Siargo Ltd.

Liji Huang

Siargo Ltd.

Santa Clara, California

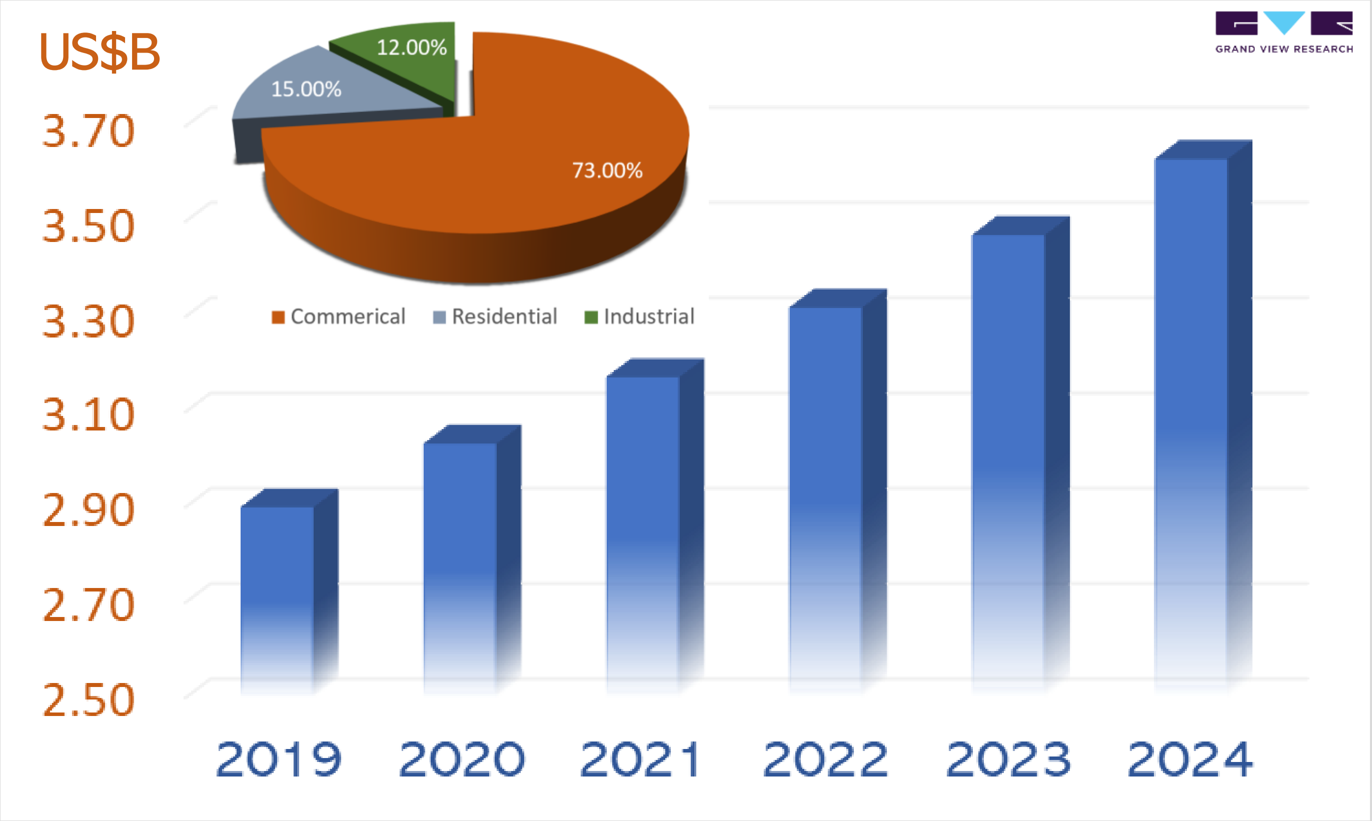
Gas Flow Meters with Thermal Time-of-Flight Technology

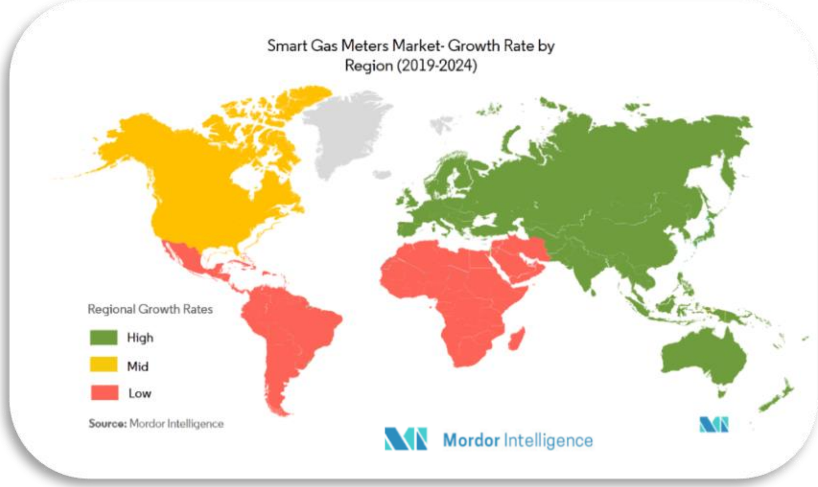
Utility Gas Meters

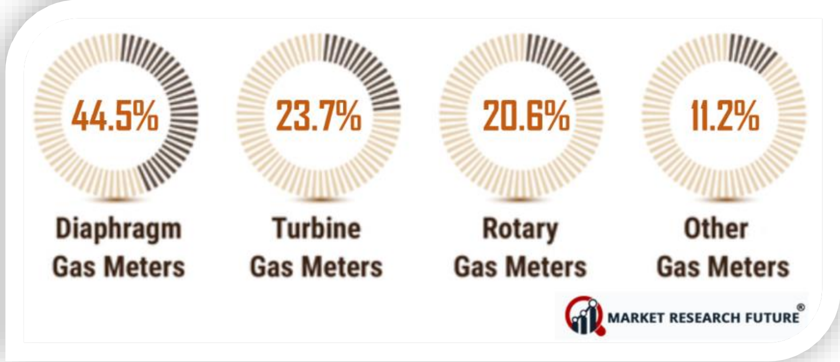
FLOMEKO2019
18th International Flow Measurement Conference
Portugal | Lisbon | LNEC | 26-28 june 2019

