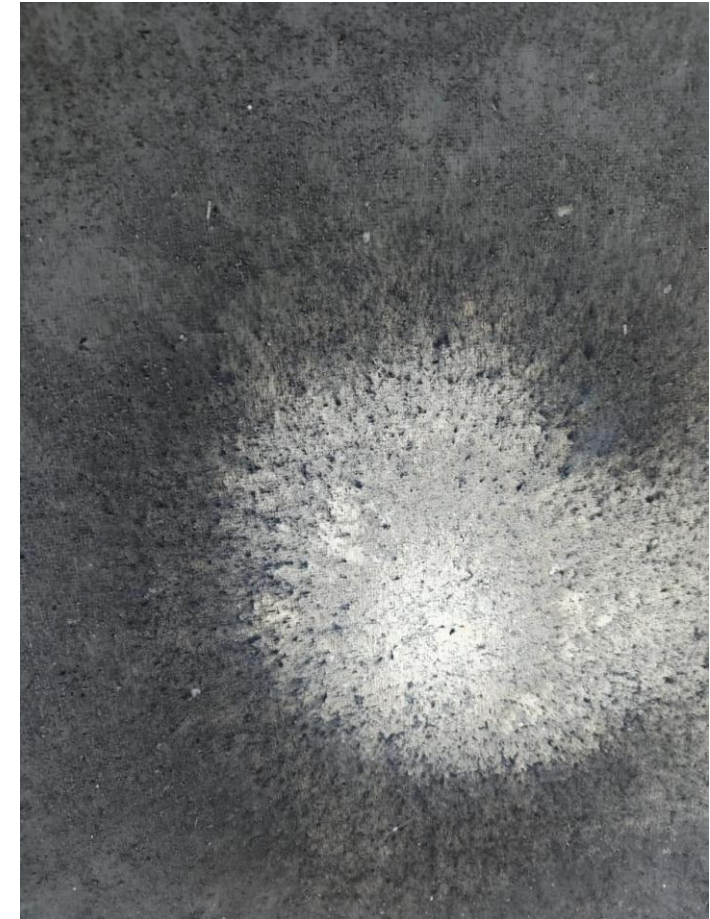
KIT Experimental Task 4.4

High speed camera recording



KIT Experimental Task 4.4

Photographic record: Dry wall



LH2 no changes; fire generated deformations in the plane but only one side

KIT Experimental Task 4.4

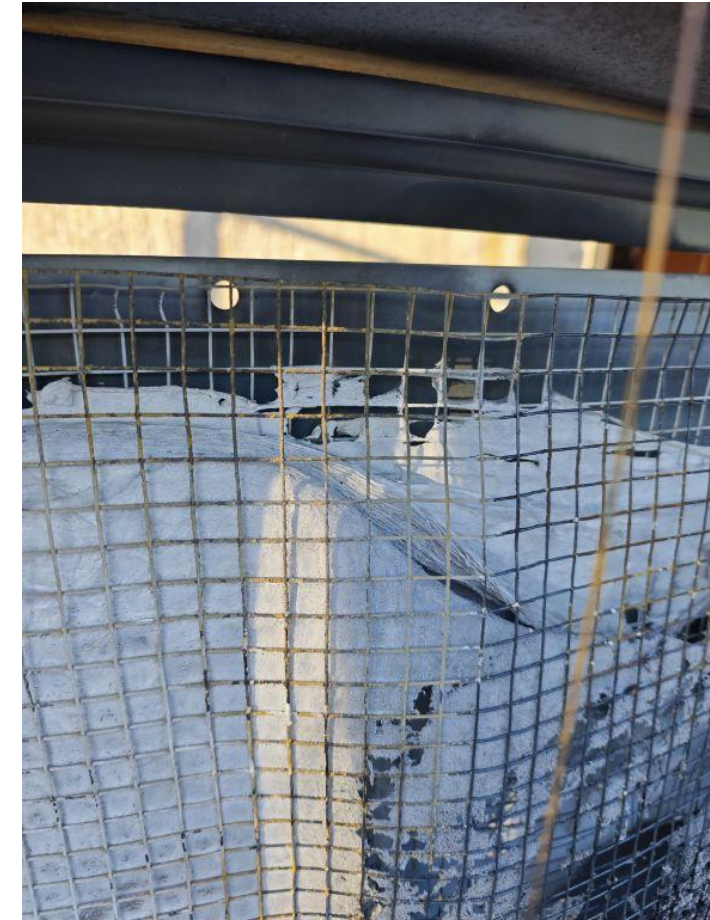
Photographic record: Aerogel



LH2 absorbed by fibers; fire generated deformations in the material.
There was bending and a gap formatted. Should be repeated

KIT Experimental Task 4.4

Photographic record: MLI 40 layers



LH2 no changes; fire destroyed all the structure of material affected

KIT Experimental Task 4.4

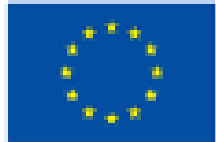
Conclusions and final remarks

- Unignited LH2 impinged at 50cm and 100 cm no observable changes on the target surfaces.
- Unignited jet seems to not remain liquid after 10 cm.
- It was possible to effectively ignite the jet (not in the axis) and showed stable behaviour.
- Ignited LH2 partially degraded the surface of aerogel and dry wall at 50 cm and 100 cm ; it degraded completely the MLI.
- Ignited LH2 at 50 cm and 100 cm showed different heat flux. Higher at 100 cm.
- The temperature achieved with unignited jet is as low as 50K on the outer wall of the tip (≈ 20 K inside) and the temperature impinging the target at 1 m was 134 K (min) (front wall).
- Max temperature achieved with ignited LH2 was 1695 K (max) (front wall).
- Configuration showed to be promising in order to develop a downsize scale geometry of ISO 20088.
- The used LH2 was in the order of 50 l per experiment
- The pressure was always 3,7 bar(g) (due to small amount used pressure was stable)
- Ongoing activities and processing. All be openly published.



Thank you for your attention

eugenio.ritter@kit.edu



Co-funded by
the European Union



UK Research
and Innovation

ELVHYS project No. 101101381 is supported by the Clean Hydrogen Partnership and its members. UK participants in Horizon Europe Project ELVHYS are supported by UKRI grant numbers 10063519 (University of Ulster) and 10070592 (Health and Safety Executive).

Disclaimer: Despite the care that was taken while preparing this document the following disclaimer applies: Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Clean Hydrogen JU. Neither the European Union nor the granting authority can be held responsible for them.