Investigation of in-line pressure effect on Pitot tube measurements

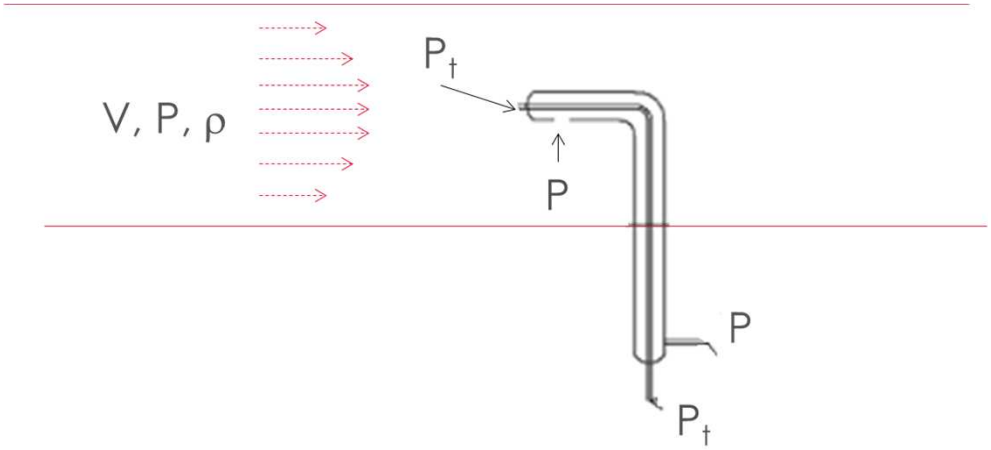
Isabelle CARE, LNE-CETIAT (France)

CETIAT
ensemble, innover et valider

Introduction

- Flow measurement with a Pitot tube
  - **Bernoulli's equation**
    - $P + \rho \times \frac{V^2}{2} = P_t$
    - Solved for velocity

$$V = \sqrt{\frac{2 \times (P_t - P)}{\rho}}$$



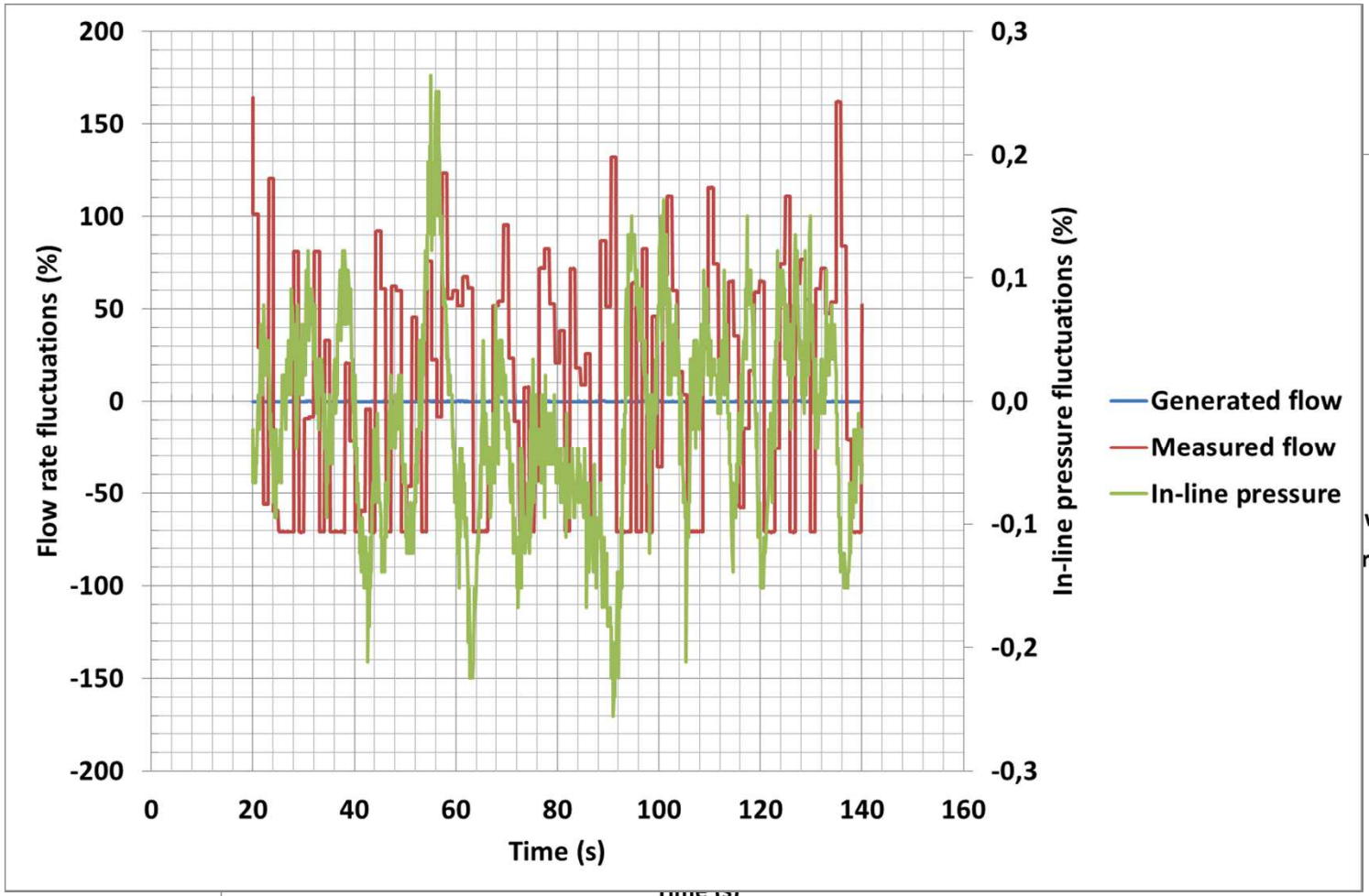
Measured by a differential pressure instrument assuming:

