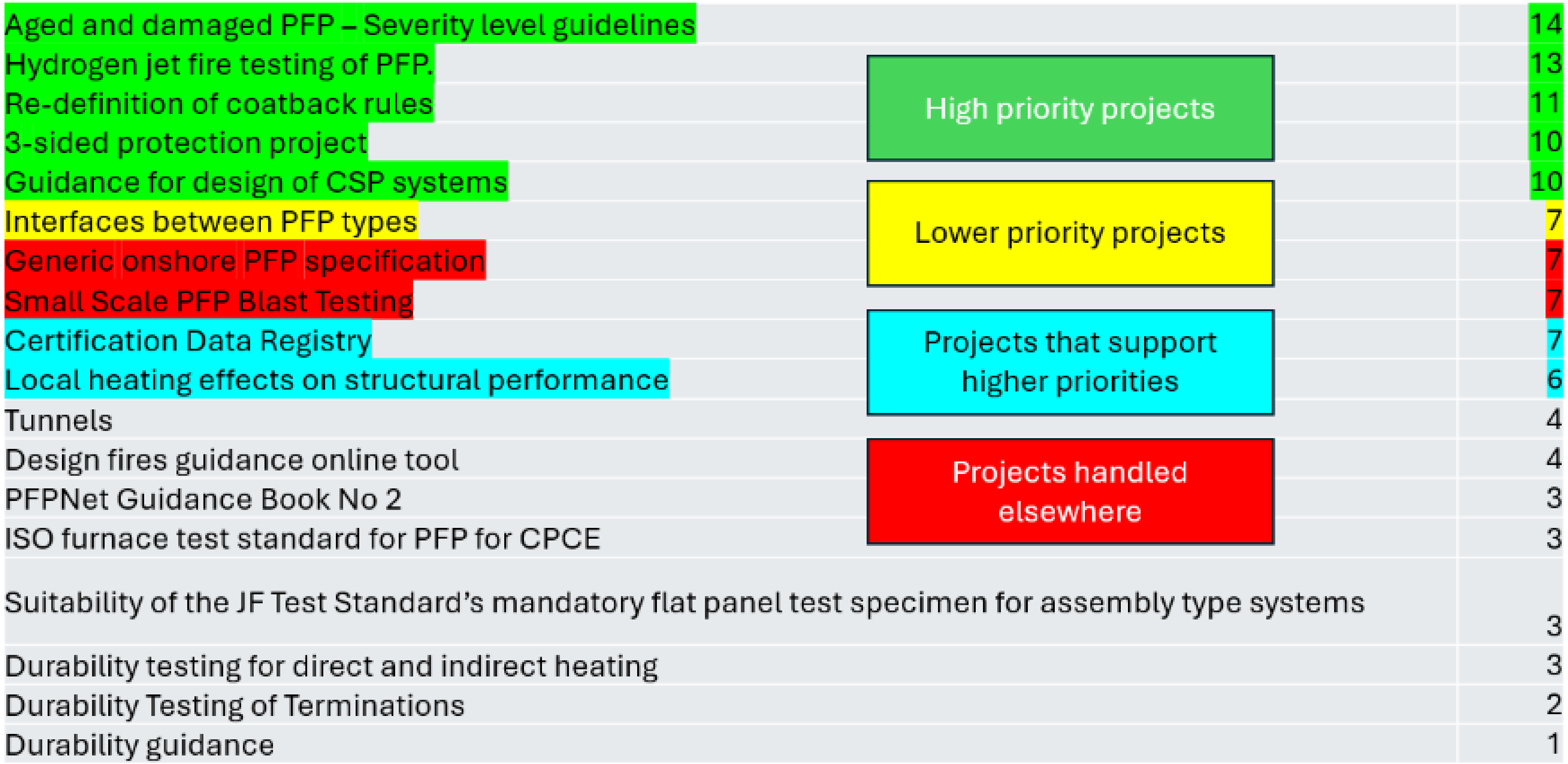
H_2 Jet Fire Project

Hydrogen jet fire testing of PFP

H_2 was the second highest priority of the members



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🟩 High priority projects

🟨 Lower priority projects

🟦 Projects that support higher priorities

🟥 Projects handled elsewhere

Hydrogen project

The key questions:

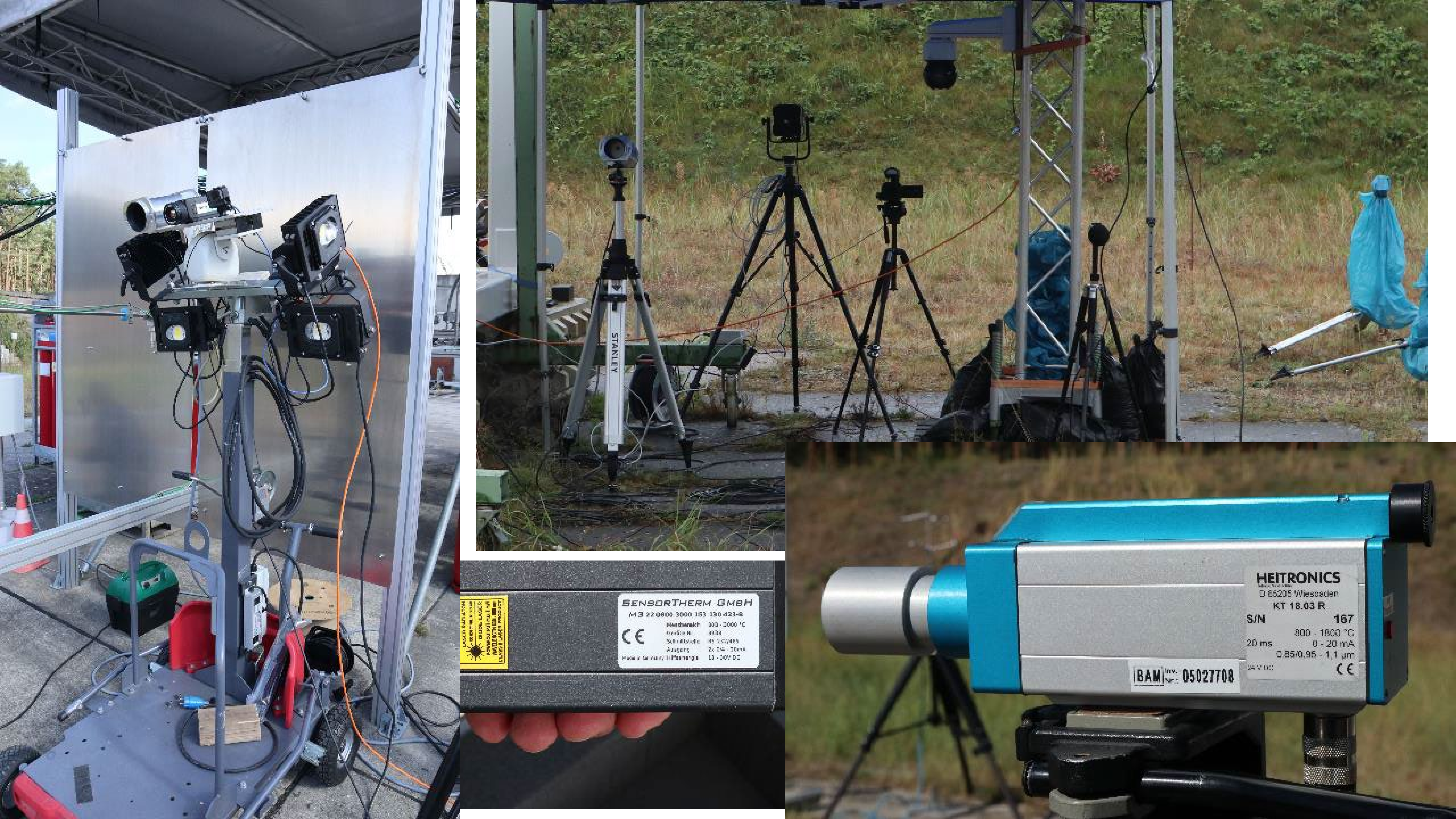
- Can (do) exist PFP materials protect against H2 jet fires?
- Can we model the conditions of an object engulfed in a H2 release?
- Are existing test methods adequate?
- If not, what would a test method look like?

