

Fraunhofer UMSICHT

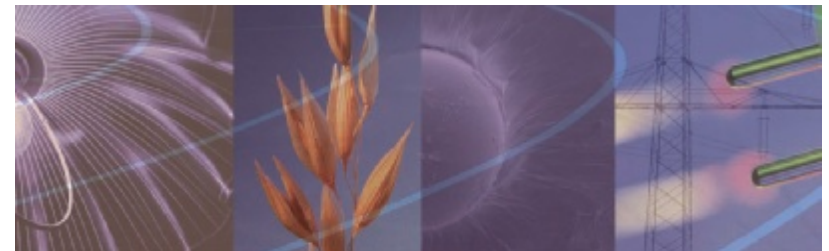
Geschäftsfeld Prozesstechnik

»Praxistest an der Großversuchsanlage bei
Fraunhofer UMSICHT«

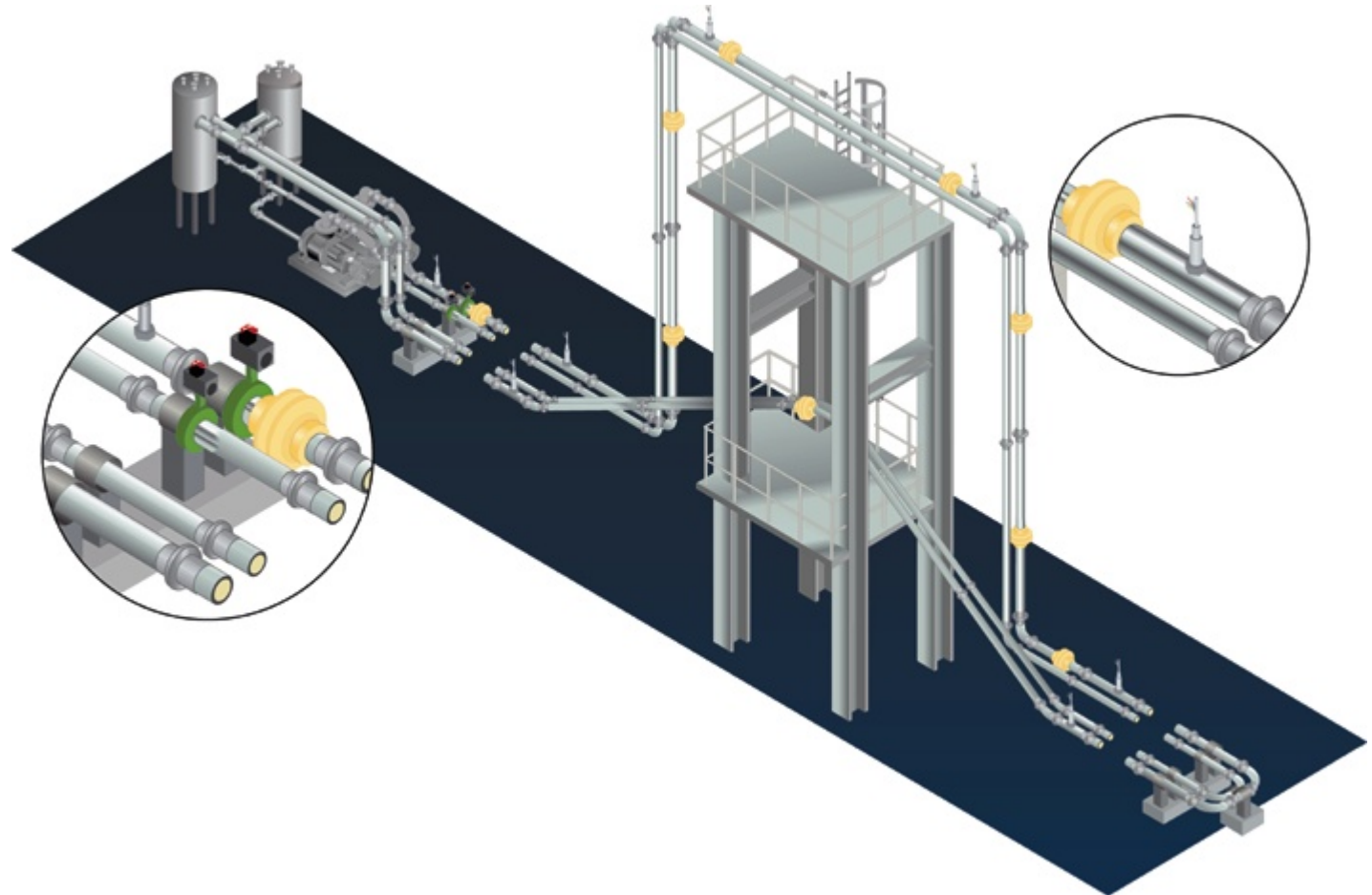
Fachveranstaltung

Druckstöße, Dampfschläge und Pulsation in Rohrleitungen

Dr.-Ing. Andreas Dudlik



Rohrleitungsversuchsfeld bei UMSICHT, $L = 230$ m



Transiente Messtechnik (Messfrequenz: 1-10kHz)

§ Druck: 25 Piezoresistive Druckaufnehmer (0 – 140 bar)

§ Kraft: 2 Dreidimensionale Sensoren (± 80 kN)
3 Eindimensionale Sensoren (± 50 kN)

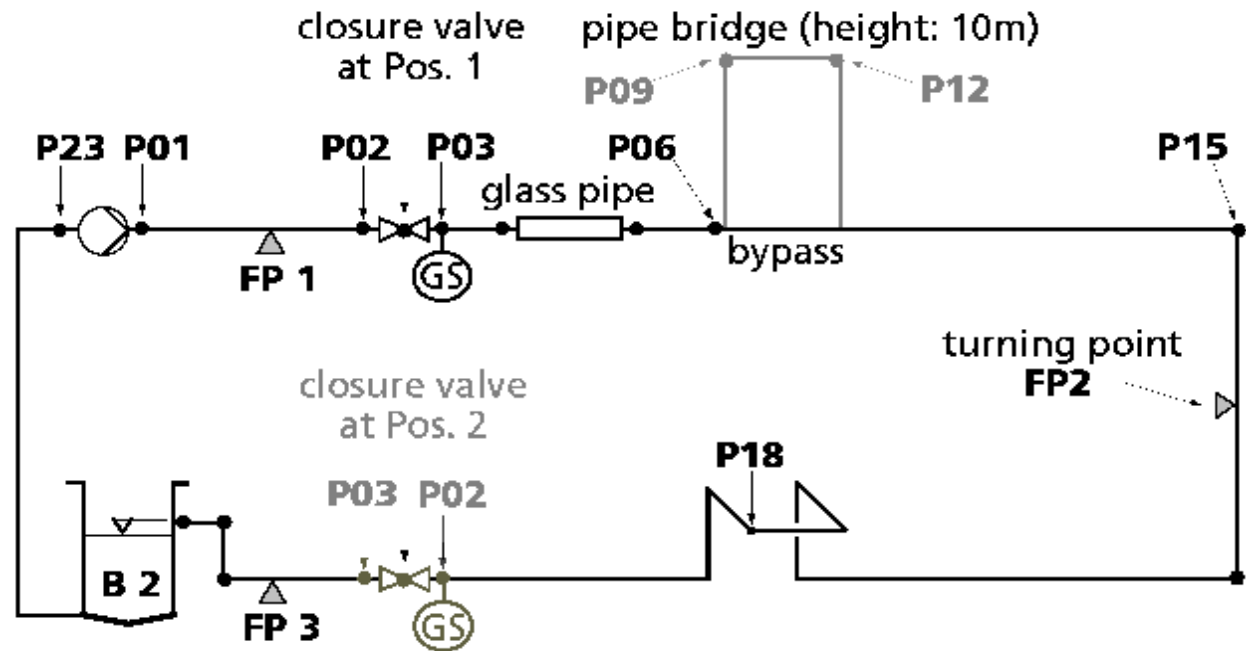
§ Fluidgeschwindigkeit: 1 Ultraschall Messgerät

§ Wasserdampf, Gas und Flüssigkeitsanteil: 4 Gittersensoren

§ Strömungsprofil: 1 VHS Highspeed-Kamera

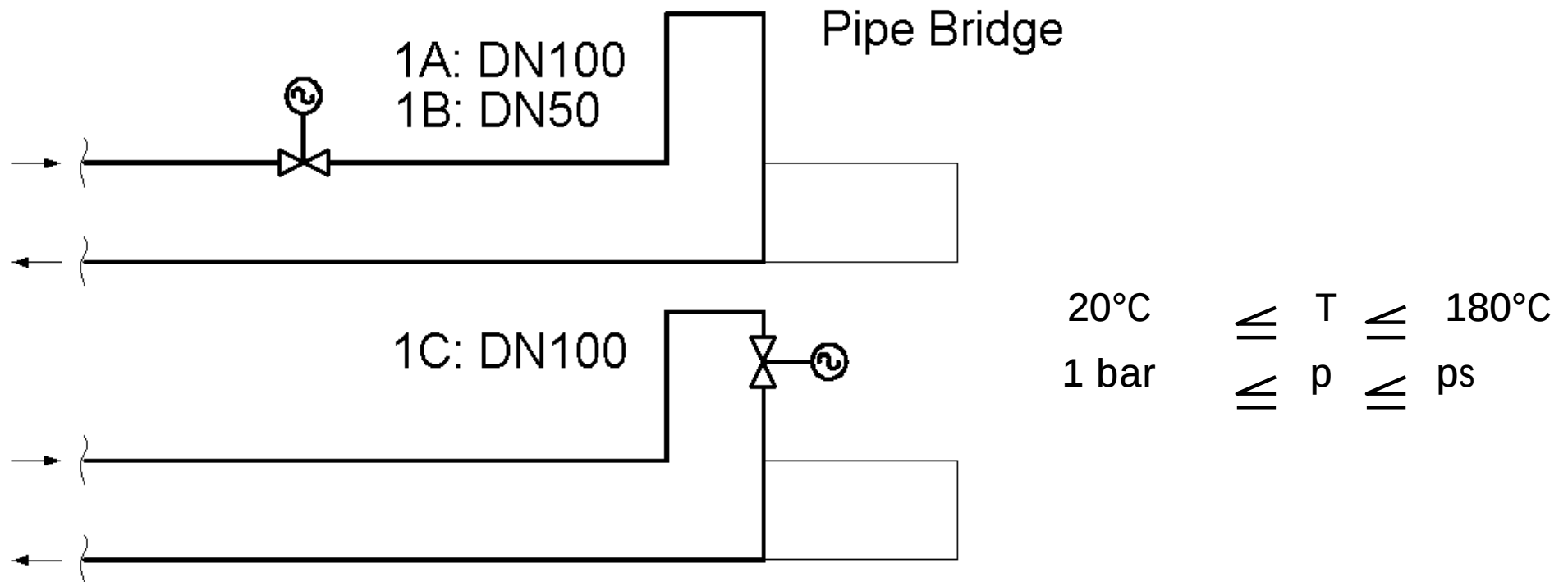
Experimental set-up and test scenario

- § Steady state liquid flow
- § Fast valve closure (pump keeps running)
- § Valve re-opening

