Smart pressure driven and regulated dispenser for the nanoliter and microliter range

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Overview

- **Non-contact dispenser** for the microliter range
- Driven and **regulated by pressure**
- **Direct control of the dispensed volume**
- **Autonomous temperature compensation**
- **One parameter change for 500 nl to 10 µl**
- Viscosities from 1 to 17 mPas

Introduction

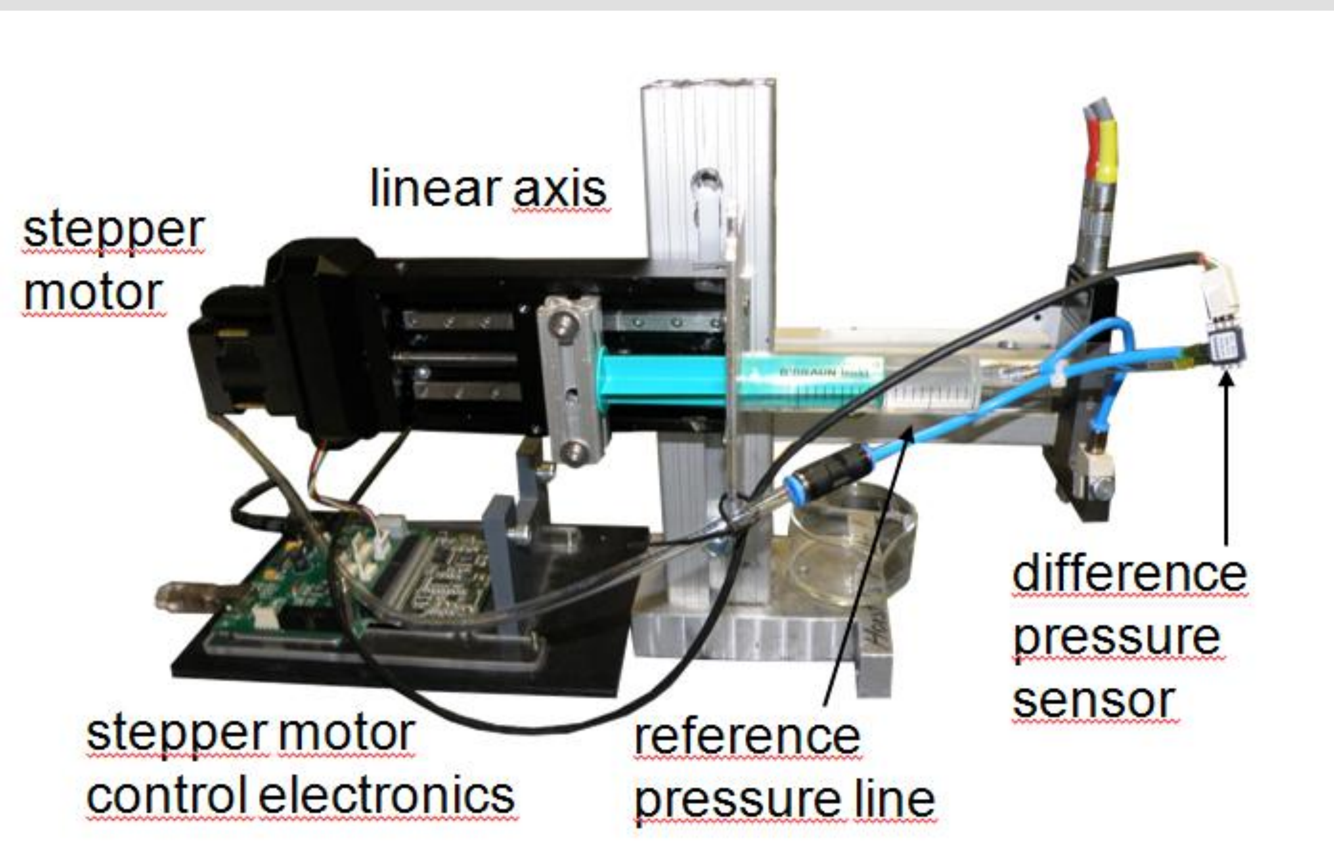
The precise non-contact dispensing of volumes between 250 nl and 25 µl is an important issue for in vitro-diagnostics (IVD), high-throughput screening (HTS) and industrial applications [1, 2]. Covering such a large volume range with high precision is a challenging problem, especially when non-contact dispensing of different liquids is required. Pipetting tools currently used present two main problems:

- 1 – Cross-contamination risks and cleaning protocols
- 2 – No online monitoring of the dispensed volumes
- 3 – Calibration for different liquids needed