✓ Exactly the same static pressure at the two pressure tap types (static/total)

✓ Exactly the same time response of the two pressure lines

CETIAT ensemble, innover et valider

Introduction

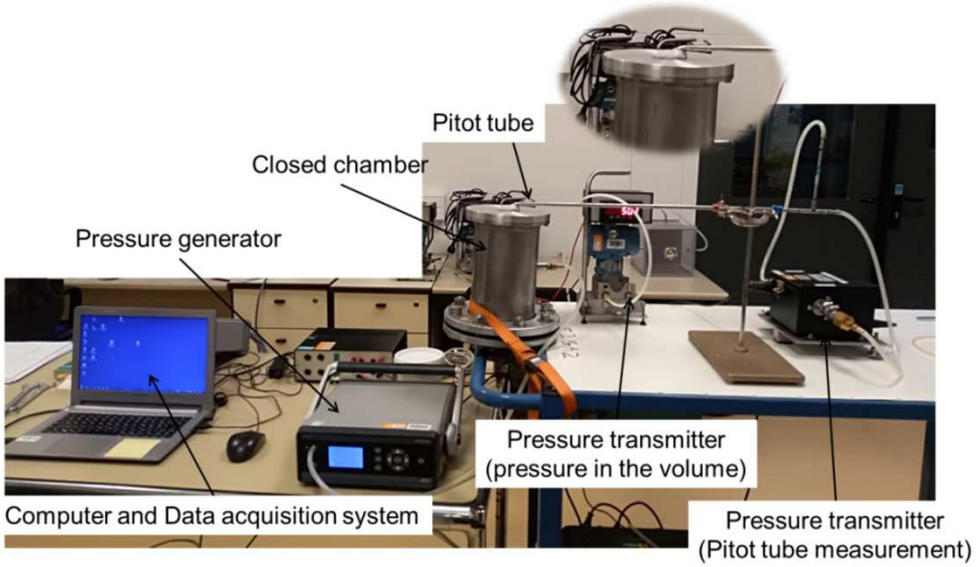


- ✓ Stable flow rate (3 m^3/h)
- ✓ Stable over pressure in the duct (150 mbar)