Backgrounds
– market for utility gas metering

Huge market with smart gas meters for commercial application leads the growth.





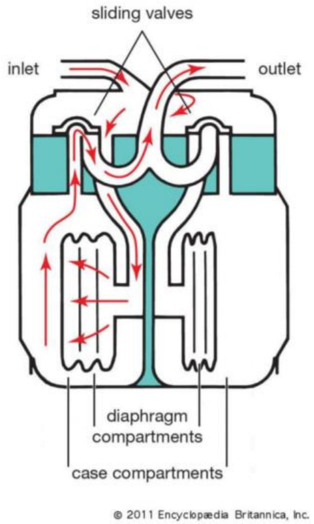


Backgrounds

Diaphragm meter is the best flow meter technology that enjoys the longest lifetime in the vast installation

1860

1910

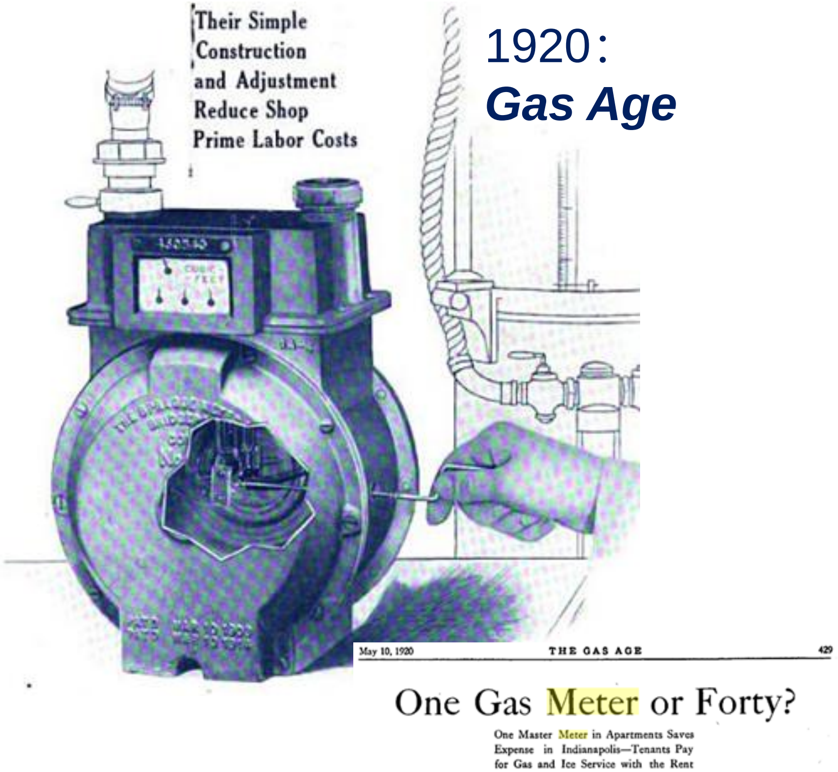


Prepayment meter from Cleveland Meter Company.

2010

1920:

Gas Age



Electronic utility gas meters

Starting in 1980s-90s (ultrasonic) and 2000s (MEMS calorimetric)

- The earlier ultrasonic meter deployment was not very successful, but it revives in recent years with limited success; it is however still volumetric custody transfer
- Siargo deployed its commercial calorimetric gas meters since 2007
- MeteRSit installed its calorimetric gas meters since 2013, very successful in Italy.