Experimental setup


LIPAC® duo
Linde
300
413

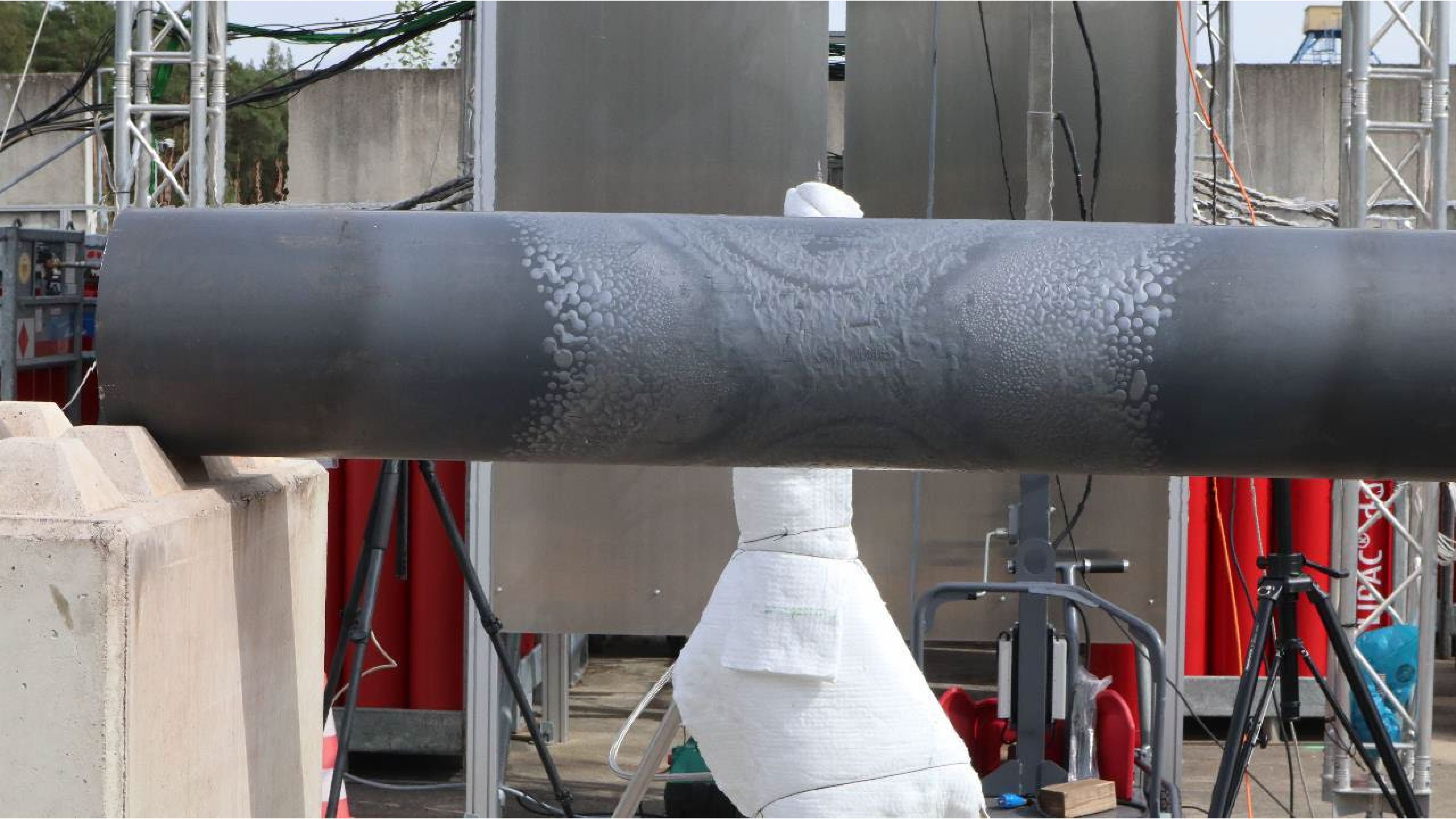

Linde
300
Linde
300
duo

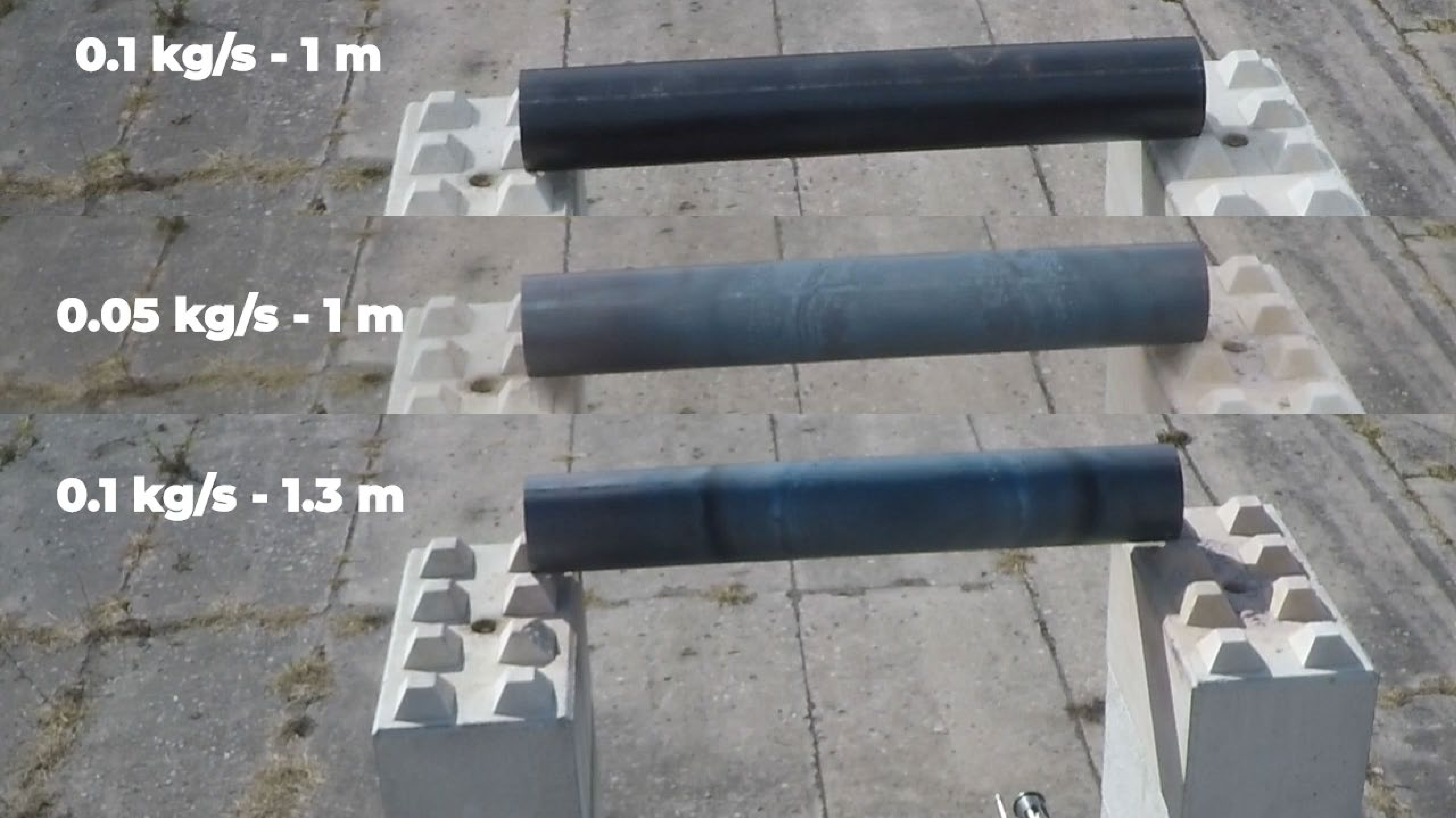

V9
PAC® duo

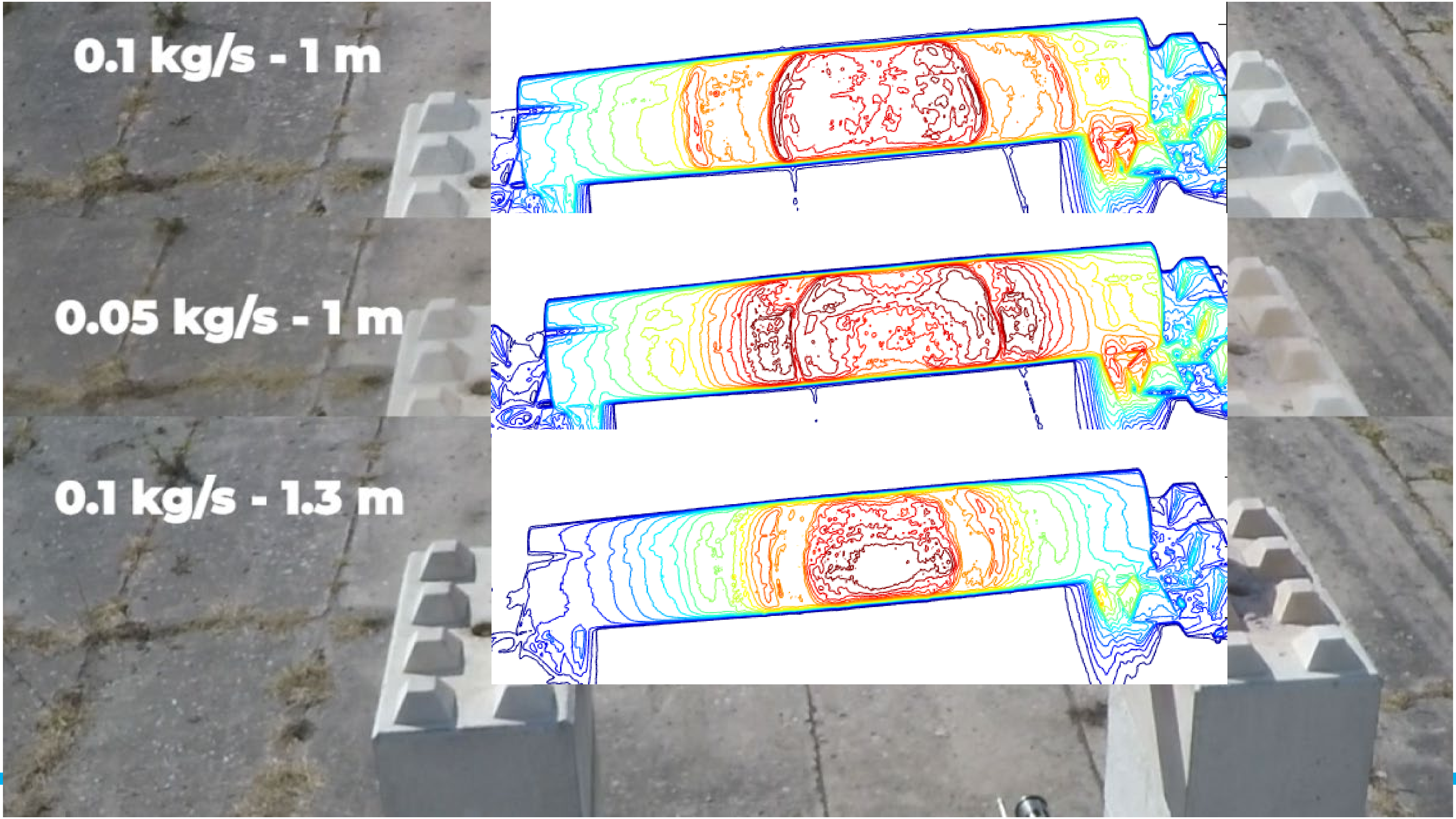

STANLEY
SENSORTHERM GMBH
CE
HEITRONICS
D 65205 Wiesbaden
KT 18.03 R
S/N
167
800 - 1800 °C
20 ms
0 - 20 mA
0.85/0.95 - 1.1 µm
CE
BAM
05027708