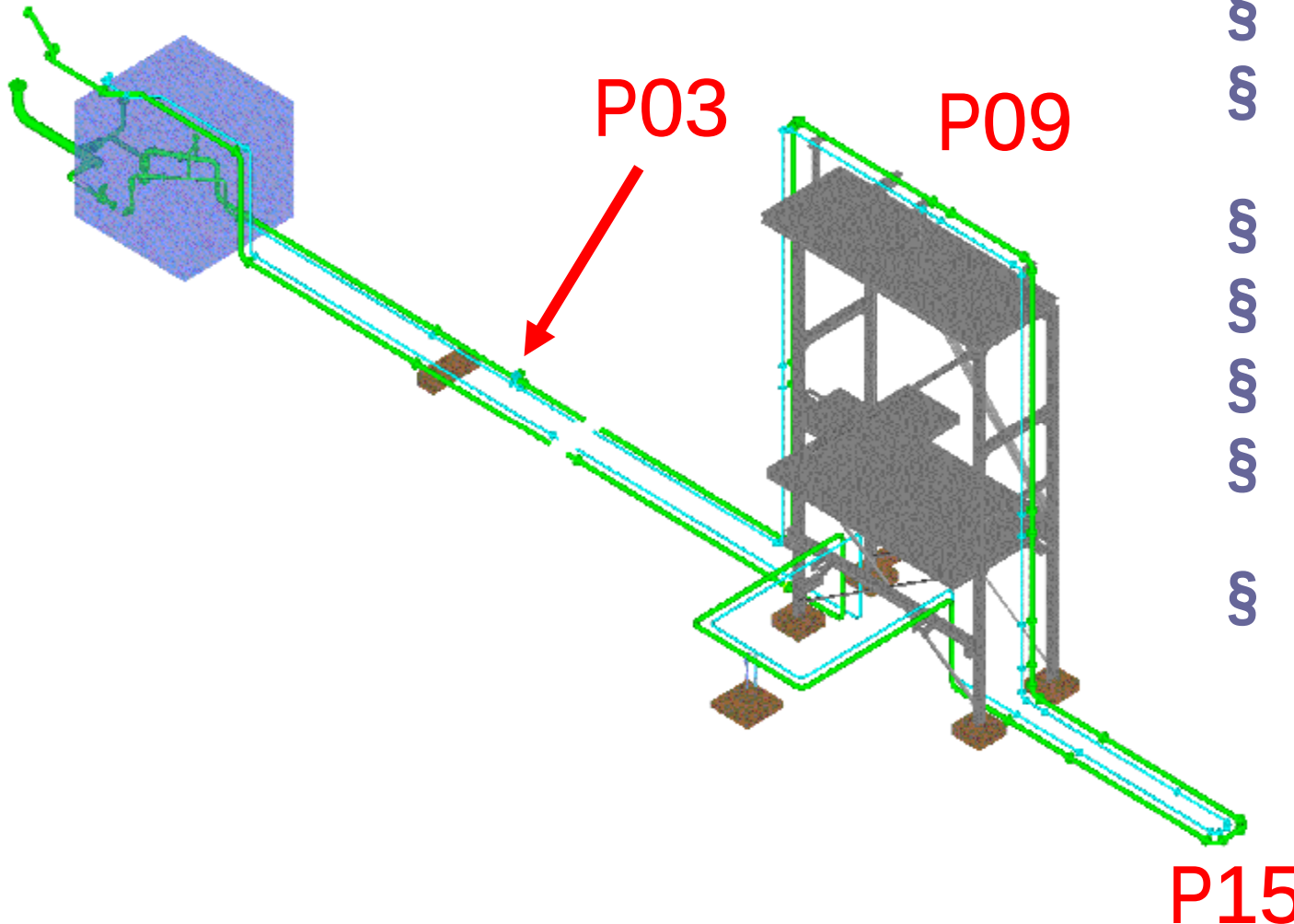


Test Scenarios

Scenario 1: Water Hammer and Cavitation at Increasing Temperature



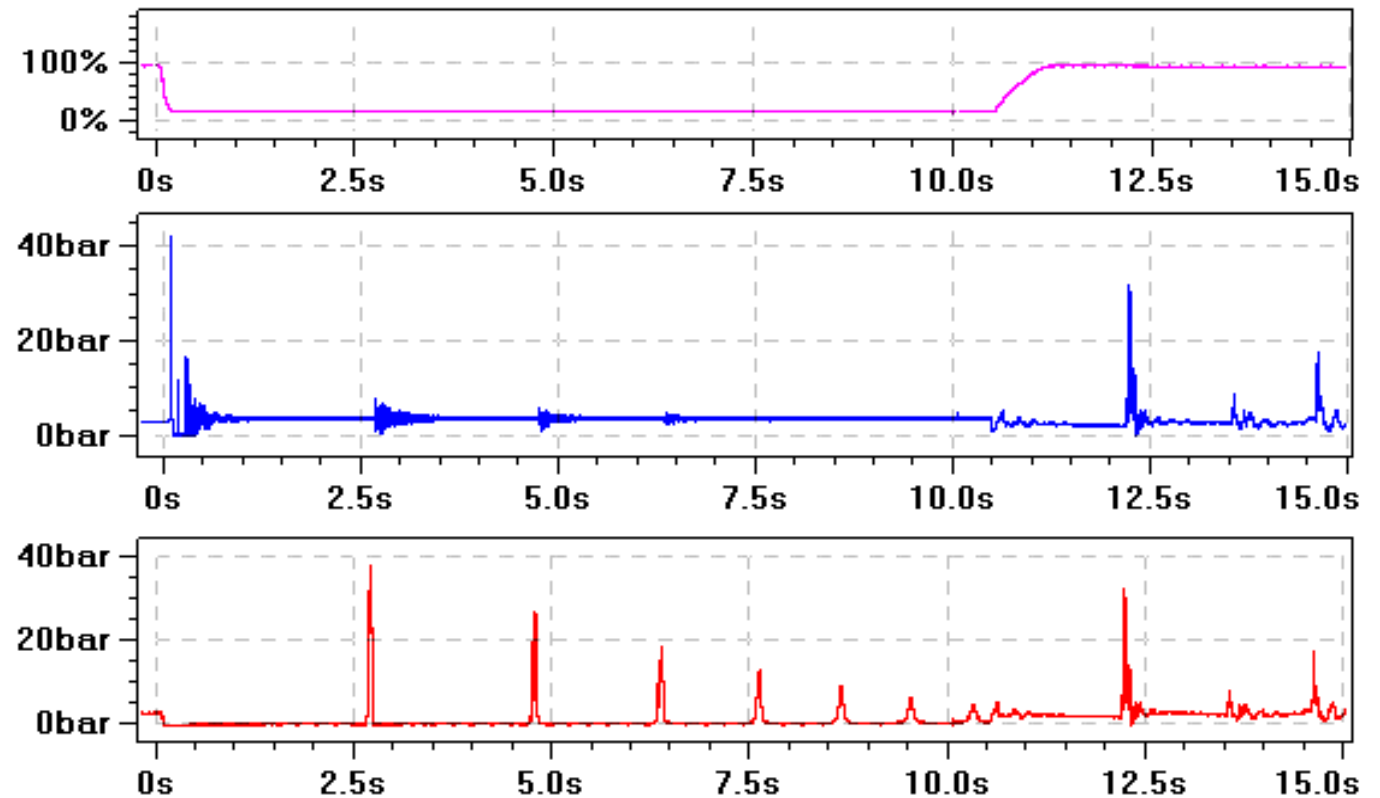
UMSICHT Experiments in the Pilot Plant Pipework (PPP)



- § DN 100 - pipe (~100 mm)
- § pipelength after the valve (at P03): 148 m
- § 10 m pipe bridge
- § water temperature: 6 °C
- § initial fluid velocity: 3-4 m/s
- § initial pressure profile: 2.5 to 1 bar
- § experiment starts with quick valve closure

Experimental Results I, L=230 m

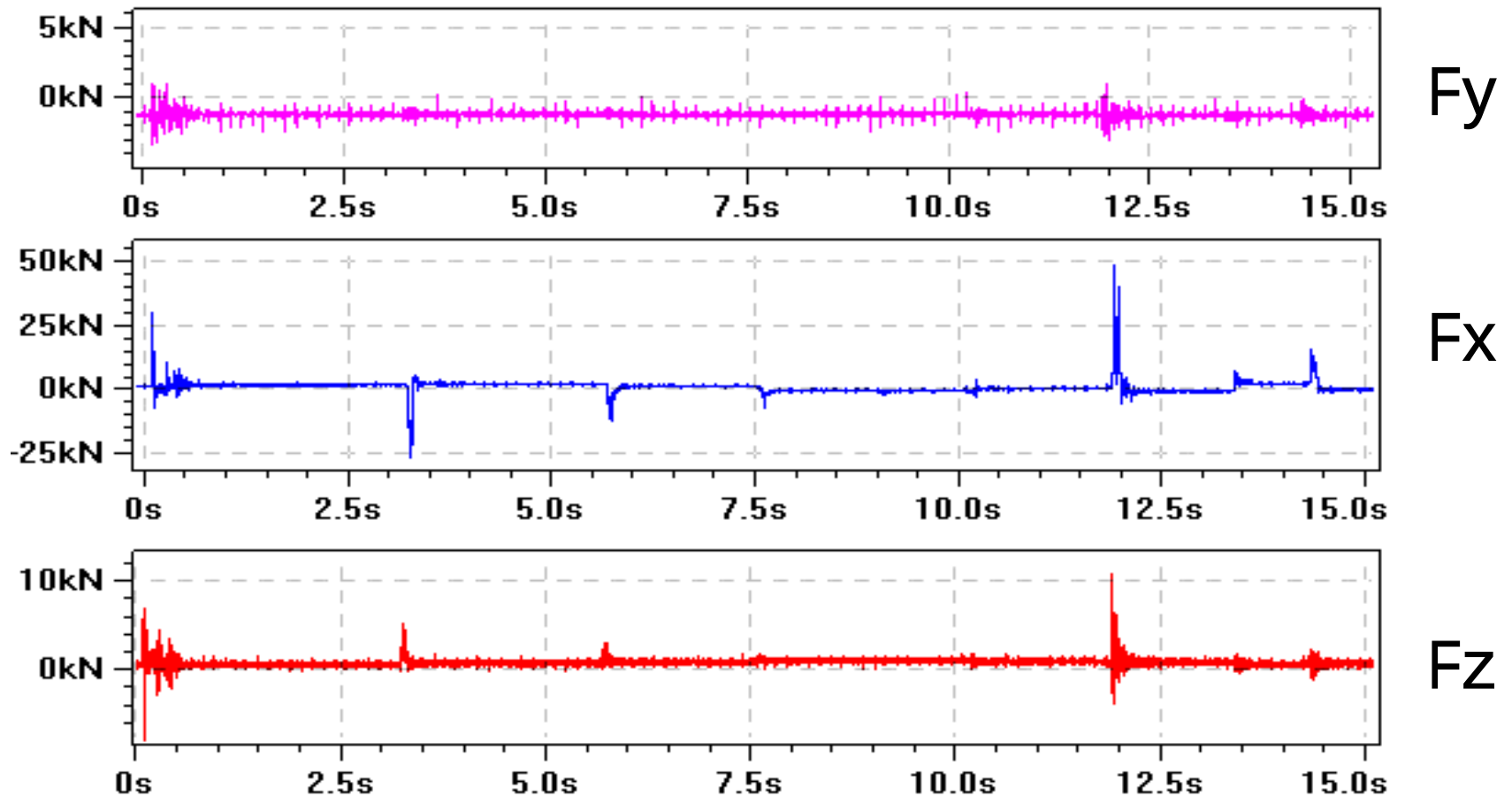
Pressure & valve position time-history upstream (P02) and downstream (P03) the fast closing butterfly valve. Steady state flow velocity: 3 m/s, with pipe bridge



Experimental results II, L=230m

Force time-history at the measuring places 1 (FP 1) due to fast closing and re-opening of eccentric butterfly valve.

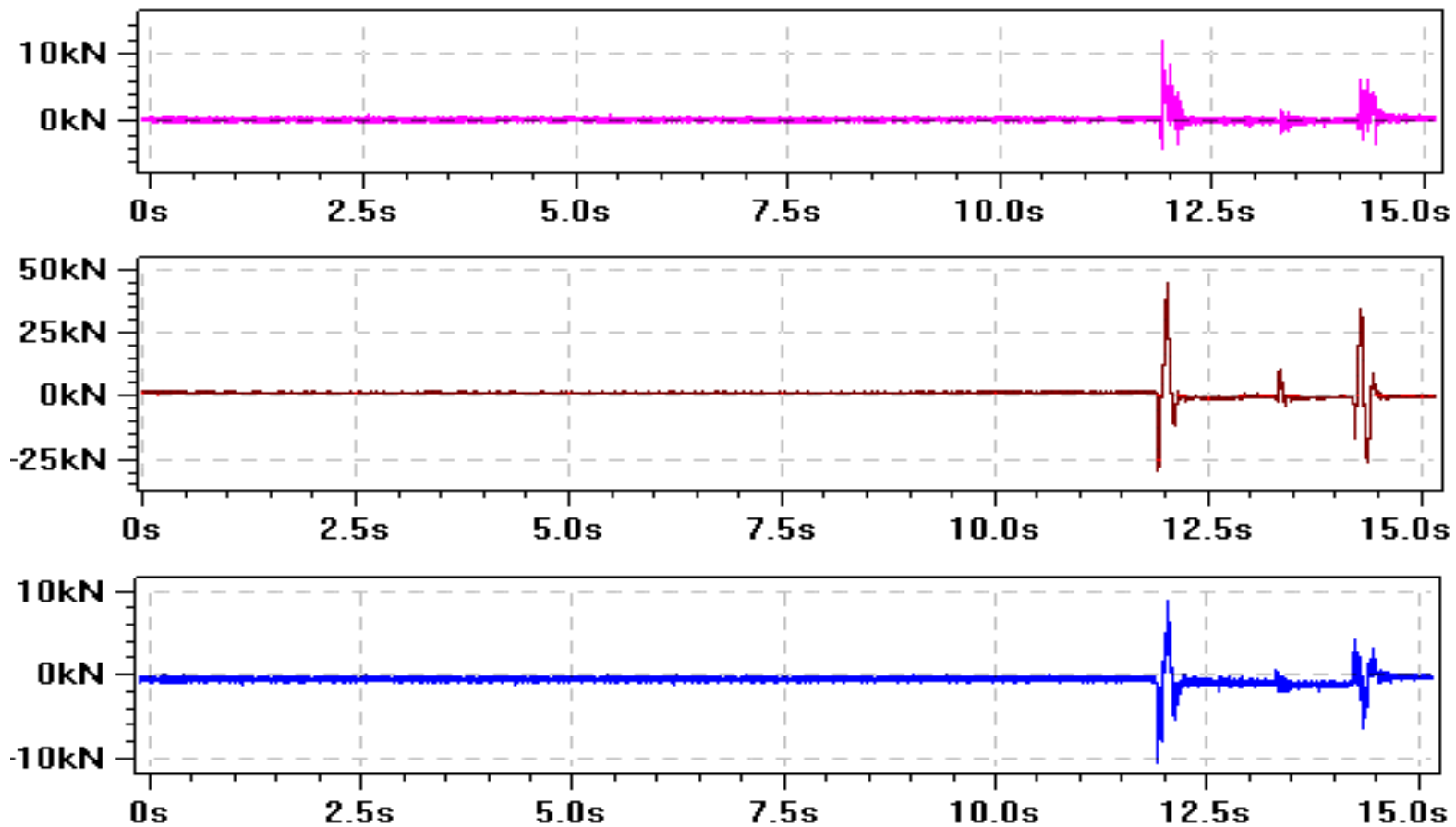
Initial velocity: 4 m/s.



Experimental results III, L=230m

Force time-history in the three spatial co-ordinates x, y, z at the measuring places 1 (FP 2) due to fast closing and re-opening of eccentric butterfly valve.

Initial velocity: 4 m/s.



