Time-resolved investigation of the exhaust emissions of upgrading units

2nd IBBA workshop on methane emissions
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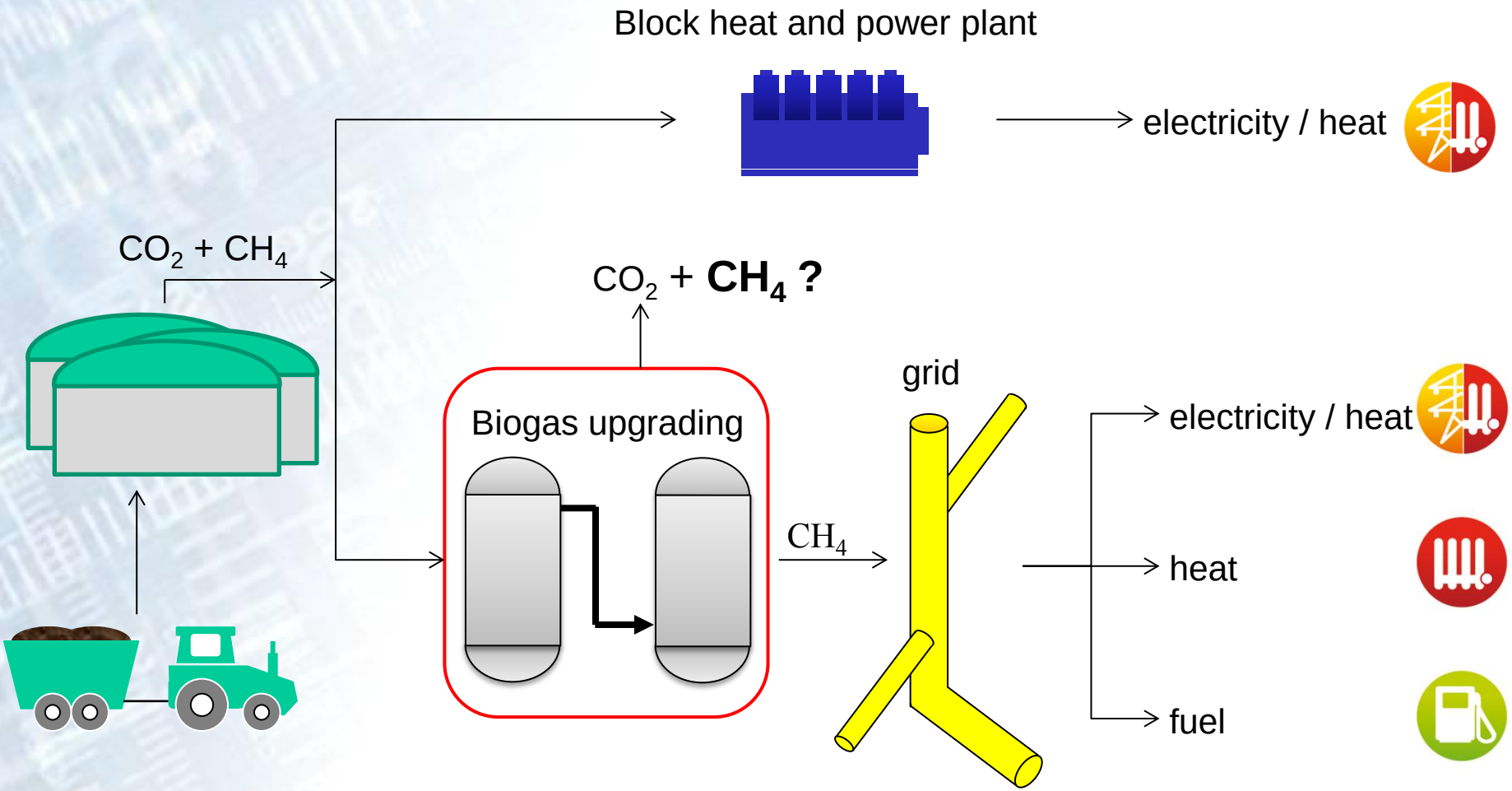
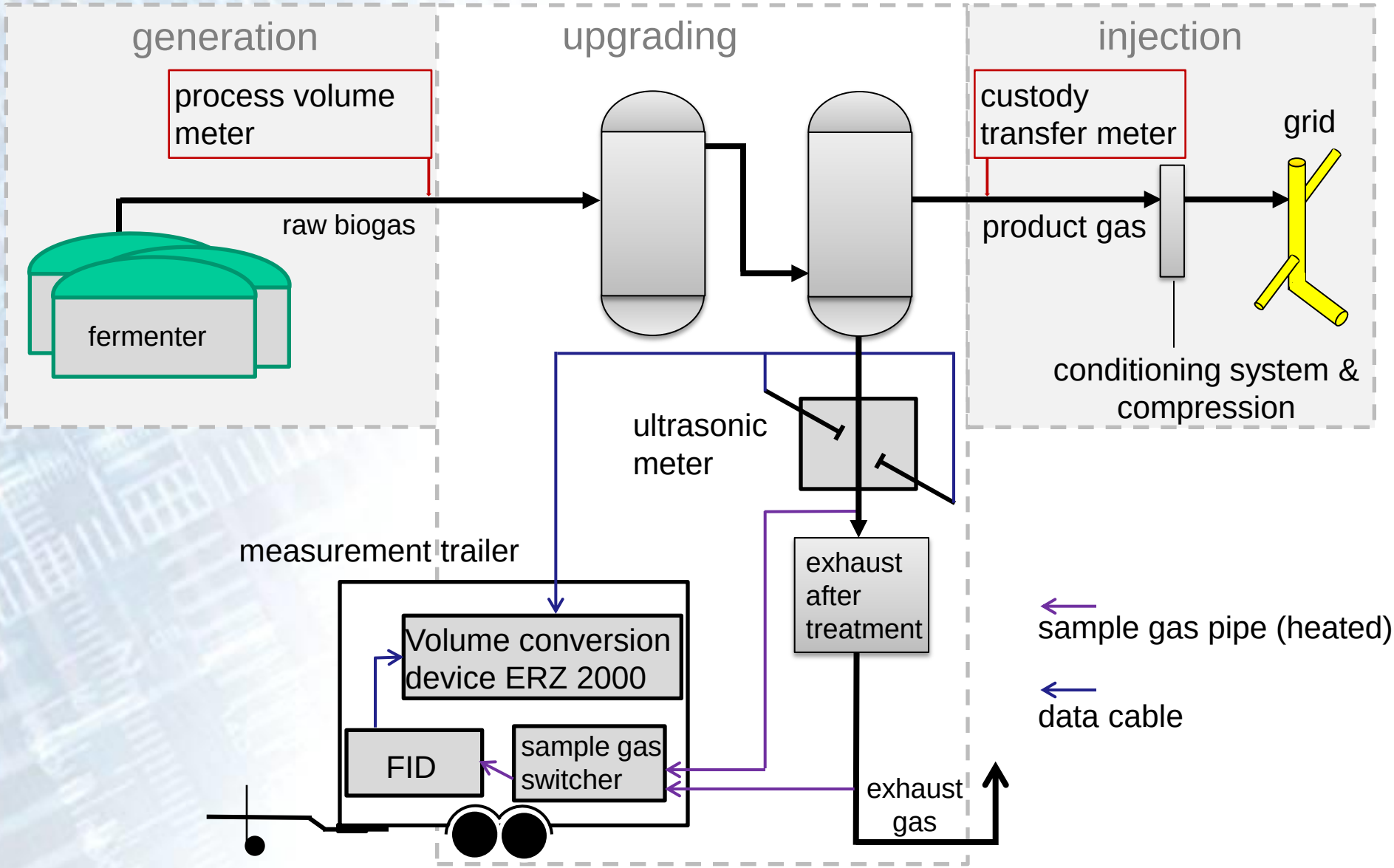
Introduction



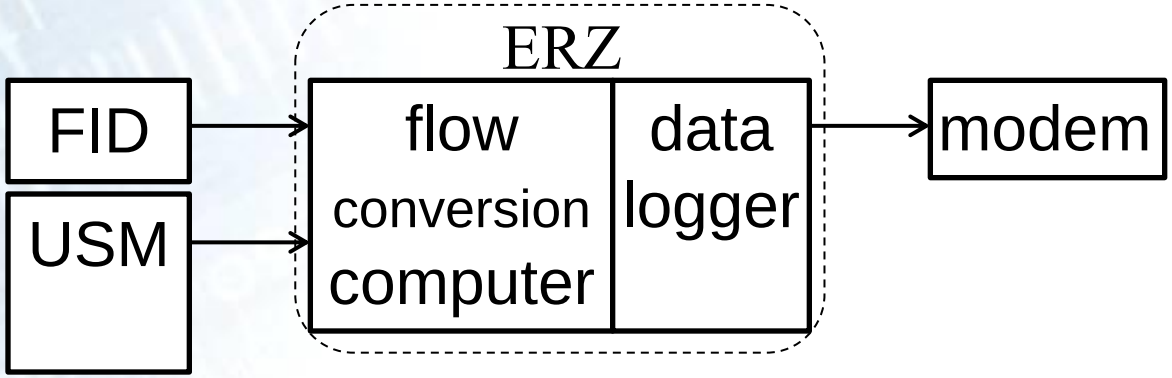
Biogas upgrading technologies

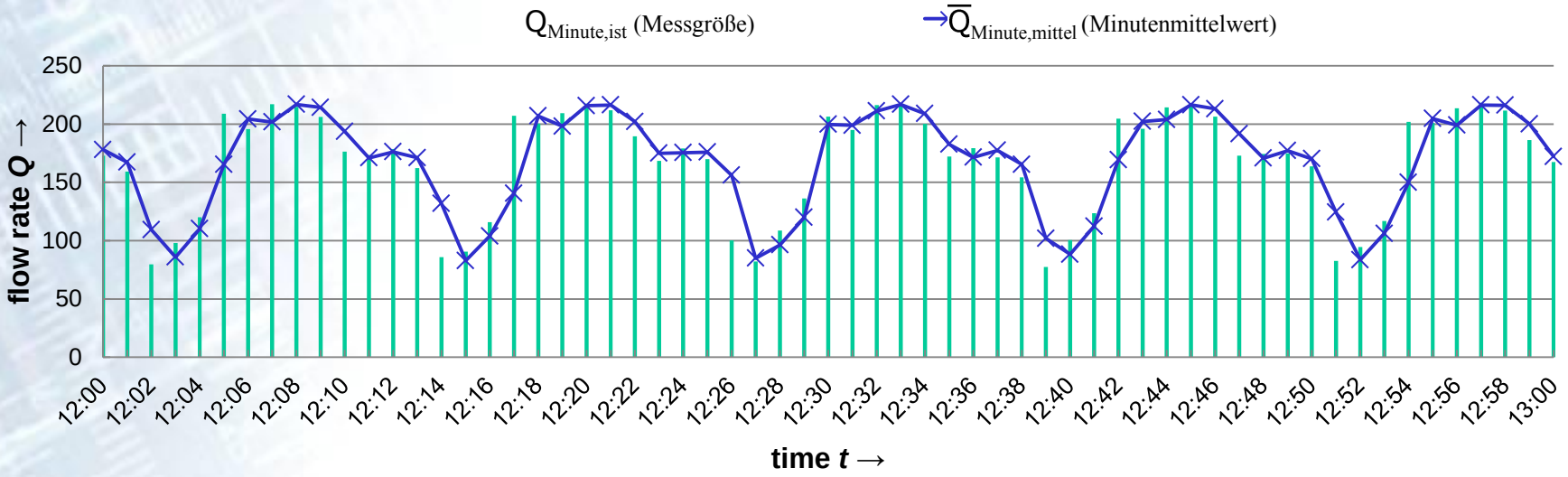
- Steps for the upgrading process
  - desulphurization
  - drying
  - extraction of other contaminates
    - ➢ the order of steps depends on the upgrading technique
  - **CO_2 extraction**
- common upgrade techniques
  - pressure swing adsorption
  - water scrubbing
  - chemical scrubbing
  - membrane technologies