Pre-tests

- A blank tube was used to give an indication of expected temperatures (using pyrometers)




0.1 kg/s - 1 m
0.05 kg/s - 1 m
0.1 kg/s - 1.3 m

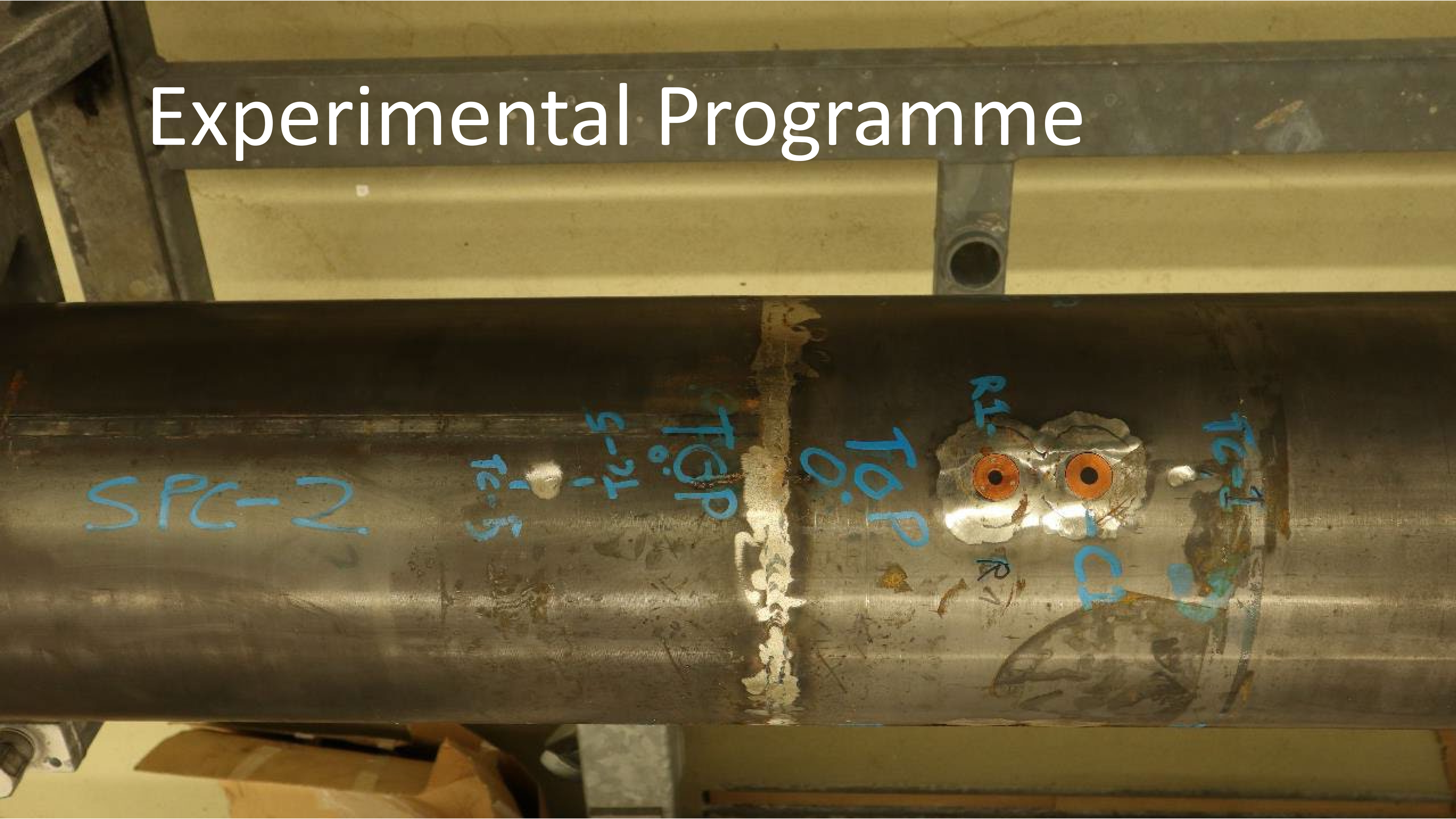


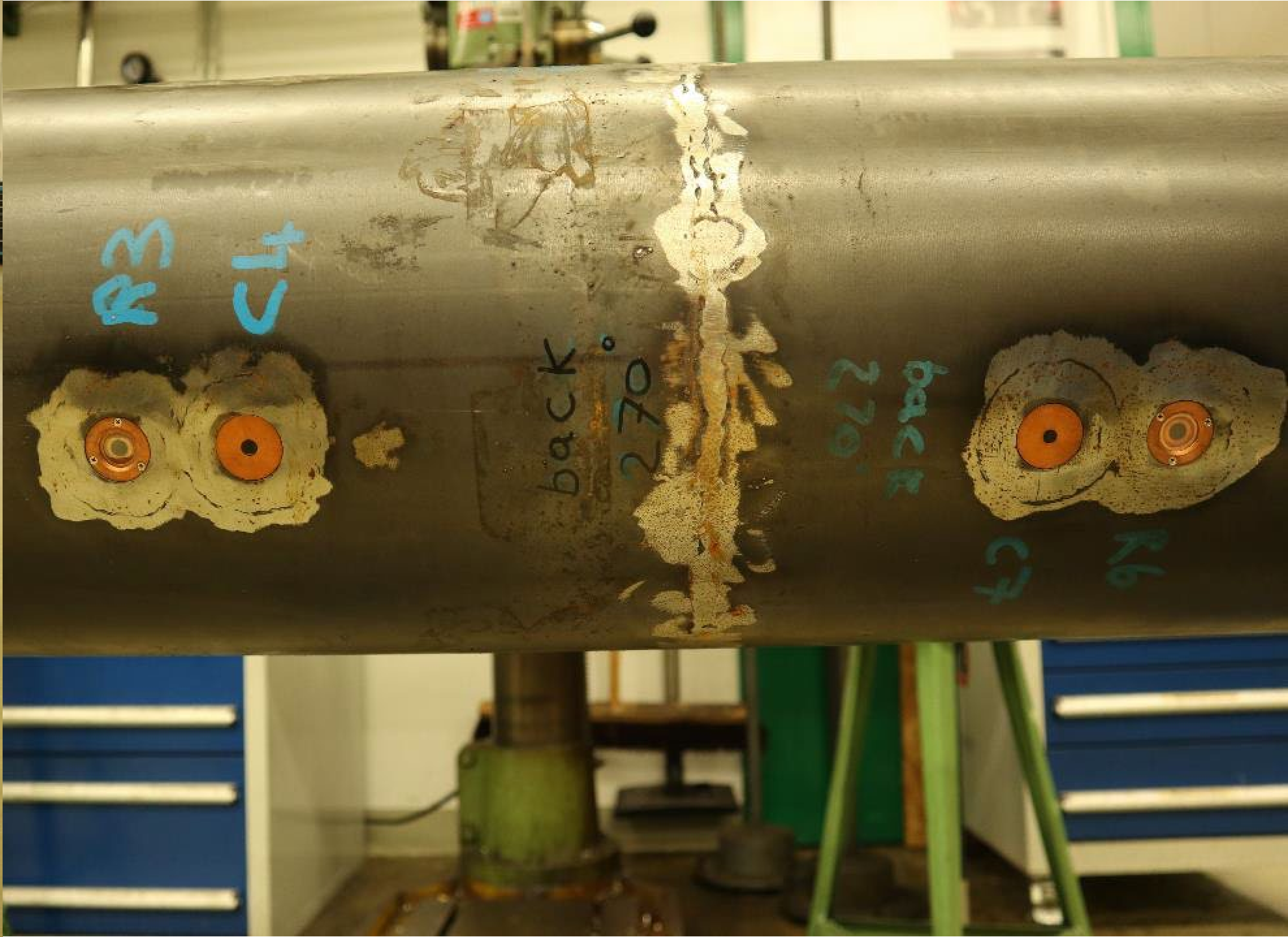
0.1 kg/s - 1 m

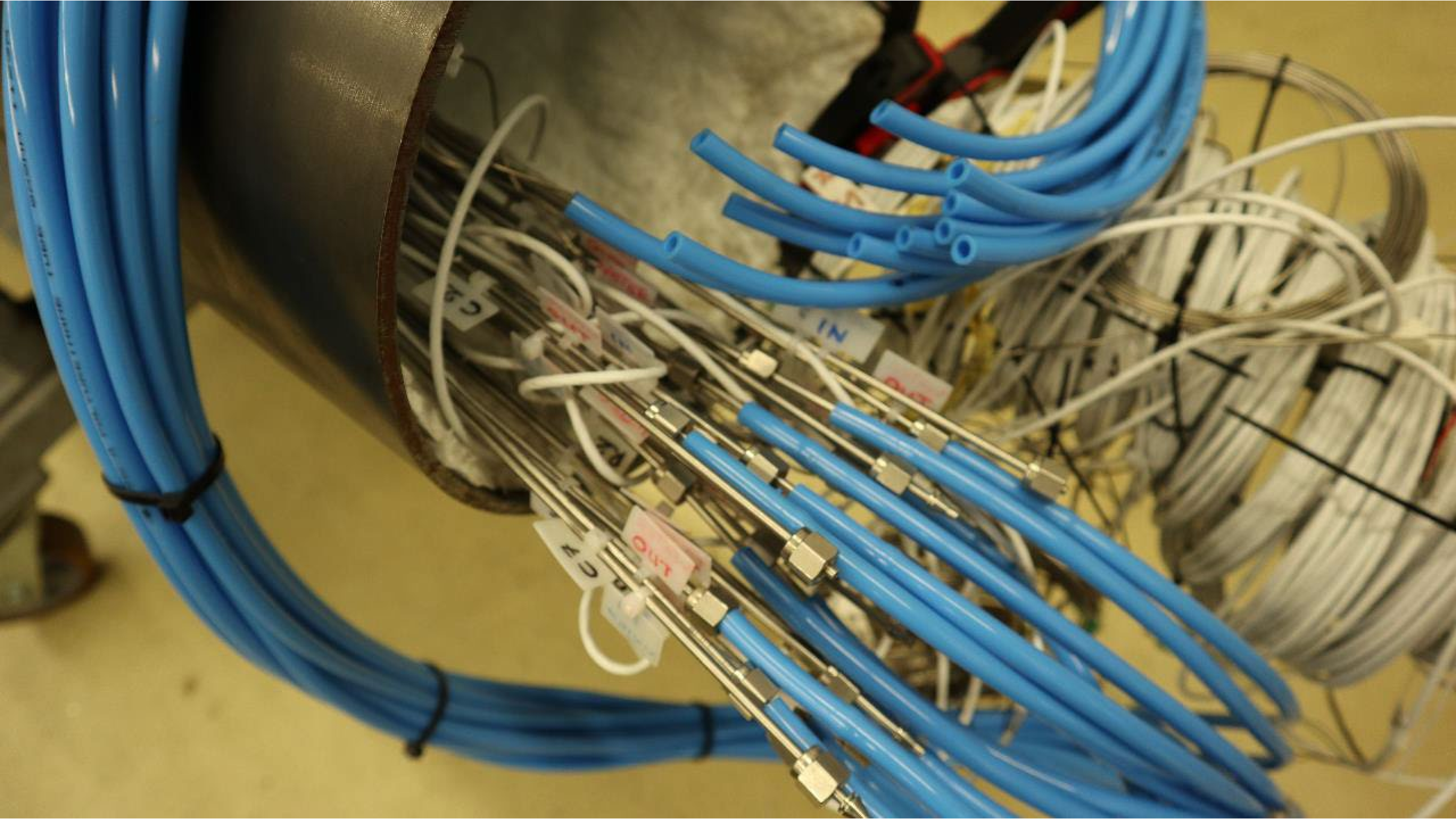
0.05 kg/s - 1 m

0.1 kg/s - 1.3 m

Experimental Programme

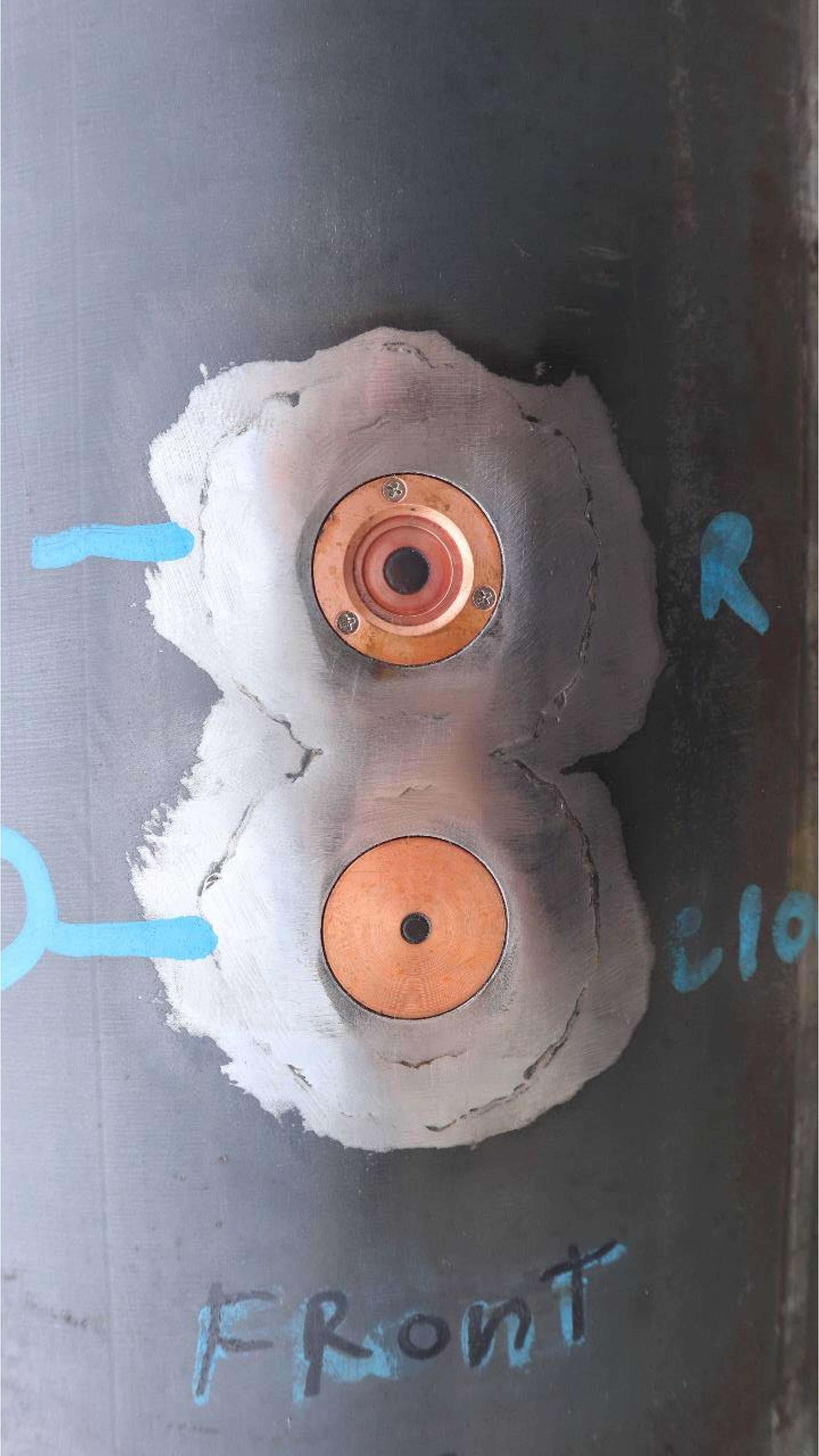


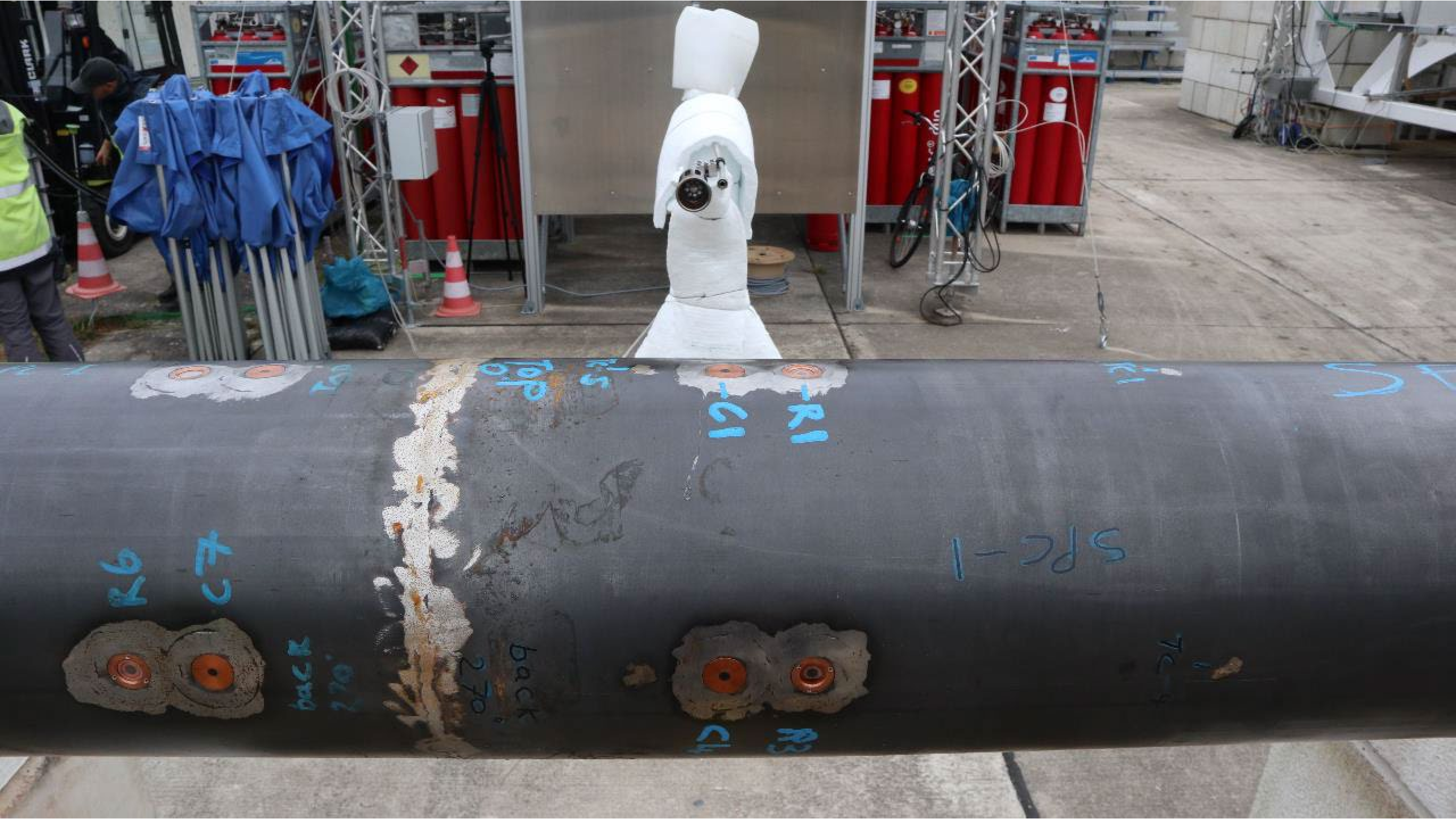

R3
C4
back
270°
270°
back
C7
R6

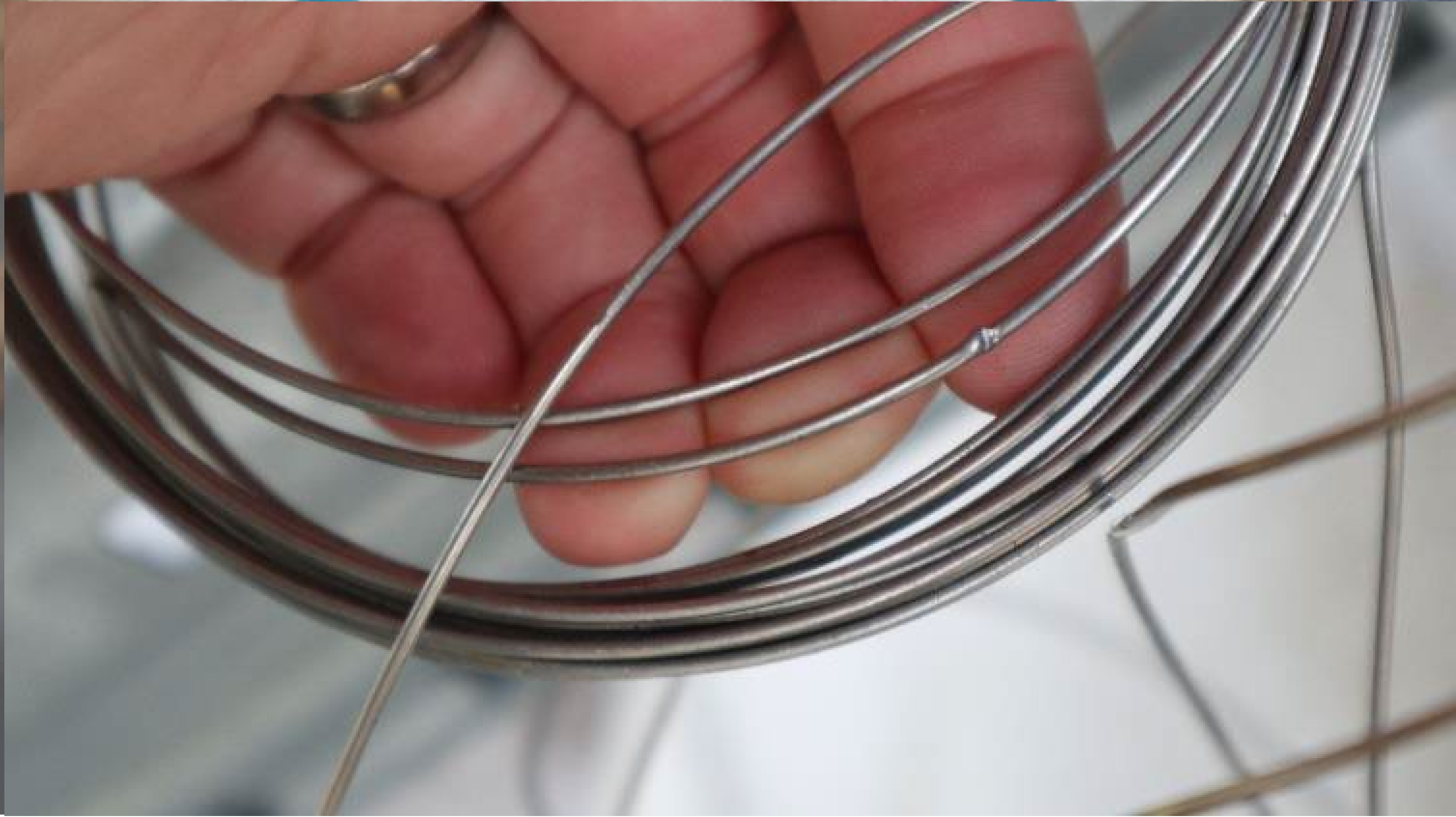


IN
OUT
OUT


TC2
C2
1000
TC6
FRONT
C6
R5


R
EL10
FRONT


TOP
R1
C1
SPC-1
R6
C7
back 270°