- ✓ **Measured flowrate with Pitot tube:**
  - ✓ **Overestimation of 10%**
  - ✓ **Highly fluctuating: 60%**

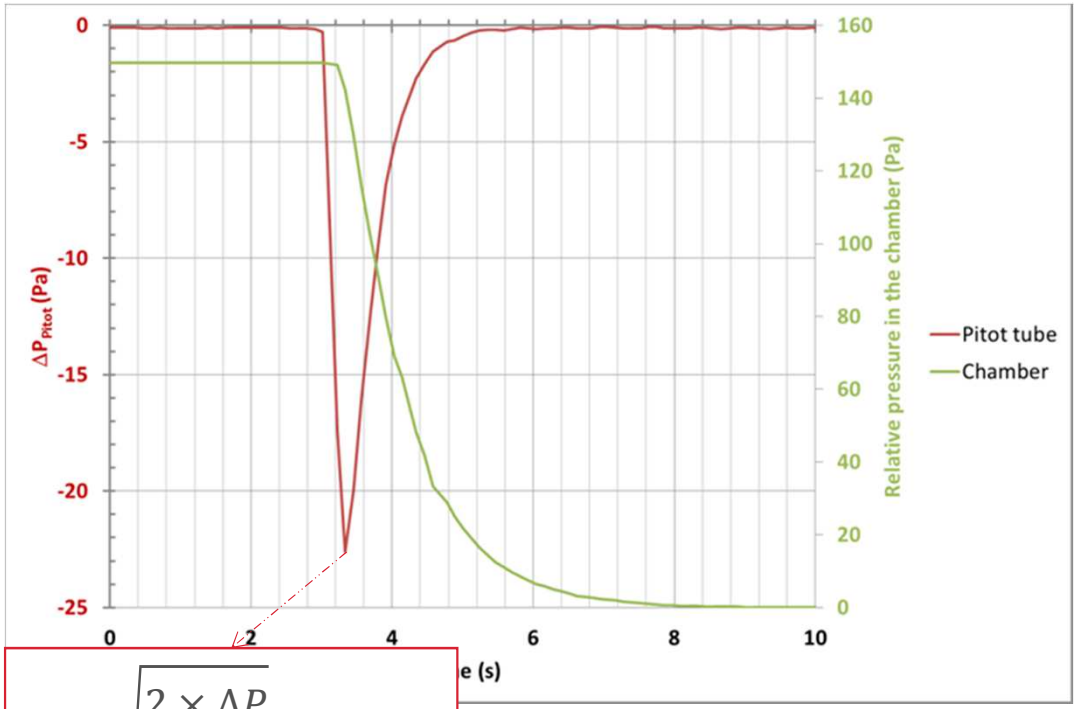
Introduction

- Experimental tests in 2018
  - **8 different Pitot tubes**
  - **Measurement of the response time when changing the pressure in a vessel**