MEMS calorimetric utility meters deployment in Italy

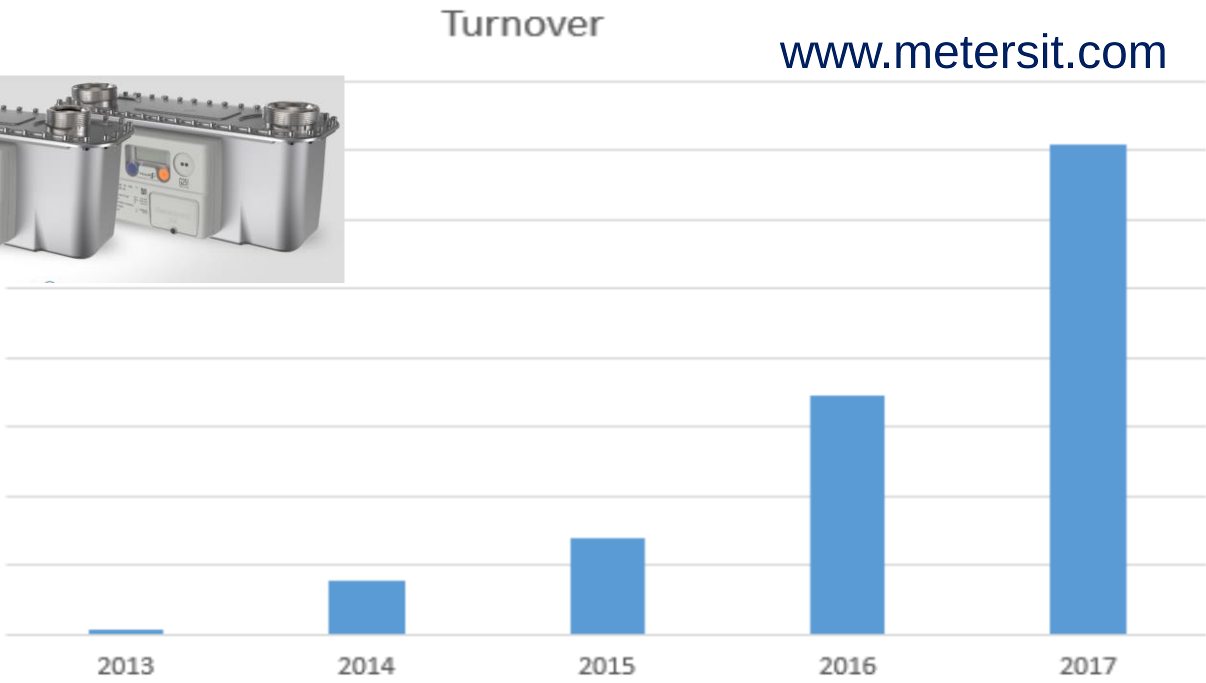
1.900.000

The installation of our meters started in second Half 2012.
Today (2018) more than 1.900.000 MeteRSit meters are working in field, with a proven failure rate from field of 0,26%.

+200%

We faced a strong growth during these last years and we foresee an additional growth rate for the future

www.metersit.com



MeteRSit

Current issues with calorimetric utility gas meters

- Conflicts with the existing metrology standards (volumetric)
  - Gas composition induced varieties (EN 437)
    - Establishing the metrology relevance
- Intrinsic temperature effects
  - Added additional metrology uncertainties
- Contamination – dust test uncertainties with EN 14236
- Electronic drifting – quantification methodology
- Power issue – battery life and failure

Histroy of the products

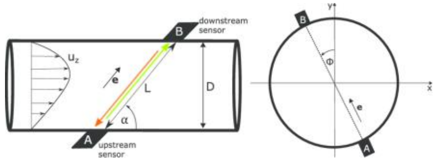
- Calorimetry
- CH_4 + GCF
- Battery powered
- 2 Serials/10 Models

- Calorimetry
- Gas Identification
- Offset stability
- Battery power
- 2个 Serials/10 Models

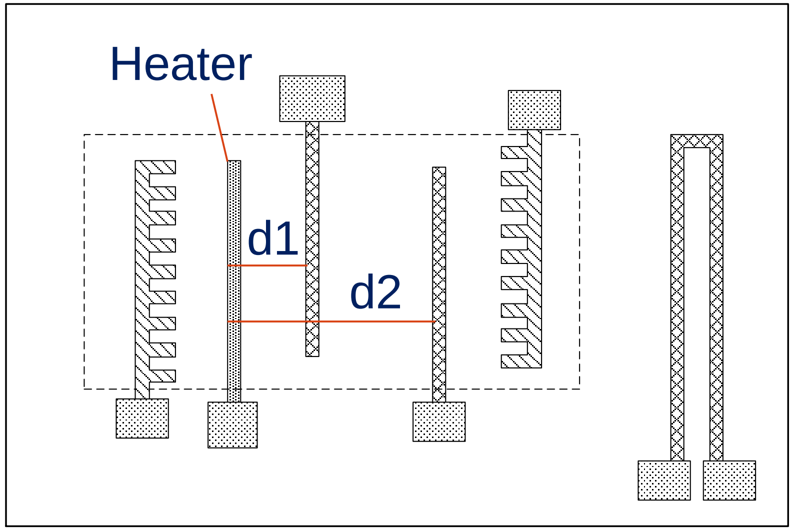
- TTOF+Calorimetry
- Gas identification
- Offset stability
- Thermal values
- Contamination diagnosis
- Battery + Energy Harvester

2004 – 2010 (GEN 1) 2014 – 2020 (GEN II) 2020 - (GEN III)

Technology advantages

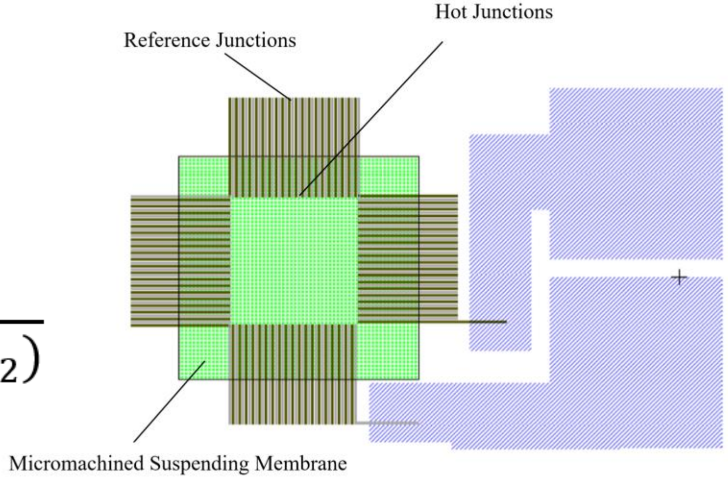
	Ultrasonic	Thermal Time-of-flight
		 
Metrology	Volumetric	Calorimetric + volumetric
Digital data	√	√
Temperature	Additional device	√
Pressure	Additional device	√
Thermal value	X	√ **(possible)**
Contamination	X	Via comparison and conductivity
Offset	X	√
Energy harvester	X	√

