

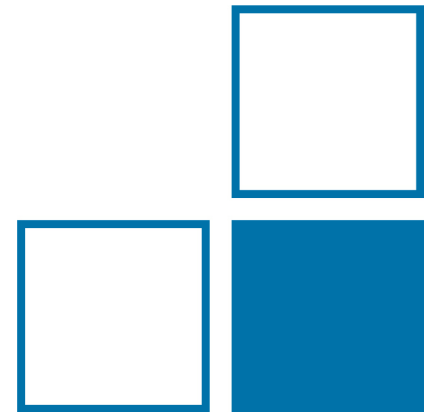


Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

Urban Legends in Gasmetering

Jos van der Grinten

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Enquiry – three statements



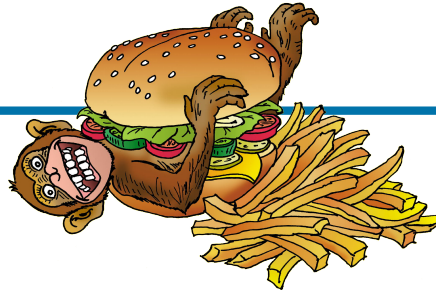
- A national standards institute can disseminate the m^3 accurately without re-calibration. Yes / No
- A calibration lab can measure accurately without re-calibration. Yes / No
- Your gasmeter can measure accurately without re-calibration. Yes / No



- Urban legends
- Definitions and terminology
- Cases
 - Calibration on air, application with natural gas
 - Forward curve adjustment used for reverse application
 - No recalibration required when using two meters in series
 - Calibration up to 70% extrapolation to 100%
 - Z configurations
 - 50 bar calibration for 60 bar operation
- How to deal with statements
- Conclusions and recommendations



Urban legends



- 1978 - Broodje Aap.
De folklore van de post-industriële samenleving. (*Urban legends. The folklore of the post industrial society.*)
- Characteristics:
 - Fictional, told as true
 - Sources are missing
 - No exact data, names, locations
 - Sensational or bizarre story
 - Latent fears or prejudices
 - Pseudoscientific nonsense
- Alternative facts / fact-free journalism

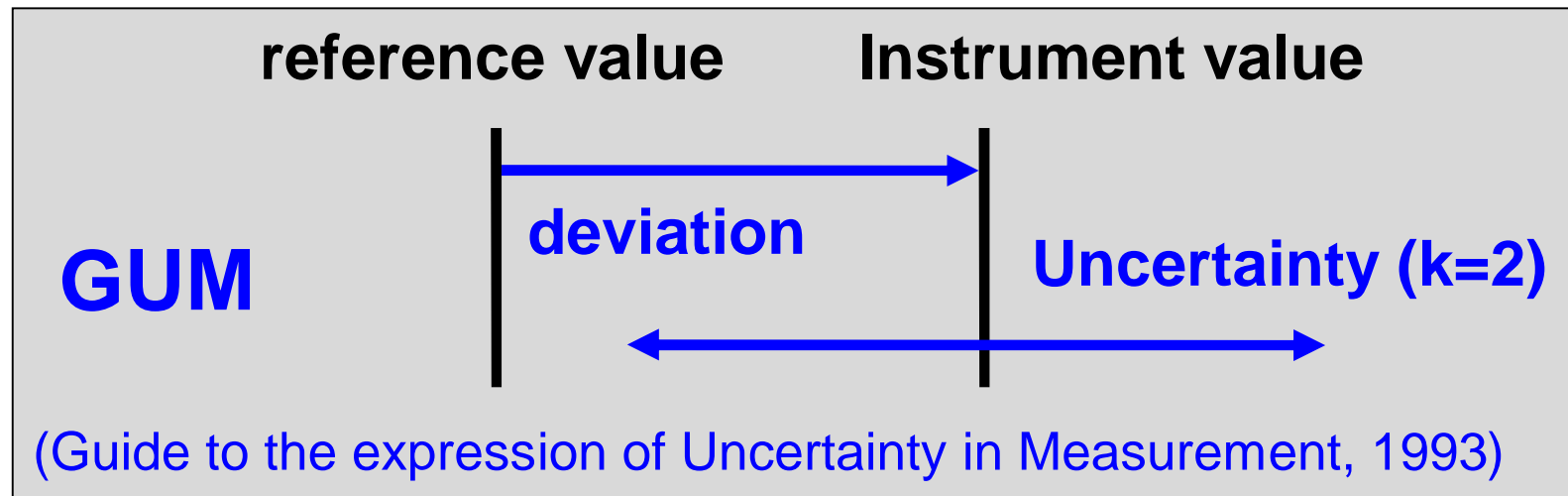


Ethel Portnoy (1927–2004)

1979 Photo: Hans van Dijk - Anefo

Definitions and terminology – 1

- Step 1: Calibration → deviation ± uncertainty



Uncertainty

- the range of values that can reasonably be attributed to the measurand
- a measure for the amount of missing information