back 270°
C4
R3




BAM


TC-2
C2
R2
FRONT
90°

Test Programme

Test	Specimen	Flow rate (kg/s)	Duration (s)	Nozzle (mm)
01_002	1	0.1	15	9.5
01_004	1	0.05	15	9.5
01_005	1	0.05	30	9.5
01_007	1	0.2	10	9.5
02_001	2	0.05	5	9.5
02_002	2	0.1	5	9.5
02_003	2	0.2	5	9.5
02_004	2	0.1	100	9.5
02_CH4	2	0.05	15	30
02_005	2	0.05	15	30

Heat fluxes – 0.05 kg/s

PFPNet

PASSIVE FIRE PROTECTION NETWORK

		CL-50 (R)	CL (T)	CL+300 (T)	CL+350 (R)
Top	0°	X	347	273	13
Front	90°		720	320	18
Bottom	180°	X	325		
Back	270°	50	316	166	27

		CL (T)	CL+50 (R)
Top	0°	461	33
Front	90°	670	35
Bottom	180°	309	34
Back	270°	378	51

Heat fluxes – 0.10 kg/s

PFPNet
PASSIVE FIRE PROTECTION NETWORK

		CL-50 (R)	CL (T)	CL+300 (T)	CL+350 (R)
Top	0°	56	421	362	22
Front	90°		798	380	27
Bottom	180°	42	396		
Back	270°	60	367	216	43

		CL (T)	CL+50 (R)
Top	0°	561	34
Front	90°	694	32
Bottom	180°	362	38
Back	270°	436	57

Heat fluxes – 0.20 kg/s

PASSIVE FIRE PROTECTION NETWORK

		CL-50 (R)	CL (T)	CL+300 (T)	CL+350 (R)
Top	0°	X	483	491	45
Front	90°		735	492	37
Bottom	180°	X	482		
Back	270°	64	438	309	62

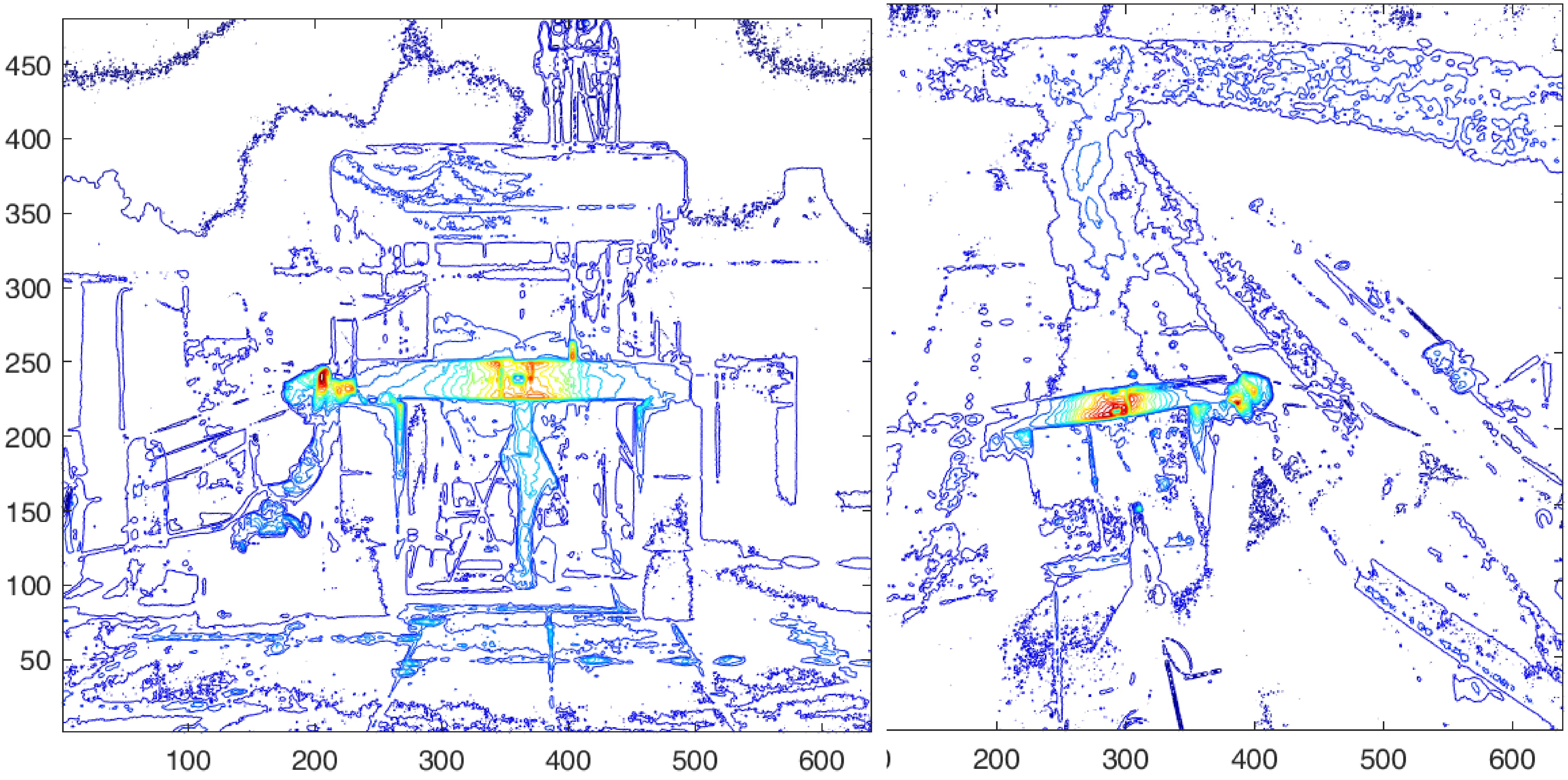
		CL (T)	CL+50 (R)
Top	0°	513	31
Front	90°	698	27
Bottom	180°	434	36
Back	270°	505	60