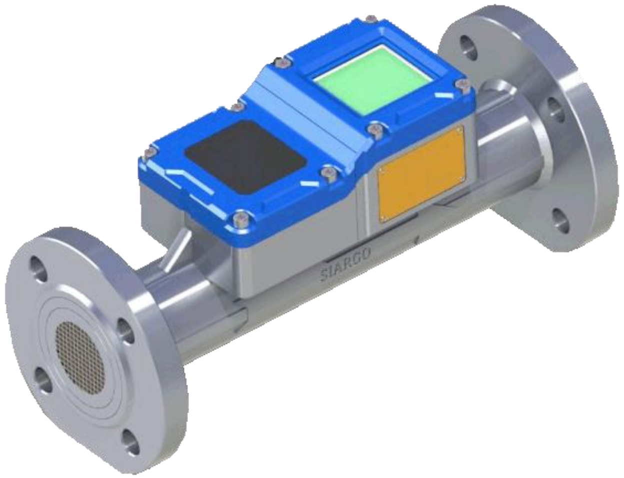
Design of the sensor and meter

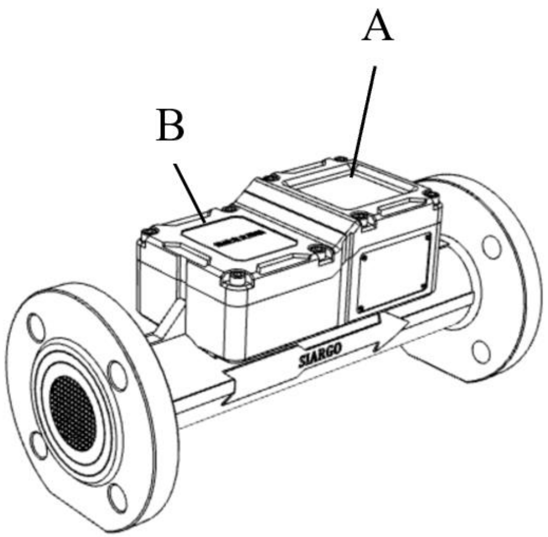


$$\frac{\partial T}{\partial t} = D\left(\frac{\partial^2 T}{\partial x^2}\right) - V_x\left(\frac{\partial T}{\partial x}\right)$$

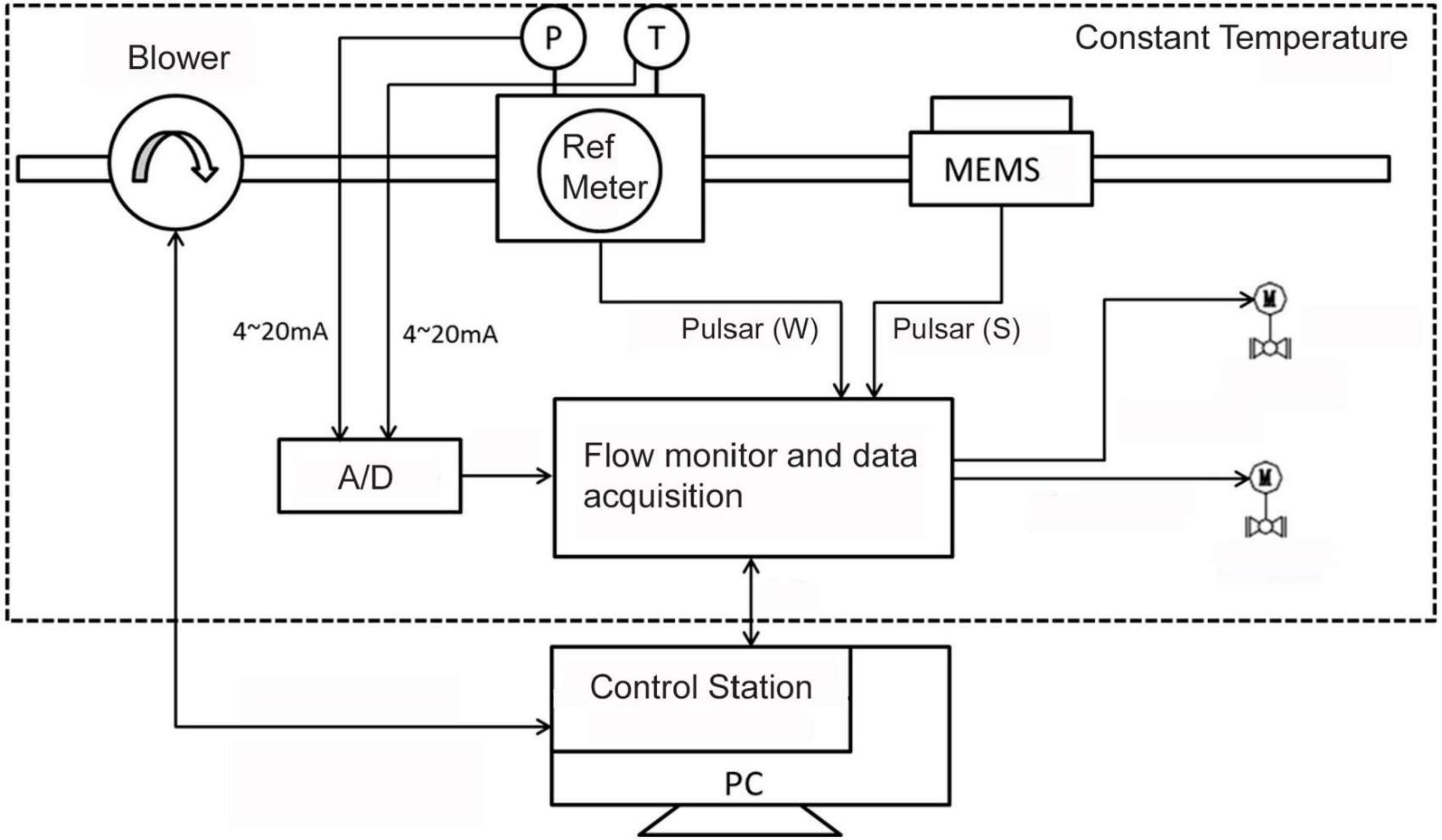
$$V_x = \sqrt{(d_1^2/t_1 - d_2^2/t_2)/(t_1 - t_2)}$$