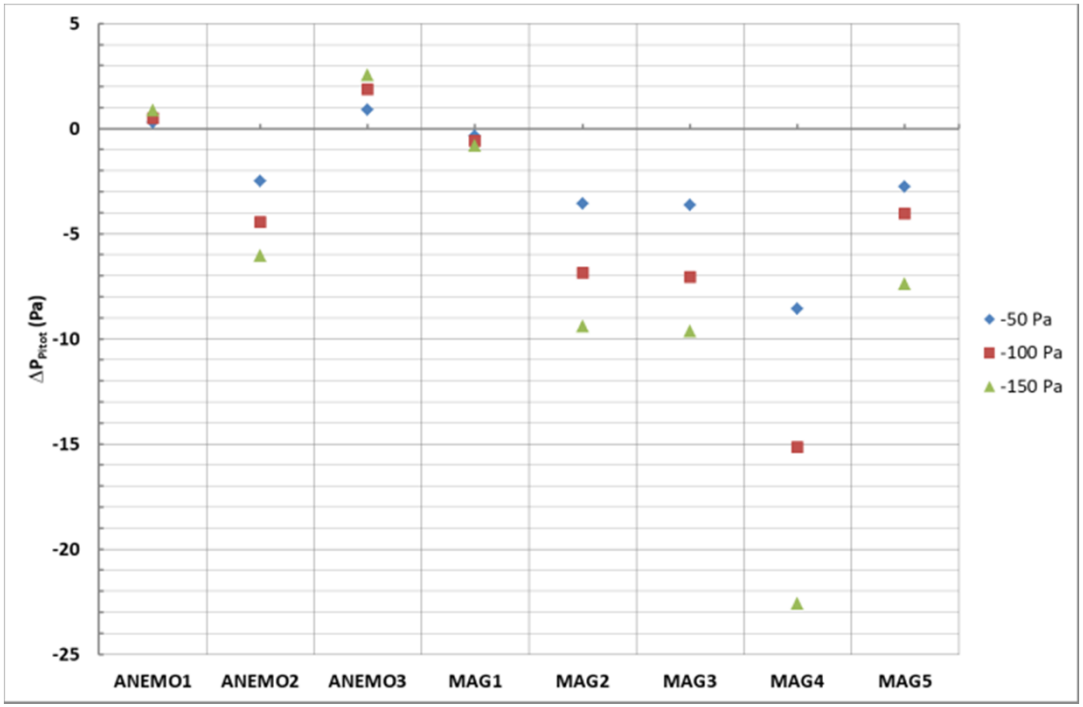


CETIAT
ensemble, innover et valider

Introduction



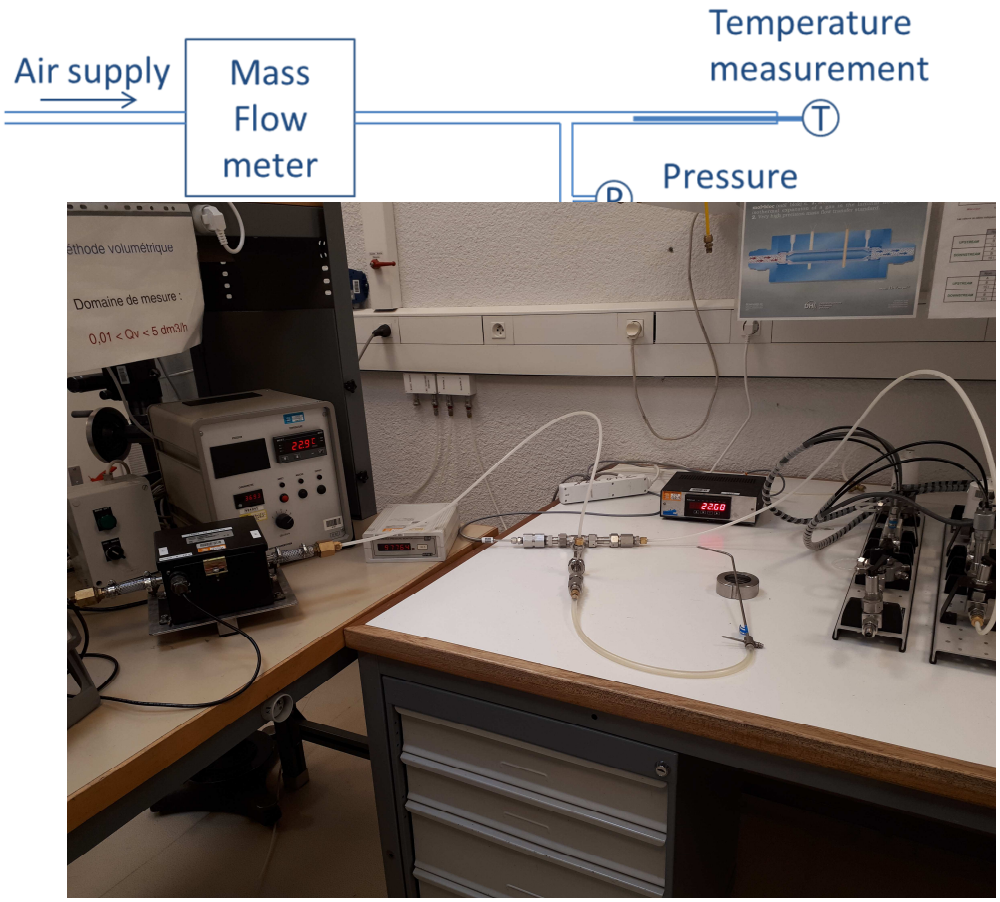
$$V = \sqrt{\frac{2 \times \Delta P}{\rho}} \approx 6\ m/s$$