Definitions and terminology – 2

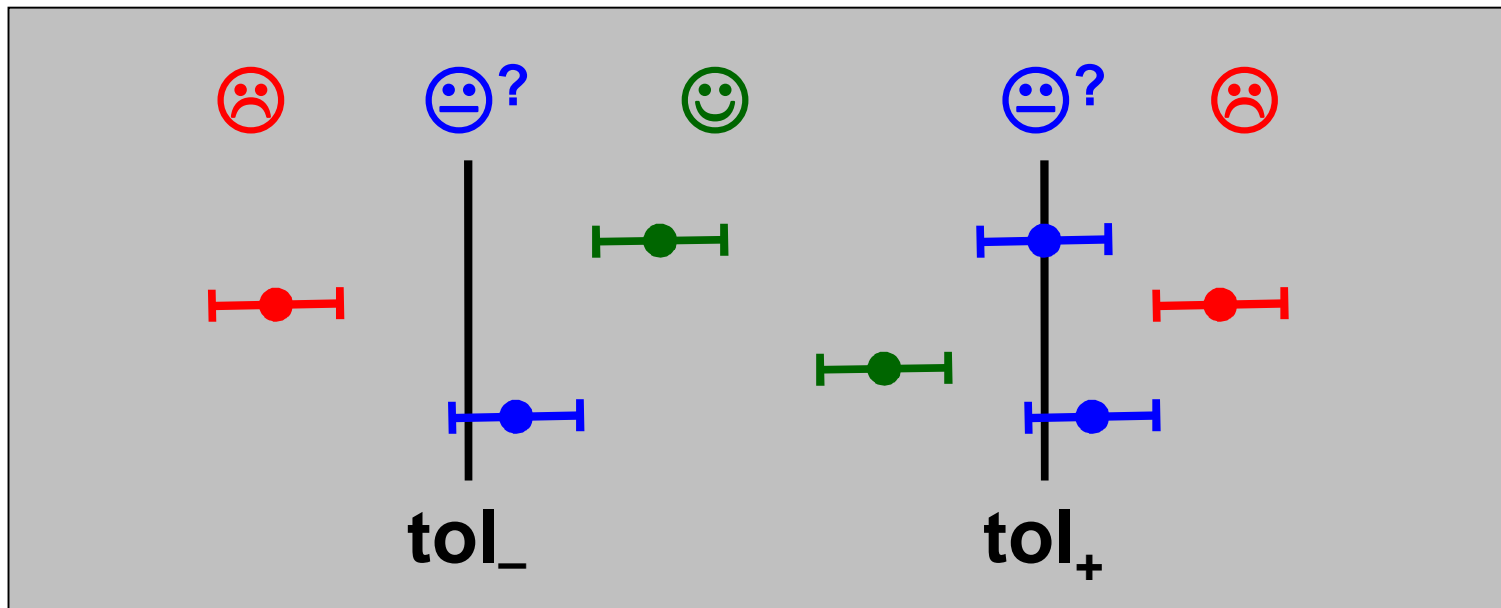
- Calibration results on certificate

Flowrate [m ³ /h]	Deviation [%]	Uncertainty [%]

- Validity of certificate expires after
 - After the end of the re-calibration period
 - Accident with the meter
 - Modifications made to the meter
(parameter list part of the certificate)

Definitions and terminology – 3

- Step 2: conformity assessment → compliance with regulations, e.g. tolerances ($\geq 95\%$ confidence)



- Test / verification: **conforming** or **not**
- Inspection: **non-conforming** or **not**