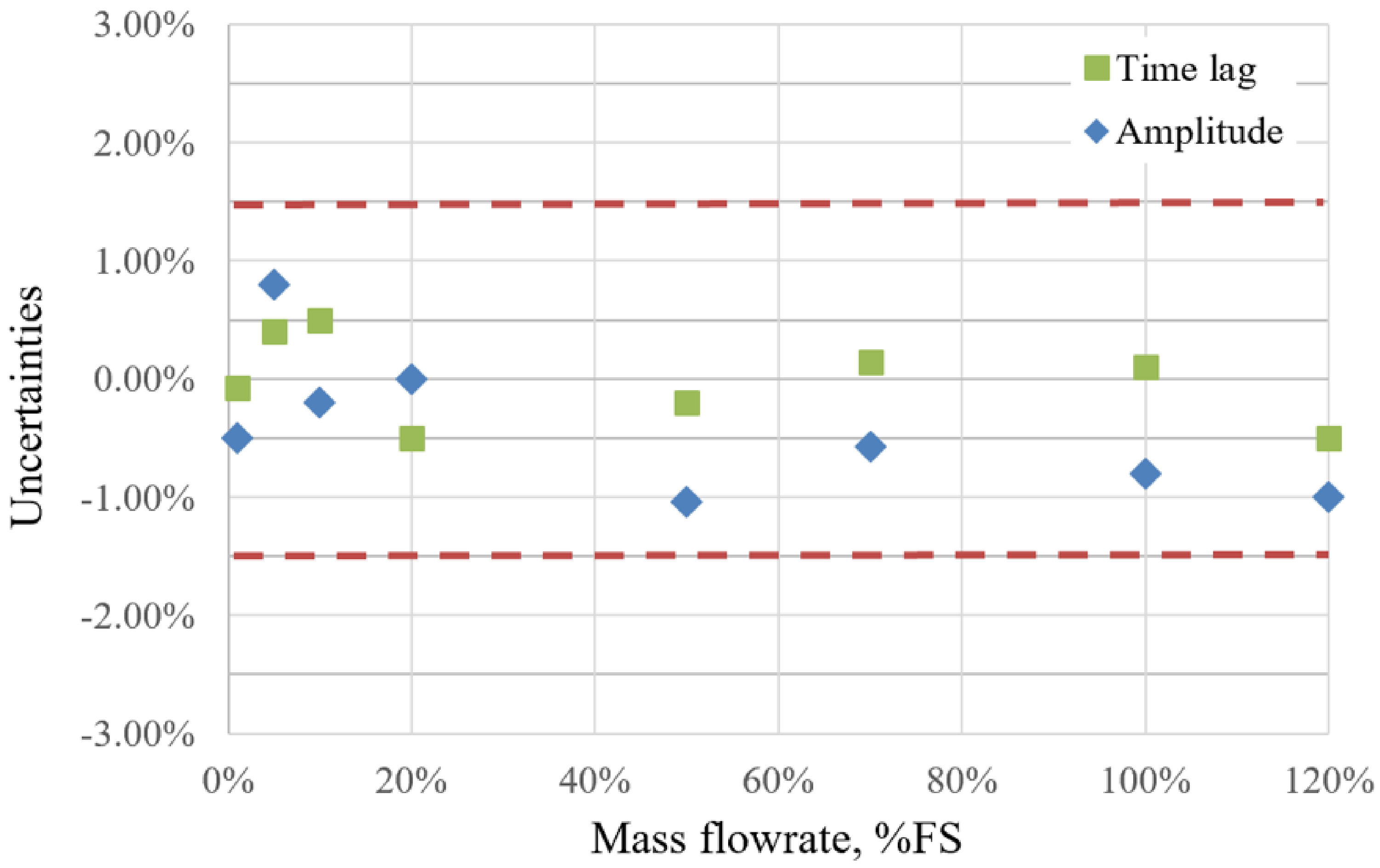


Positive pressure real gas test ring



- Shinagawa W-NK Wet meter as the reference; ±0.5% uncertainties
- A blower with variable frequency to adjust flowrate

