METROLOGY for DRUG DELIVERY

MEDD II
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Displacement methods

Hugo Bissig (METAS), Elsa Batista (IPQ), Oliver Büker (RISE)

Workshop on microflow calibration methods
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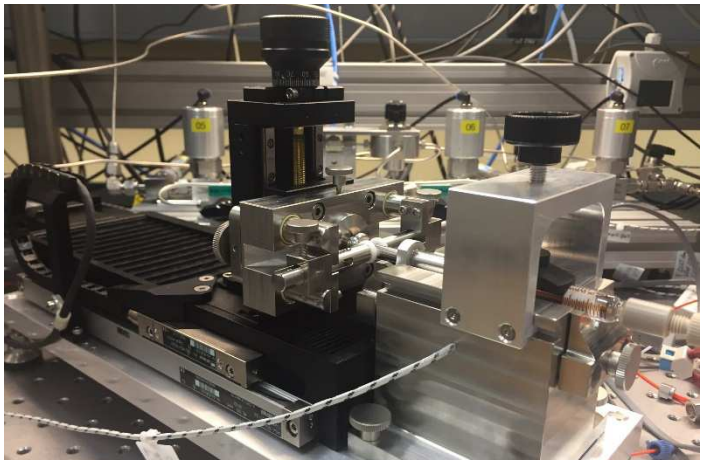
Displacement methods

Other expression for Piston Prover / Syringe pump to generate flow

METAS



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Piston Prover

Model function

$$Volume\ flow\ rate = speed \cdot cross\ section \cdot f_{stabilisation\ motion} \cdot f_{heating\ effects}$$

$$Q = \frac{dx}{dt} \cdot \pi r^2 \cdot f_{stabilisation\ motion} \cdot f_{heating\ effects}$$

Uncertainty components

- Travel distance d from linear measuring system or from motor encoder signal
- Time measurement
- Inner radius of the piston and ist variation over the length of the measuring distance
- Instability of the linear motion
- Repeatability
- Leakage of the sealing
- Heating effect due to the motion of the plunger
- Stability of temperature gradient along tubing inducing virtual flow

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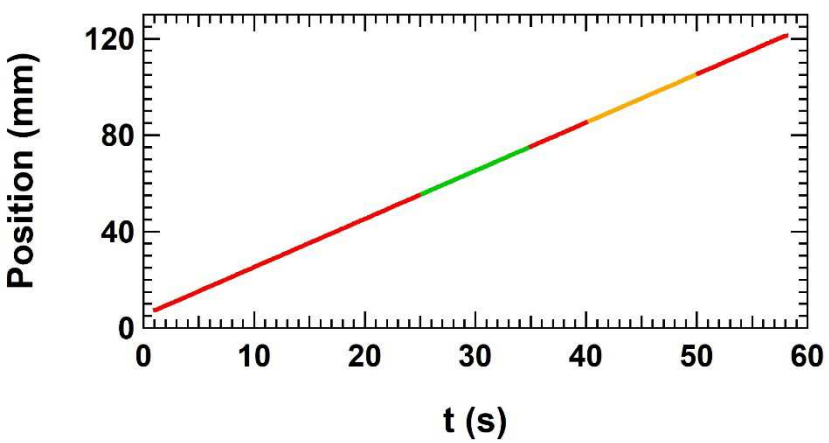
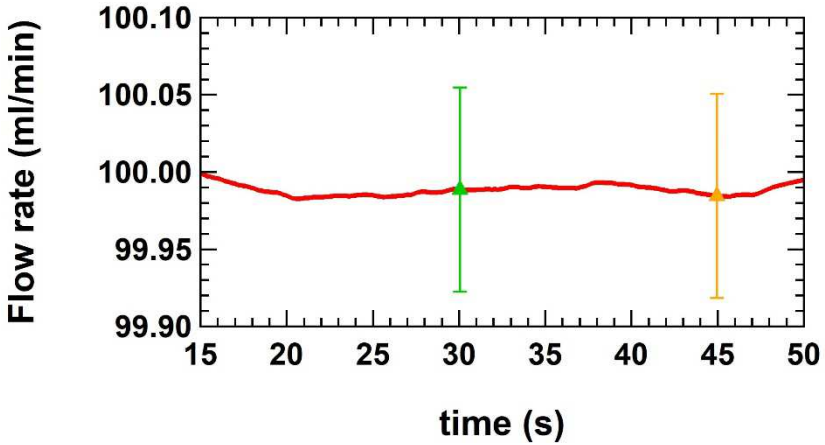
Speed of piston plunger

How to determine the speed of the piston plunger?