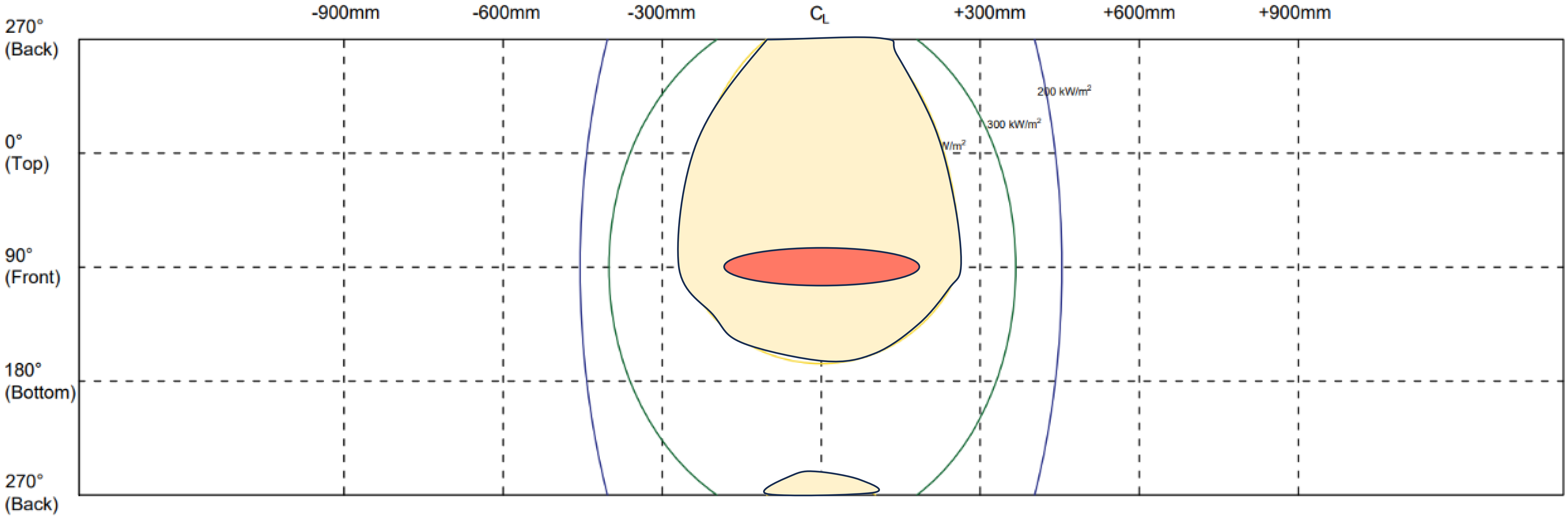
Radiative fraction

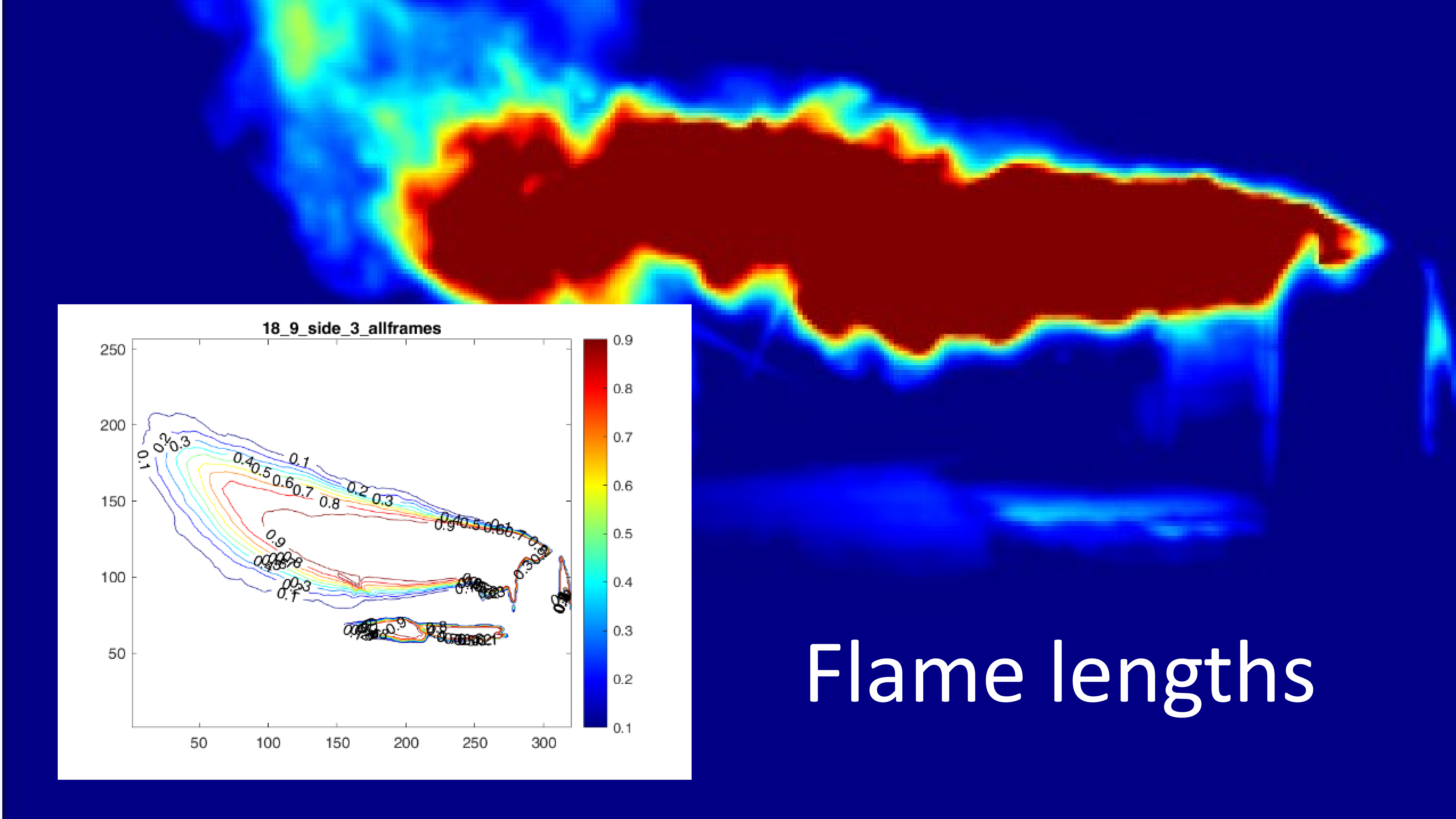
PFPNet
PASSIVE FIRE PROTECTION NETWORK

	0.05 kg/s	**Specimen 1**	**Specimen 2**	**Specimen 1**
		CL-50/CL	CL/CL+50	CL+300/350
Top	0	X	0,07	0,05
Front	90		0,05	0,06
Bottom	180	X	0,11	
Back	270	0,16	0,14	0,16

	0.2 kg/s	**Specimen 1**	**Specimen 2**	**Specimen 1**
		CL-50/CL	CL/CL+50	CL+300/350
Top	0	X	0,06	0,09
Front	90		0,04	0,07
Bottom	180	X	0,08	
Back	270	0,15	0,12	0,20