Determination of methane loss

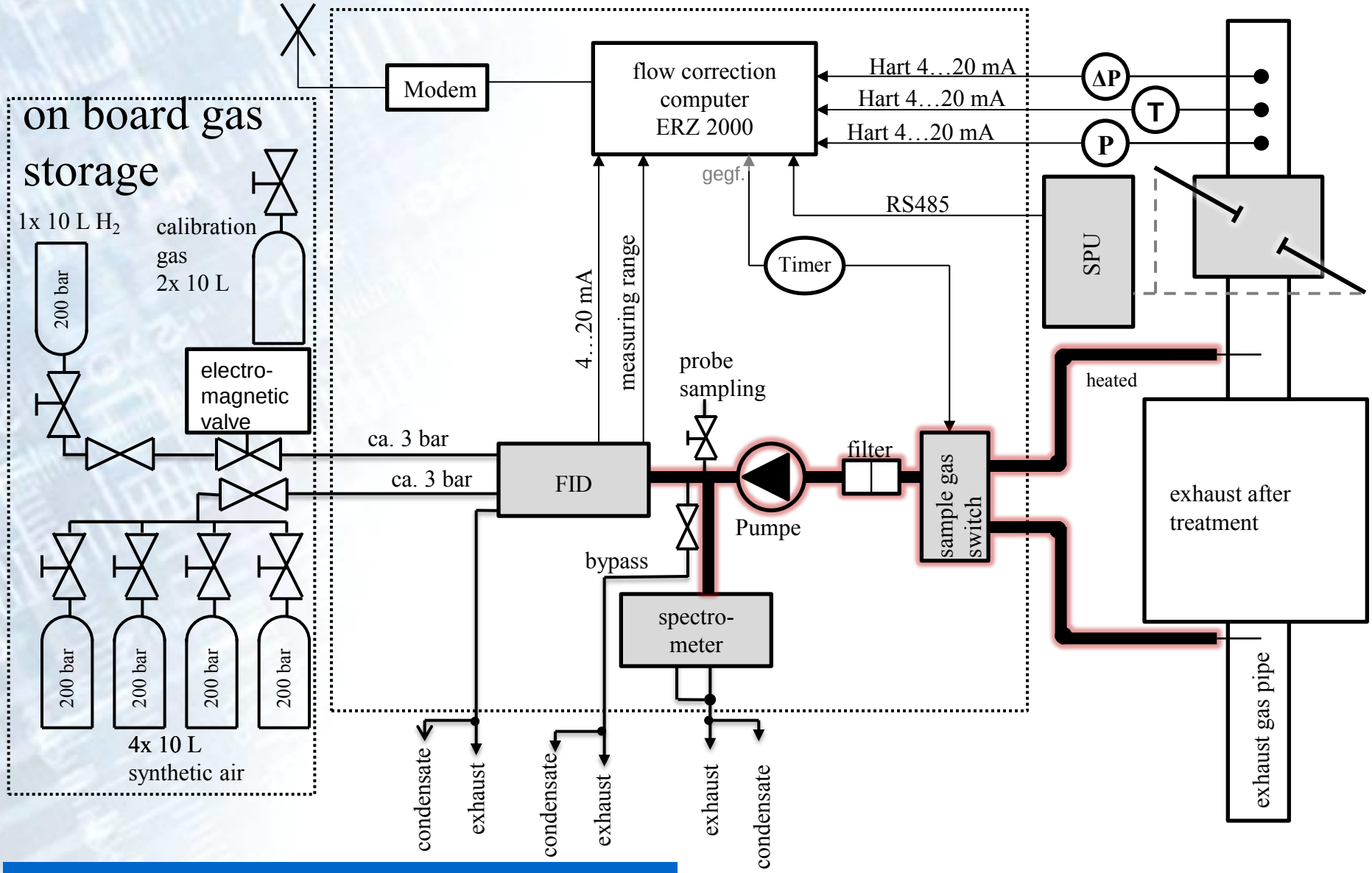


Determination of methane loss





Measuring equipment



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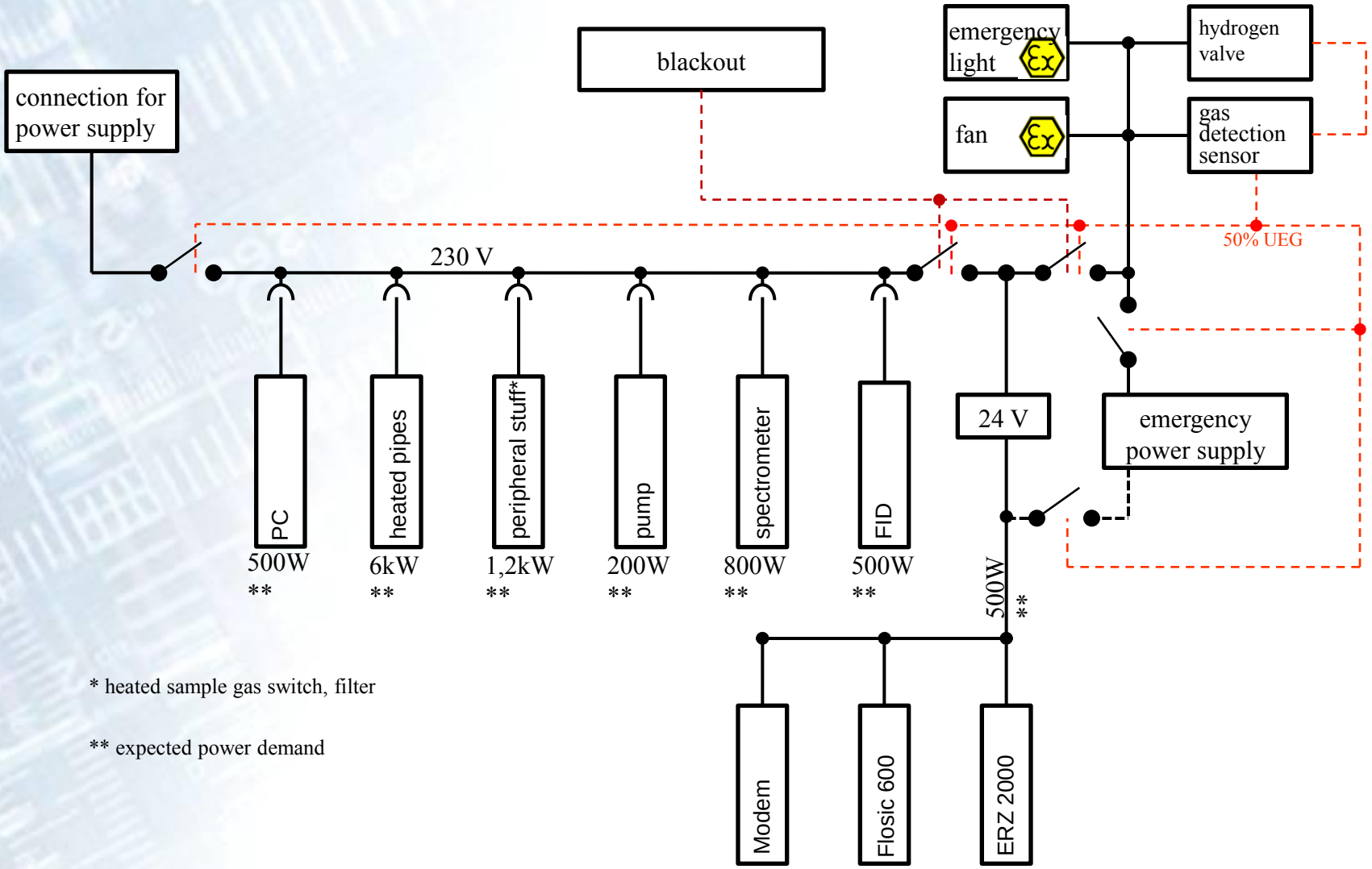
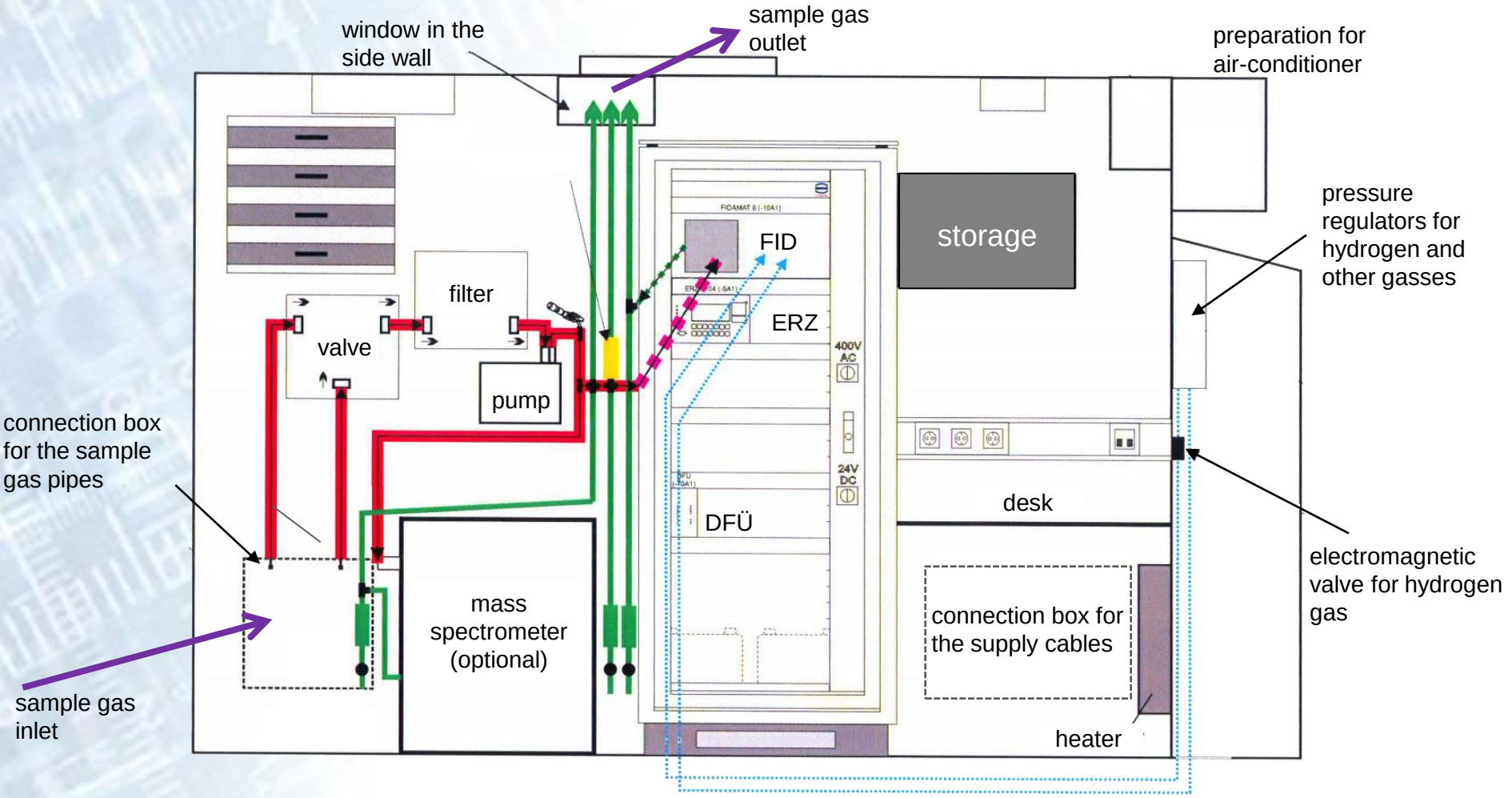


* heated sample gas switch, filter

** expected power demand

Measuring equipment



Measuring equipment

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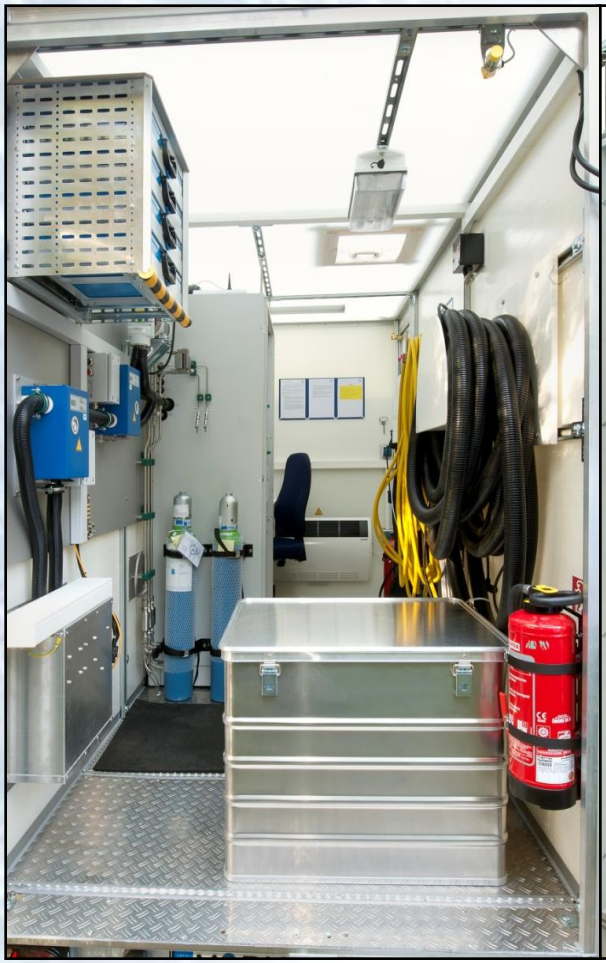

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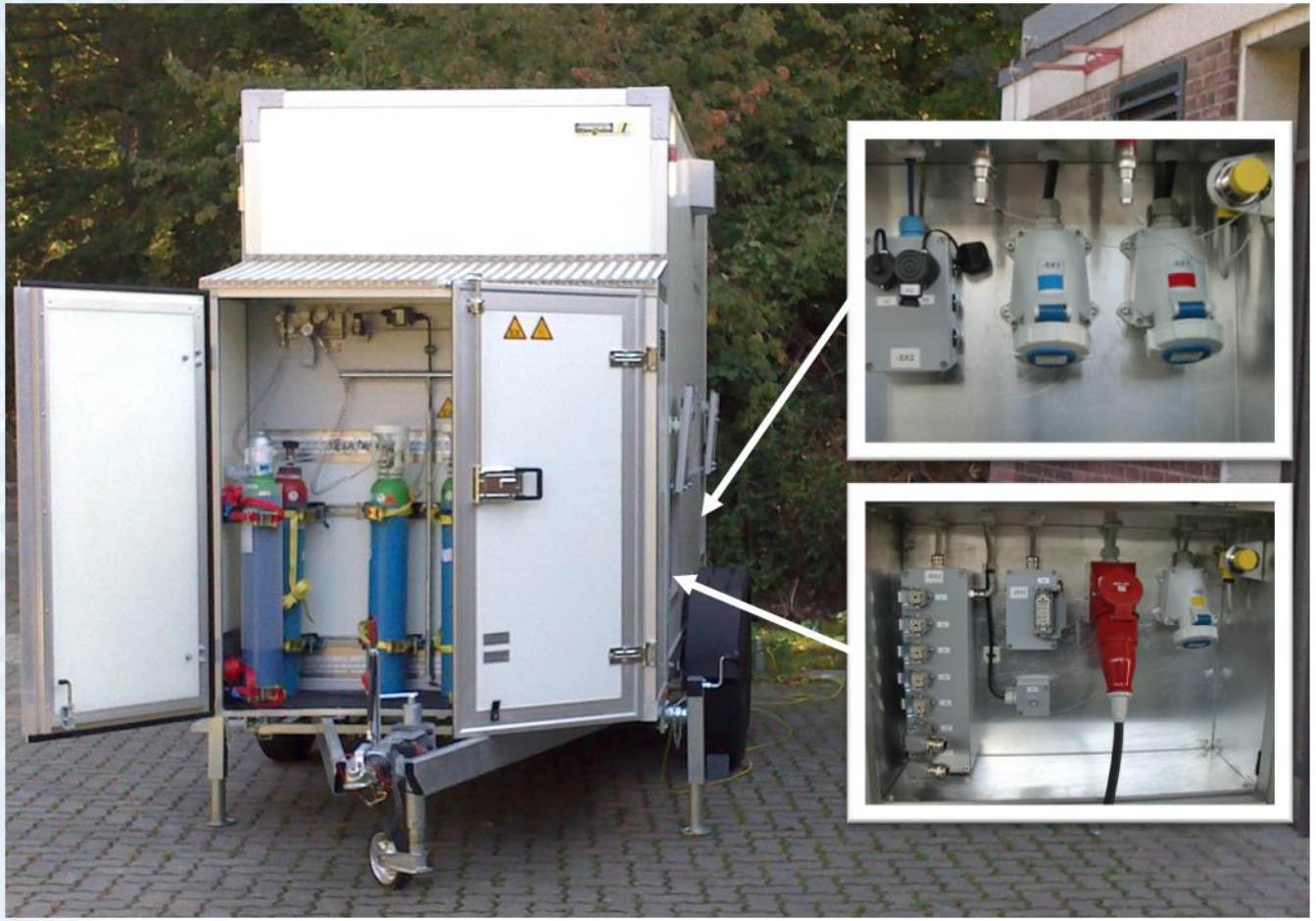