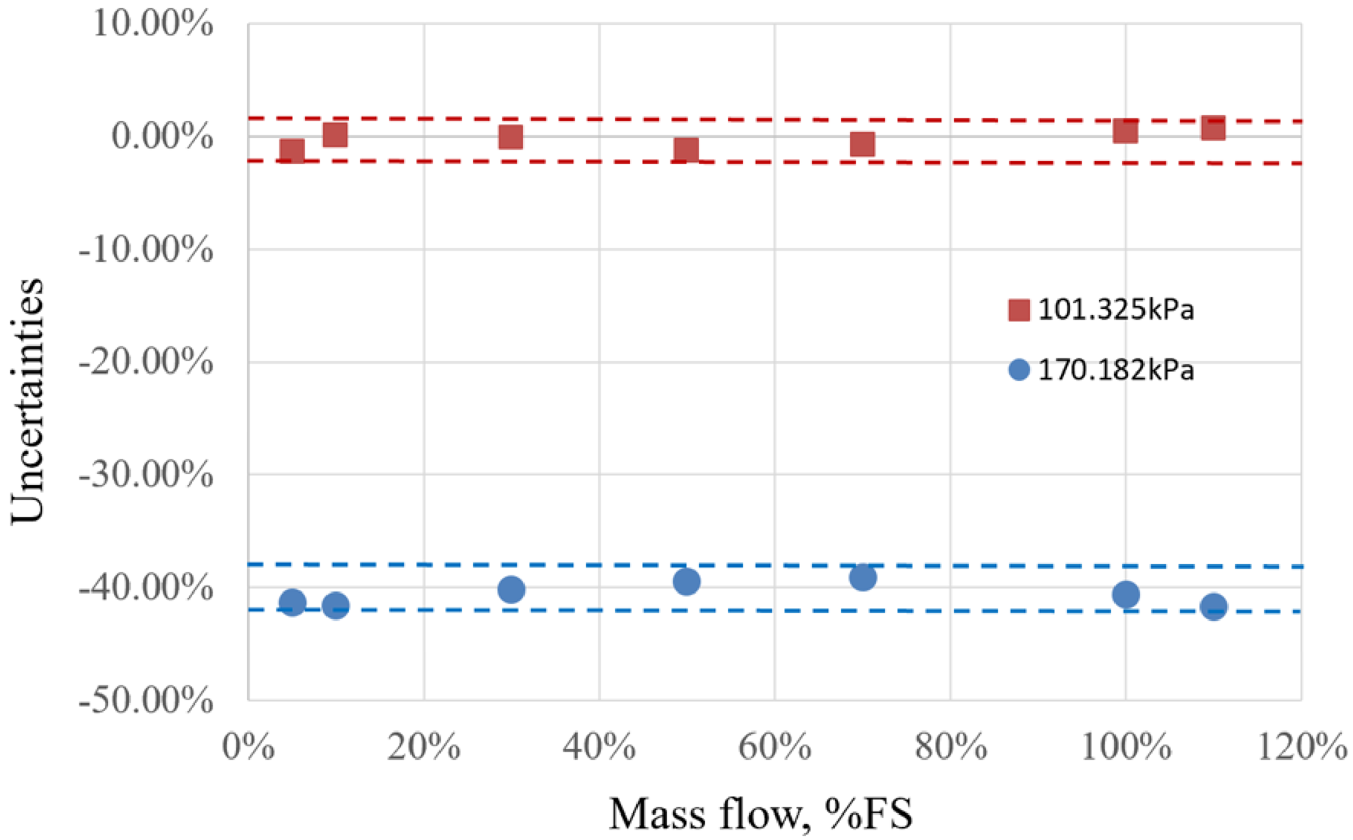
Calibration in air



Calibration in air: The uncertainties measured from time lag and amplitude data at the reference conditions.

Pressure verification for TOF

$$(V_1 - V_0)/V_0 = (P_0/P_1) - 1 = 101.325/170.182 - 1 = -0.404$$



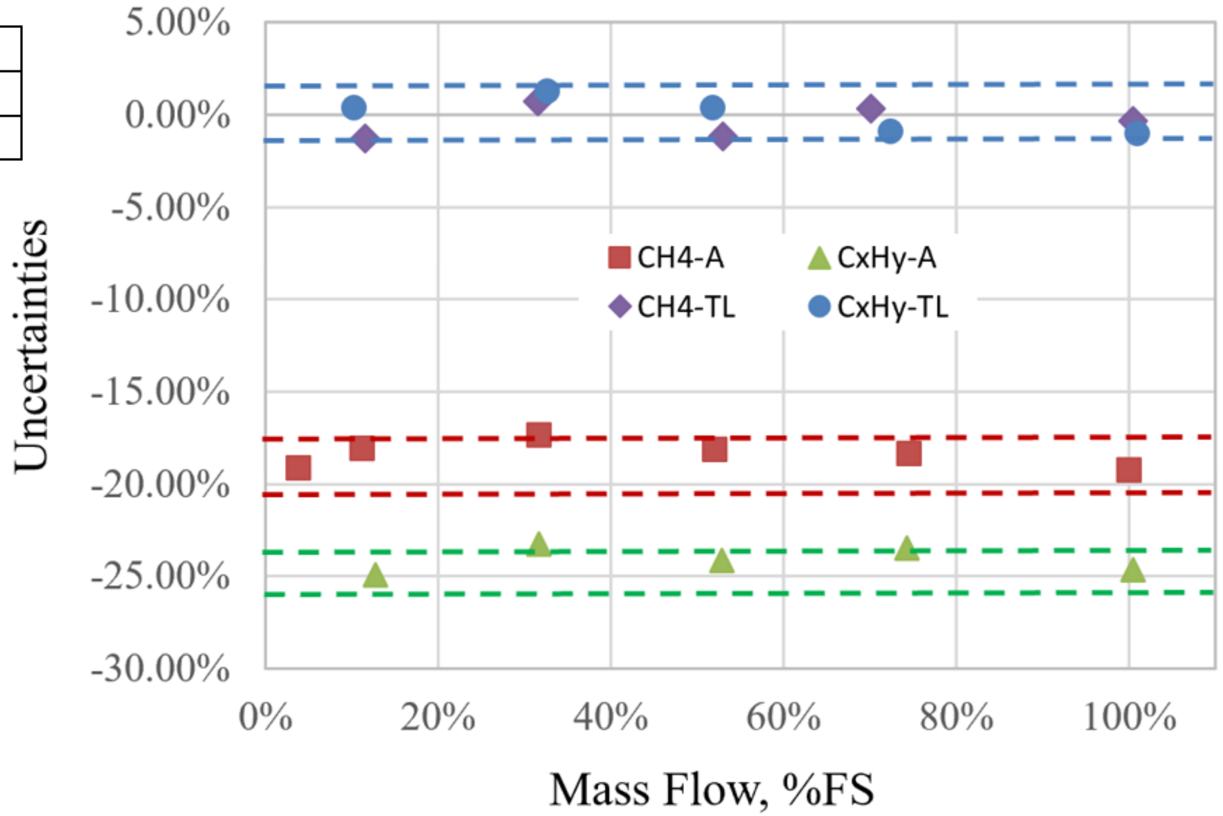
Pressure verification: Time lag data verification against different pressure at the reference temperature.