Get the position as a function of time





What are the options?

- Linear Measuring system calibrated by Interferometry
- Motor Encoder Signal calibrated by Interferometry
- Interferometer directly to get position vs time

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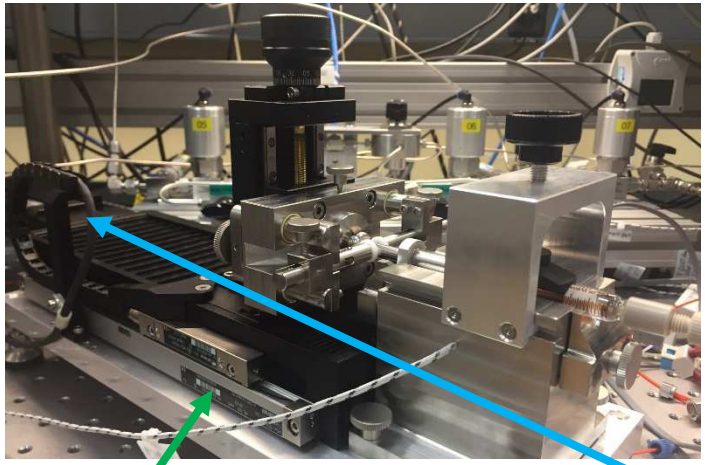
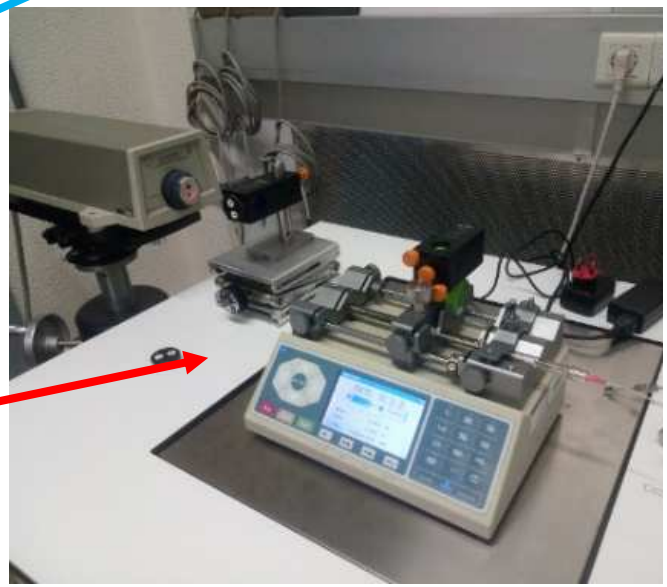
Speed of piston plunger





Linear Measuring system

Motor Encoder Signal

Interferometer directly

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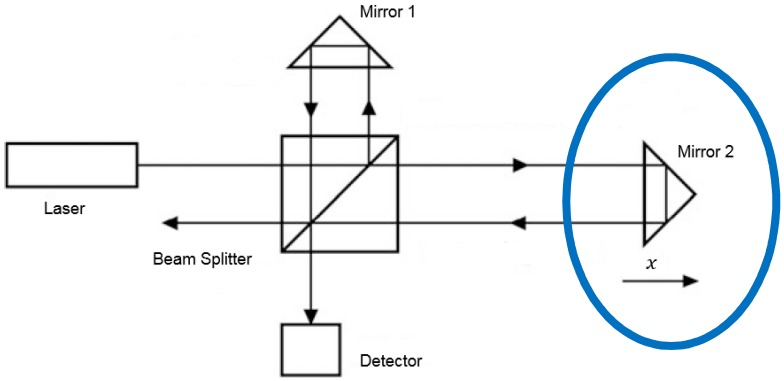
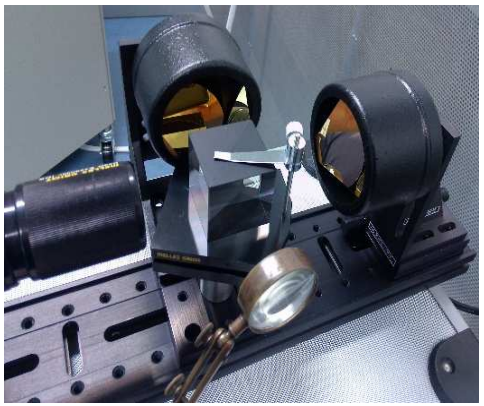
Speed of piston plunger

Interferometry

An interferometer is any optical arrangement in which two or more light waves are caused to interfere.