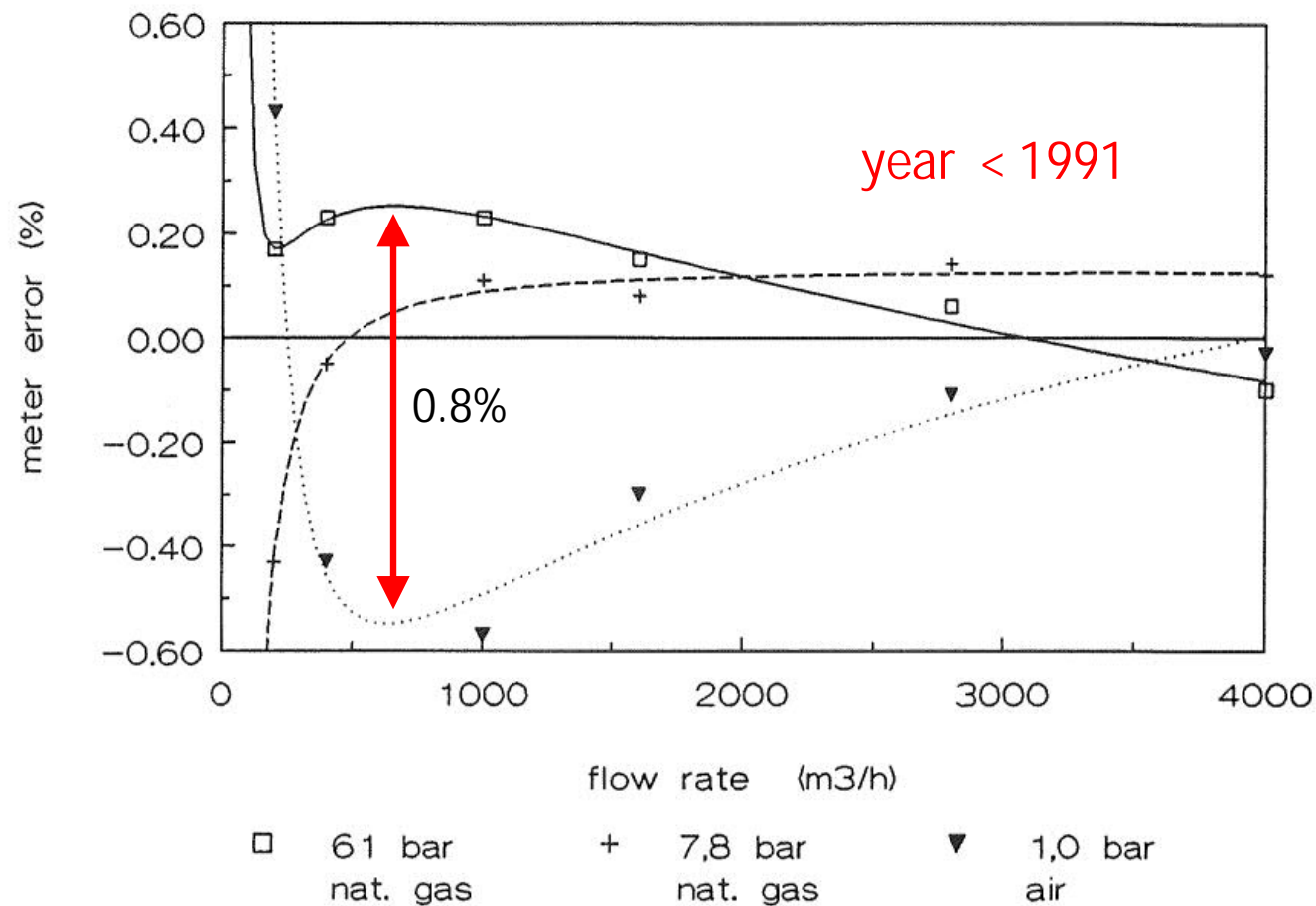
Definitions and terminology – 4

Gas meters	MID, annex IV (MI – 002)		Normative document OIML R 137			TSO contracts
Class	1.5	1.0	1.5	1.0	0.5	
$Q_{\min} \leq Q < Q_t$	3% *	2% *	3% 6%	2% 4%	1% 2%	– –
$Q_t \leq Q \leq Q_{\max}$	1.5% *	1% *	1.5% 3%	1% 2%	0.5% 1%	0.3% 0.3%
WME	– –	– –	0.6% –	0.4% –	0.2% –	0.3% 0.3%

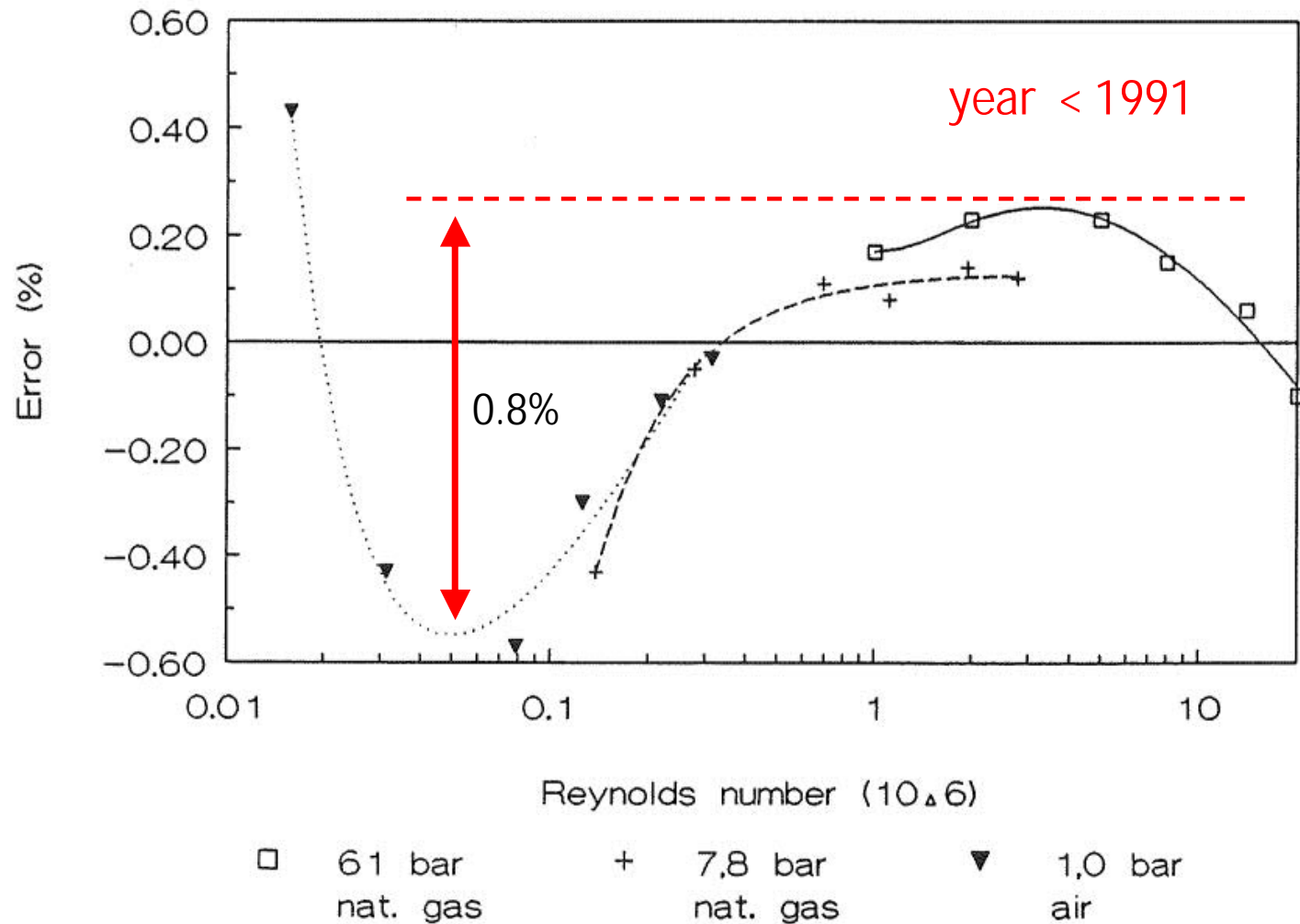
- **In-service** requirements → national law
- **TSO**: high-volume → financial risk → high accuracy