Pressure verification for TOF

Table 1: Compositions of the natural gases tested.

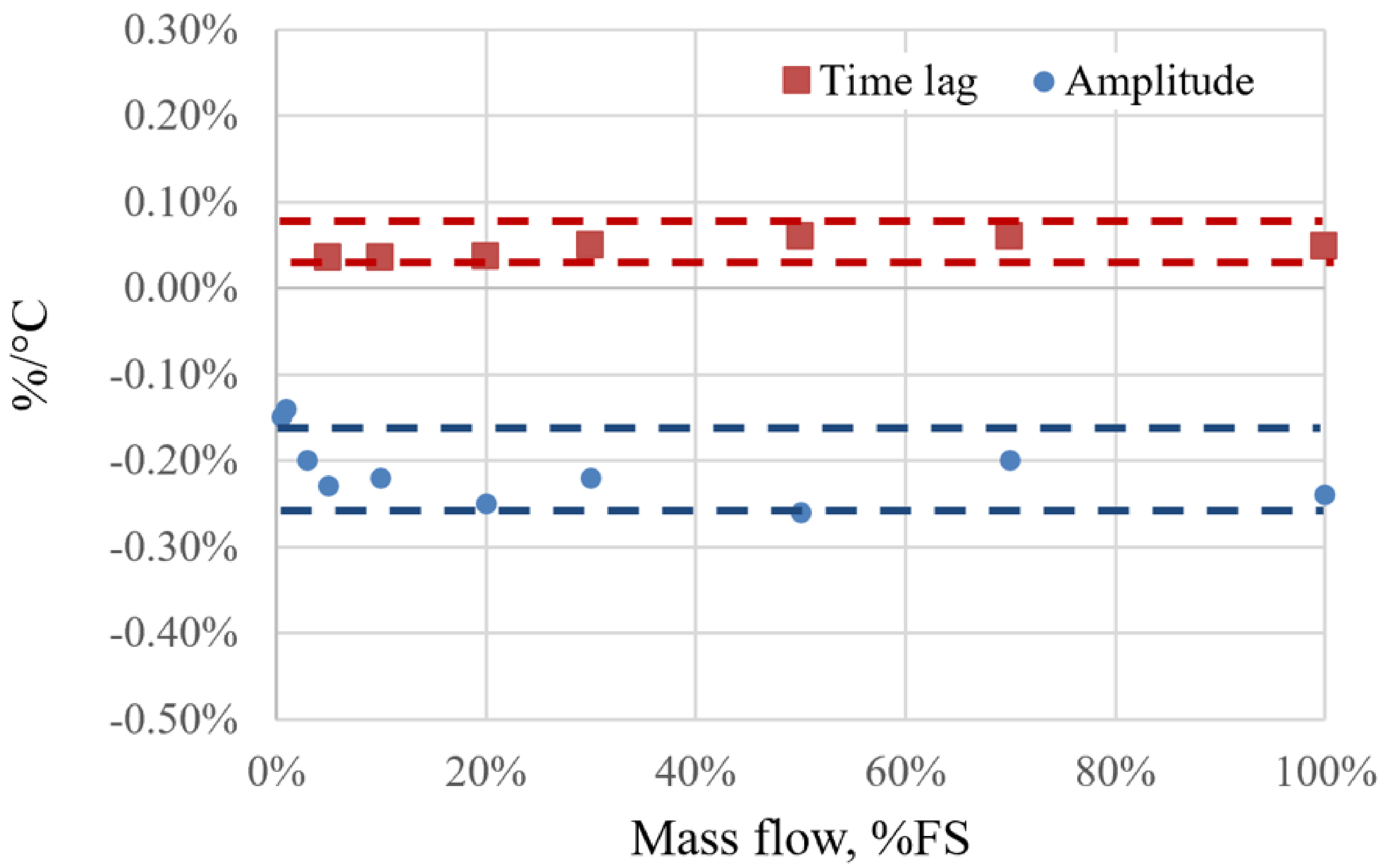
Gas \ Con.	CH4	C2H6	C3H8	Others
CH4	100%	0	0	0
CxHy	86.9%	8.5%	2.3%	2.3%