Position of the mirror



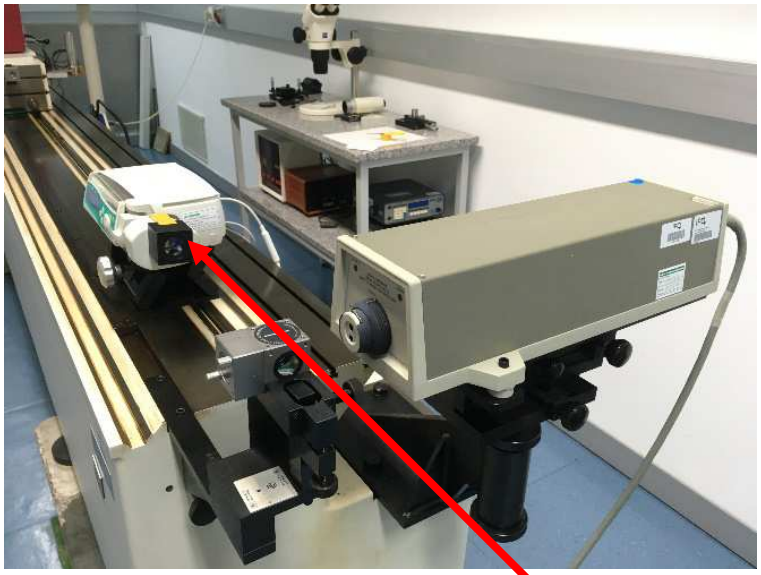
An interferometer determines distances in multiples of laser wavelength

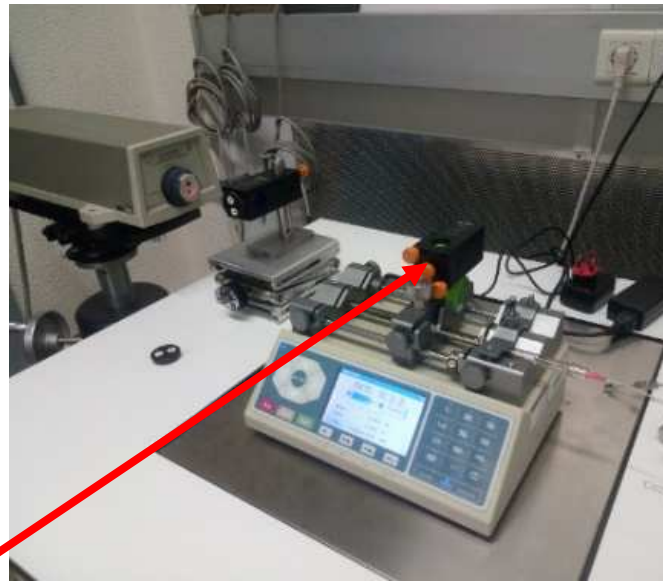
Uncertainty contributions from linear motion:

- Abbé offsets such as pitch yaw and roll
- linear and angular error

Speed of piston plunger

Interferometry





Mirror plugged on the plunger without any other signal from the movement

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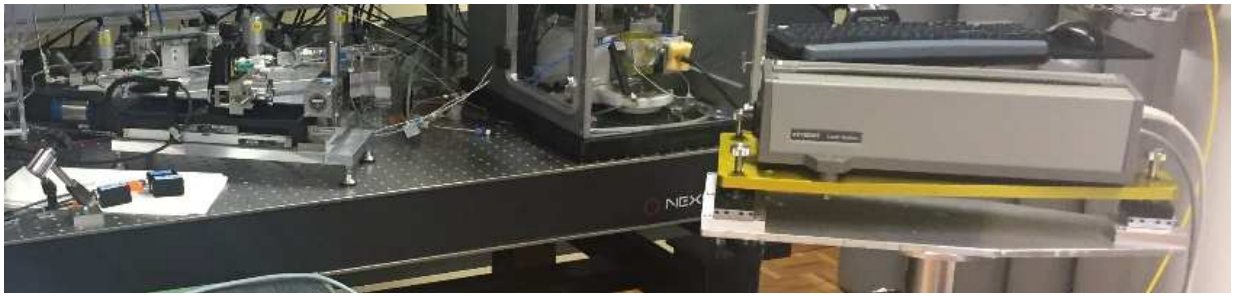
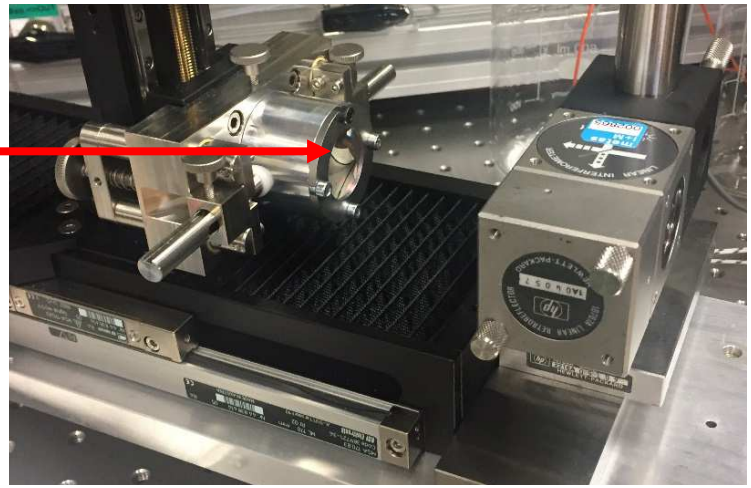
Speed of piston plunger