Measuring equipment

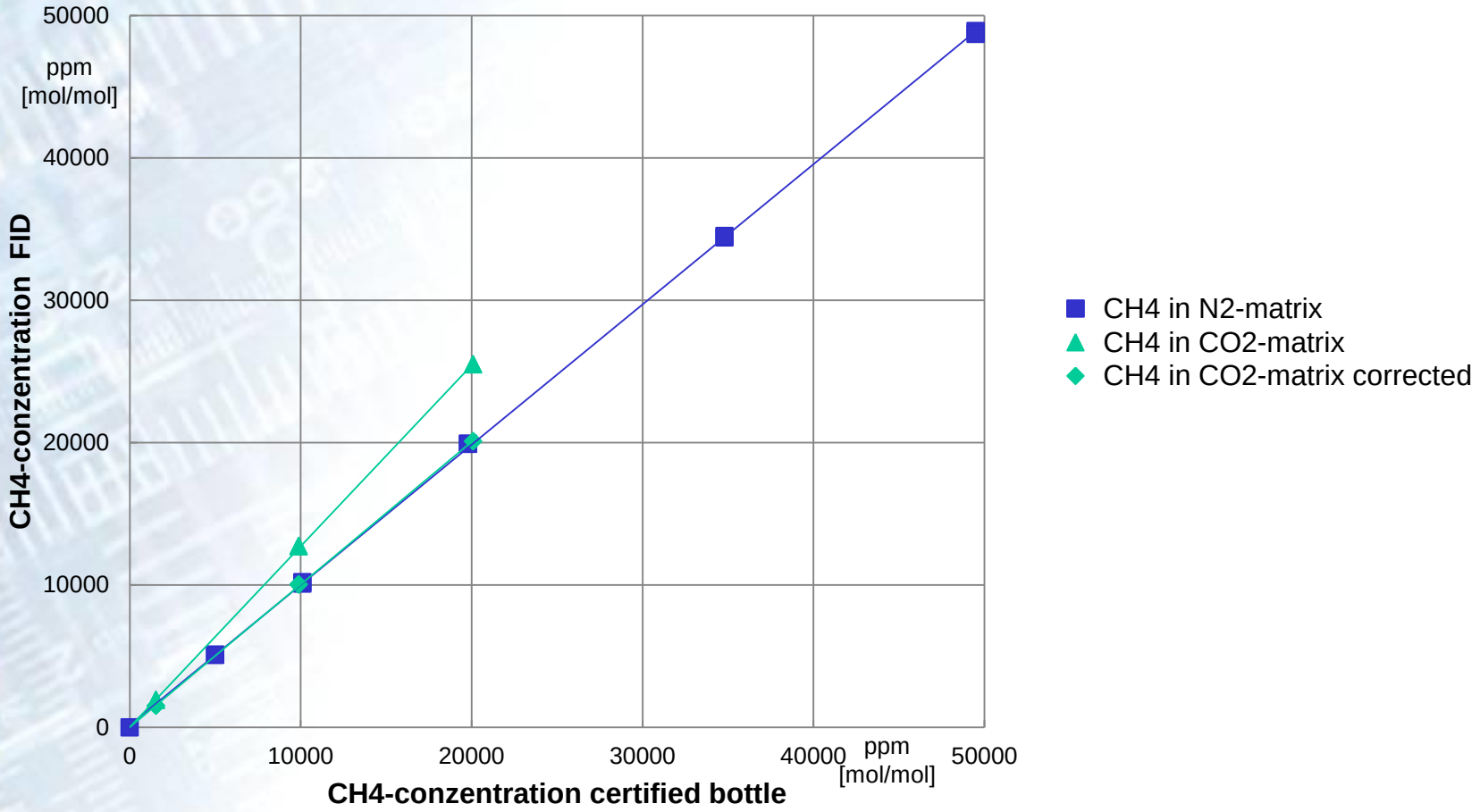
- methane measurement
  - flame ionisation detector (FID)
  - in presence of up to 100 % H_2O vapor
  - calibration with 0.1 to 5 Vol.-% methane in nitrogen
  - calibration with 0.15 to 3 Vol.-% methane in carbon dioxid
- Methan Emissionen

$$E_{CH_4} = Q_{Abgas} \cdot x_{V,CH4}$$

$$x_{V,CH4} = \frac{x_{CH4} \cdot \frac{\tilde{M}_{CH4}}{\rho_{n,CH4}}}{\sum_{i=1}^{k} x_i \cdot \frac{\tilde{M}_i}{\rho_{n,i}}}$$

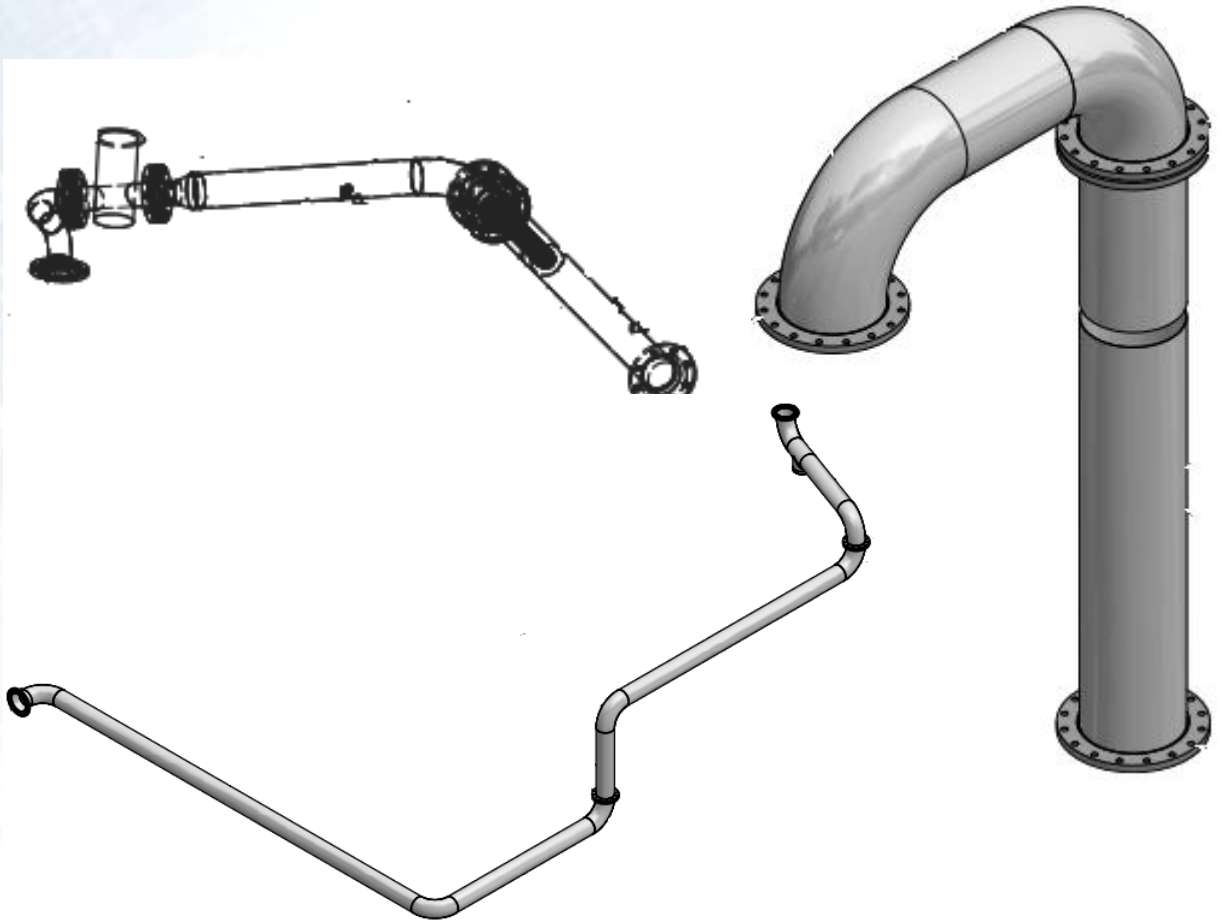
Quelle: Siemens

Deviation of FID



Measuring equipment

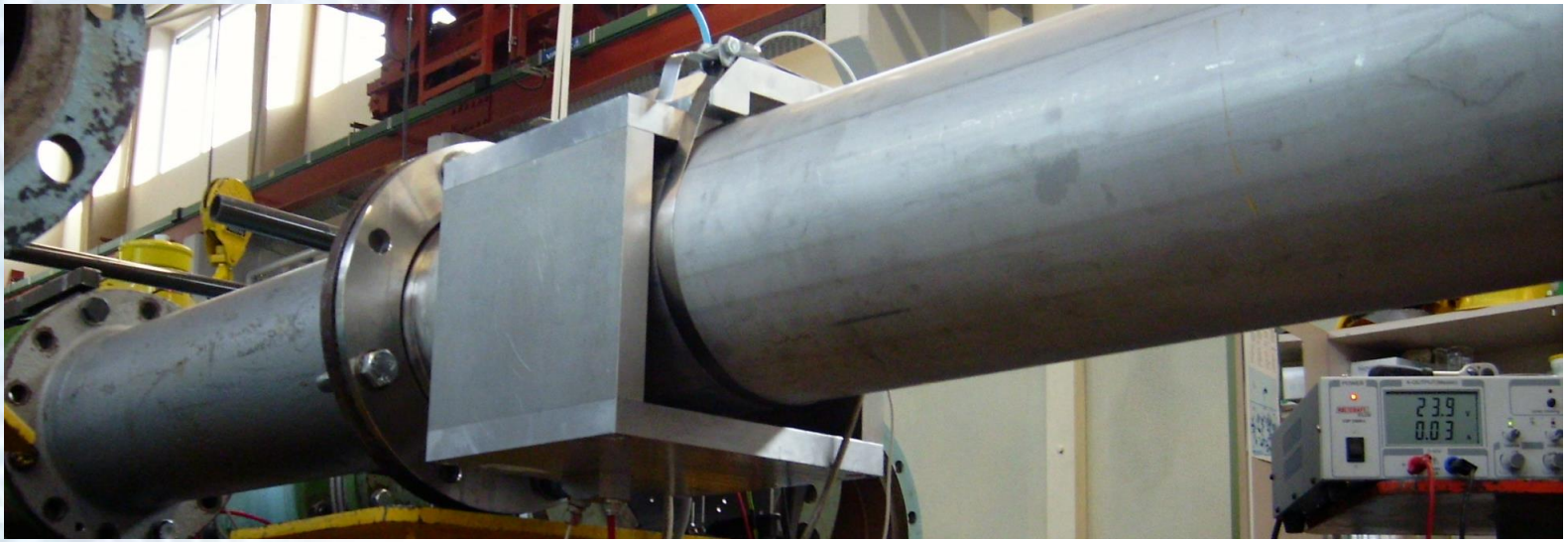
pipeline route: exhaust gas

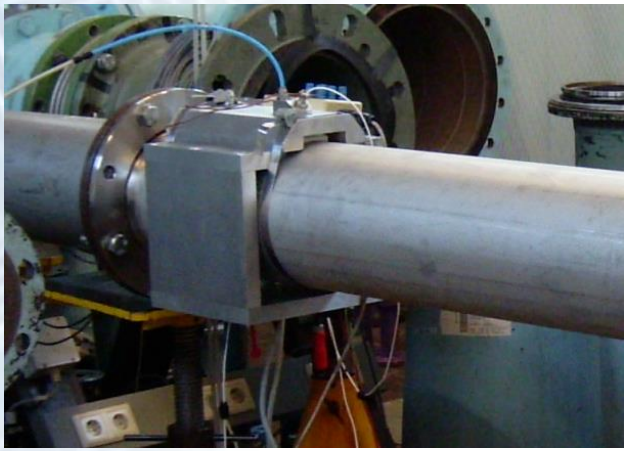


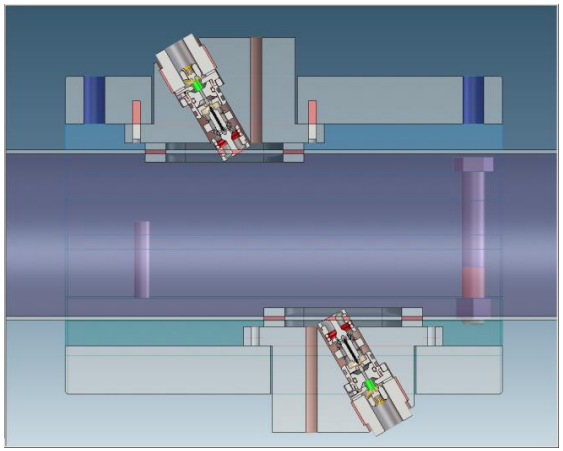
Flow measuring technique

technique	advantage	disadvantage
commercial available meter	• high measurement accuracy • low perturbation sensitivity (type-dependent)	• flanges are needed • big interference in local structure • high installation effort
ultrasonic measuring probe	• low interference in local structure (only one drilled whole necessary) • speed of sound is available	• only parts of the flow profile are measurable • adjustment of the correct angle is difficult • due to probe size a limited work capability in respect to pipe diameter is possible ≥DN100
ultrasonic meter clamp-on-technique	• no interference in local structure • speed of sound is available • sensors can be used for different pipe diameters	• fluid pressure has to be high enough • signal damping by CO_2 is problematic • temperature and pressure measurement needs tape
one-path-ultrasonic meter with sleeve	• low interference in local structure (two drills) • sensors can be used in connection with different sleeves for different pipe diameters • speed of sound is available	• relatively high perturbation sensitivity
differential pressure (with Prandtl/ Pitot -probe)	• low interference in local structure (only one drilled whole is necessary)	• very high perturbation sensitivity • density of gas has to be determined