F_z

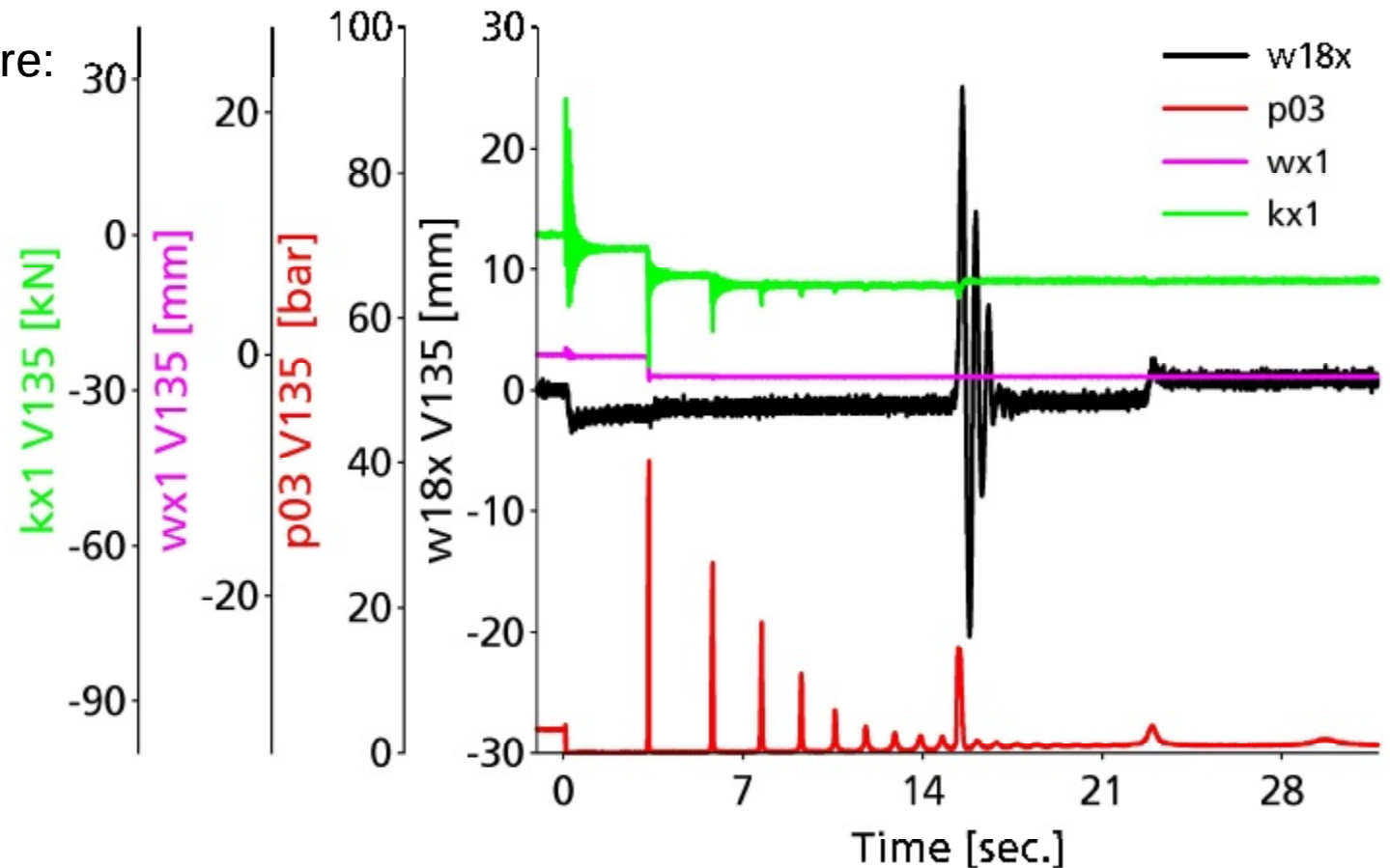
F_x

F_y

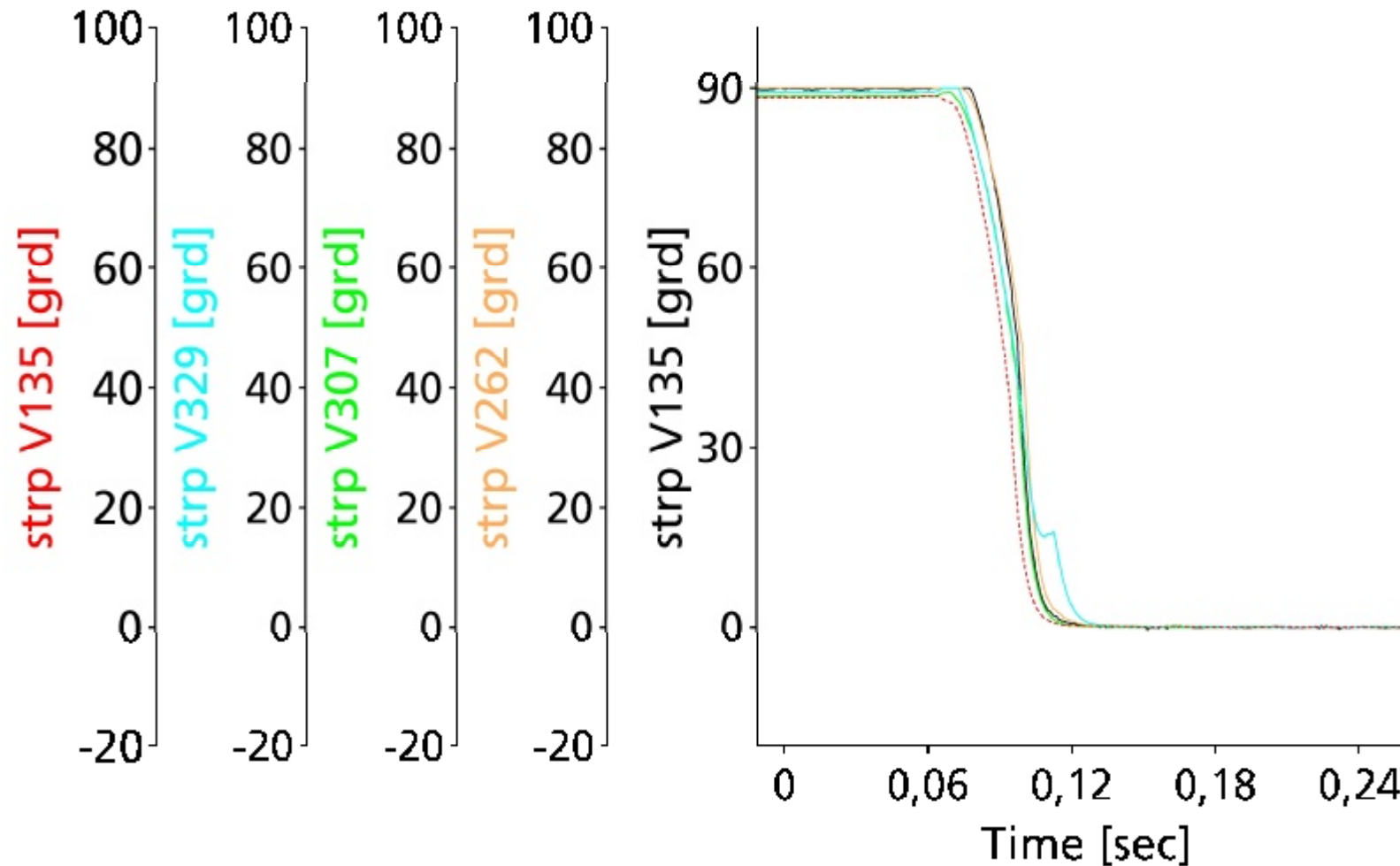
Experimental Results, L=146m

Experiment V135 -
interaction with structure:

Force and displacement
measurements
at different positions



Scenario 1 - Experimental Results, L=146m



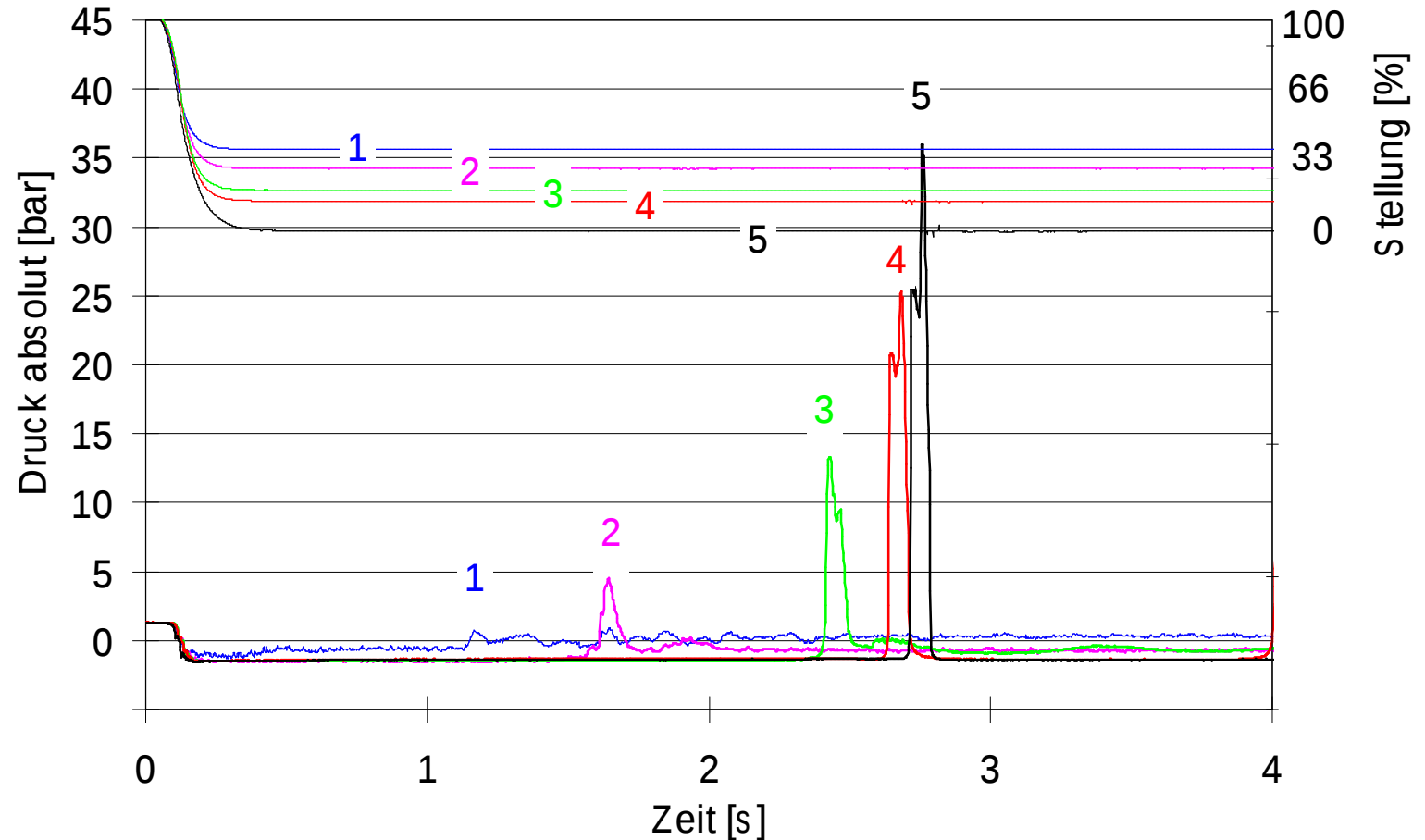
Stell- bzw. Regelvorgänge mit Armaturen, L=230m