Calibrate on air, use on natural gas?

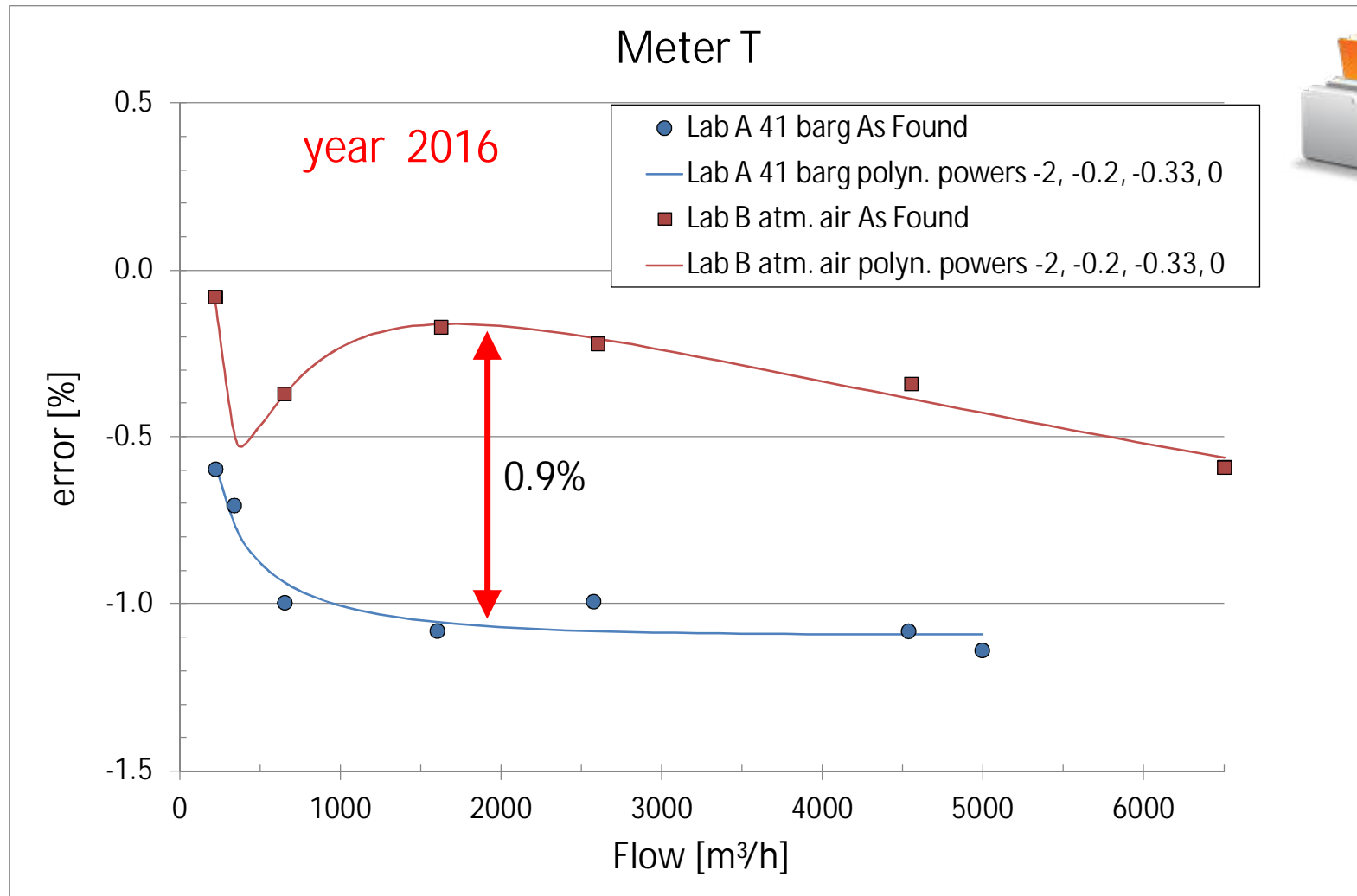
error curve of a turbine gas meter
with air and nat. gas at three pressures



Calibrate on air, use on natural gas?