Measuring equipment





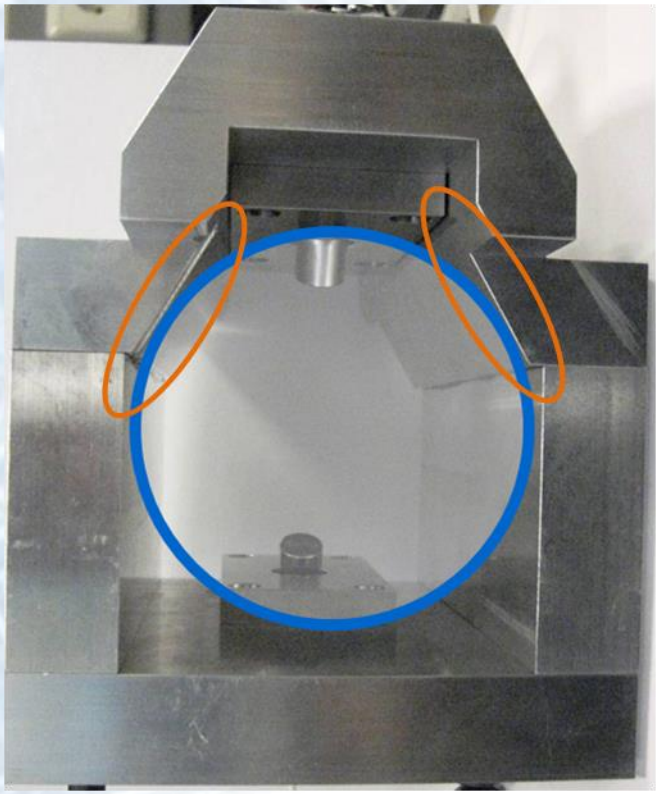


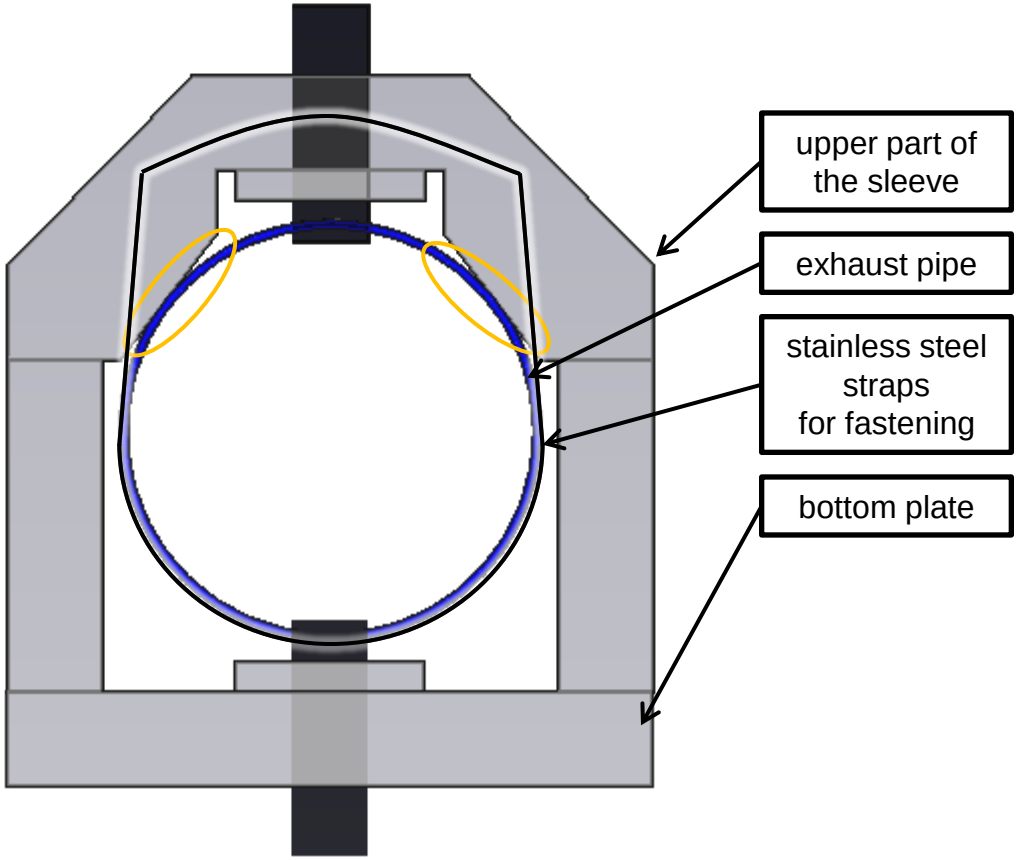
Quelle: SICK

sleeve sizes:

- DN 80
- DN 200
- DN 300

Measuring equipment





Measuring equipment

- flowmeasurement

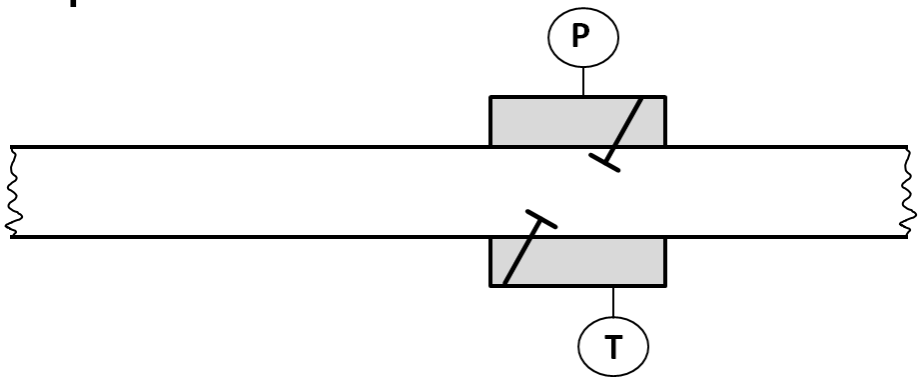
$$Q_V^* = \bar{v} \cdot \frac{D_i^2 \cdot \pi}{4}$$

$$Q_V = Q_V^* \cdot \left(1 + k(Q_V^*)\right)$$

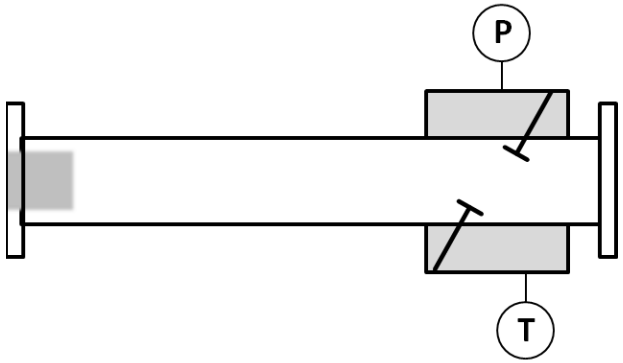
$$k(Q_V^*) = 0$$

  - uncorrected

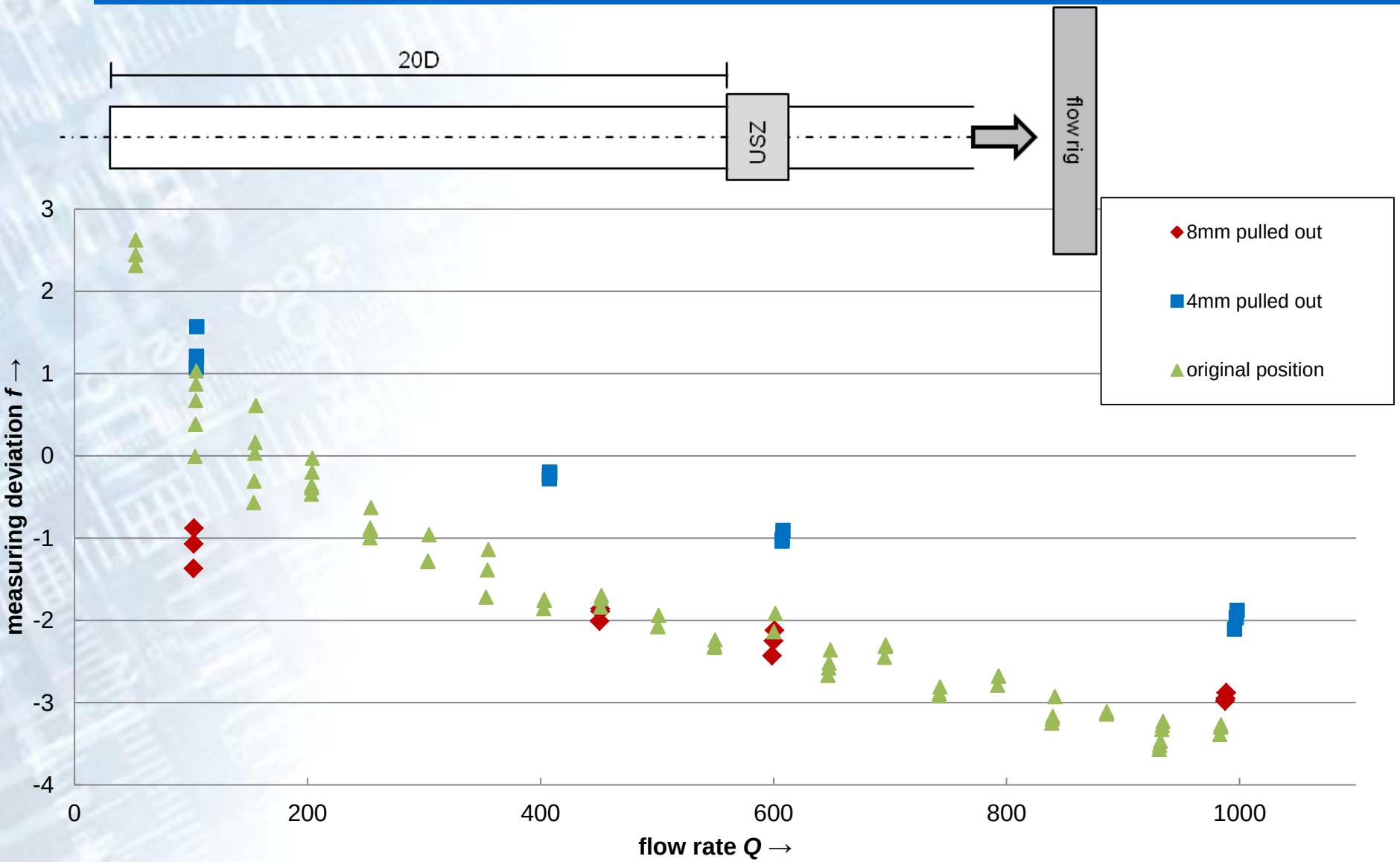
Option 1



Option 2



Investigation of the characteristics of the flow metering unit



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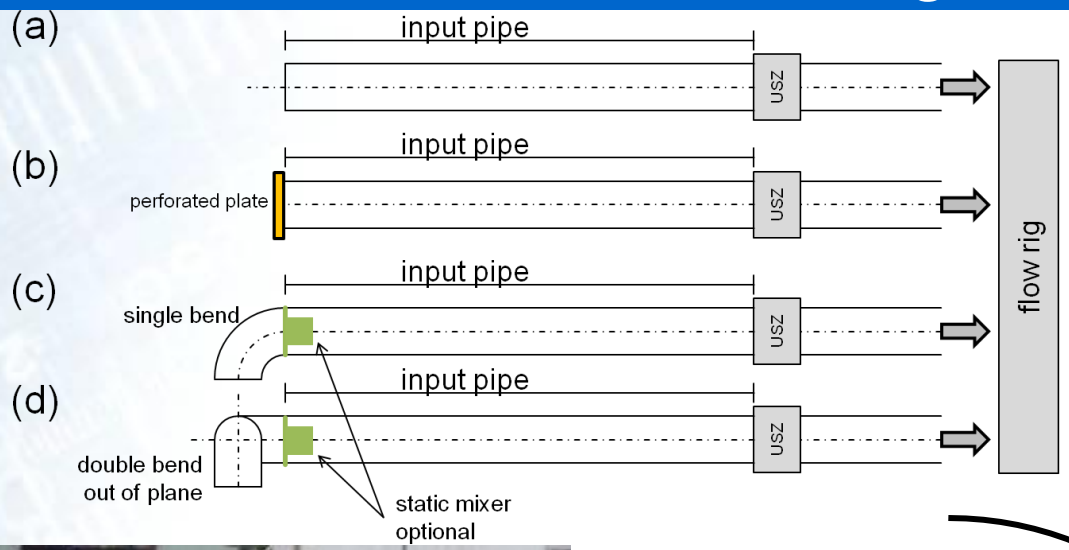