Calibration of the position of the linear stage with the interferometer:

- Signal from Motor-Encoder
- Signal from Linear Measuring System



Mirror at the plunger position
in the axis of the motion



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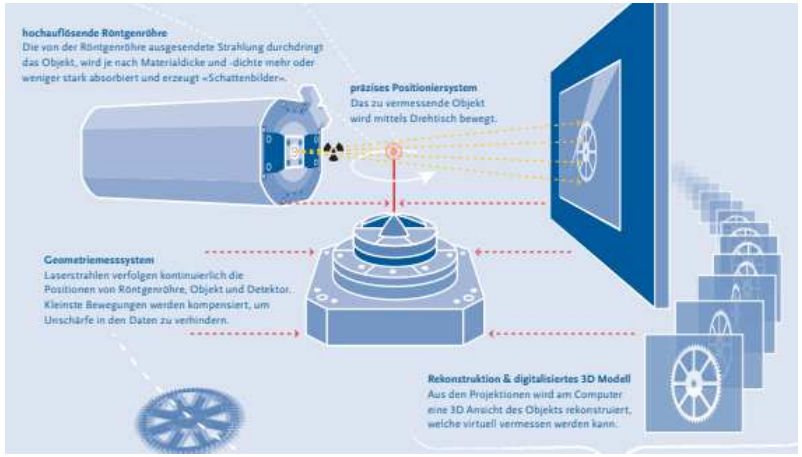
Cross section of the piston

Current methods for the calibration:

µ-CMM (tactile length measurement)

µ-CT (radiation method)