CETIAT
ensemble, innover et valider

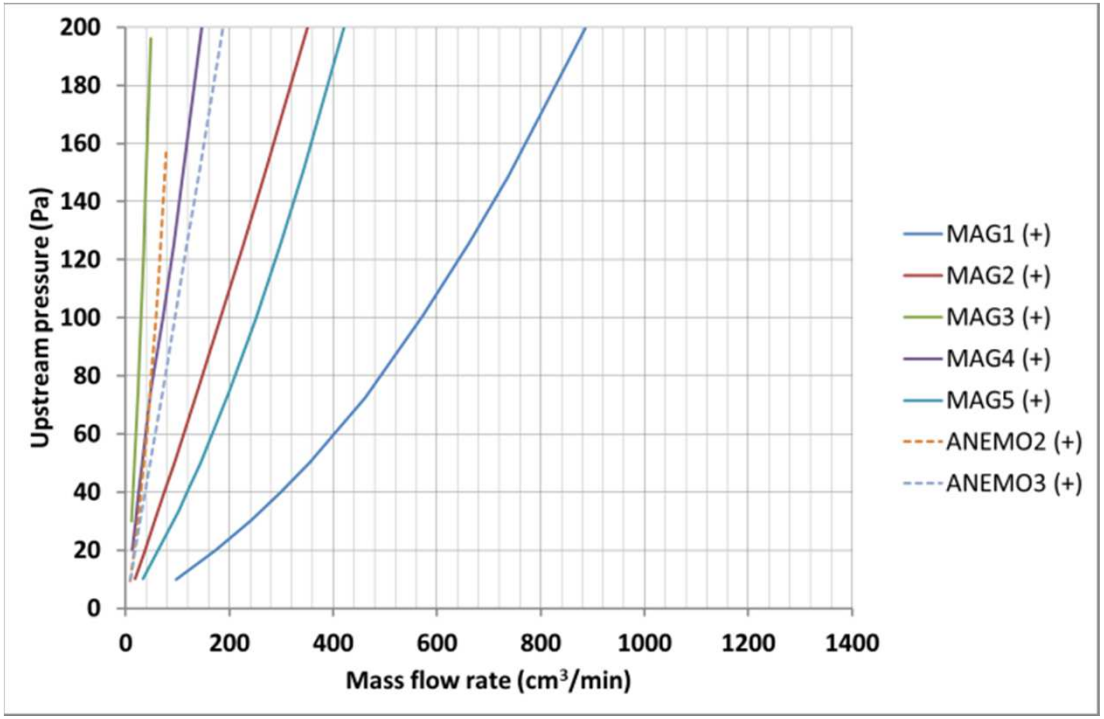
Experimental setup

- Objective
  - **Resistance of the two pressure lines (static, total)**
- Method
  - **Measurement of the flow rate**
    - Given upstream pressure at line 1
    - Atmospheric pressure at line 2