Calibrate on air, use on natural gas?



Calibrate forward – Adjust reverse



Claim

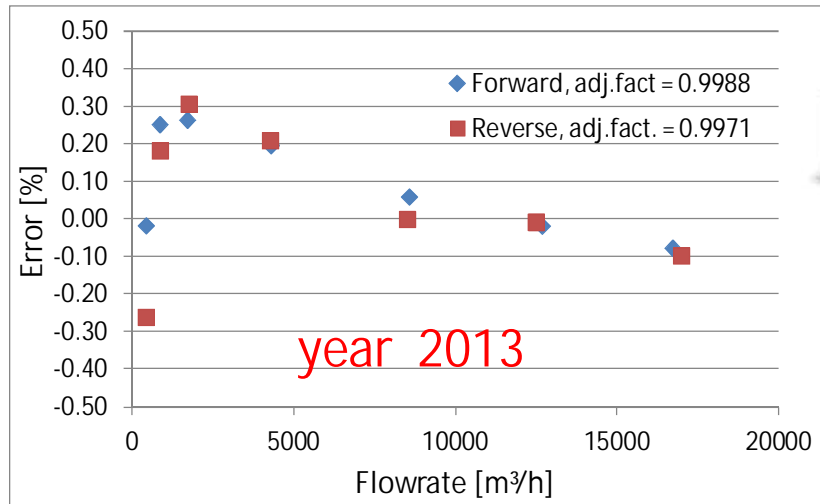
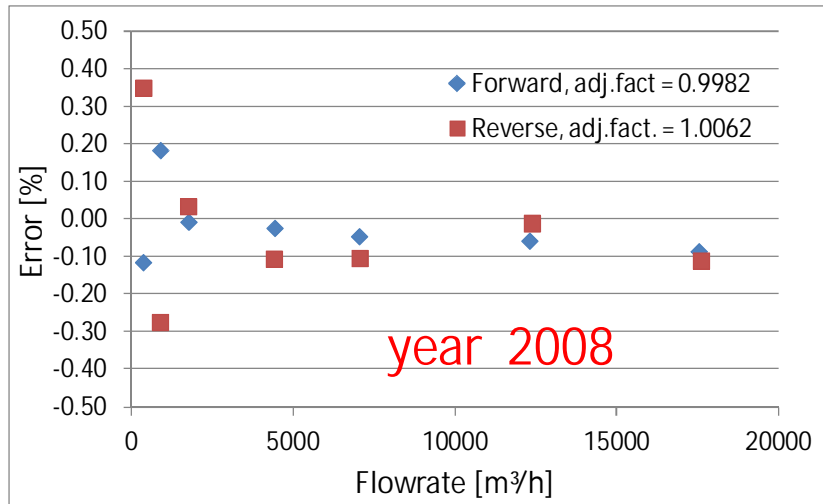


*“The **adjustment and verification** of a meter carried out for one direction is **sufficient and valid** for a usage **in both flow directions**, if the meter run including input and output pipes is carried out as described in the type examination certificate for a bidirectional usage.*

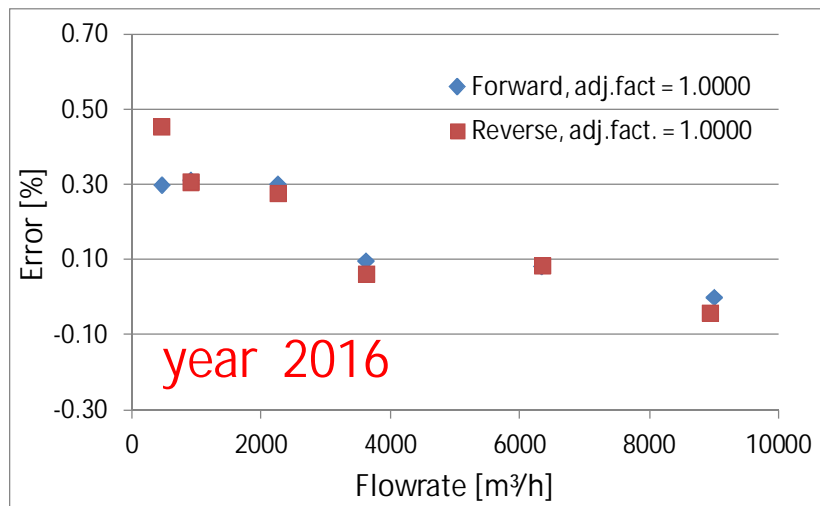
*In this case the meter provides **results** which **fulfill** the **MPE independent** from the **flow direction**.”*

- Claim is for USM of a specific brand
- Refers to legal metrology
- No restrictions to adjustment method

Calibrate forward – Adjust reverse



- USMs as found fw & rev
- Adjust factors
 - 0.80% diff. in 2008
 - 0.17% diff. in 2013
 - < 0.05% diff. in 2016!