- Time lag data vs. amplitude data showing the different metrology characteristics



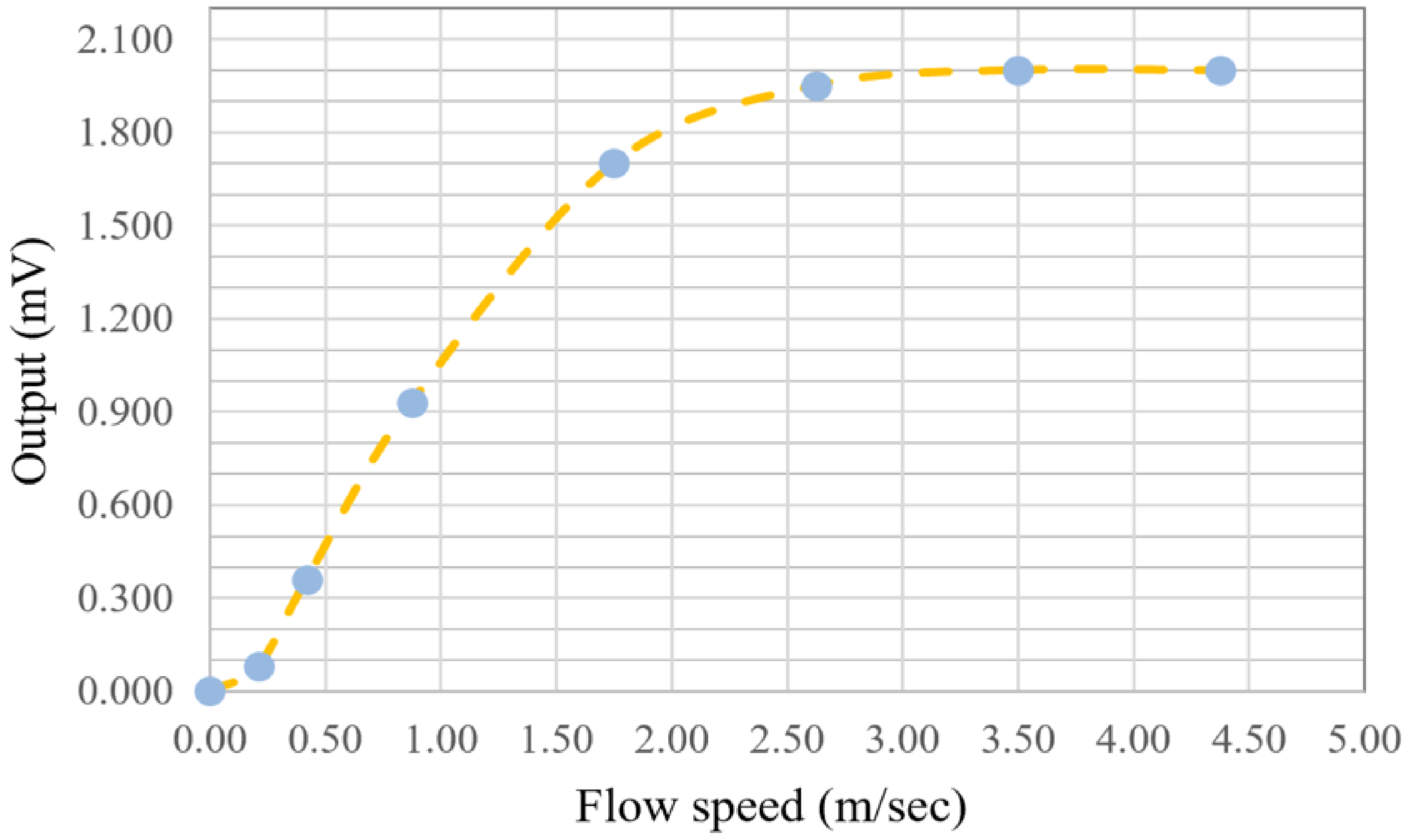
Gas data Verification measurements for gases with different compositions.

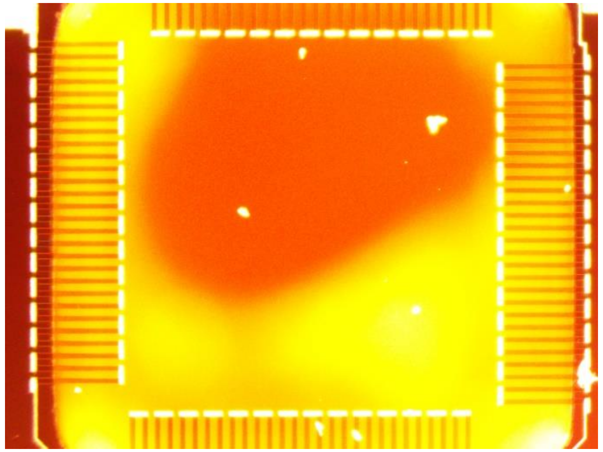
Temperature performance



Temperature performance: Verification measurements for gases with different compositions.

Thermal harvester





Raw output of the harvester: Direct output from a thermal (temperature) energy harvester.

Concluding remarks

- **A thermal time-of-flight technology based on MEMS sensing scheme is demonstrated**
  - **Have better stability in performance compared to calorimetry**
  - **Easy to perform gas identification**
  - **Multiple parameters for self-diagnosis**
  - **Thermal value direct measurement viable**
- **“Powerless” thermal mass flow with energy harvesting can be achieved in a limited dynamic flow range**