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Cross section of the piston

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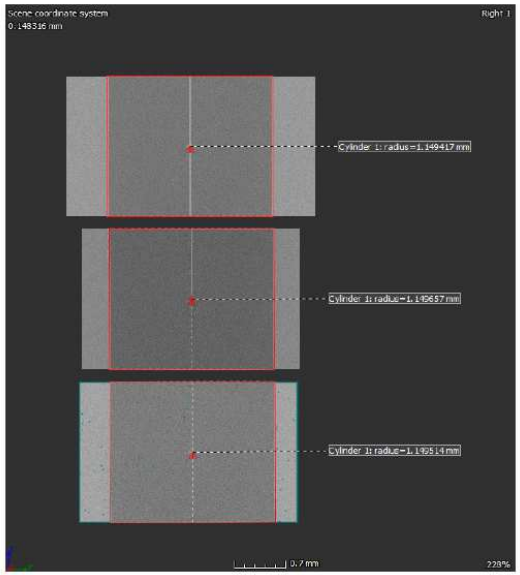
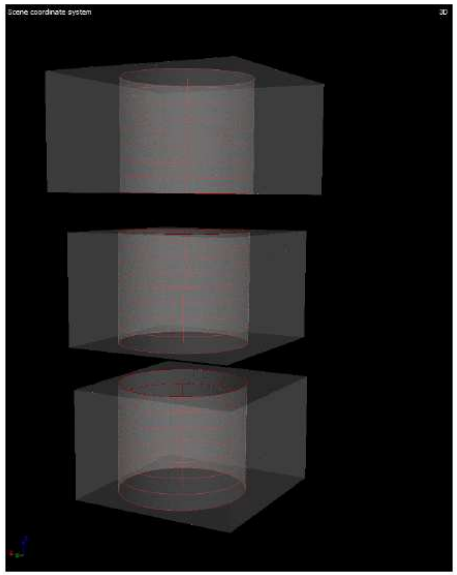
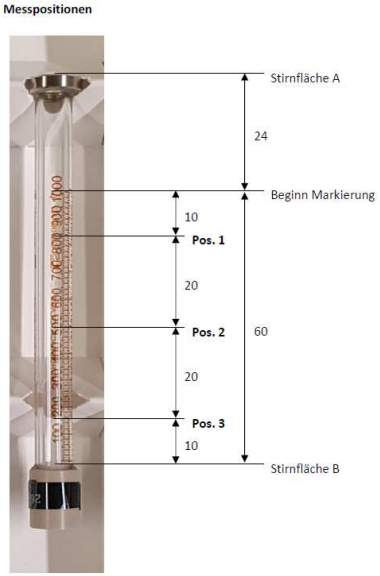
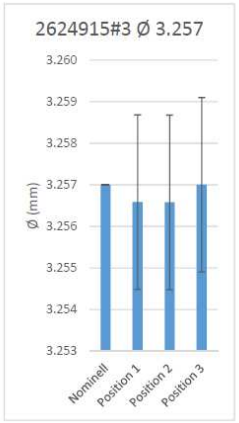
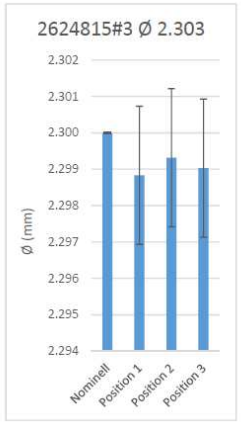
µ-CT (radiation method)

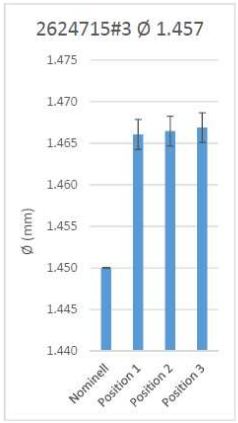


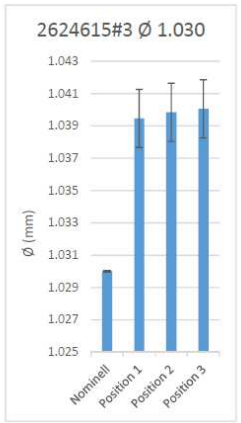




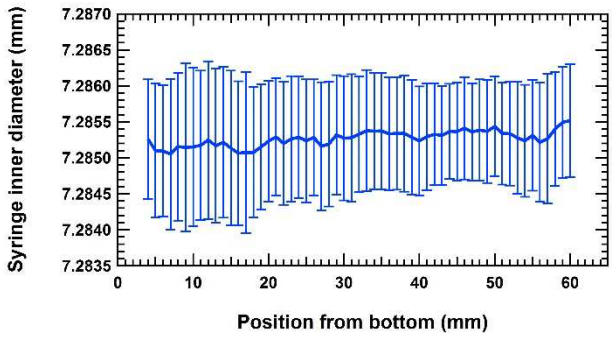








µ-CMM (tactile)



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Stabilisation of the motion

Contributions to be characterized

- Influence of the spindle pitch and rotation
- Influence of the gear between the motor and the spindle (motor encoder signal vs real motion)

Effects of heating

Contributions to be characterized

- Heating from the plunger motion, if present
- Heating from the ambient conditions, if not very stable conditions
- Creating virtual flow at these very small flow rates due to the tubing volume and temperature and temperature gradient variations (needs to be stabilized very good)