Schnellschluss

Zeitlicher Verlauf von
Druck und Stellung an
Messstellen p03 und
p02

Exzentrische Klappe
 v_{L0} : 3,0 m/s
Einbau: Pos. 1
Mit Rohrbrücke

Einfluss der Stellung
auf die Höhe
der Druckstöße

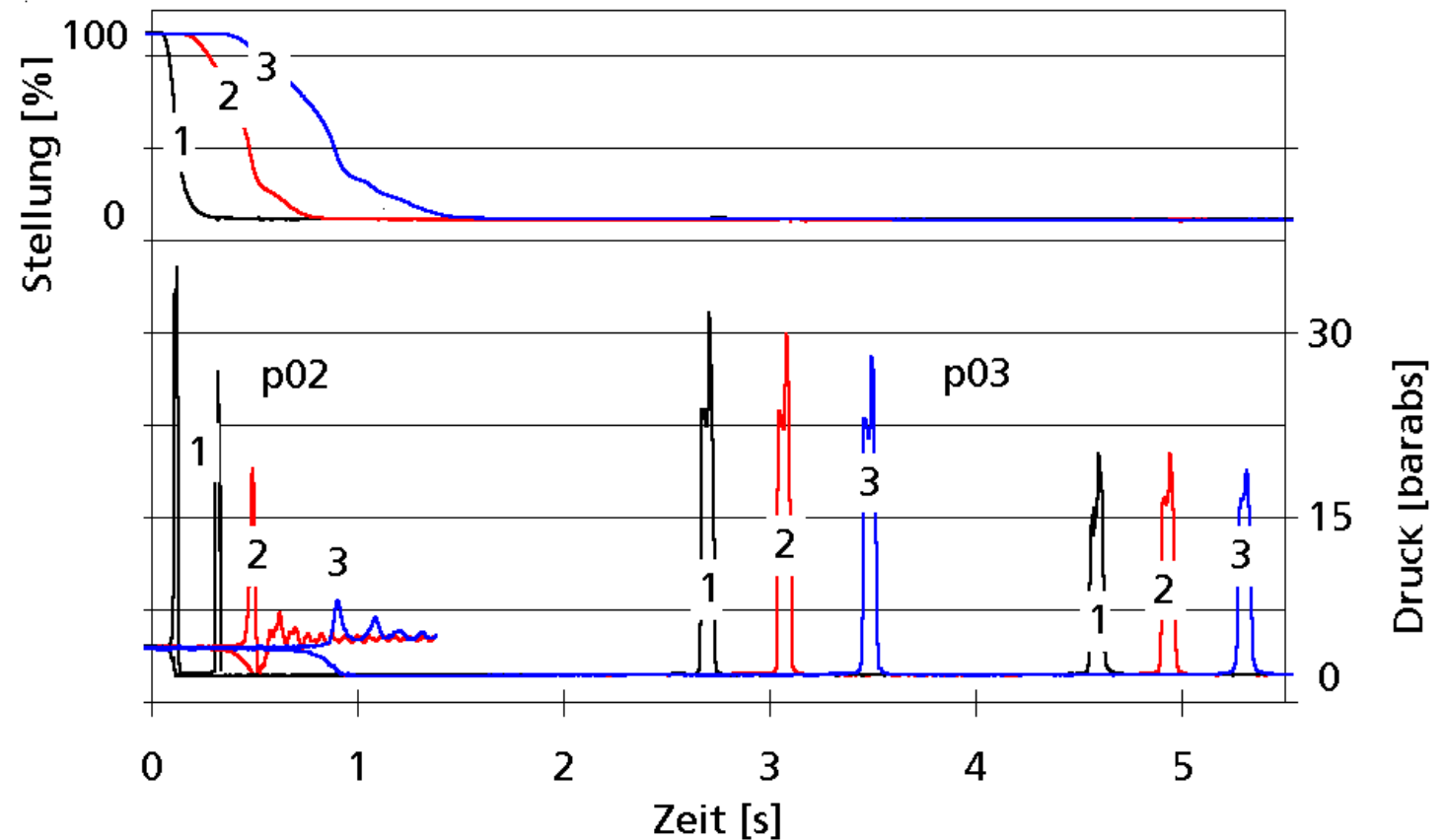


Schnellschluss, L=230m

Zeitlicher Verlauf von
Druck und Stellung an
Messstellen p03 und
p02

Exzentrische Klappe
 v_{L0} : 3,0 m/s
Einbau: Pos. 1
Mit Rohrbrücke

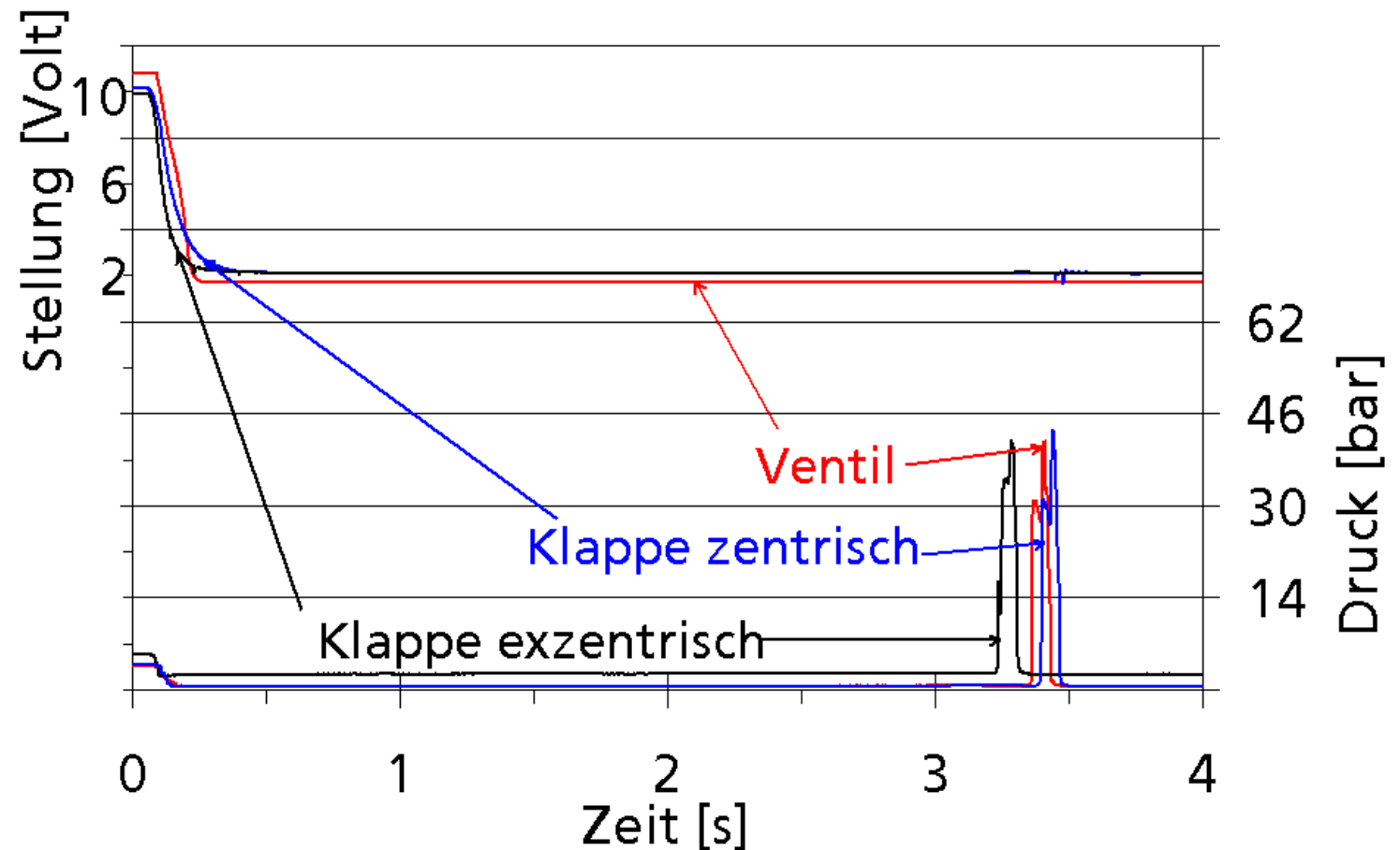
Einfluss der Schließzeit
auf die Höhe
der Druckstöße