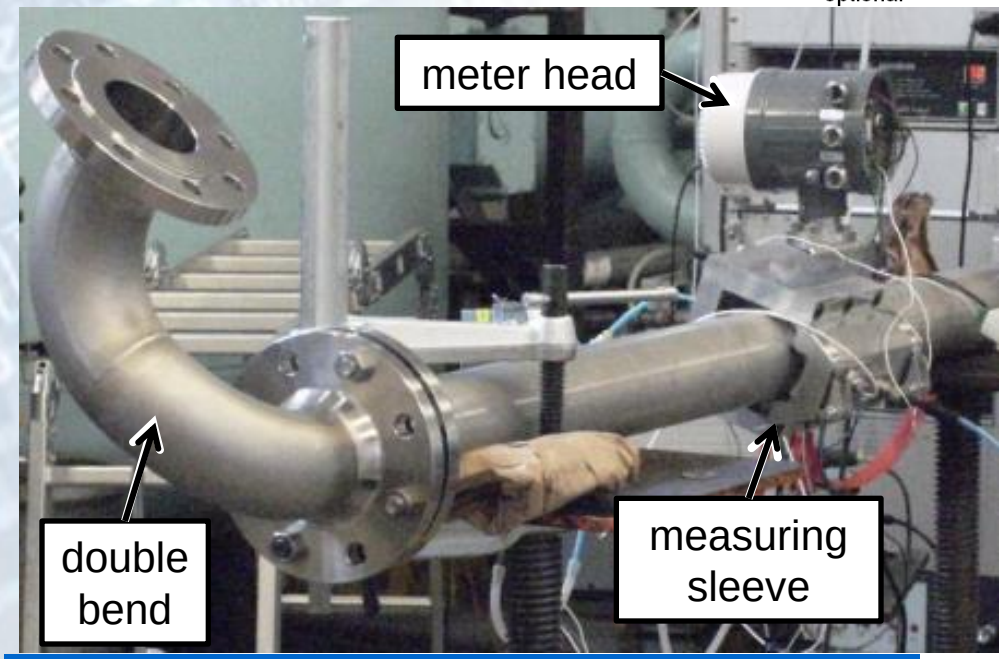

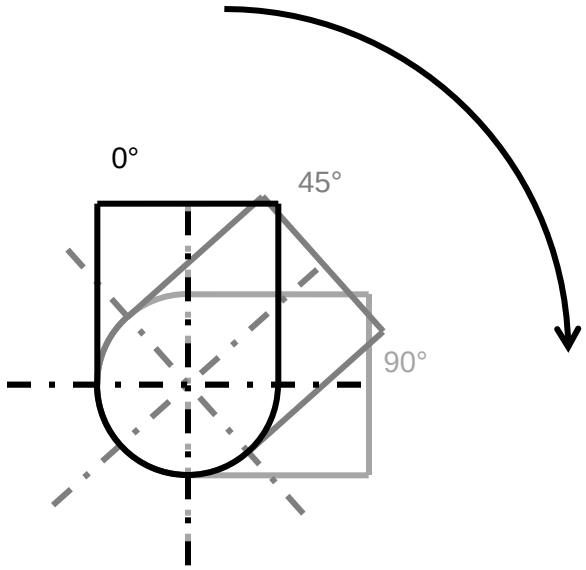

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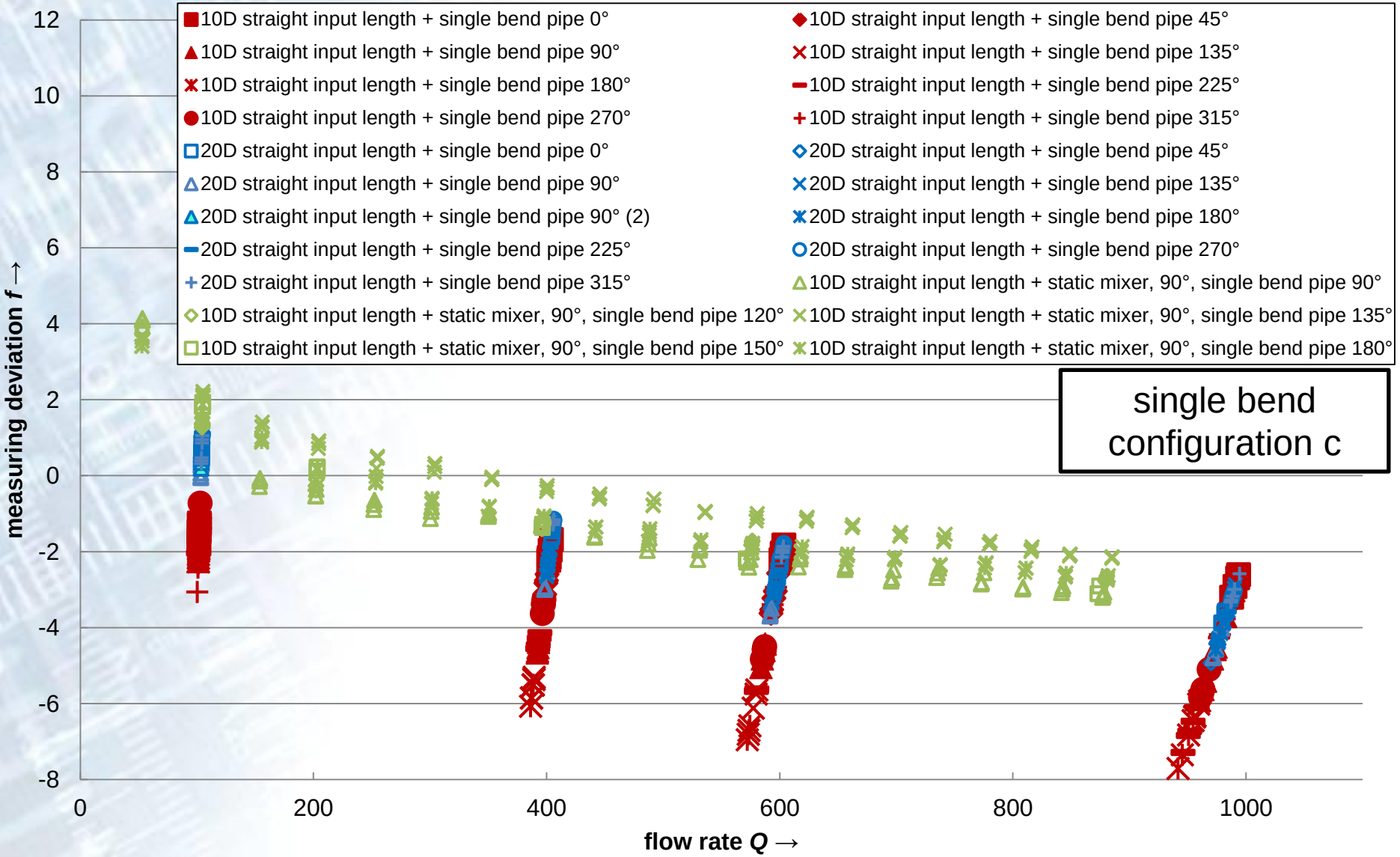

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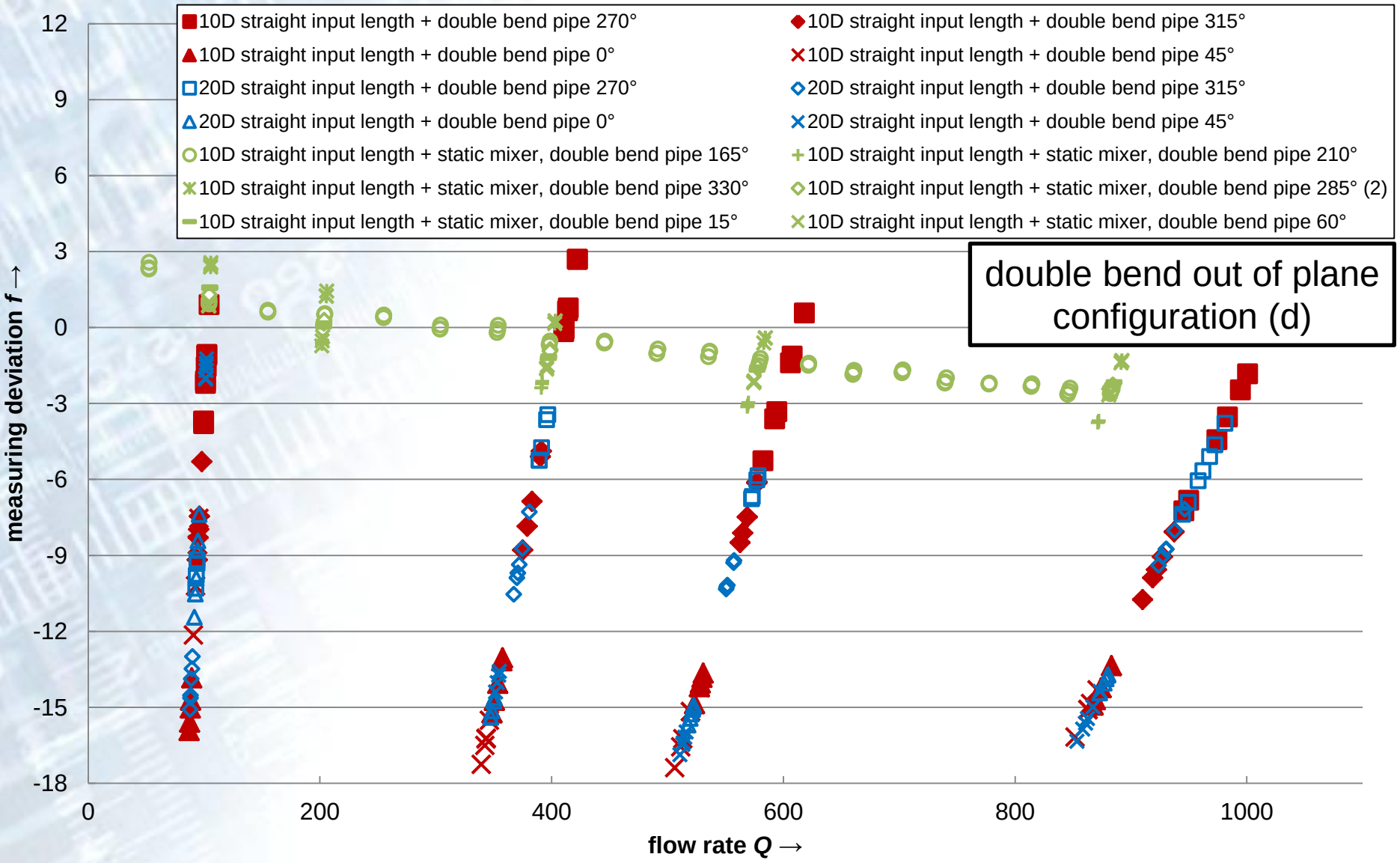
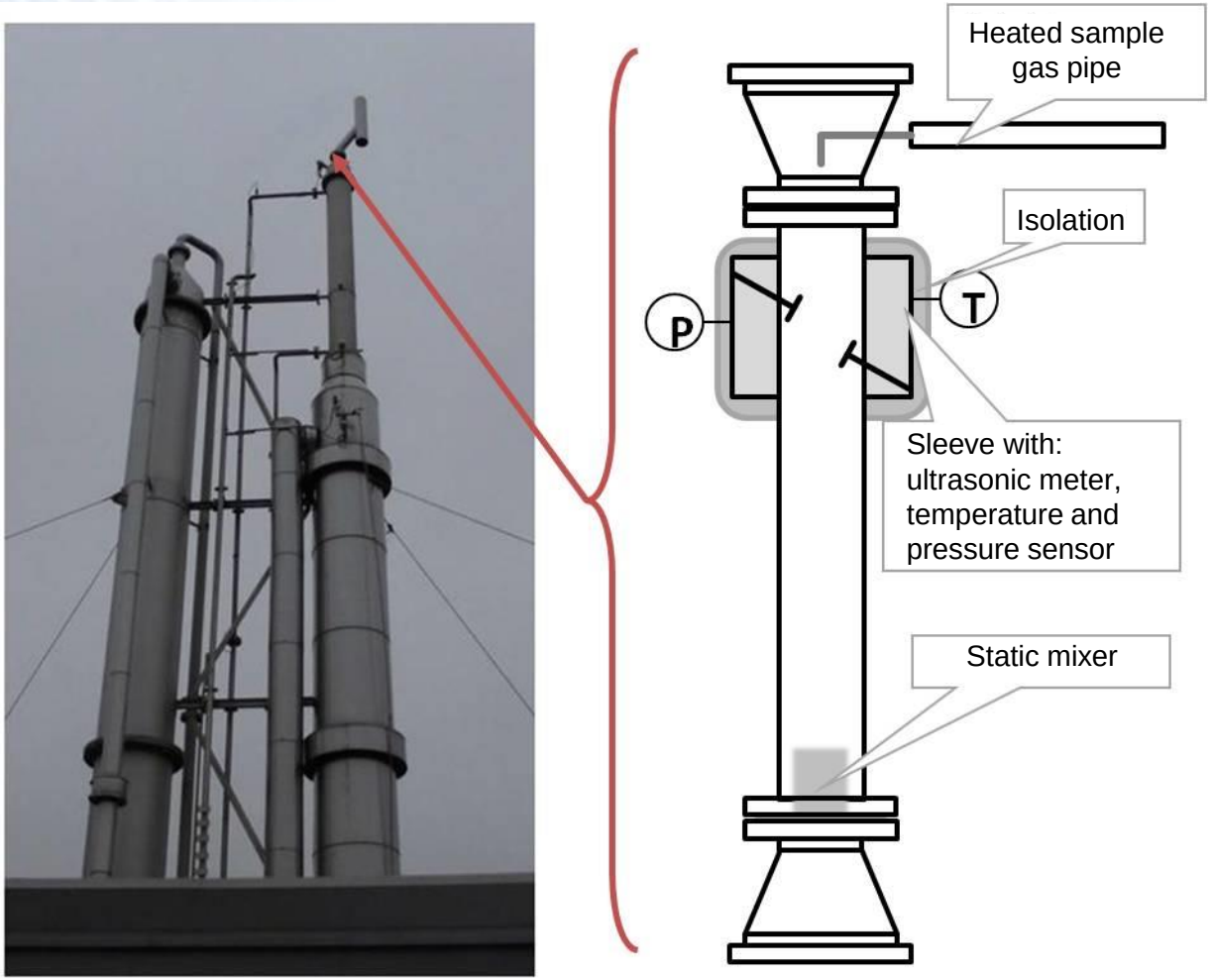
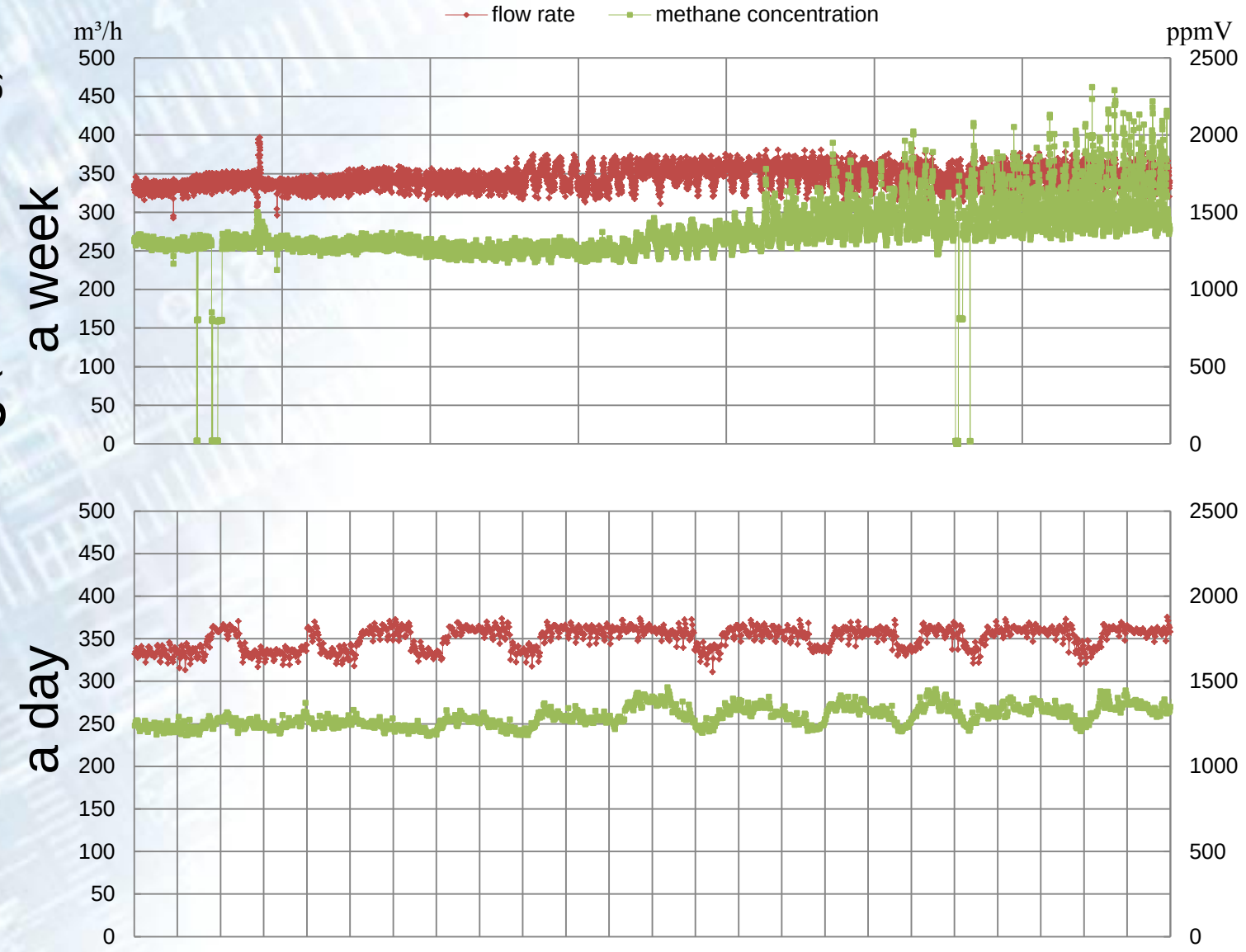