Calibrate forward – Adjust reverse

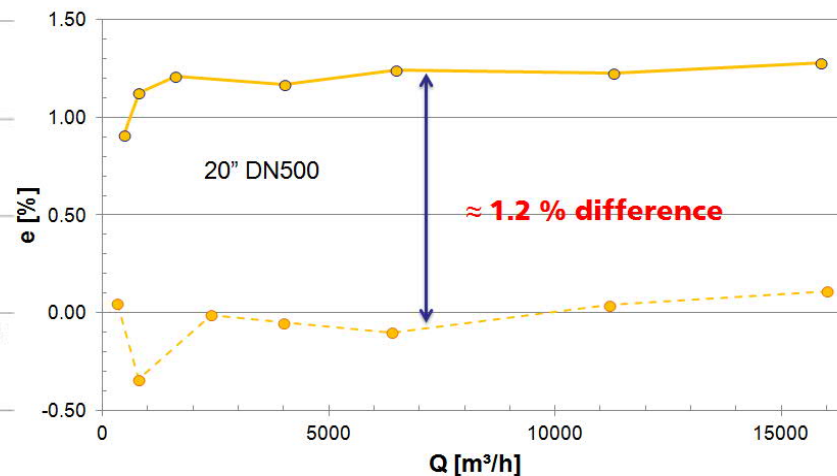
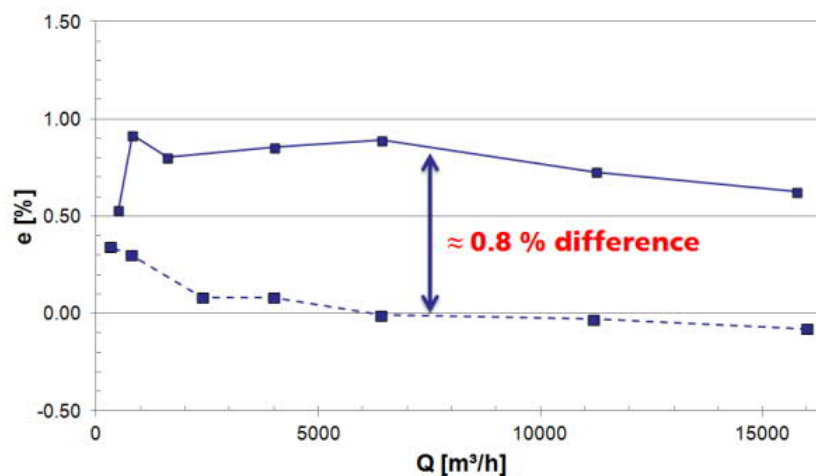
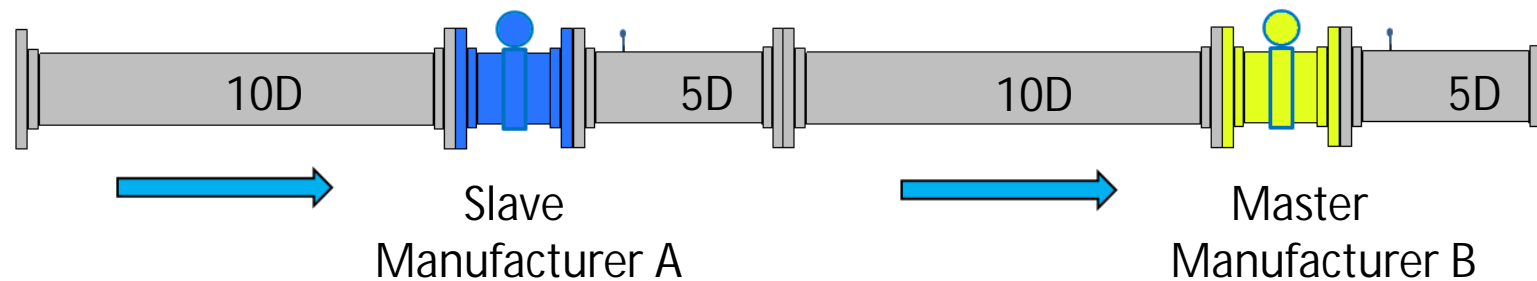


- Newer meters perform better
- Method only demonstrated for linear adjustments
- Reckon with at least 0.1% difference between forward and reverse
- No check for polynomial or multi-point adjustments



In series – no recalibration?

- In Situ comparison showed 0,4% difference

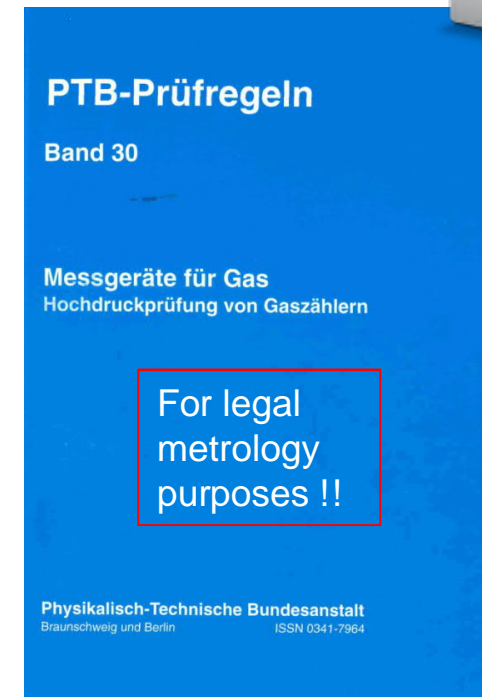


- In reality average shift = 1% !