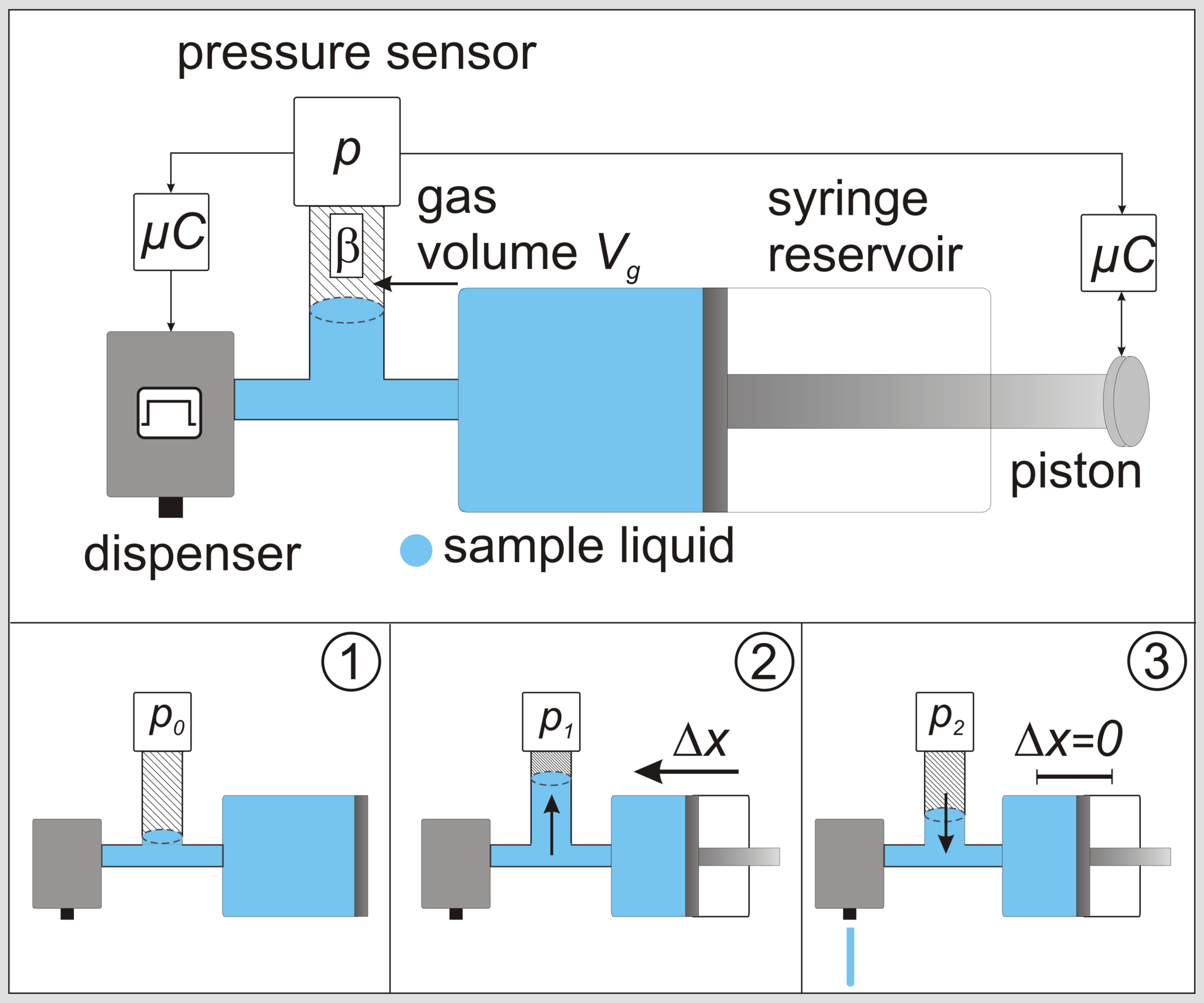
Our system addresses these problems by using a pressure actuation and a pressure sensor to control the Dispensed volume (patent pending).

Materials

Valve: ***Vermes MDV 3020A***
Nozzle: PEEK – diameter 150 µm
Stepper motor:
Syringe: ***Braun Syringe 20 ml***
Pressure sensor: ***HDIM100UF8P3 (SensorTechnics)***
Difference pressure sensor 100 mbar
Sensitivity 10 mV/mbar
µController: ***MSP430F149 – 8 MHz***



Working principle



Typical dispense run

1 – Initial state → P_0 = atmospheric pressure
2 – Syringe displacement → P_1 = elevated pressure
3 – Opening of the valve → Fluid is dispensed an pressure drops to end value → P_2

When does the dispense end?

When the integral of the pressure signal reach ***I*** (µC).

Why?

Because the volume of fluid dispensed V_{fluid} is proportional to the pressure integral ***I***

$$\underbrace{V_{fluid}} = \int Q_{fluid}\,dt \approx \frac{1}{R_{fluid}} \underbrace{\int \Delta P dt \propto I}$$

R_{fluid} is the unknown fluidic resistance

How much fluid is dispensed?