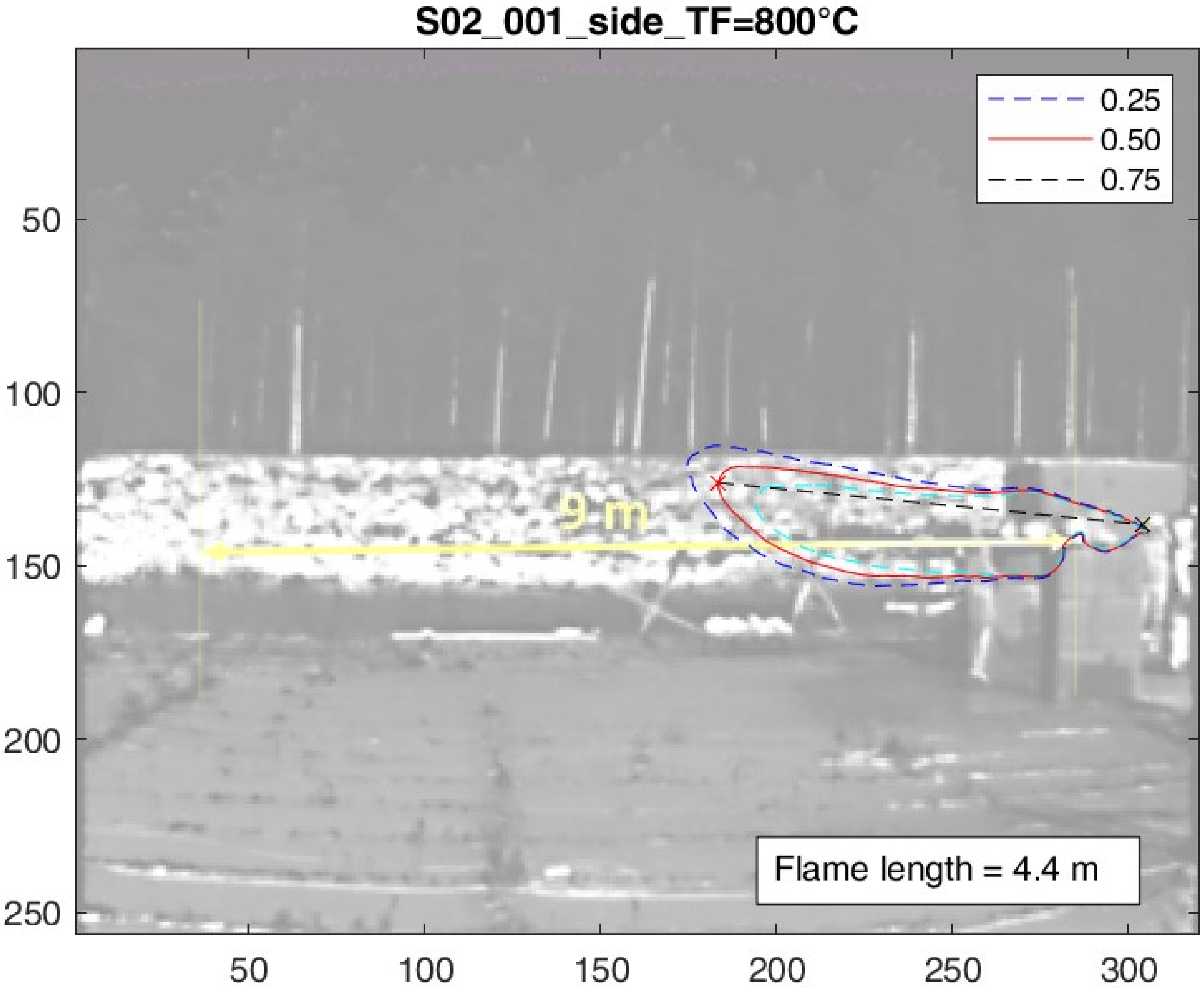

450
400
350
300
250
200
150
100
50
100
200
300
400
500
600
200
300
400
500
600


-900mm
-600mm
-300mm
C_L
+300mm
+600mm
+900mm
270°
(Back)
0°
(Top)
90°
(Front)
180°
(Bottom)
270°
(Back)
200 kW/m^2
300 kW/m^2
W/m^2

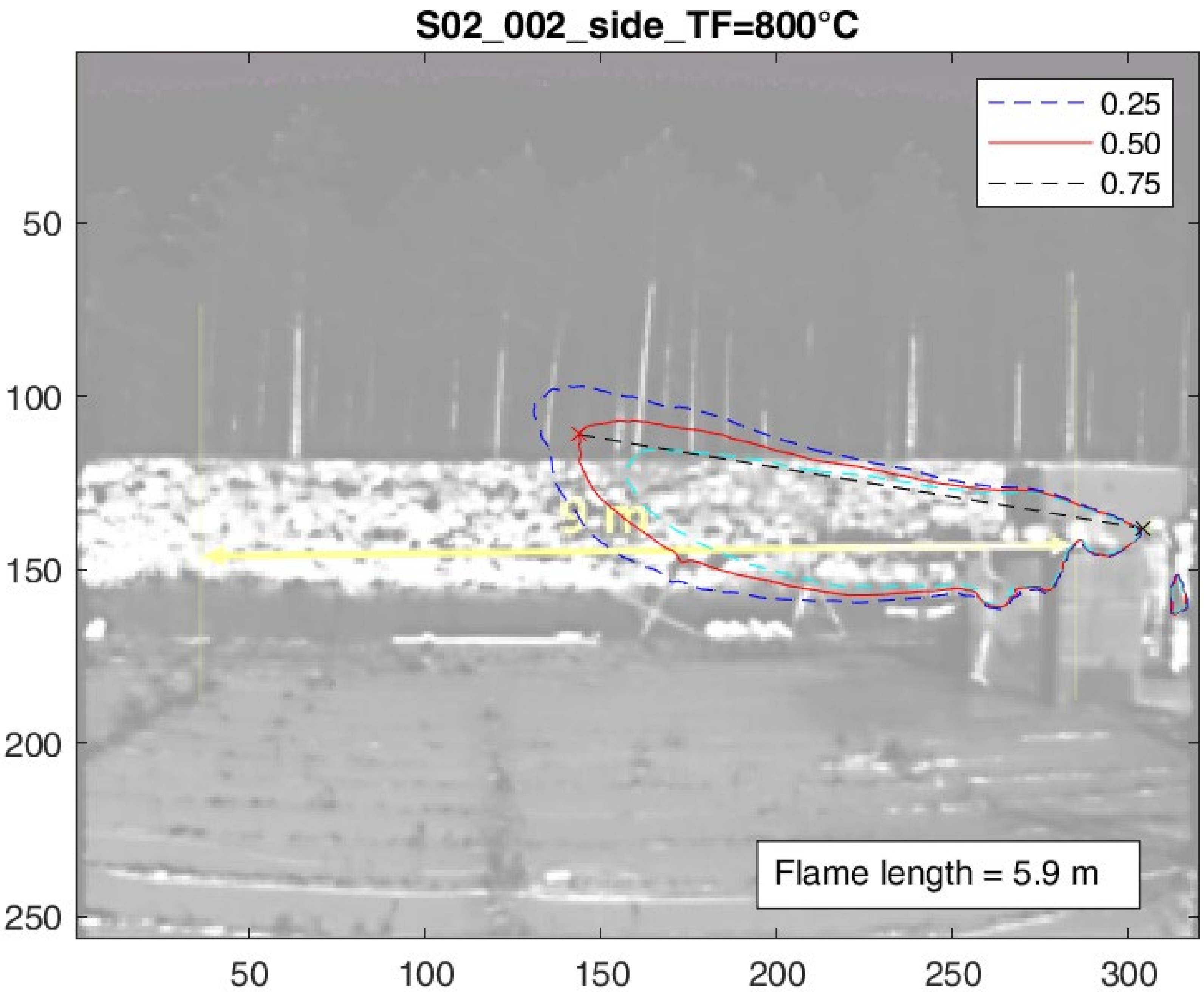


Flame lengths

0.05 kg/s

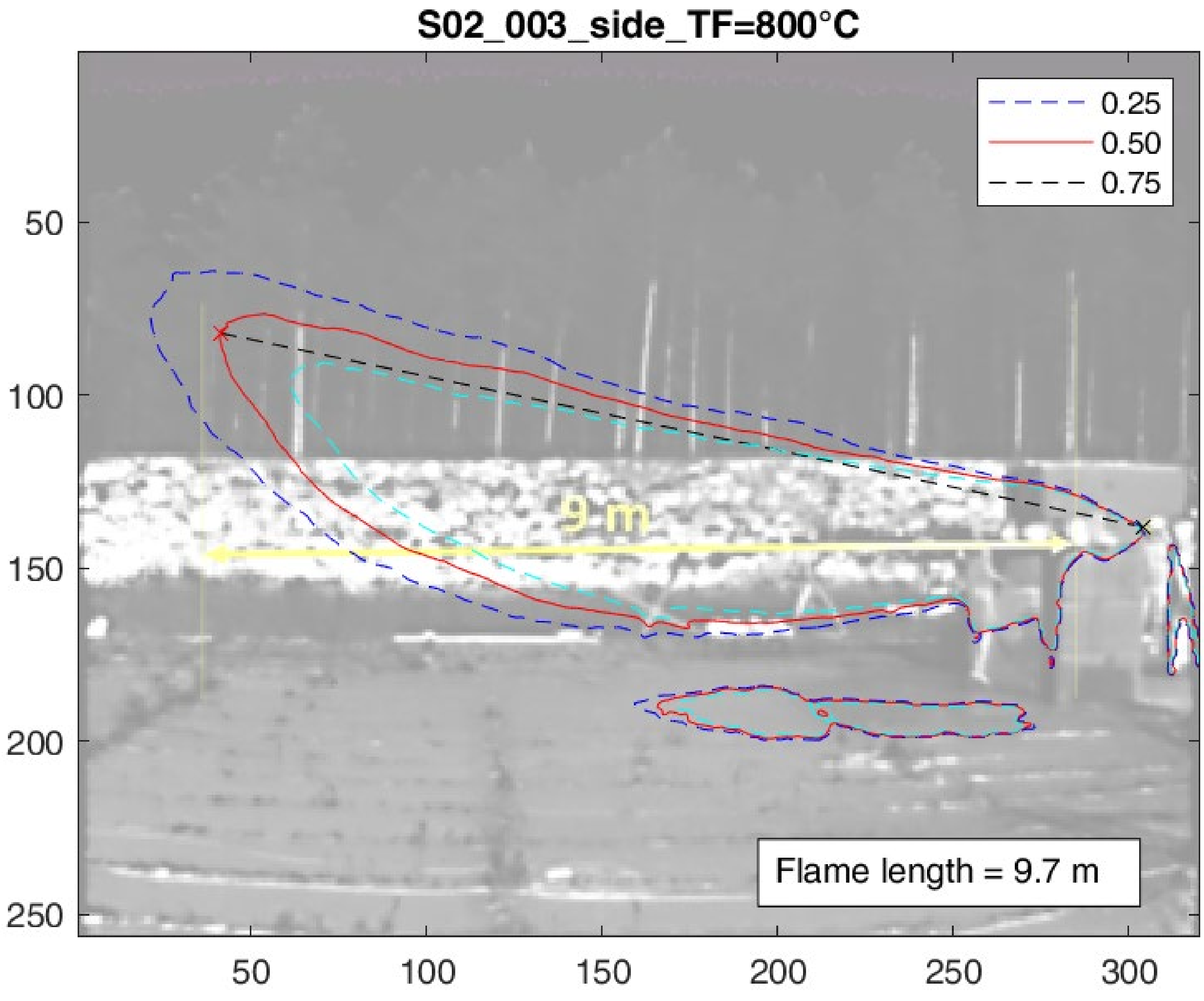

S02_001_side_TF=800°C
0.25
0.50
0.75
9 m
Flame length = 4.4 m
50
100
150
200
250
50
100
150
200
250
300