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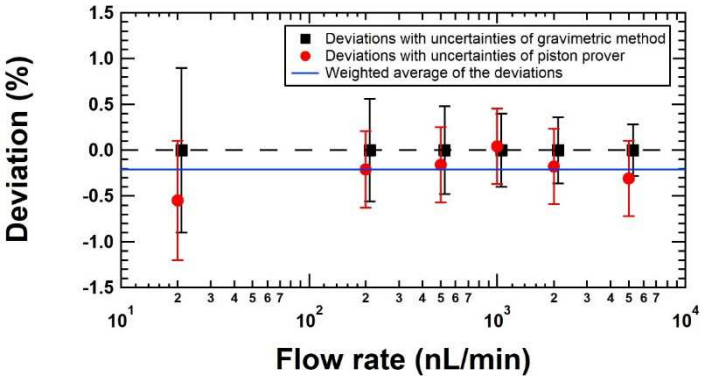
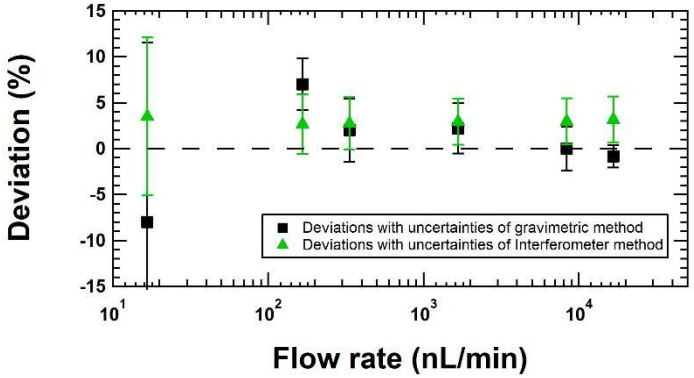
Validation of displacement method

Options for validation of the displacement method:

- Comparison with gravimetric method
- Comparison with interferometer method
- Comparison with optical methods



Piston prover vs gravimetric method



Piston prover vs gravimetric & interferometer method

- Displacement method has main uncertainty contributions from the inner diameter and the virtual flow rate
- Gravimetric method has main uncertainty contributions from evaporation rate and instabilities in the water collection technique

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Project Team

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IPQ

METAS

UMC Utrecht

INESC MN
Microsystems and Nanotechnologies

CMI CZECH METROLOGY INSTITUTE

TÜV SÜD
National Engineering Laboratory

TECHNISCHE HOCHSCHULE LÜBECK

DNV·GL

CETIAT
ensemble, innover et valider

DANISH TECHNOLOGICAL INSTITUTE

Hahn Schickard

KRISS 한국표준과학연구원
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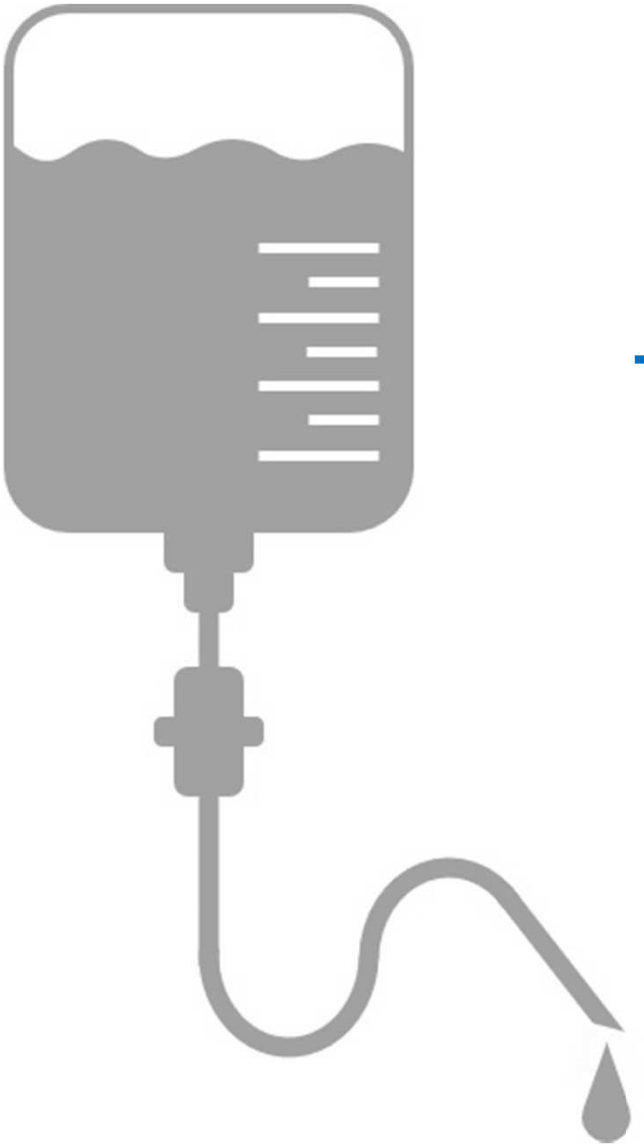

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THANK YOU

Hugo Bissig

Hugo.Bissig@metas.ch

+41 58 387 09 15

www.drugmetrology.com

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