Practical experience



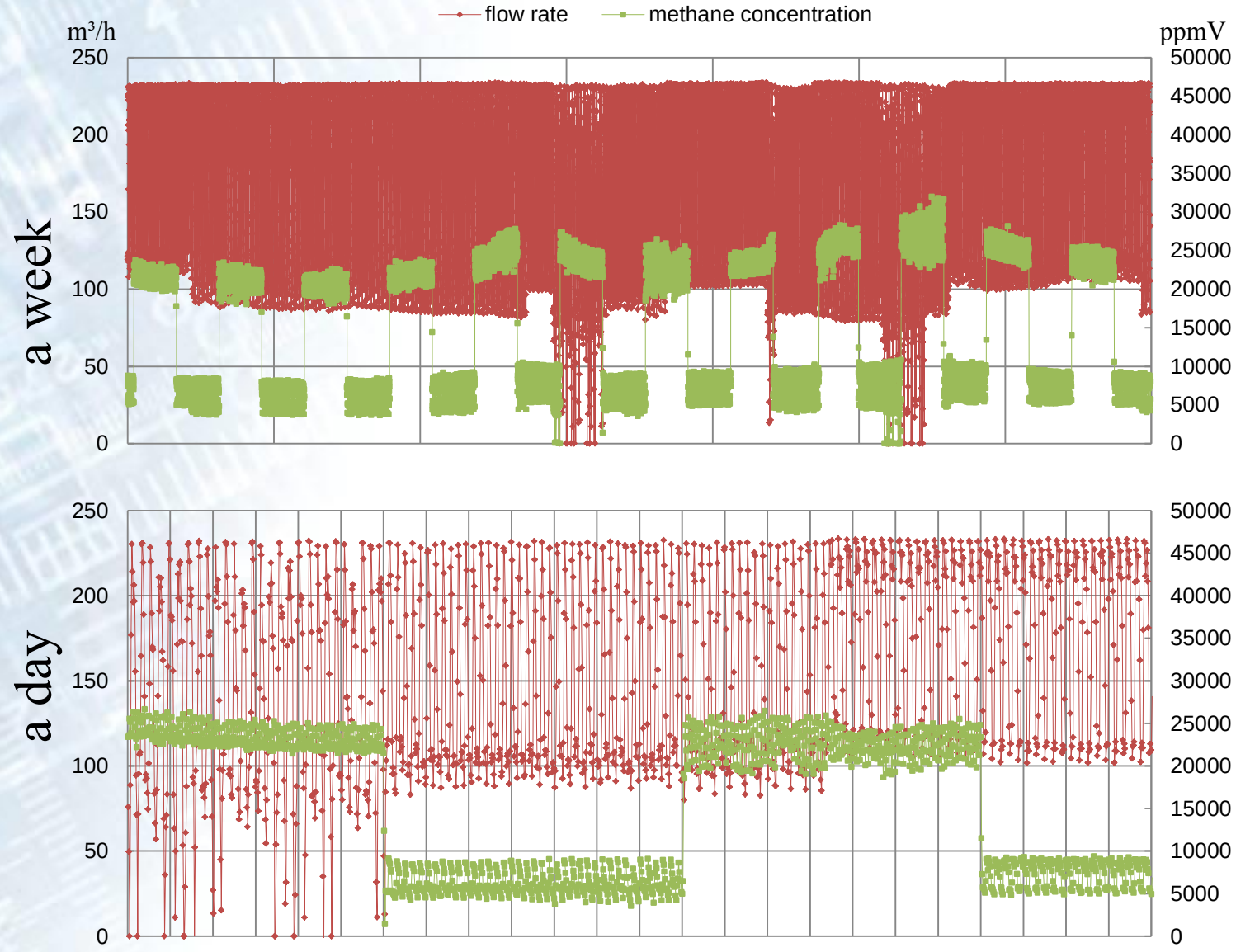
Practical experience

chemical scrubbing (amine scrubbing)