Armaturen-Schnellschluss, L=230m

Zeitlicher Verläufe
Von Druck und
Stellung

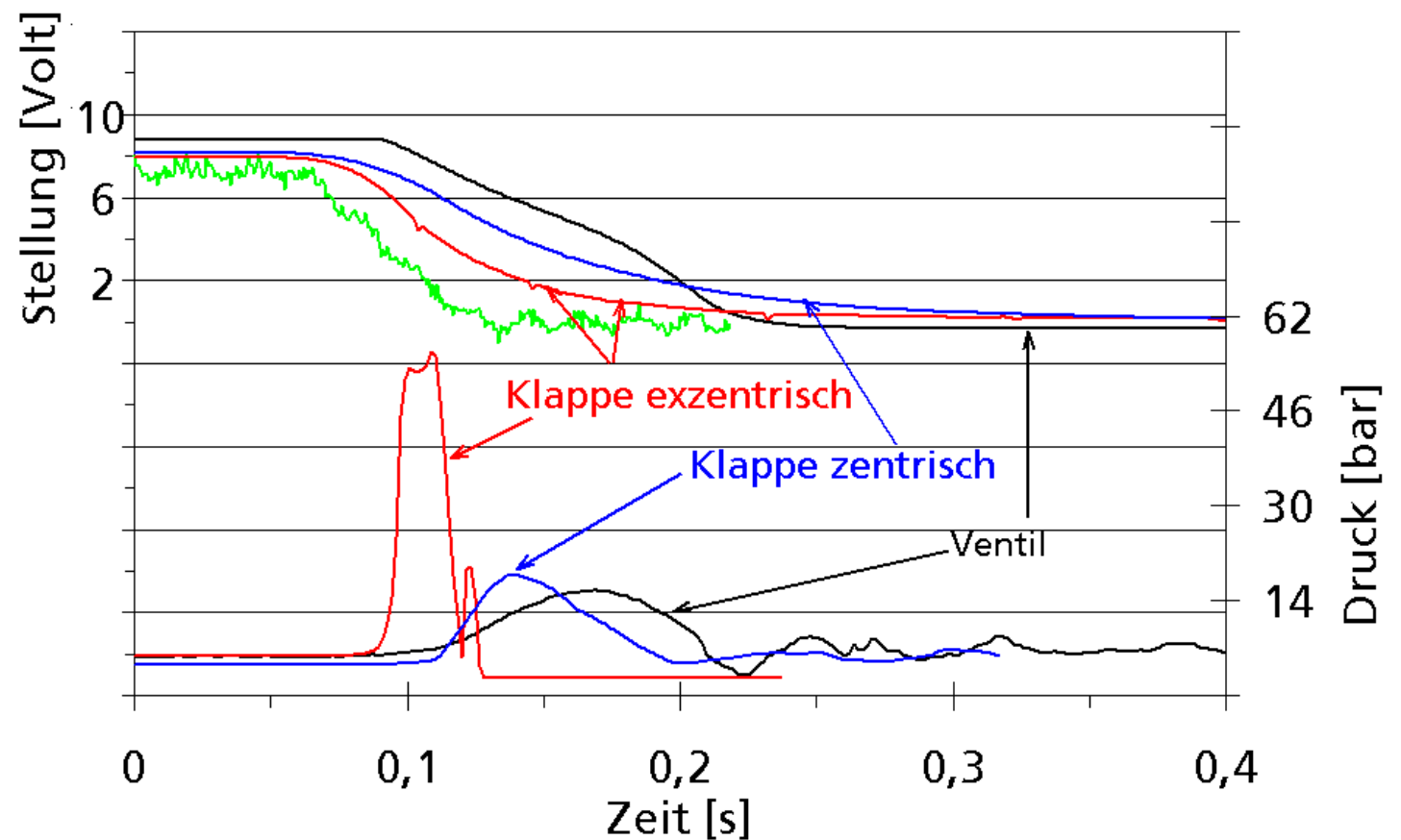
v_{L0} : 4,0 m/s
Einbau: Position 1



Armaturen-Schnellschluss, L=230m

Zeitlicher Verläufe
von Druck und
Stellung

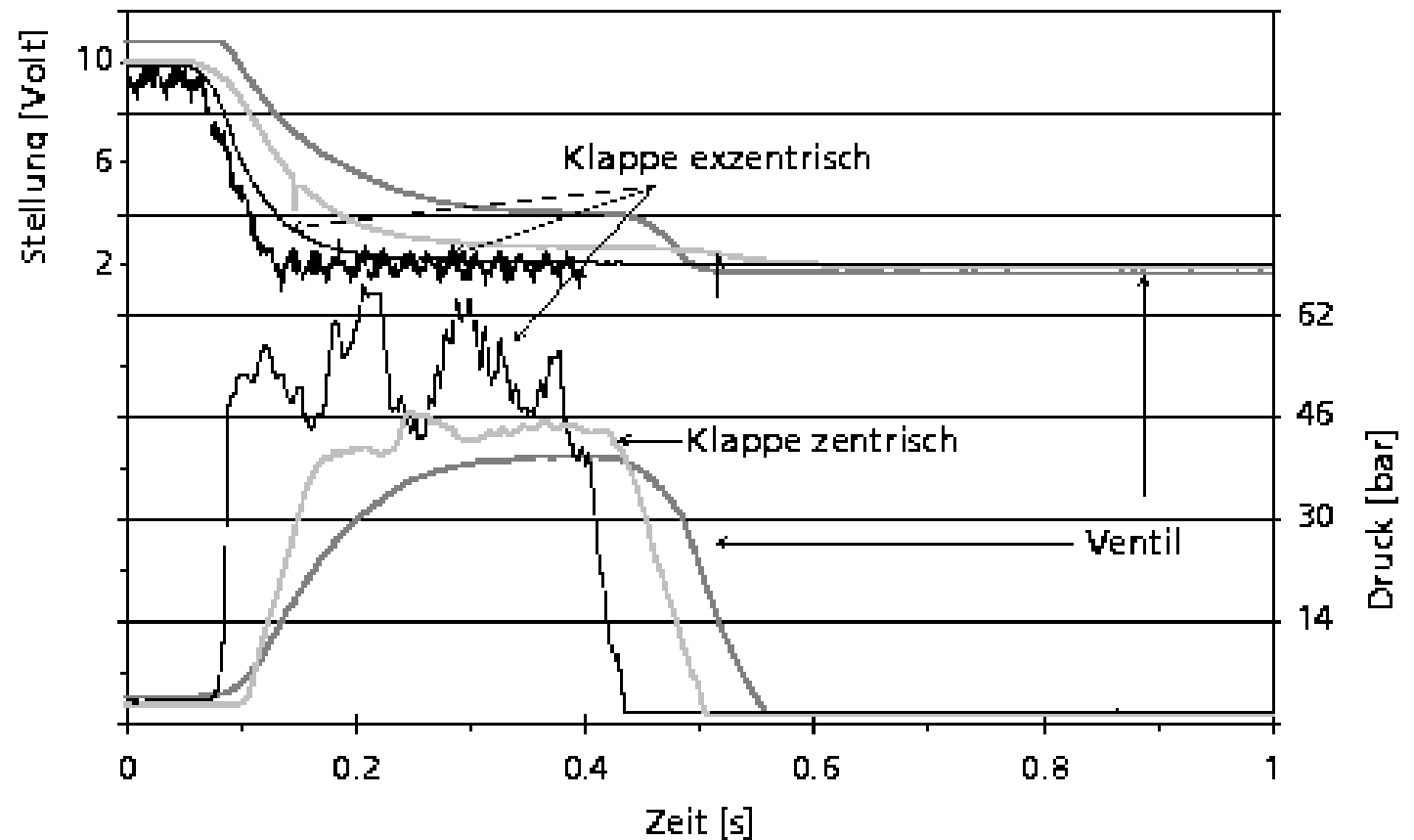
v_{L0} : 4,0 m/s
Einbau: Position 1



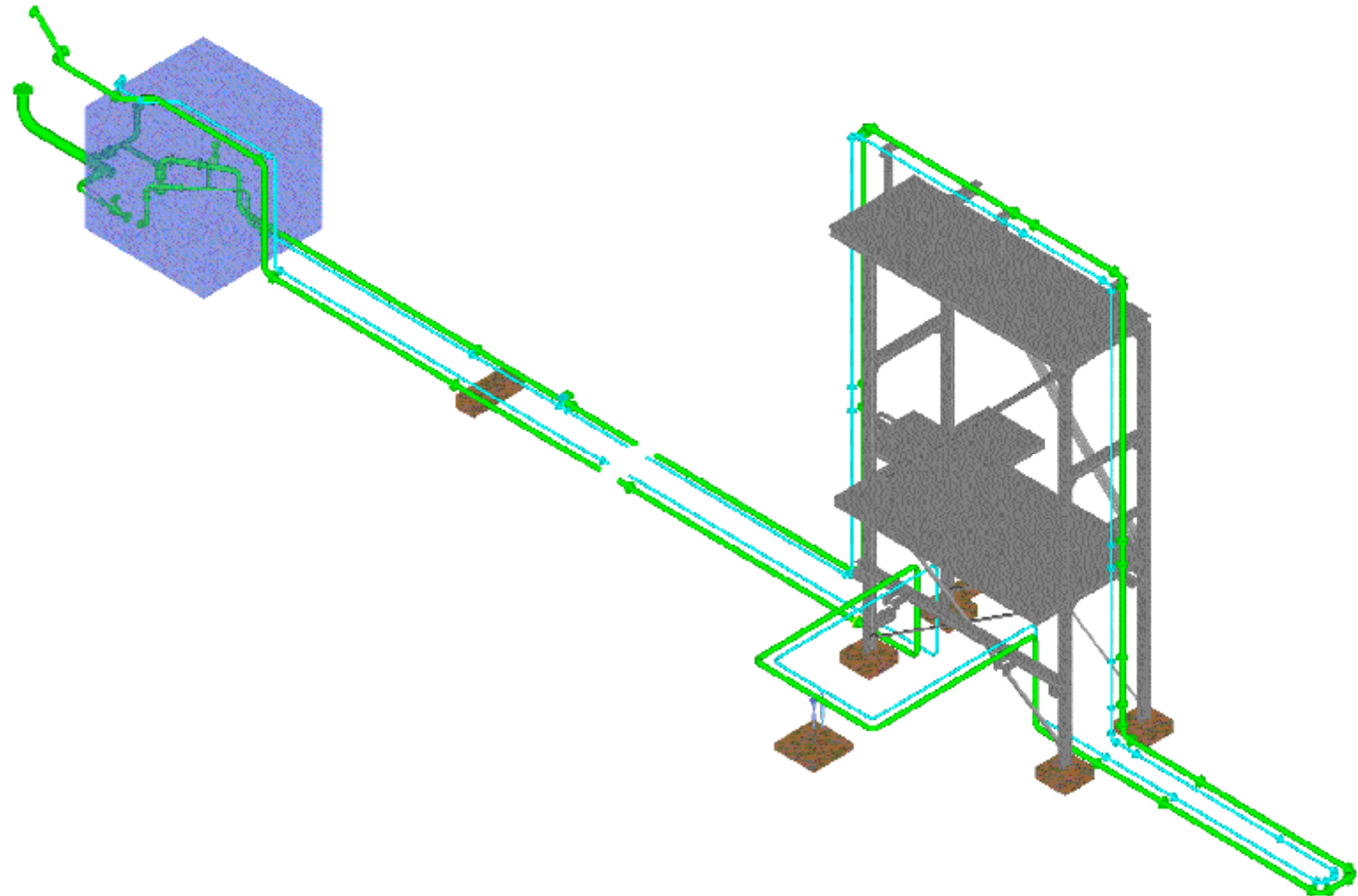
Armaturen-Schnellschluss, L=230m

Zeitlicher Verläufe
von Druck und
Stellung

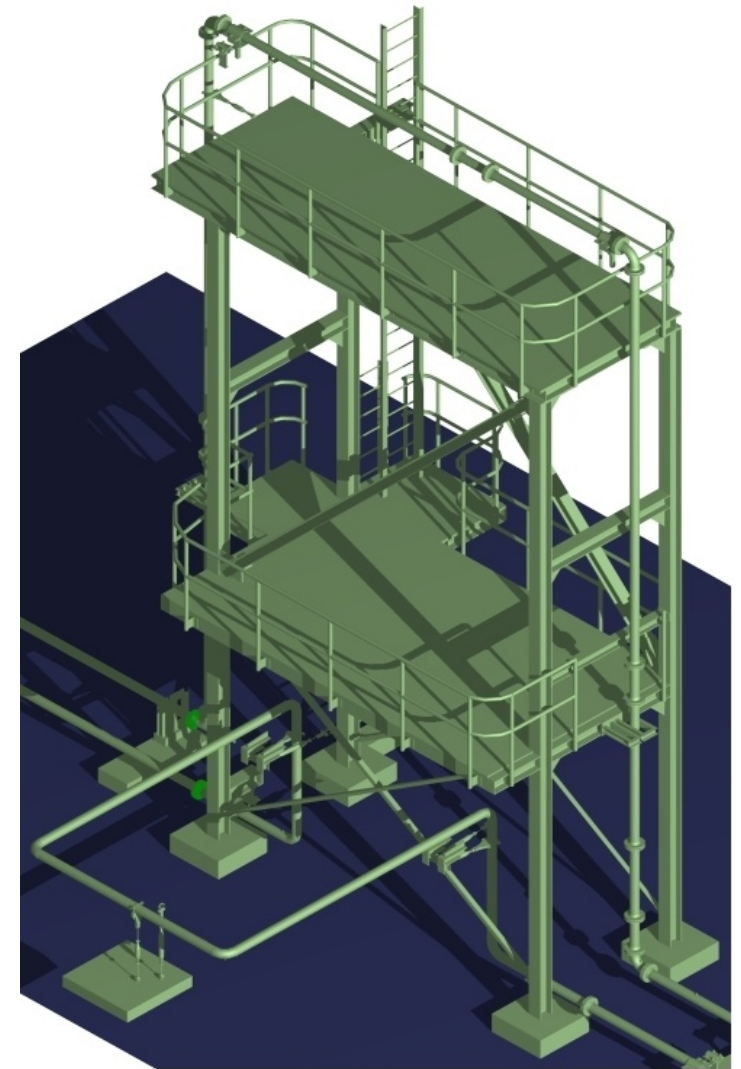
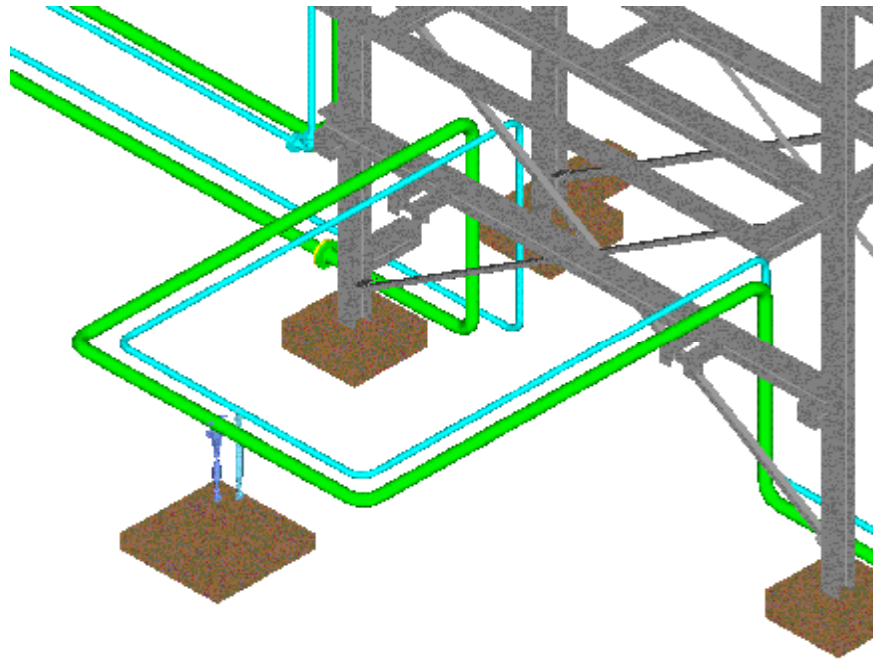
v_{L0} : 4,0 m/s
Einbau: Position 1



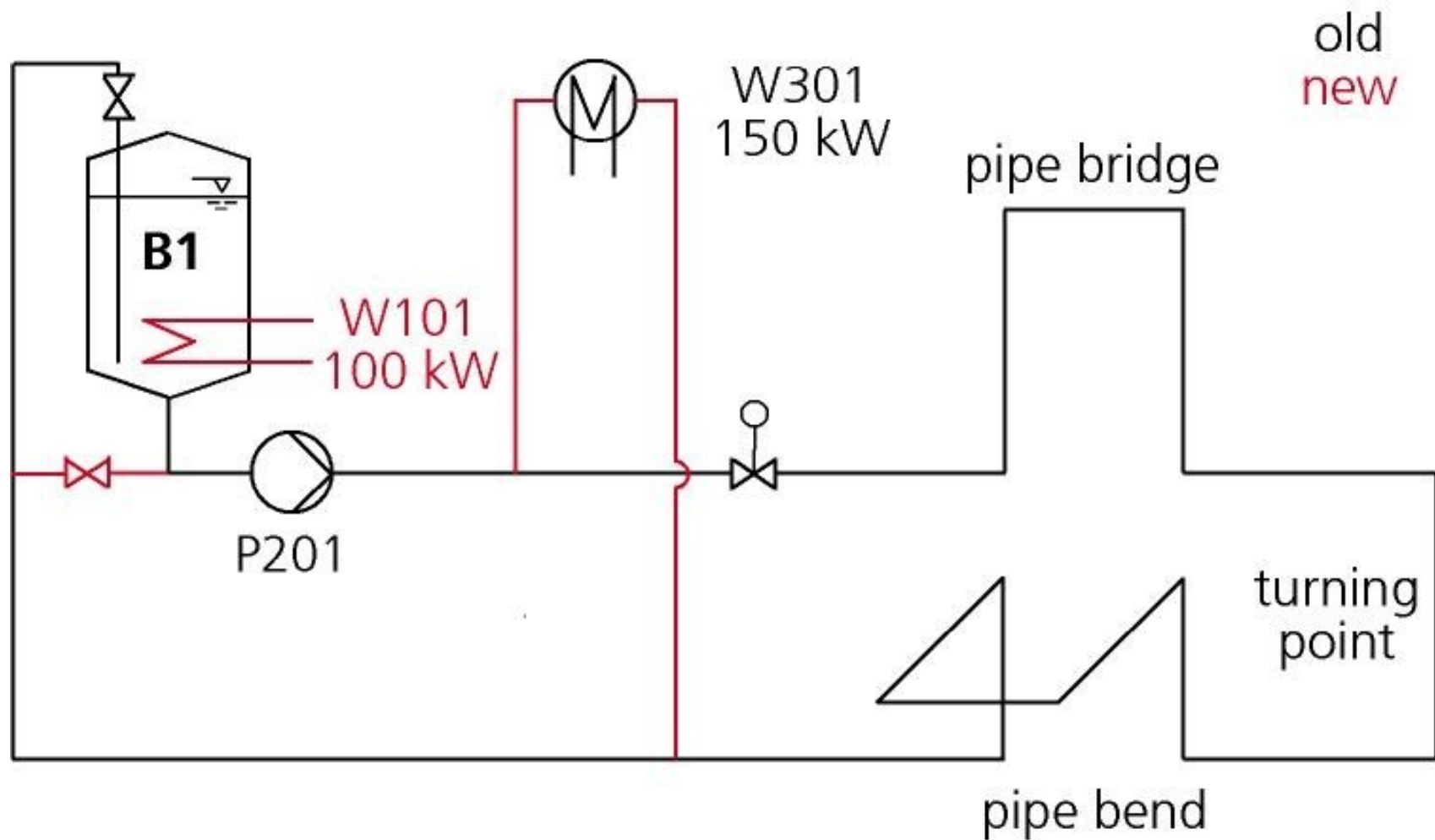
New Construction of Test Rig – Overview L = 146m