Extrapolation

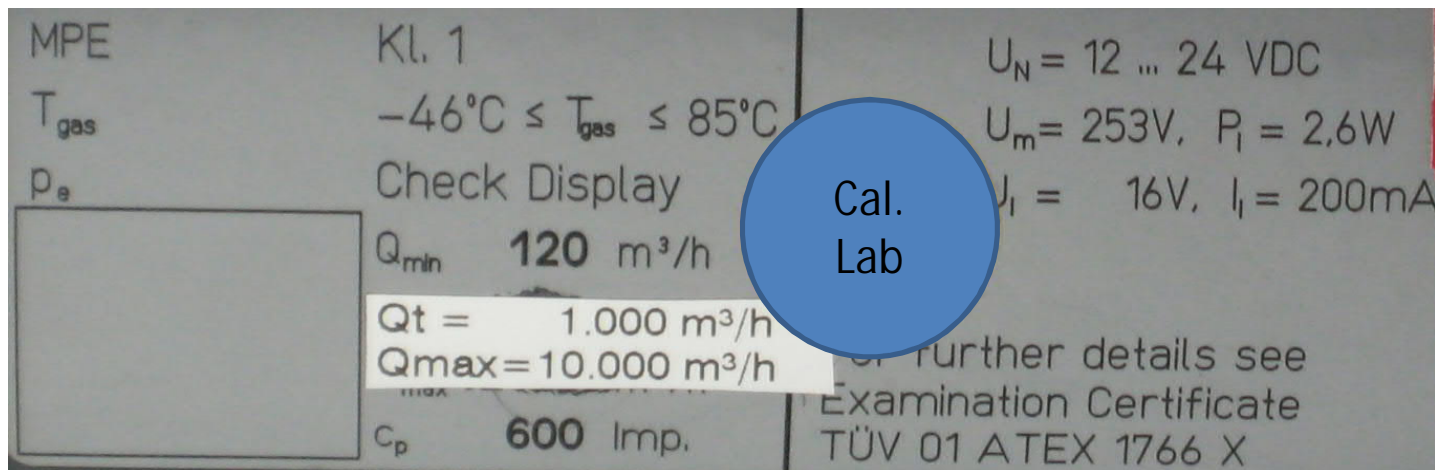


- What to do if you cannot reach Q_{\max} ?
- Take volume 30 of PTB Testing Instructions, p 46
 - Calibrate up to 70% Q_{\max}
 - Low pressure gas or air curve in full range must be available
 - Shape of the curve between $0.2 \cdot Q_{\max}$ and highest Q
 - Extrapolate in Reynolds domain until 100% Q_{\max} , Curve $< \frac{1}{2}$ MPE
- Intended for turbine meters, ... also used for USMs