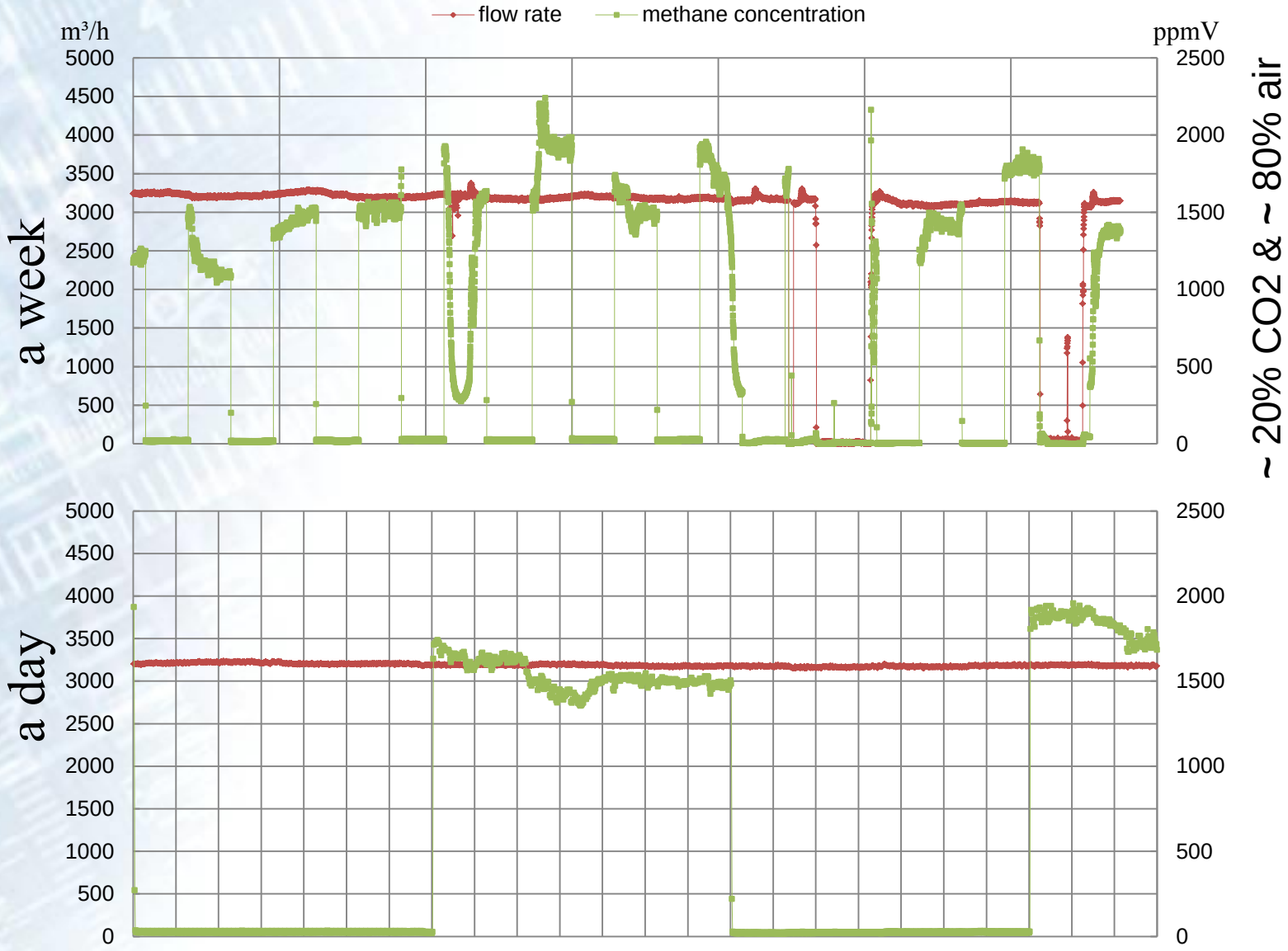
Practical experience

pressure swind adsorbtion



Practical experience

water scrubbing

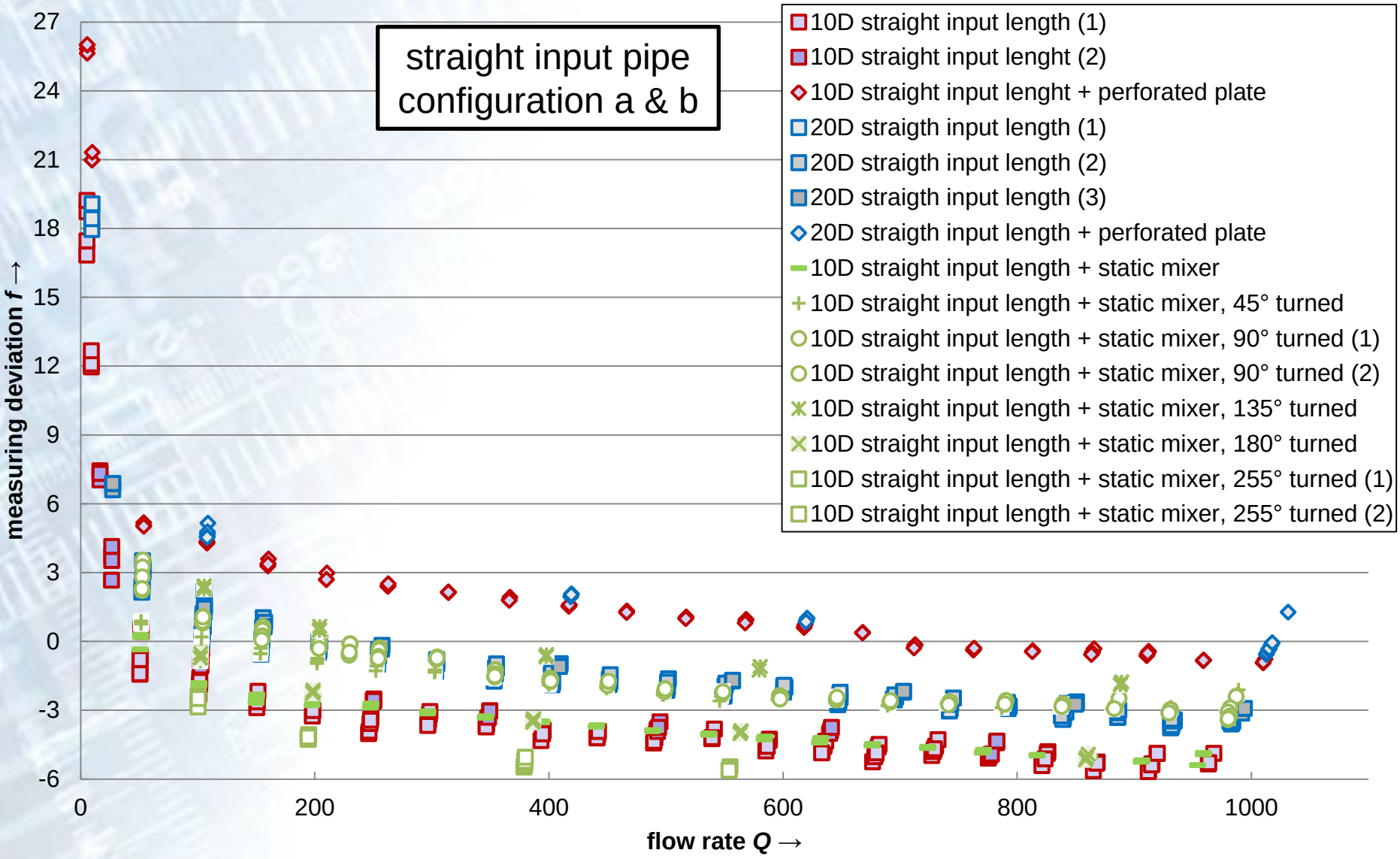


Conclusion

- the mobile measuring system is able to measure to memorise and to transmit data for flow rate and methane concentration with a resolution of 1 minute
- the system is designed to aquire data over a period of 2 weeks
- the system works after installation and putting into use without personnel on site
- an uncertainty of U = 2% for the volume flow rate determination is reachable if sufficient straight pipe length is given or if the installation of a flow straightener is possible
- the measurement on site show different emission levels, depending on the used upgrading technique
- further focus shall be on the influences of upstream conditions on the meter behavior and the influence of the matrix on the methane concentration

Time-resolved investigation of the exhaust emissions of upgrading units

Investigation of the characteristics of the flow metering unit



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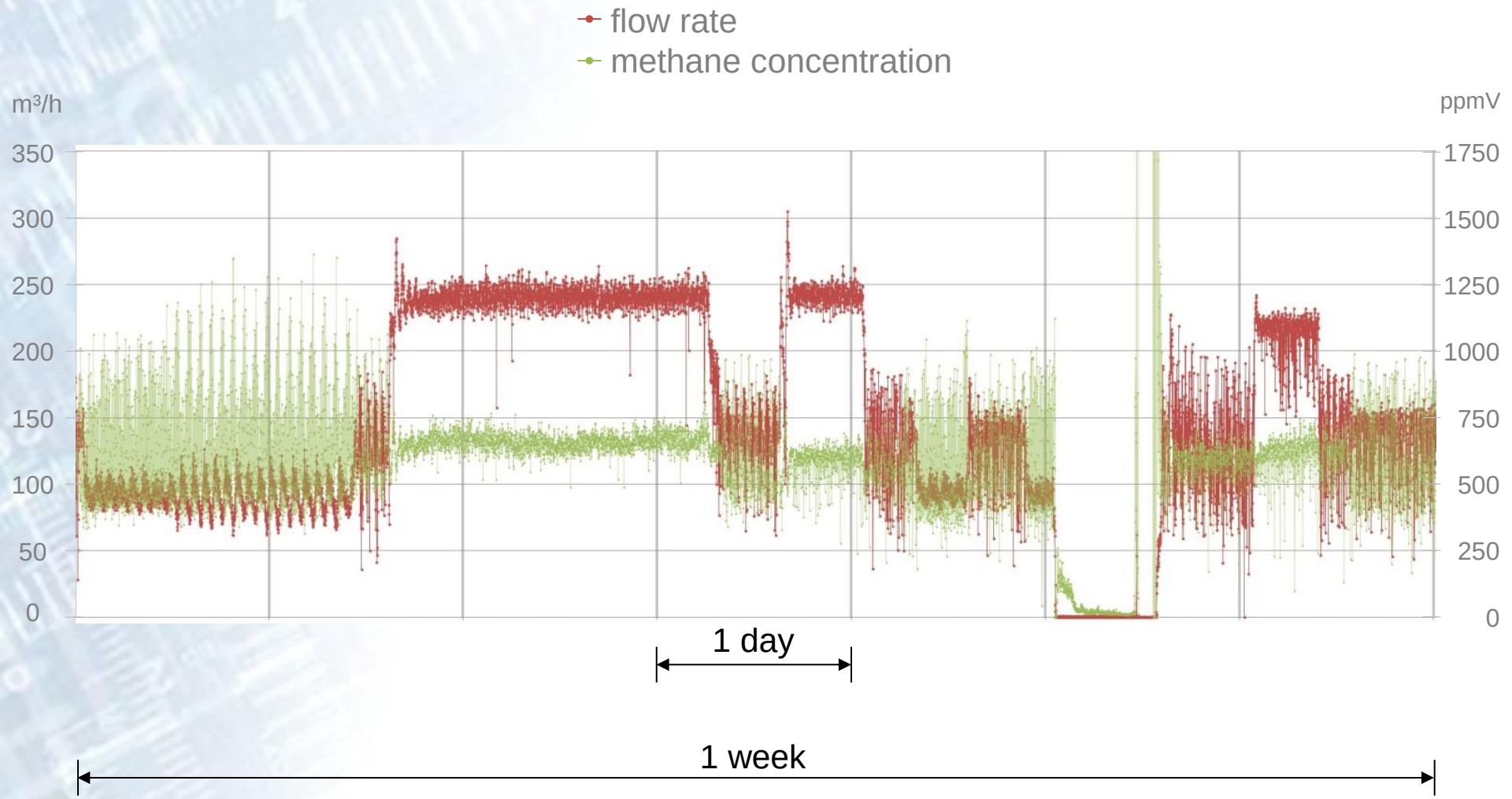

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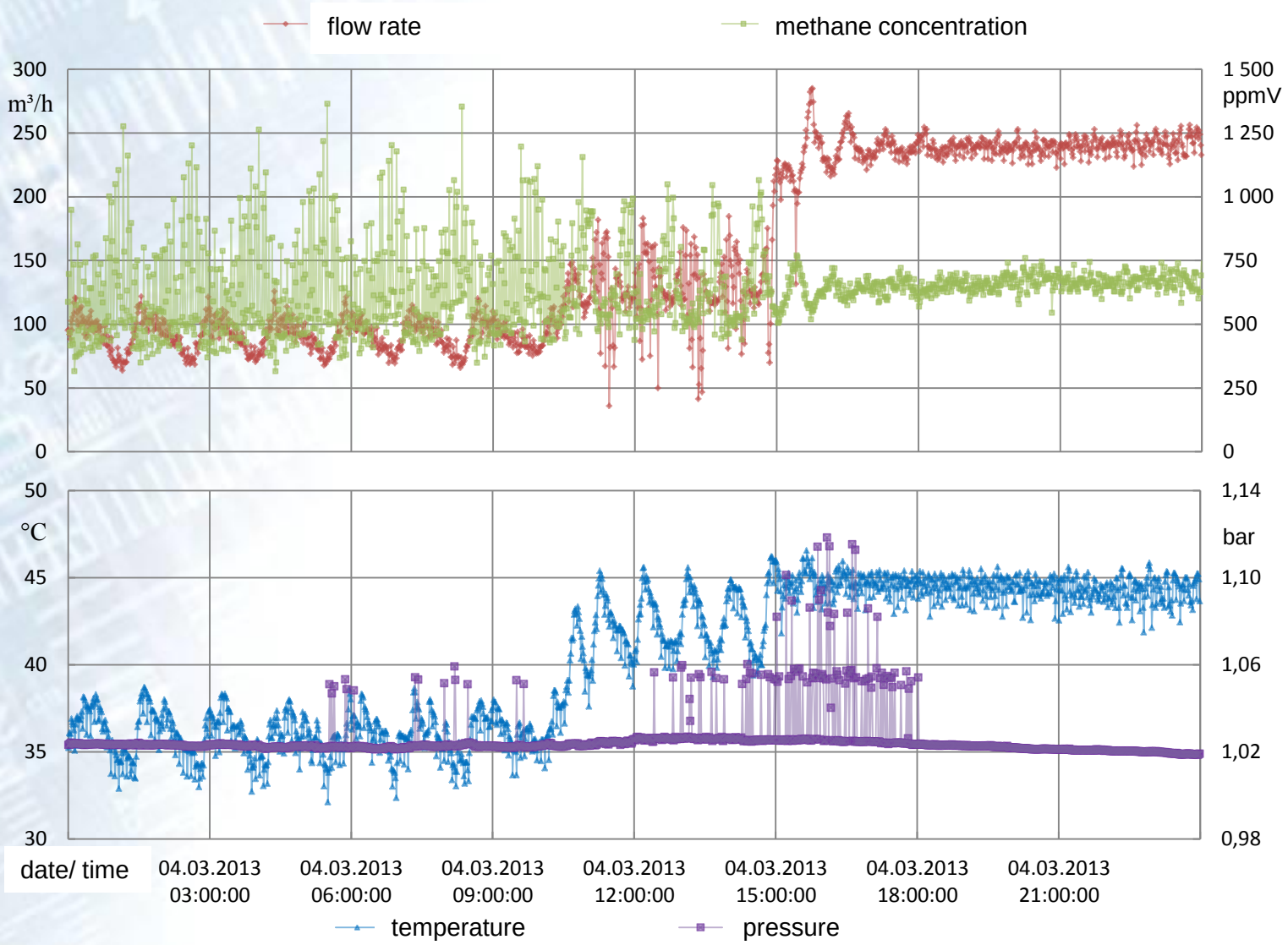

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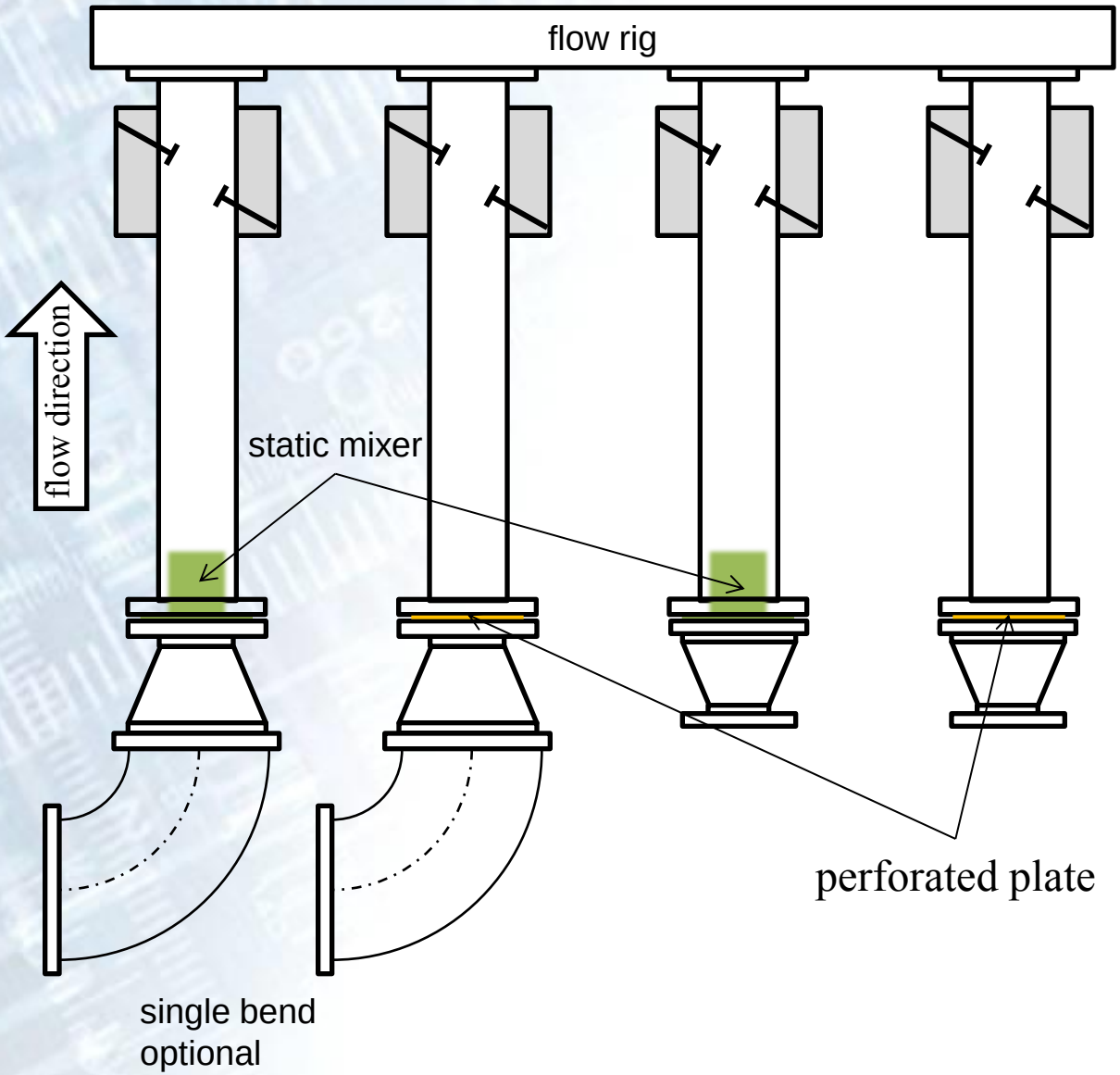