0.10 kg/s


S02_002_side_TF=800°C

Flame length = 5.9 m

0.20 kg/s

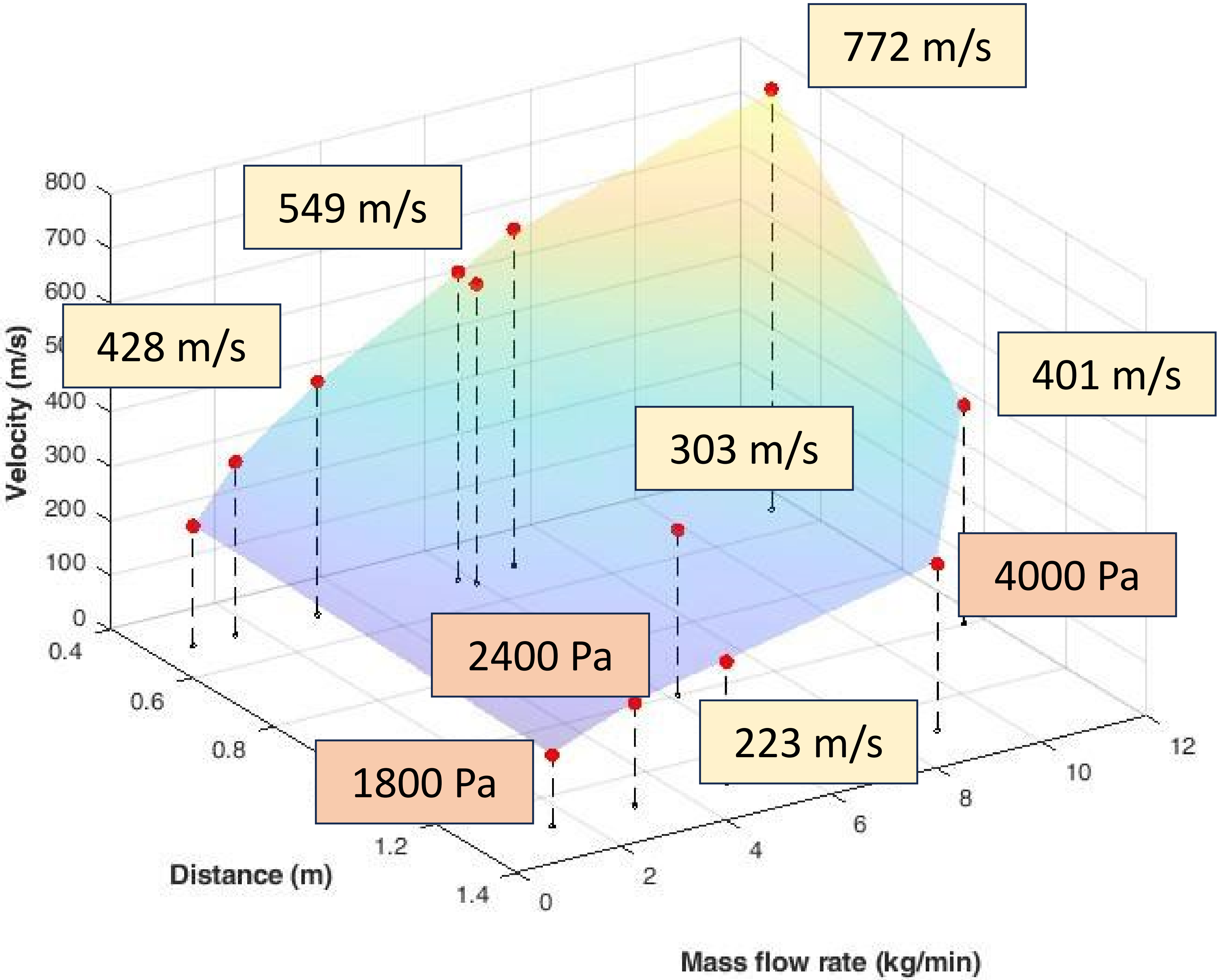

S02_003_side_TF=800°C
0.25
0.50
0.75
9 m
Flame length = 9.7 m
50
100
150
200
250
50
100
150
200
250
300

Unignited Jet Velocities

Velocities

Local dynamic pressures

For reference:
9m from 3 kg/s CH4 fire
500 Pa



772 m/s

549 m/s

428 m/s

401 m/s

303 m/s

4000 Pa

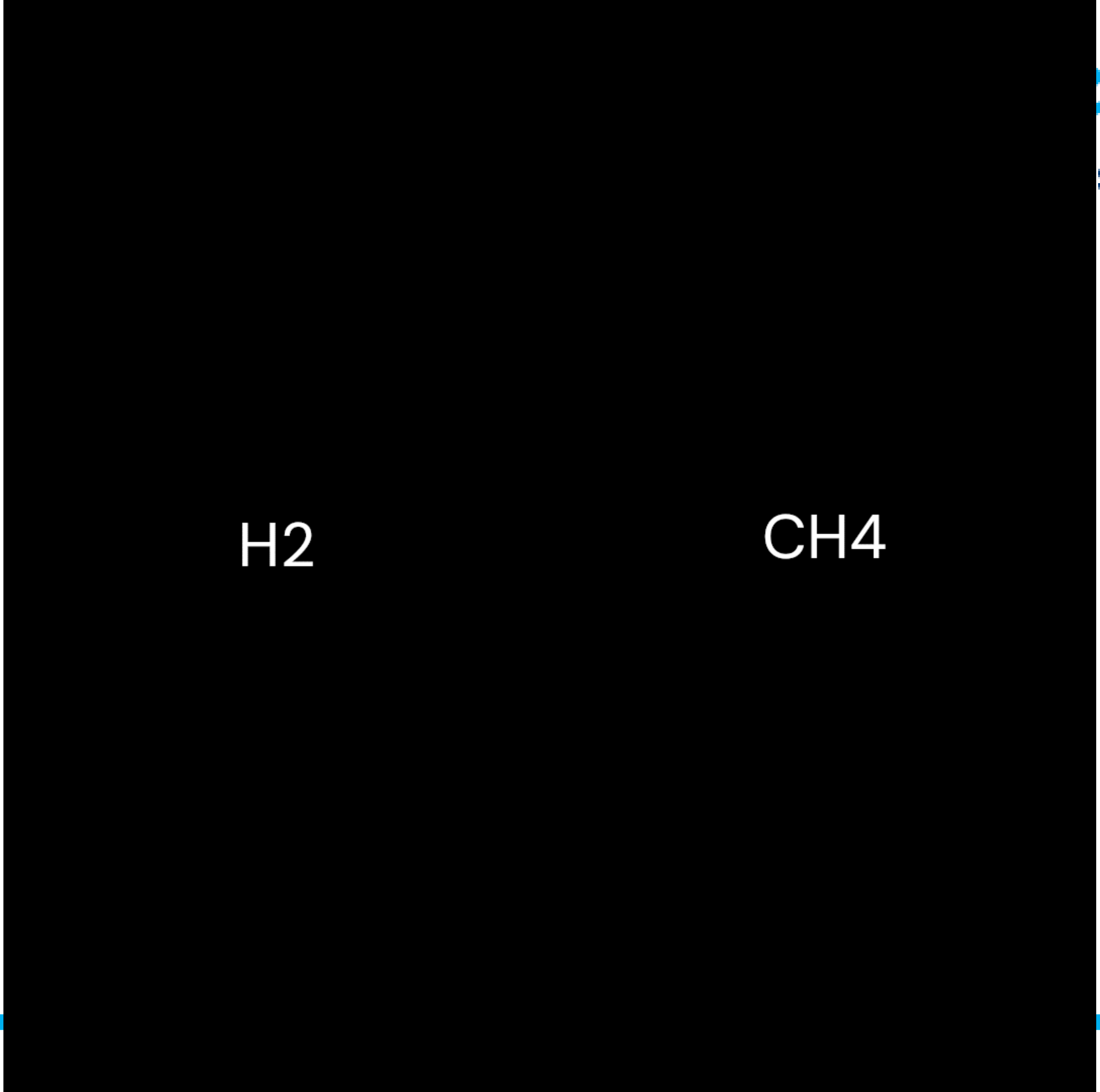
2400 Pa

223 m/s

1800 Pa

Methane comparisons


Linde
Methan, verdichtet
UN 1971
EG-Nr. 200-812-7
GEFAHR
Methan 2.5


H2
CH4

Initial Conclusions

Conclusions

- Heat fluxes to objects engulfed in gaseous H2 jet fires are dominated by convection
- The worst case position in the flame is likely to differ to hydrocarbon flames. Hyrdrocarbon X/Lf ‘worst case’ is generally 0.4-0.6 (mid flame)
- Initial results indicate H2 may be 0.2-0.3 (nearer the release point)

Conclusions

- Localised heat fluxes of 700-750 kW/m^2 were measured
- Increasing the flow rate had a relatively small effect on peak fluxes, but increased the area subjected to high heat fluxes

Conclusions

- Local gas velocities >700 m/s were measured at 1 m distance
- Unlike NG, the highest erosive forces and highest heat fluxes are coincident

Conclusions

- In summary…
- This works does raise questions over the ability of PFP systems to perform as intended…
- …and it does raise questions over the applicability of existing test methods

- A very clear next step is required: initial tests with a range of PFP systems

Next steps

PFPNet has sourced 5 different types of PFP material.

1. Penetration & cable transit sealing system
2. Blanket insulation with stainless cladding
3. Cementitious
4. Epoxy intumescent no mesh
5. Epoxy intumescent mesh

Next steps

- These 5 specimens will be tested at BAM in November
- Results will be published however the products used shall not be divulged. Specimens will be referred to by generic type only.
- Generic conclusions will be made to give confidence to industry, or to alert them to areas of concern.

Next steps

- The existing CFD modelling results should be compared against the test data.
- Further modelling work should be undertaken to validate (or otherwise) the ability of the codes used to predict the results
- Interim conclusions should be published on whether existing test methods capture the conditions possible in a H2 JF.

Questions?

PFPNet
PASSIVE FIRE PROTECTION NETWORK