Test Facility PPP New Construction of Pipe Bridge

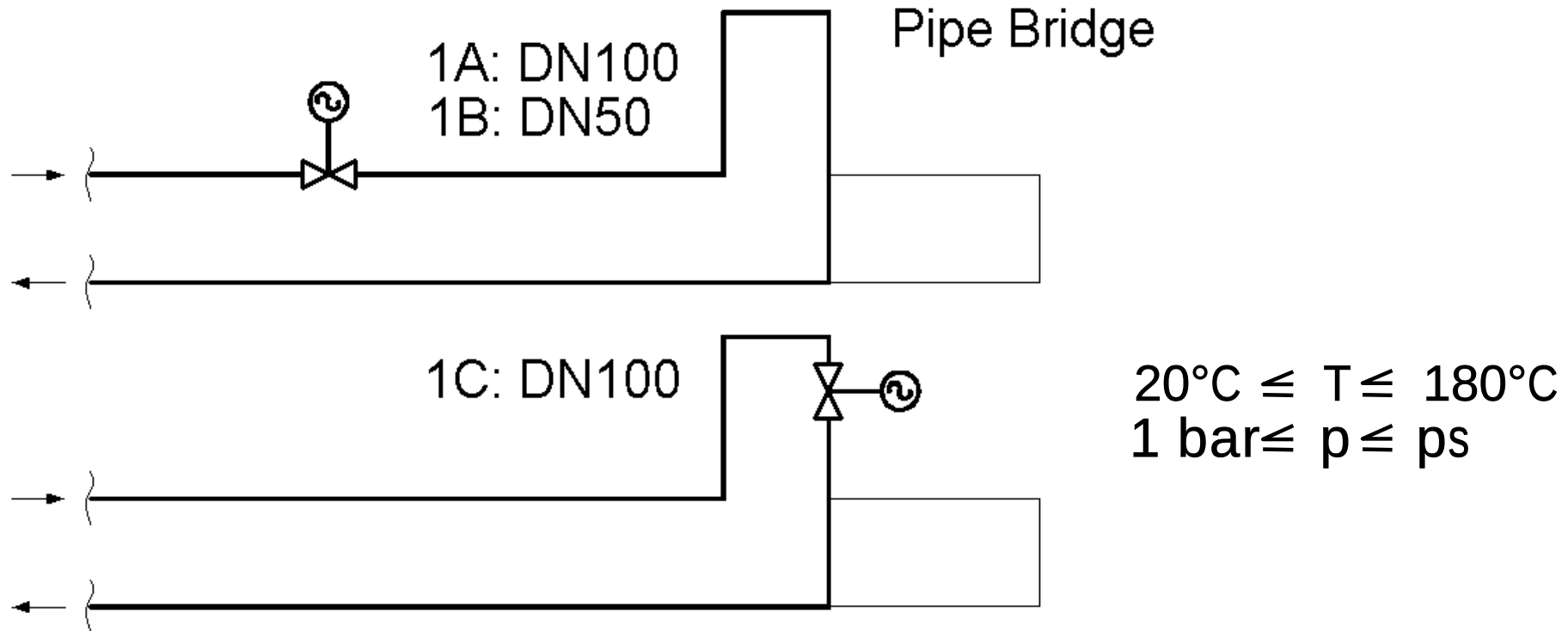


New De-Aeration System

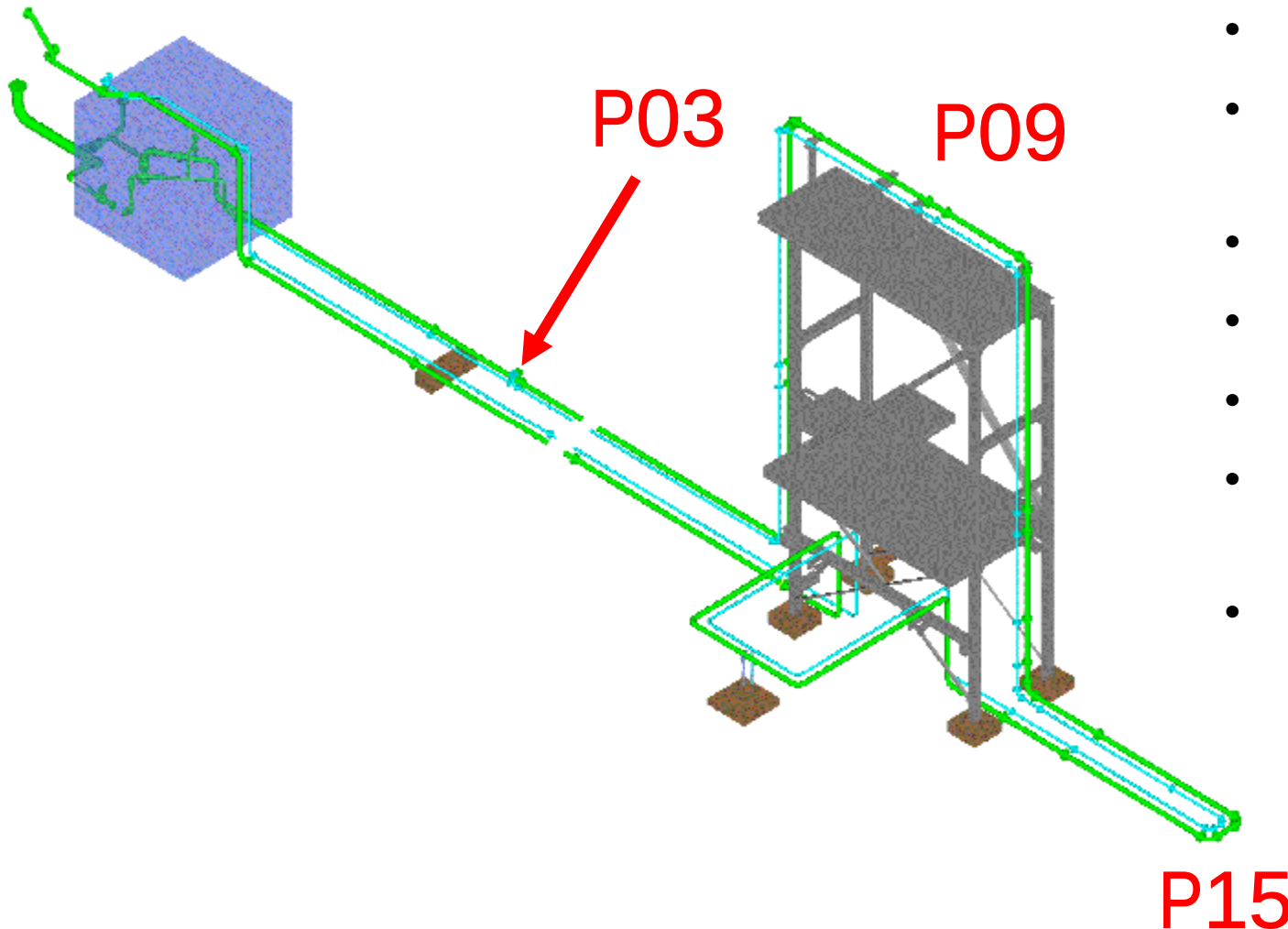


Test Scenarios

Scenario 1: Water Hammer and Cavitation at Increasing Temperature



UMSICHT Experiments in the Pilot Plant Pipework (PPP)



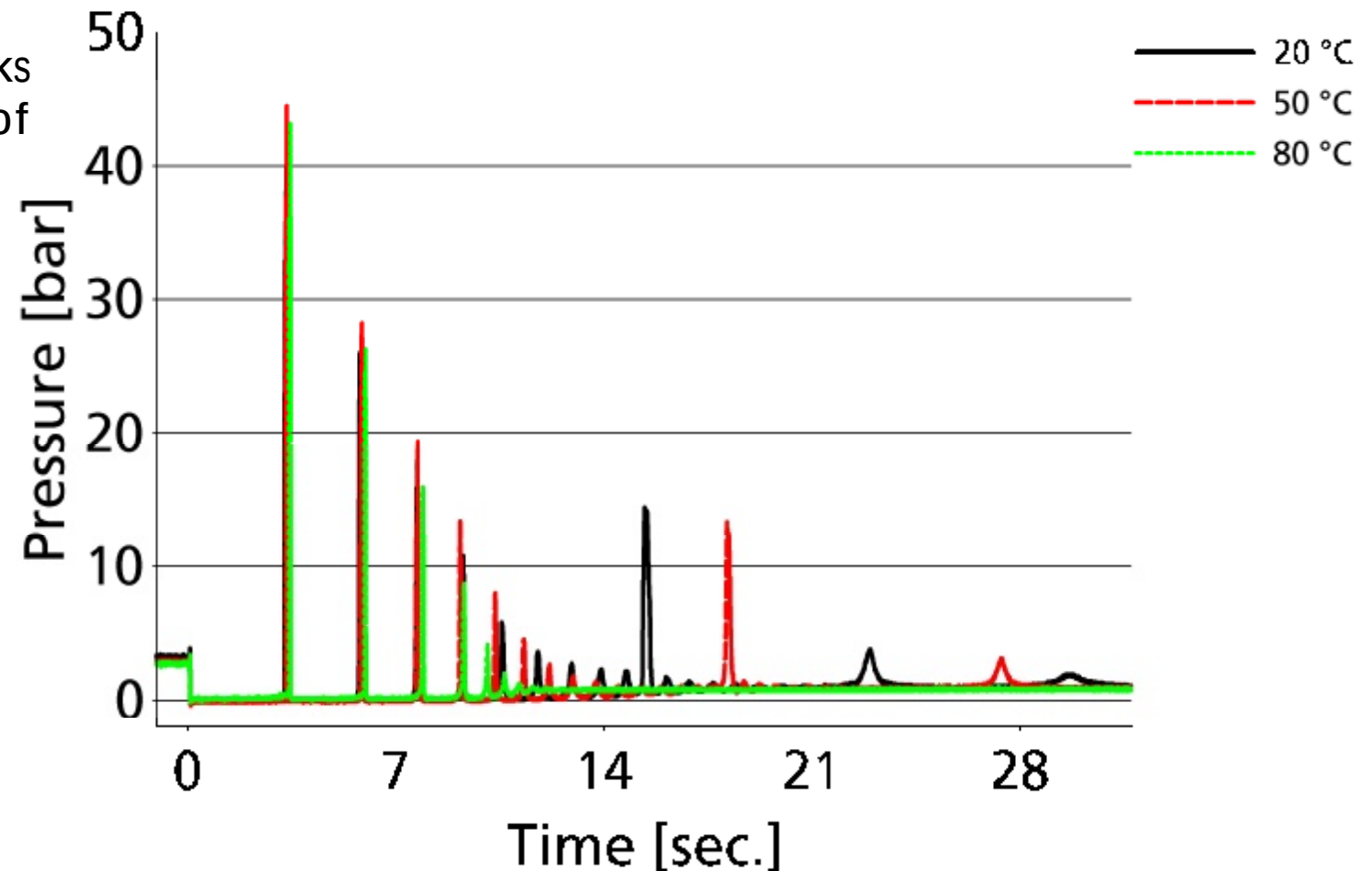
- DN 100 - pipe (~100 mm)
- pipelength after the valve (at P03): 148 m
- 10 m pipe bridge
- water temperature: 6 °C
- initial fluid velocity: 3-4 m/s
- initial pressure profile: 2.5 to 1 bar
- experiment starts with quick valve closure