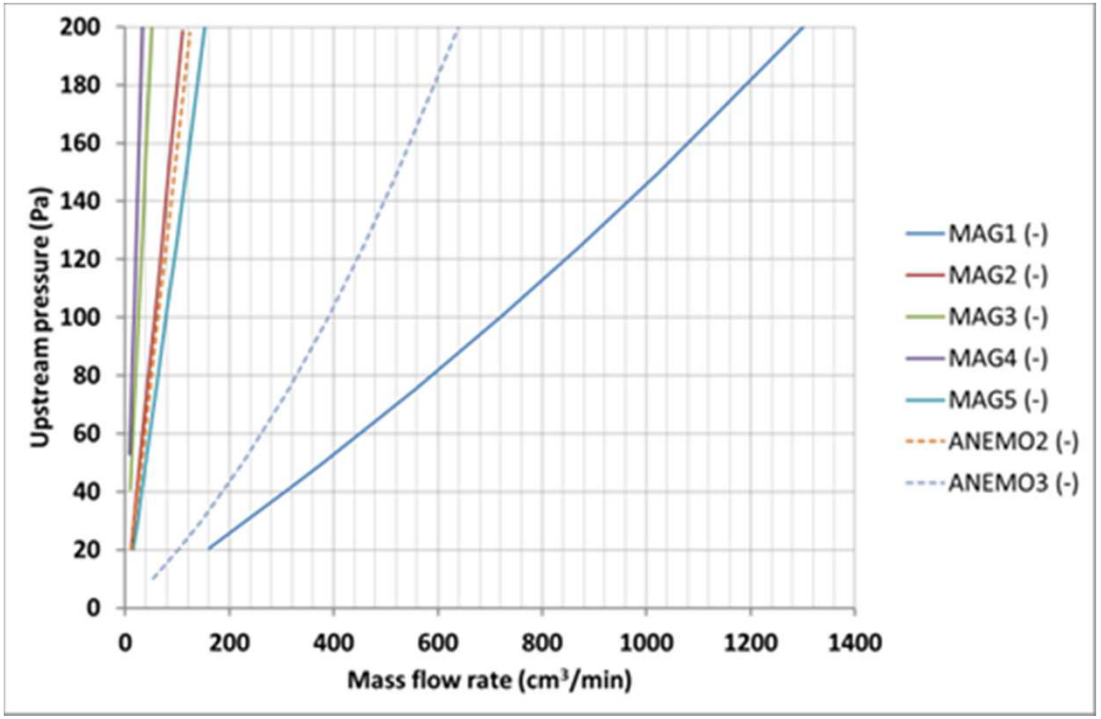


Results

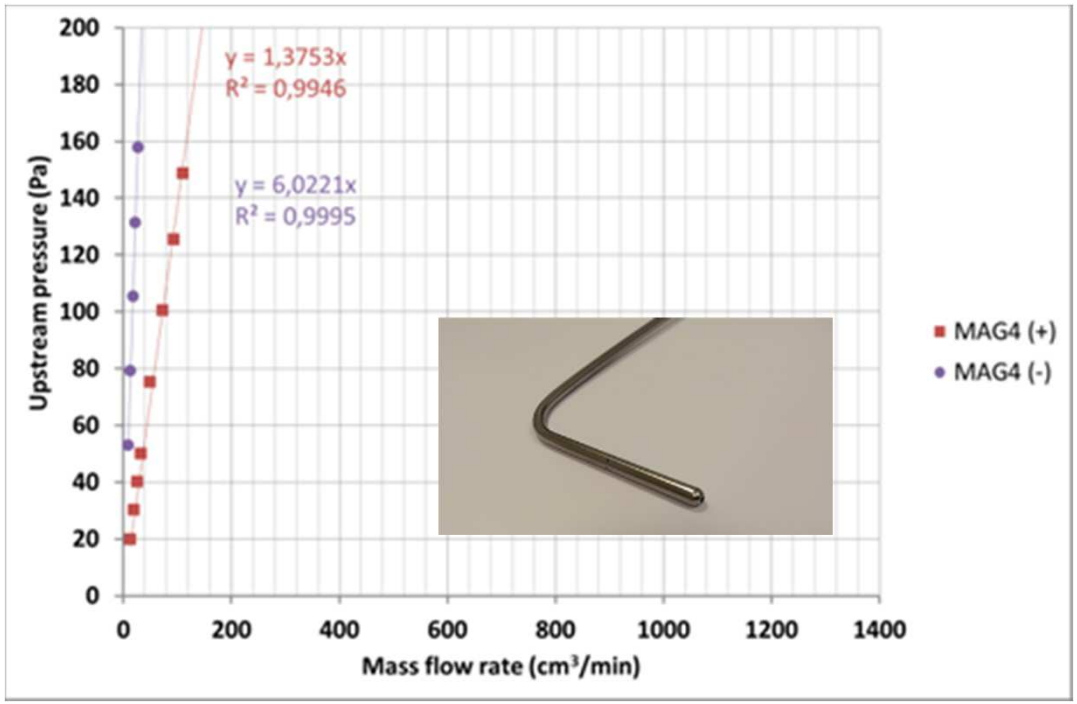
Total pressure line

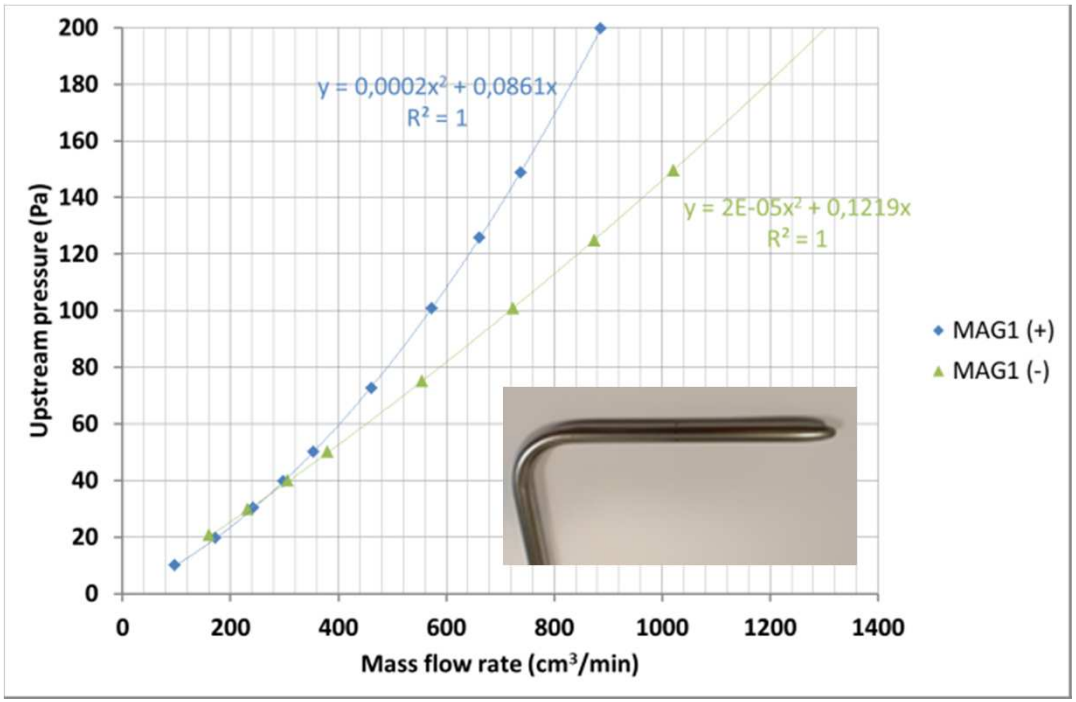


Static pressure line



Results


y = 1,3753x
R² = 0,9946
y = 6,0221x
R² = 0,9995
Upstream pressure (Pa)
Mass flow rate (cm³/min)
MAG4 (+)
MAG4 (-)