Use of the Boyle-Mariotte law after the dispense:

$$p_0 * V_g = p_1 * V_1 = p_2 * V_2$$

and

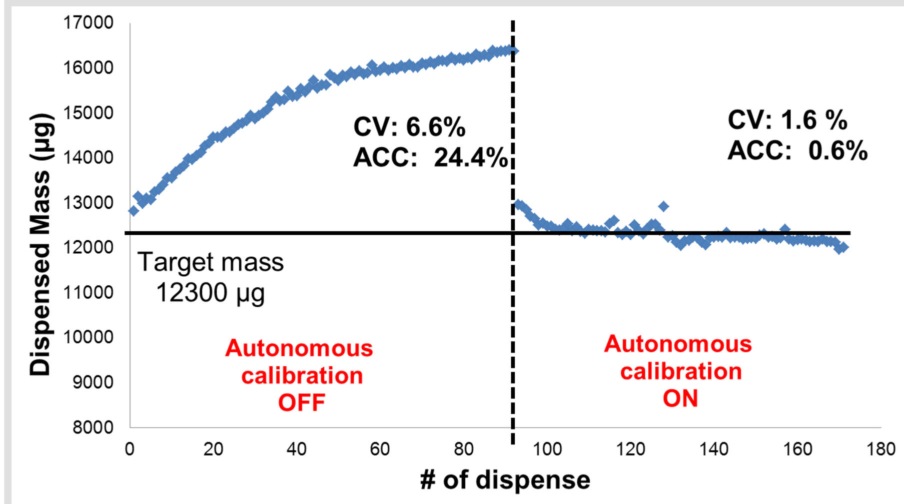
$$V_{fluid} = V_2 - V_1 = V_g * p_0 \left[\frac{1}{p_2} - \frac{1}{p_1} \right]$$

→ **Direct relation between *I* and V_{fluid}**
→ **No calibration required**
→ **Autonomous correction based on measured sensor signal**

Results

Liquid mass measurement by gravimetric method [3]:

Thermal drift compensation



 # 0 → 92: Volume grows due to change of viscosity caused by temperature

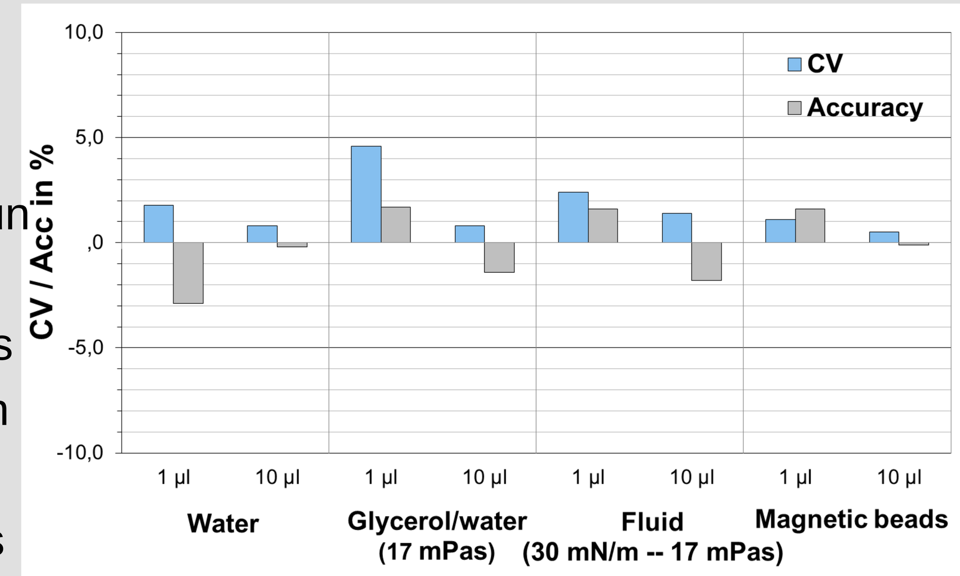
 # 92: Autonomous calibration ON

 # 92 → 170: Volume is calculated and dispense parameters are corrected.

Performance

Several fluid dispensed:

- 1 and 10 µL
- 24 dispenses/run
- Viscosities
  1 → 17 mPas
- Surface Tension
  30 → 70 mN
- Magnetic beads



Conclusion

- New pressure driven and regulated system
- **Online verification of the dispensed volume**
- Good accuracy (<3%) and precision (<5%) at 1 and 10 µl over a large range of fluids without calibration
- Successful real-time compensation of accuracy drift caused by viscosity changes due to temperature drift

Acknowledgements

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References

- [1] R. Bosse et al. Drug Discovery Today, 42-47, 2000.
- [2] J. Woelcke et al., Drug Discovery Today, 6, 637-646, 2001.
- [3] D. Liang et al, Proc. MFHS Conference, 2012.

Contact – More infos @ Booth #2032

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