Experimental Results, L=146m

The total pressure peaks at p03 in dependency of the temperature

■ V135 - 20°C
■ V199 - 50°C
■ V261 - 80°C

$v_0 = 4 \text{ m/sec}$

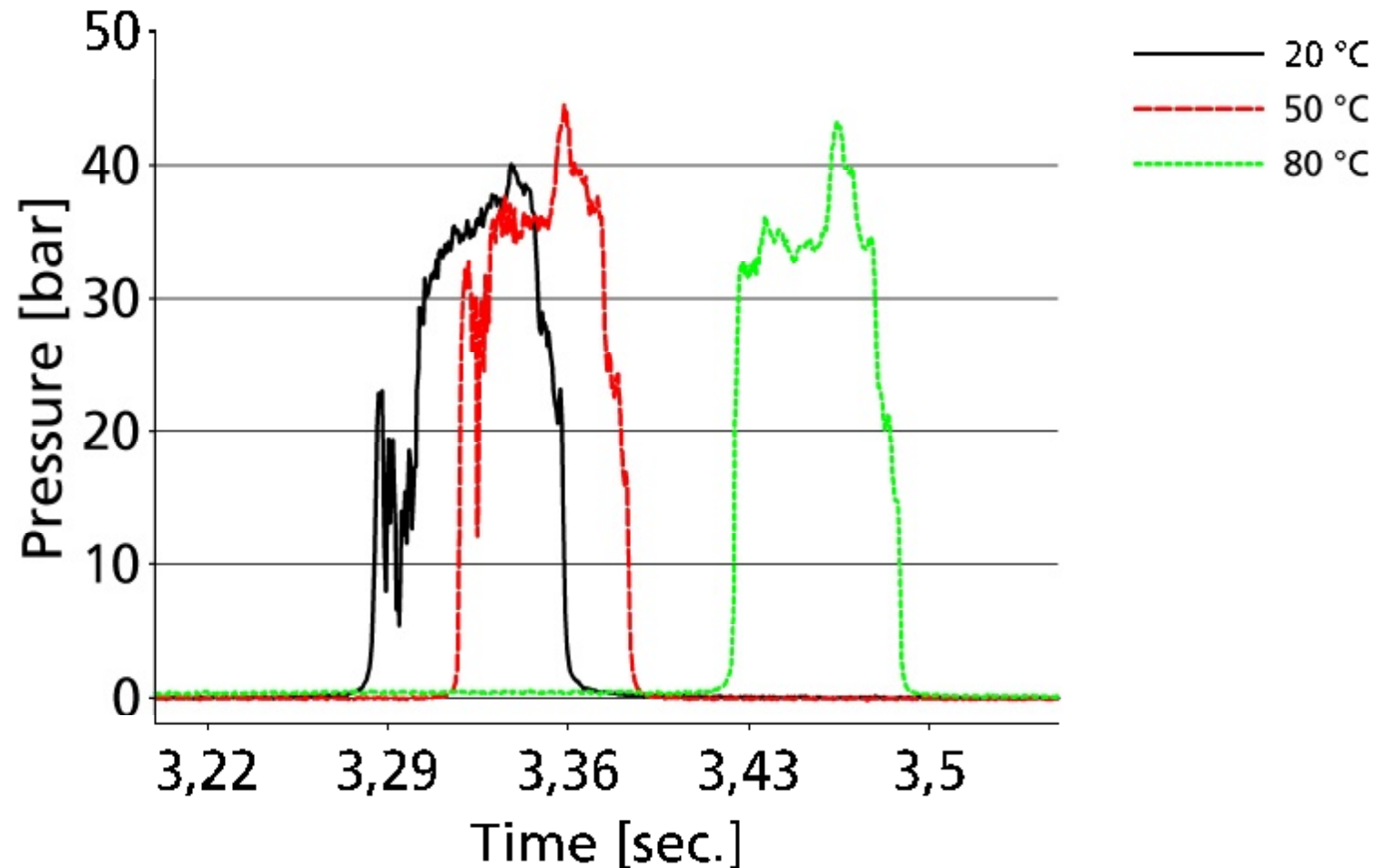


Experimental Results, L=146m

The first pressure peak at p03 in dependency of temperature

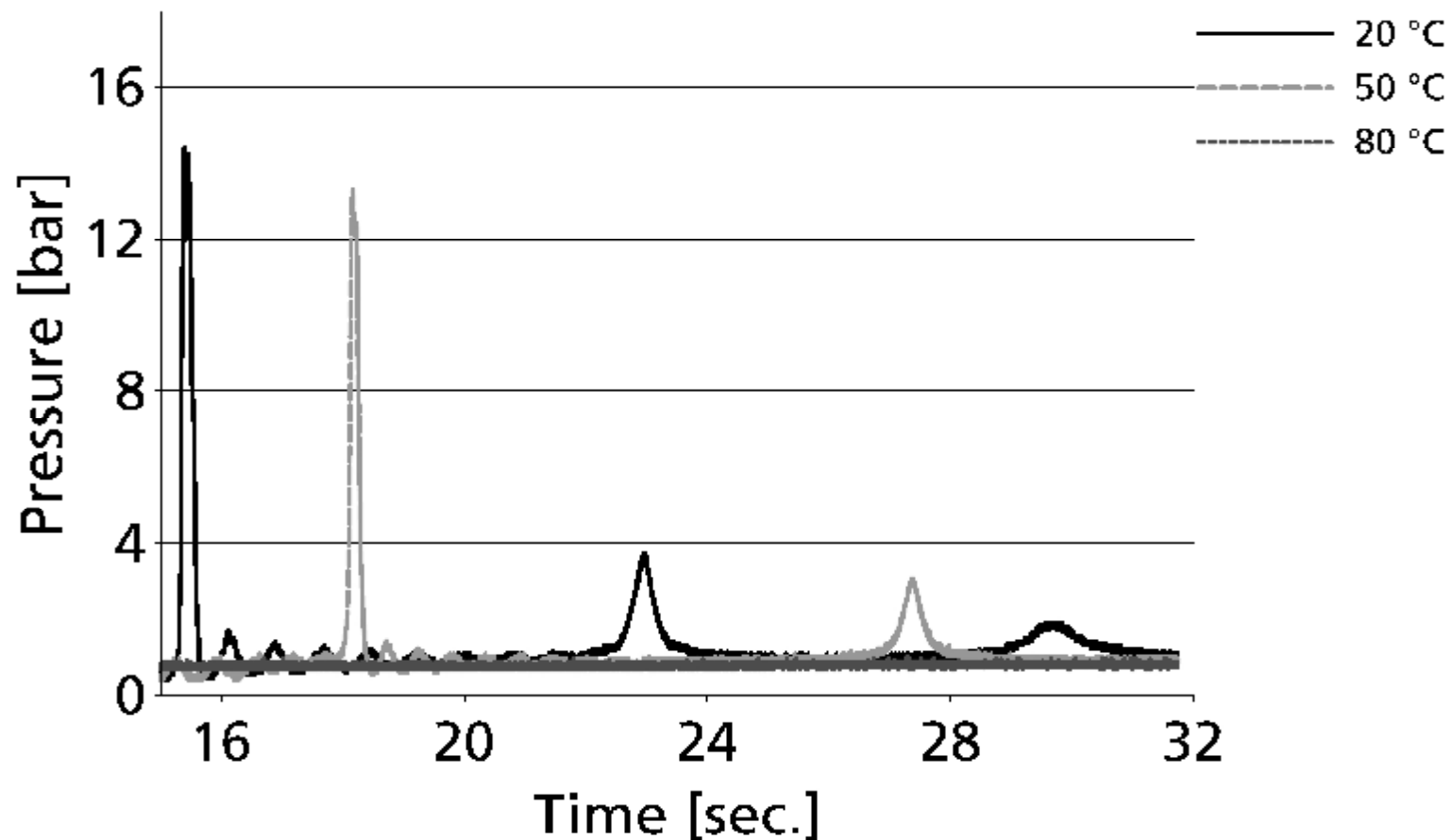
- V135 - 20°C
- V199 - 50°C
- V261 - 80°C

$v_0 = 4 \text{ m/sec}$



Experimental results, L=146m

Cavitation hammer in dependency of temperature due to collapse of the vapour bubble at P09 (pipe bridge)

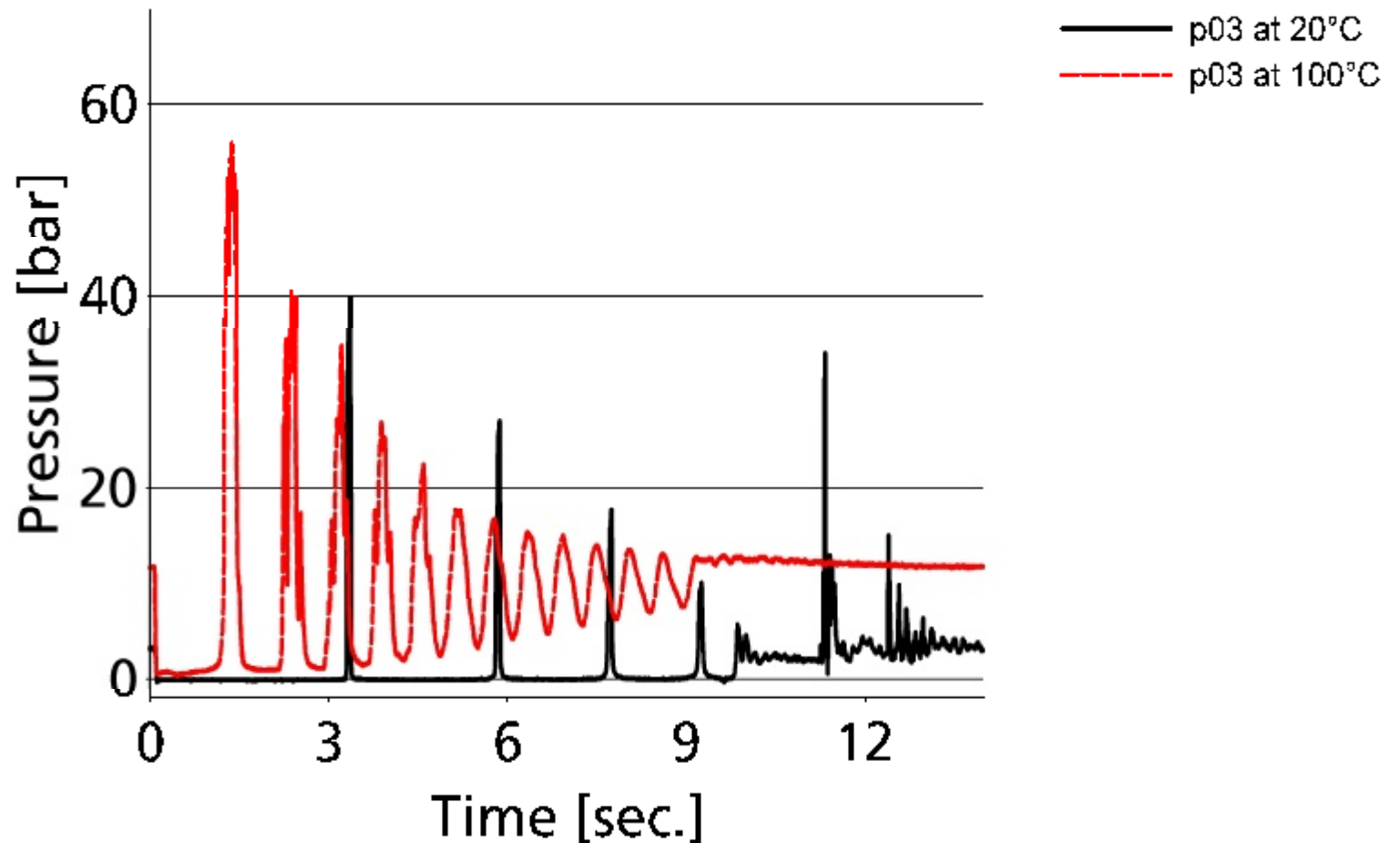


Experimental Results, L=146m

Comparison of pressure p03 at different temp. 20°C and 100°C



■ V277 – 100°C
■ V137 – 20°C

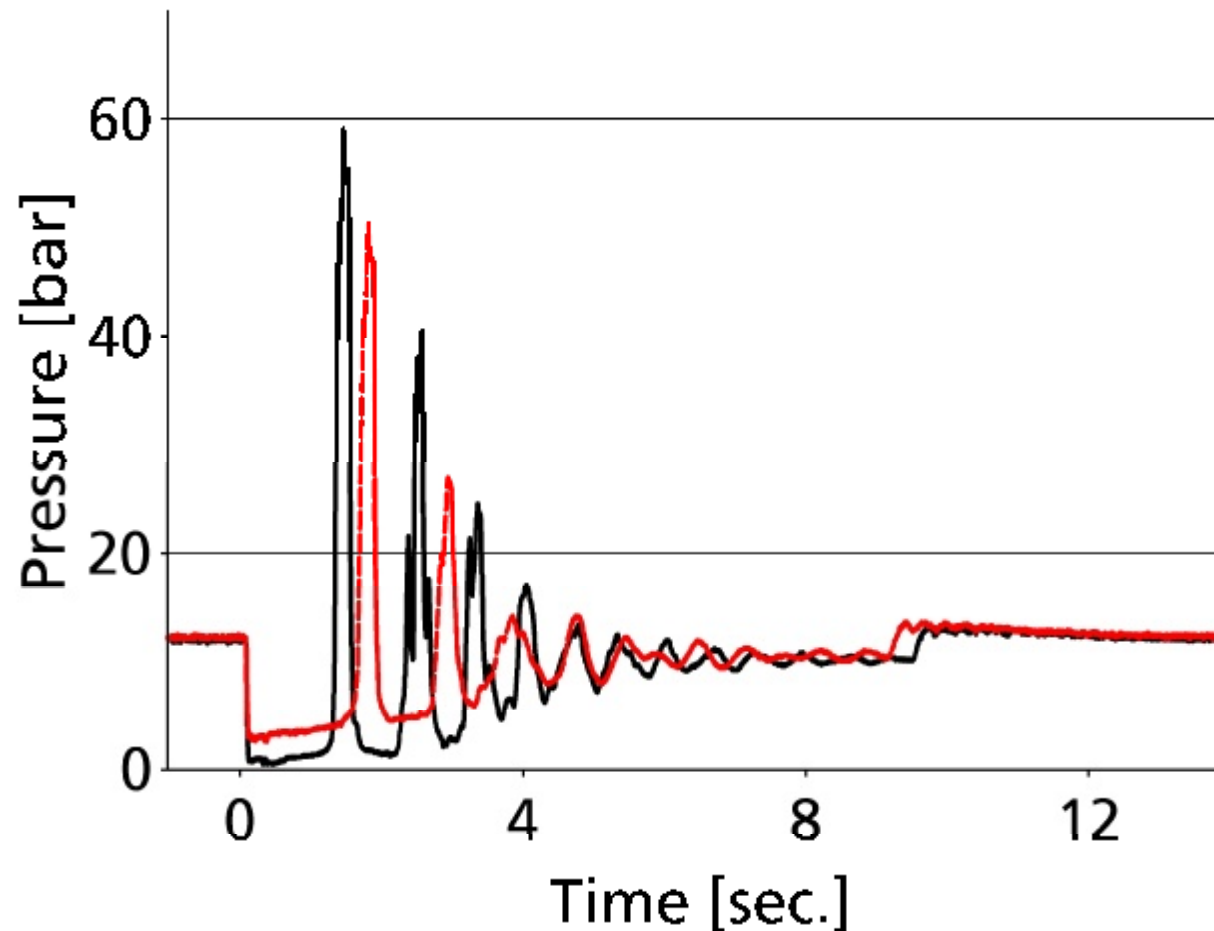


Pressure time history of P03 at different temperatures and different initial pressures - 20 °C; 1bar (Test 00137) and 100 °C; 10 bar (Test 00277)

Experimental Results, L=146m

The total pressure peaks at p02, p03, different temperatures and flow velocity of 5 m/s