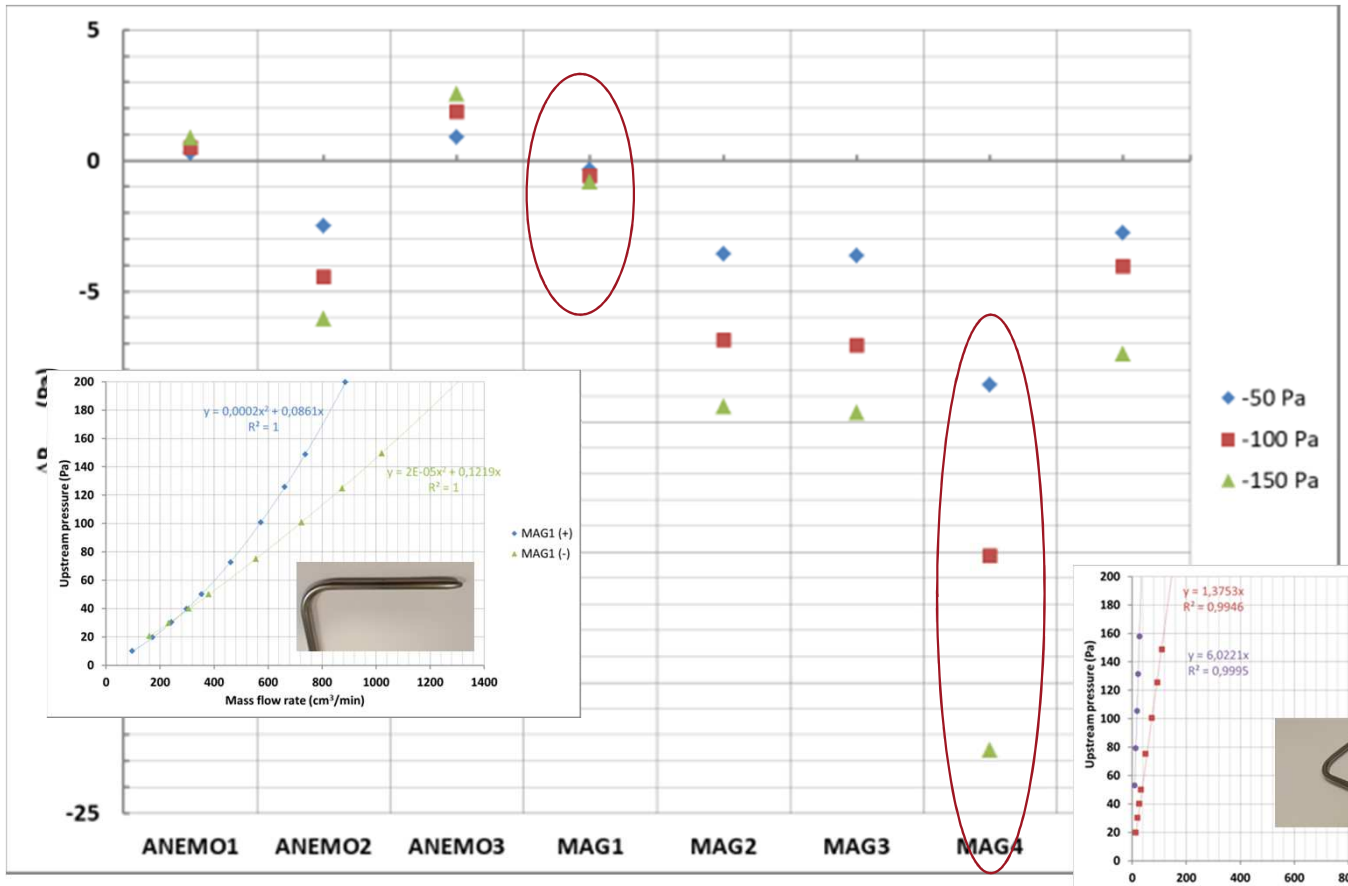

y = 0,0002x² + 0,0861x
R² = 1
y = 2E-05x² + 0,1219x
R² = 1
Upstream pressure (Pa)
Mass flow rate (cm³/min)
MAG1 (+)
MAG1 (-)

Discussion

- Resistance of the pressure line
  - **High (i.e. low flow rate)**
    - Linear relation to the flow rate
  - **Low (i.e. high flow rate)**
    - Linear + quadratic relation to the flow rate

    - Smaller time to reach equilibrium
    - Error on differential pressure measurement close to zero

Discussion



CETIAT
ensemble, innover et valider

Conclusion

- Unexpected fluctuations of flow when using a Pitot tube

- Resistance of the static pressure line
- Not related by the Pitot tube type or diameter

Domaine scientifique de la Doua
25 avenue des Arts – BP 52042
69603 VILLEURBANNE CEDEX - FRANCE

Mail : isabelle.care@cetiat.fr

www.cetiat.fr

CETIAT
ensemble, innover et valider