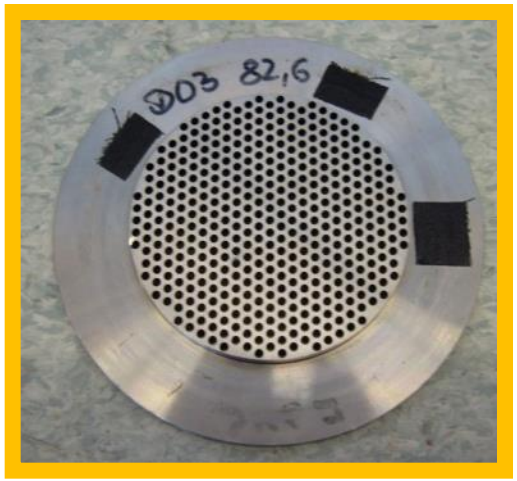

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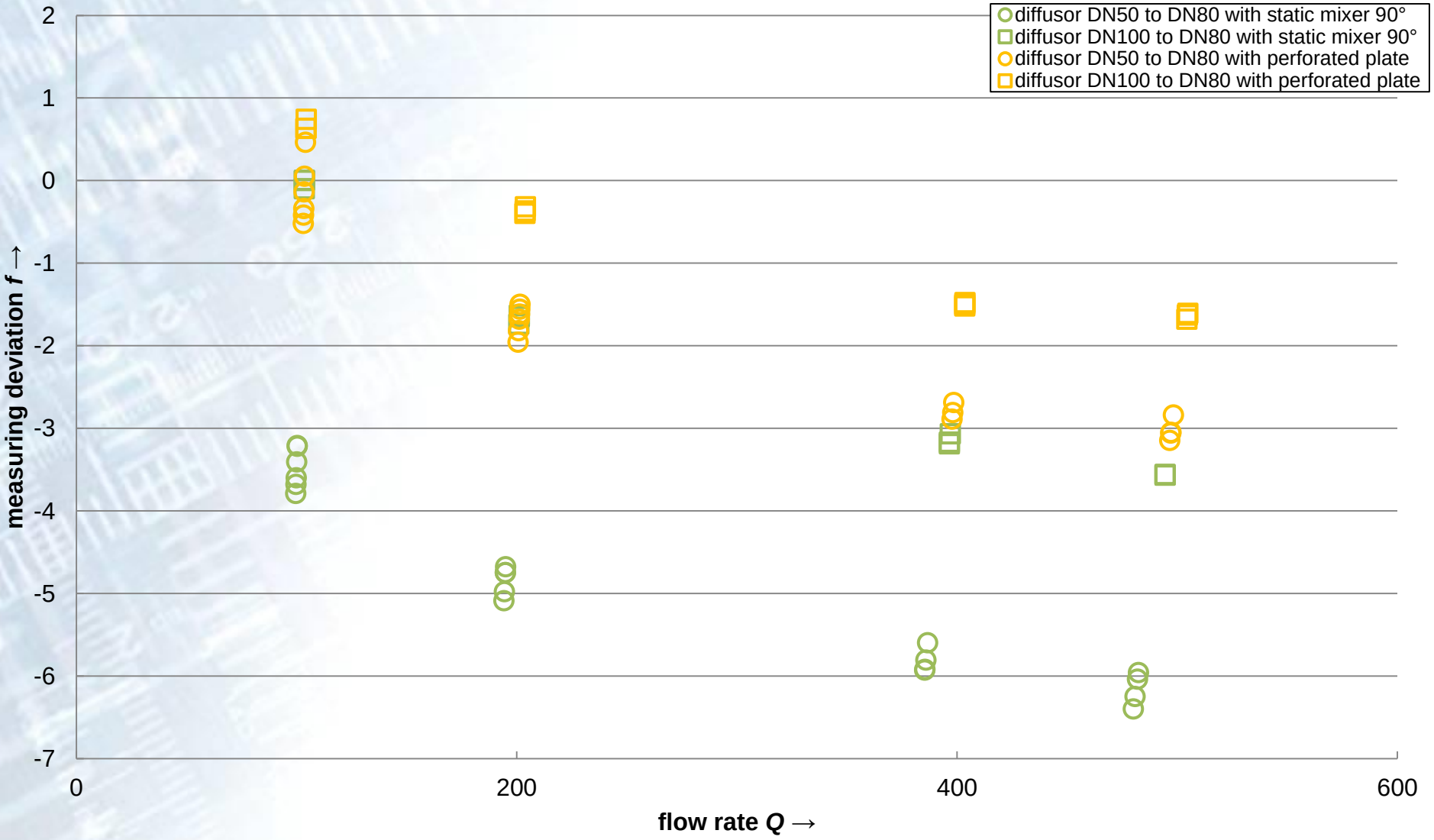

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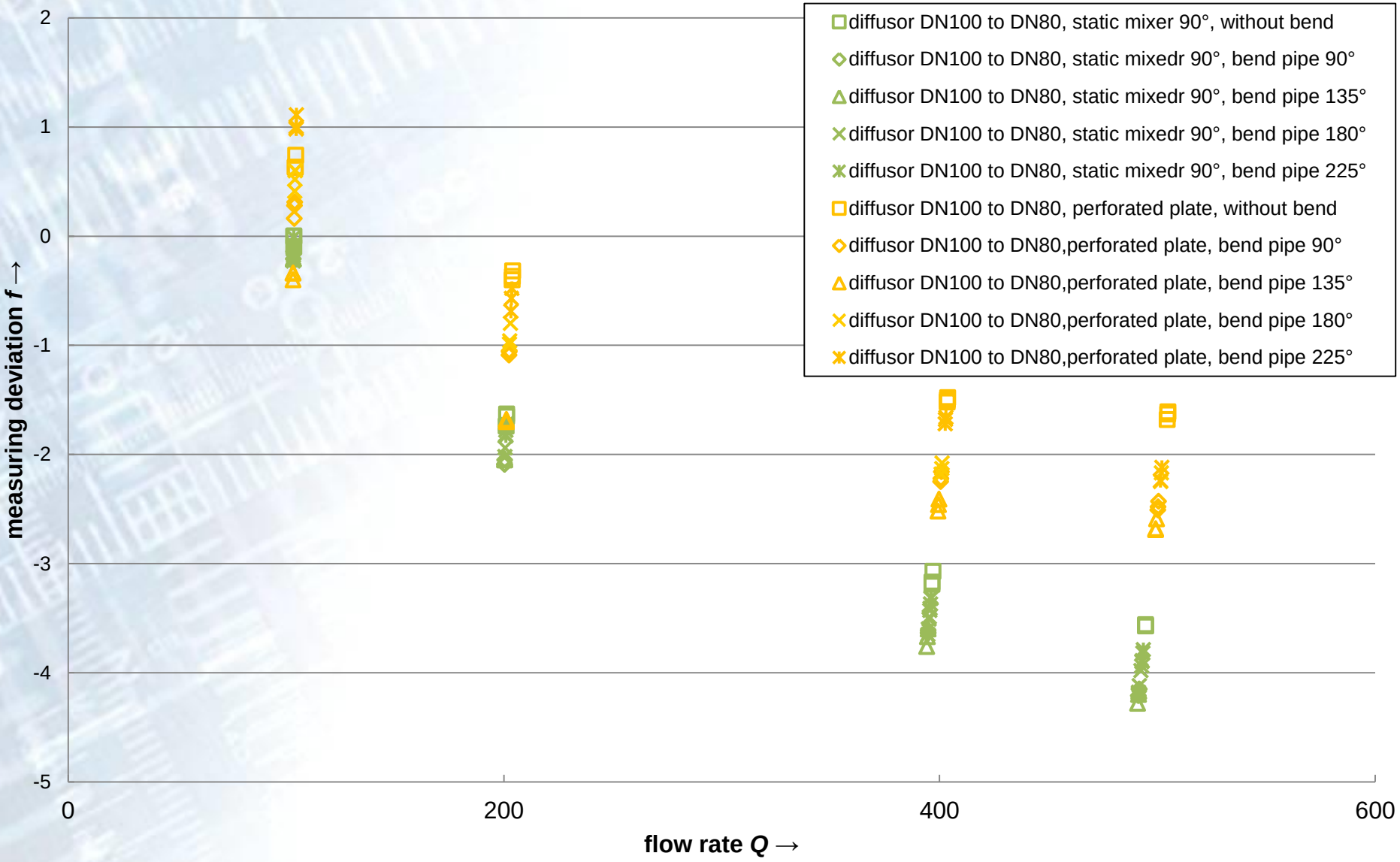
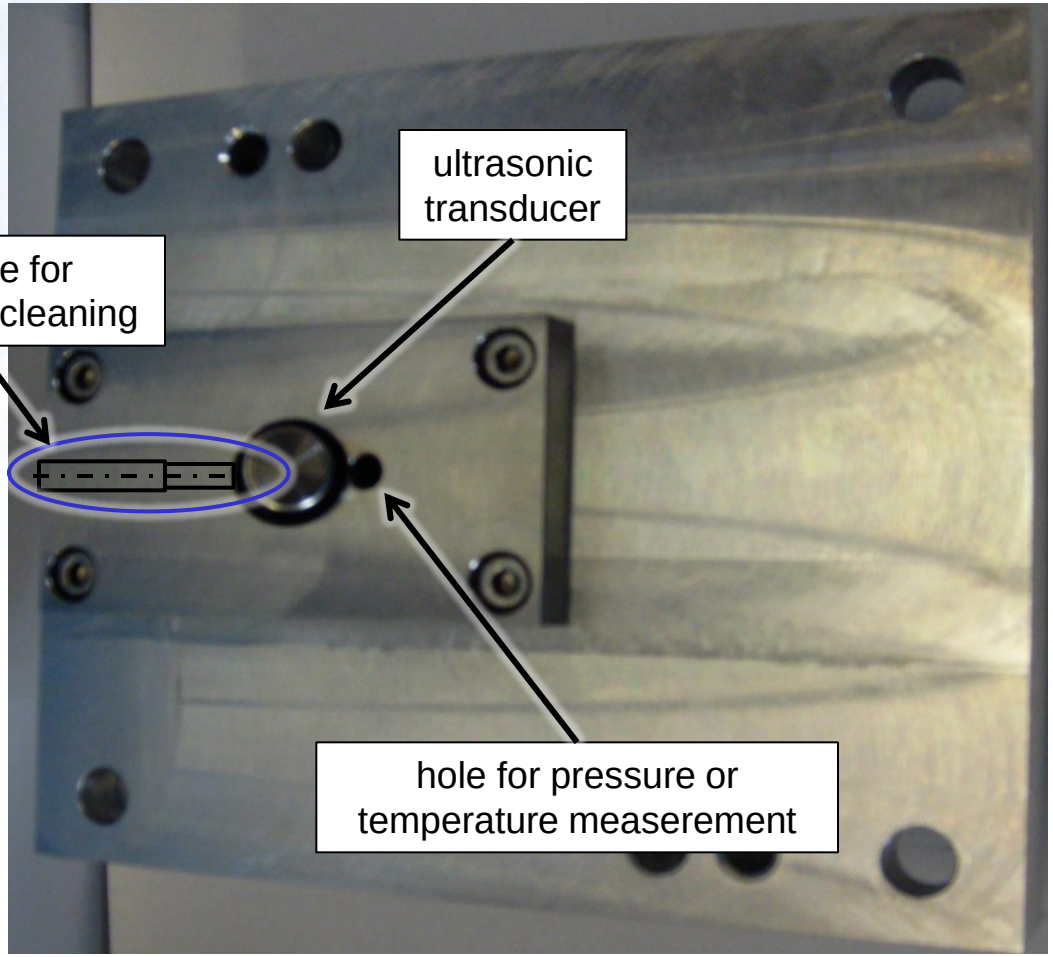


Practical experience

bottom plate of the sleeve



Measuring equipment

Verfahren	Vorteile	Nachteile
kommerziell verfügbare Zähler	• hohe Messgenauigkeit • geringe Vorstörungempfindlichkeit (typabhängig)	• keine Flansche vorhanden • starker Eingriff in die Anlagenstruktur • hoher Einbauaufwand
Ultraschalllanze	• geringer Eingriff in die Anlagenstruktur (nur eine Bohrung erforderlich)	• nur Ausschnitte des Profils messbar • Winkeljustage schwierig • wegen der Größe der Sensoren in Rohren <DN100 nur bedingt brauchbar
Ultraschallmessung als Clamp-On-Technik	• kein Eingriff in die Anlagenstruktur	• Gasdruck muss ausreichend hoch sein • Schalldämpfung von CO2 kann problematisch sein • Temperatur- und Druckmessungen sind nicht möglich • Innendurchmesser des Rohrs kann nicht direkt gemessen werden
Einpfad-Ultraschallmessung mit Manschette	• geringer Eingriff in die Anlagenstruktur (2 Bohrungen) • Sensoren können in verschiedenen Manschettengrößen eingesetzt werden	• Starke Vorstörungsempfindlichkeit
Wirkdruckmessung (mit Prandtl-Sonde)	• geringer Eingriff in die Anlagenstruktur (nur eine Bohrung erforderlich)	• Sehr starke Vorstörungsempfindlichkeit