■ 120 °C
■ 150 °C



Pressure time history at P03; initial velocity: 4 m/s, vessel pressure: 10 bar

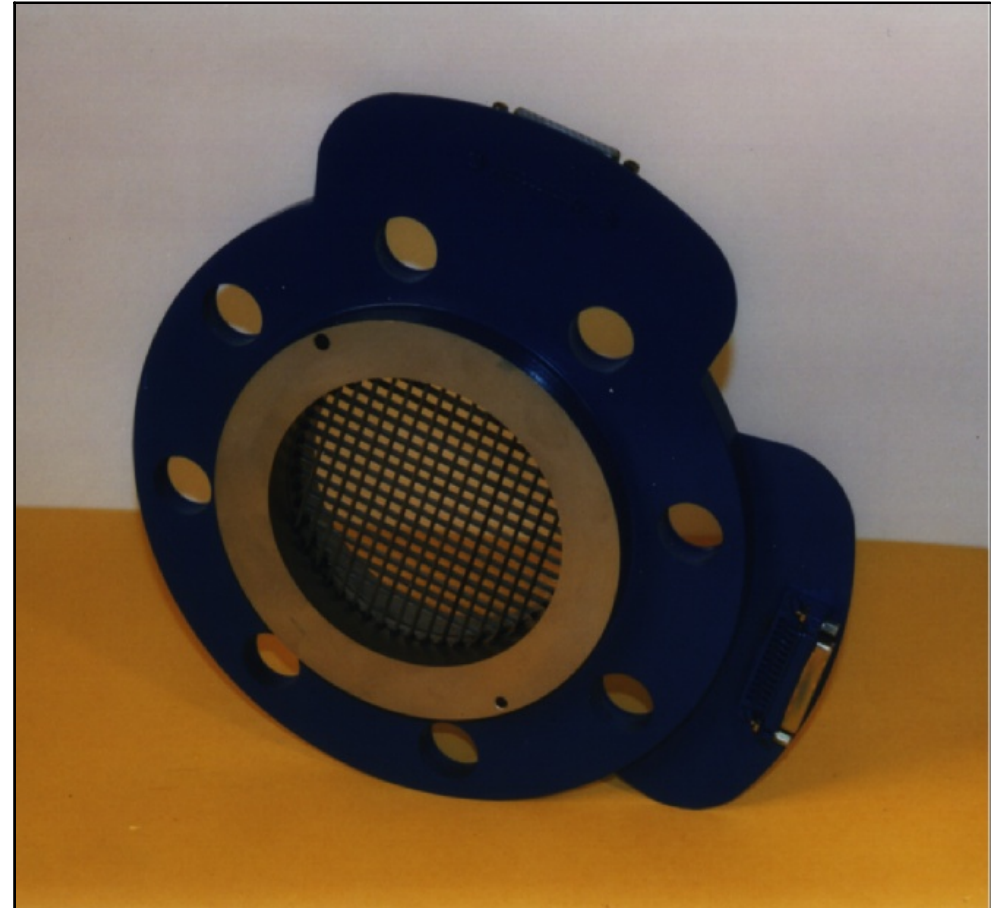
Current Projects

Steam and Liquid Content

Wire Mesh Conductivity Sensor
(FZR)

Resolution (time) 10 kHz

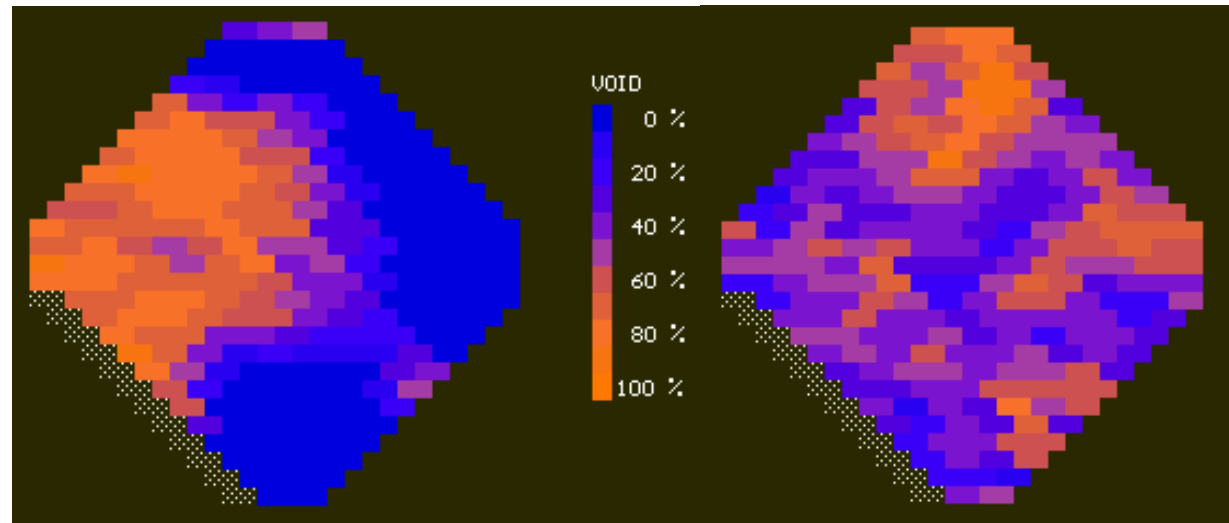
Resolution (space) 256 points



Visualisation with WireMesh Sensor, L=230m

at P03 eccentric
butterfly valve
Pipe DN100

cross-sectional view

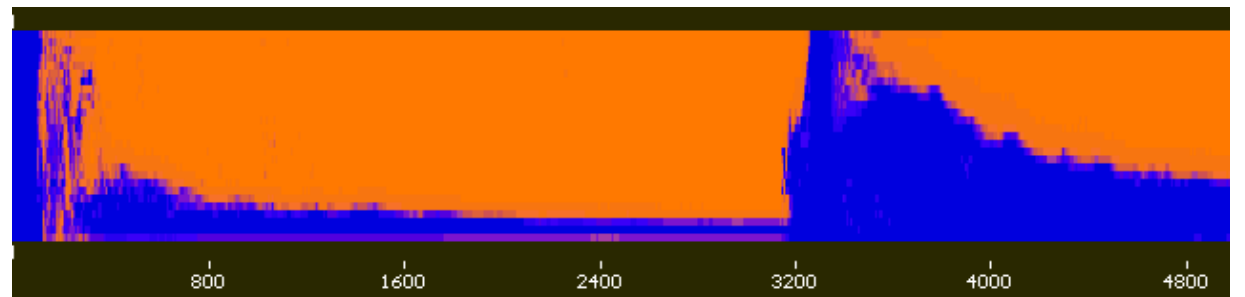


t = 105 ms

t = 150 ms

Steady state liquid
velocity: $v = 4,0$ m/s

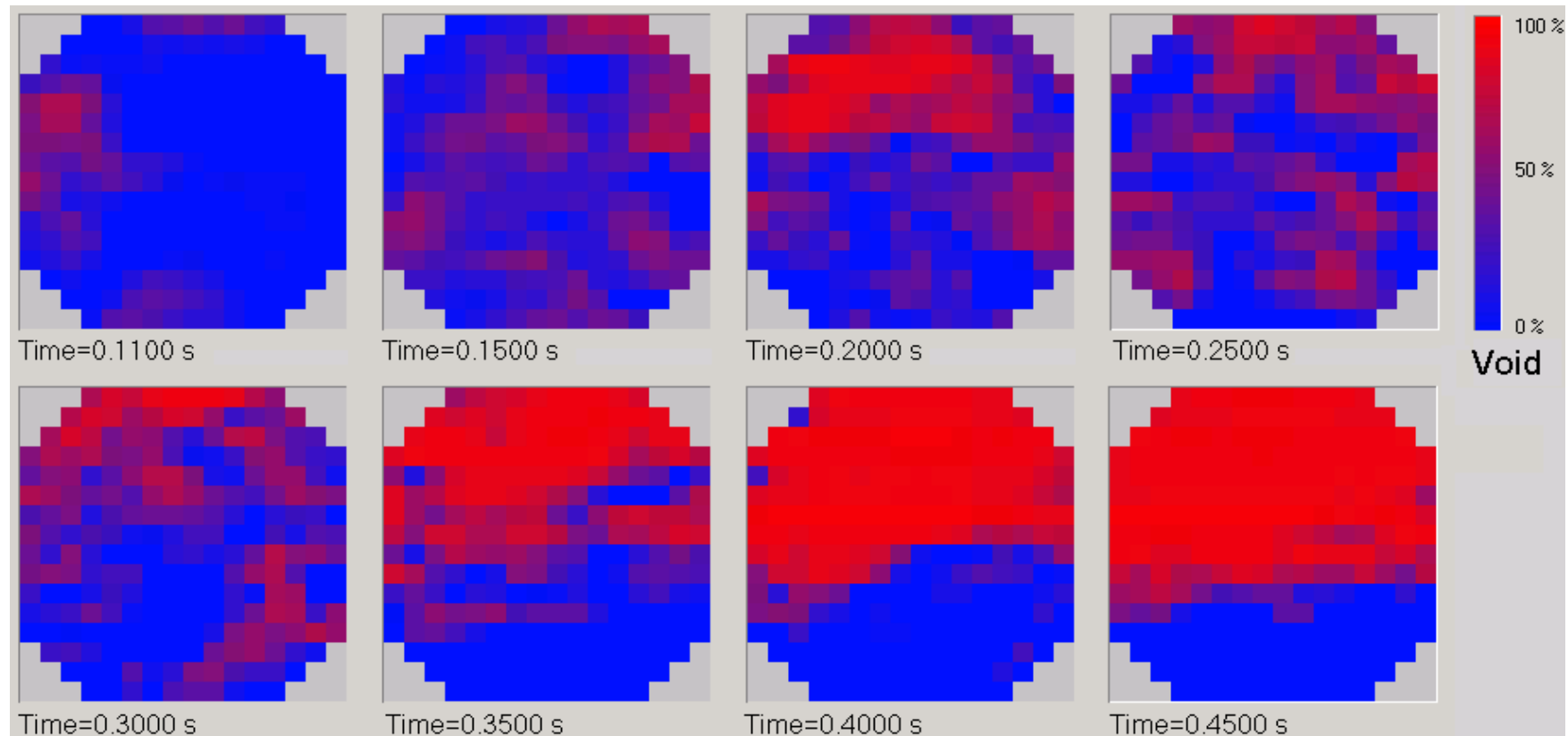
pseudo side view



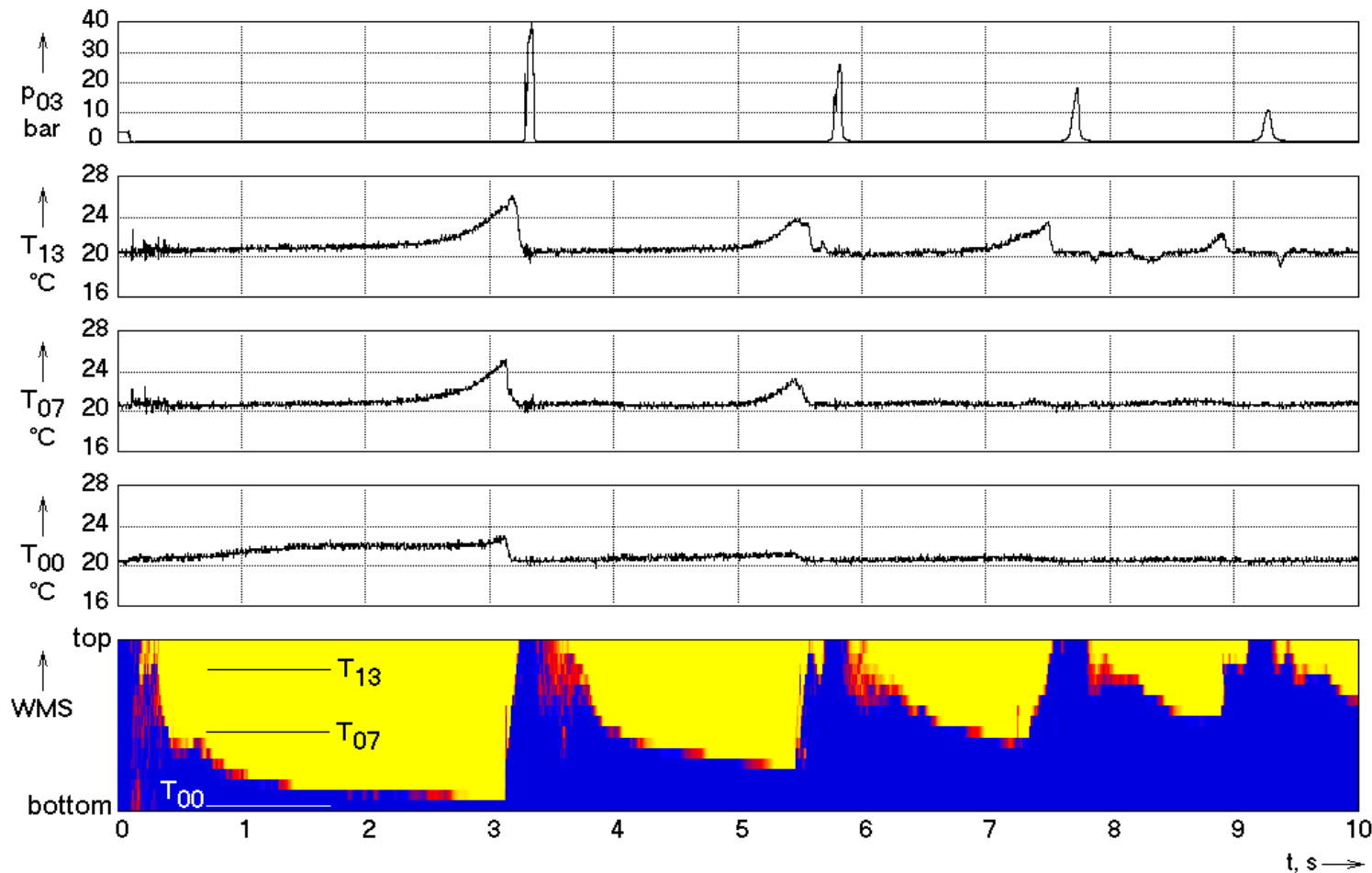
t = 800 1600 2400 3200 4000 4800 ms

Results of void fraction measurements, L=230m

Selected frames from a series of two-dimensional void fraction distributions in the first 0.45 s of the cavitation process in test run 00135 - initial evaporation and onset of stratification



Results of void fraction measurements, L=230m



Time histories of axial void fraction distribution, pressure downstream of fast acting valve and selected temperatures from the micro-thermocouples inside the mesh sensor for test run 00135

Results of void fraction measurements, L=146m

Behaviour of the pressure downstream of the fast acting valve during the cavitation, the temperature and the local void fraction close to the top of the pipe cross-section, test run 00307