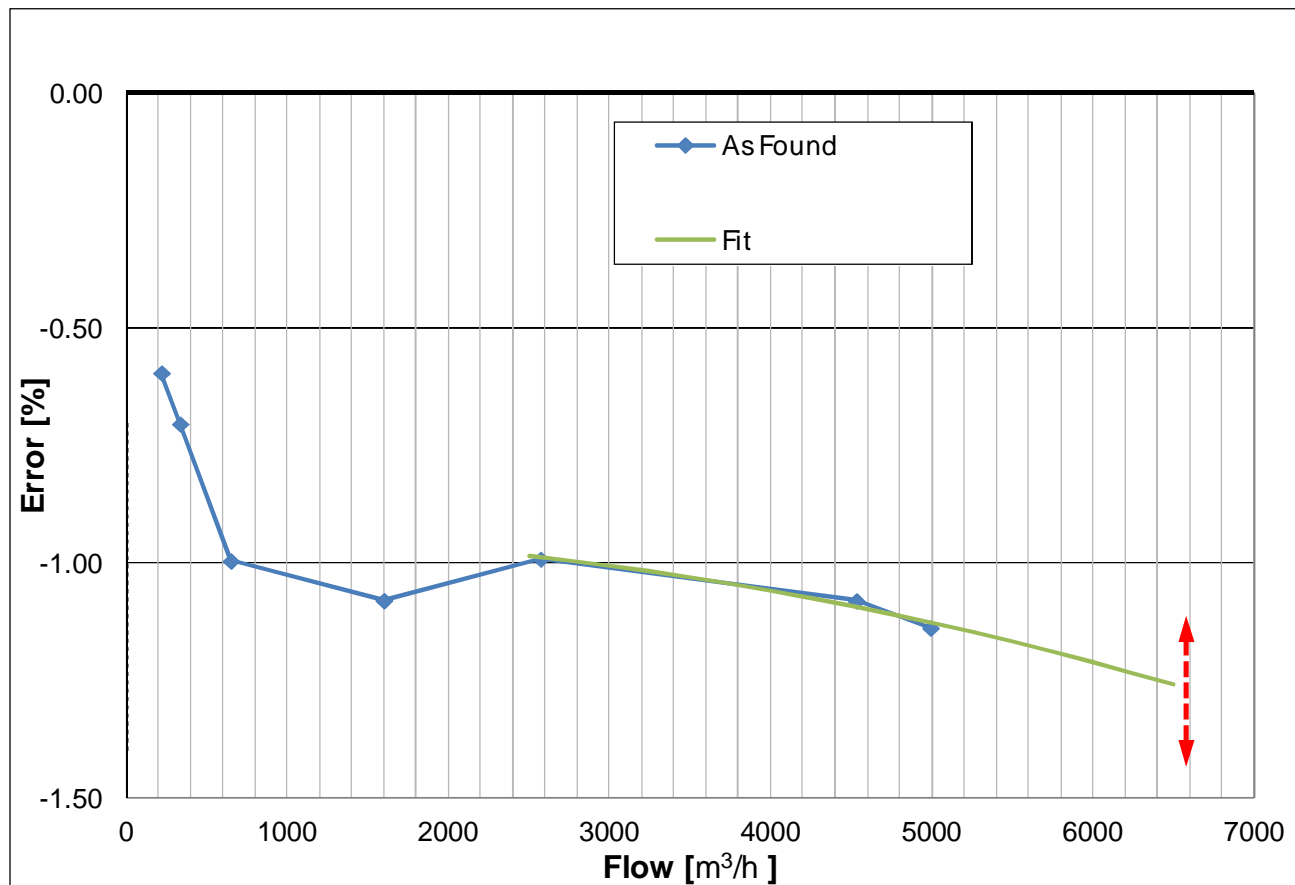
Extrapolation

- Result of a recalibration

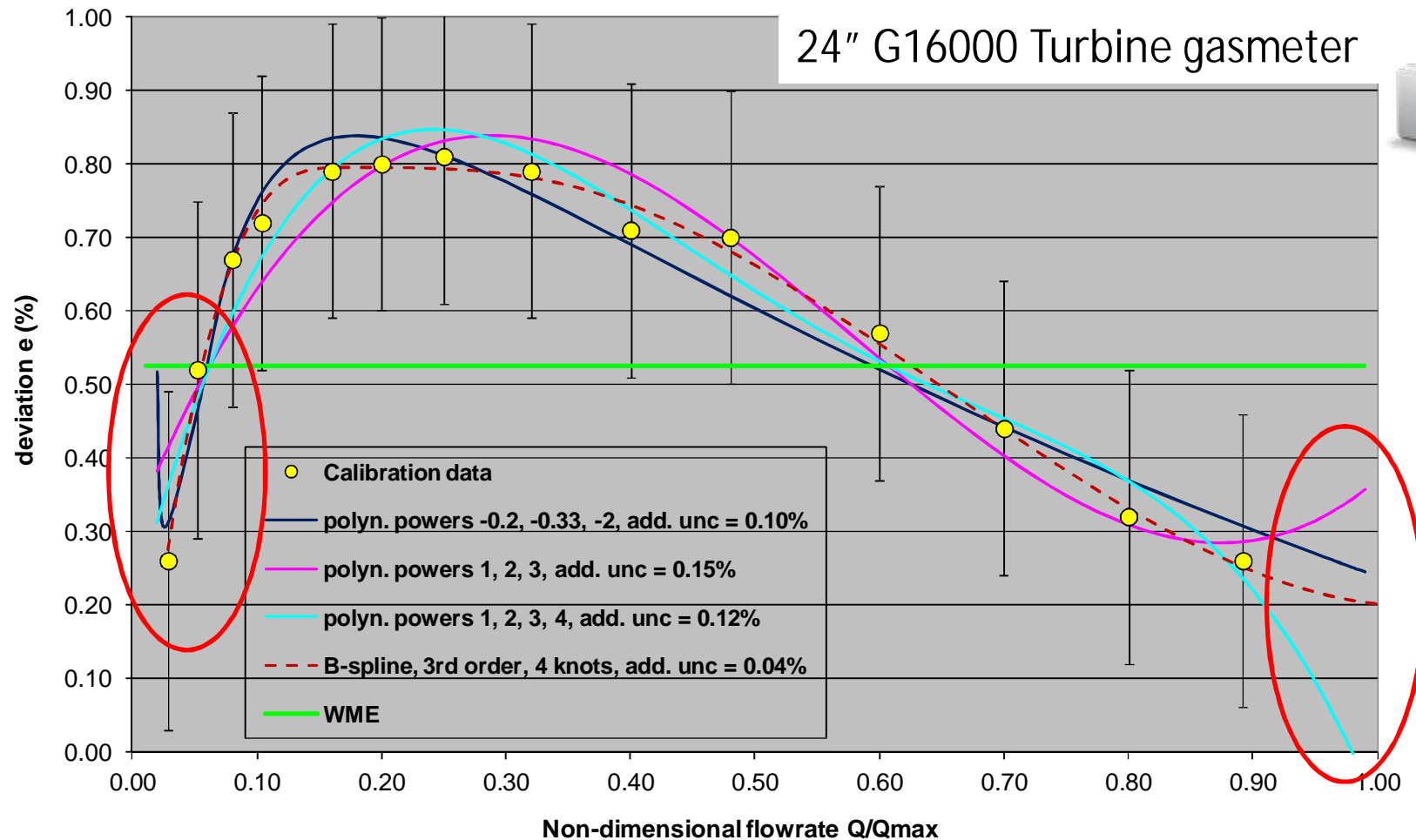


- Often
 - No low-pressure or air curve available (e.g. recalibration)
- Base extrapolations on smooth curves
 - Higher order polynomials will be unstable outside the calibrated range

- Turbine gasmeter, 42 bar, natural gas



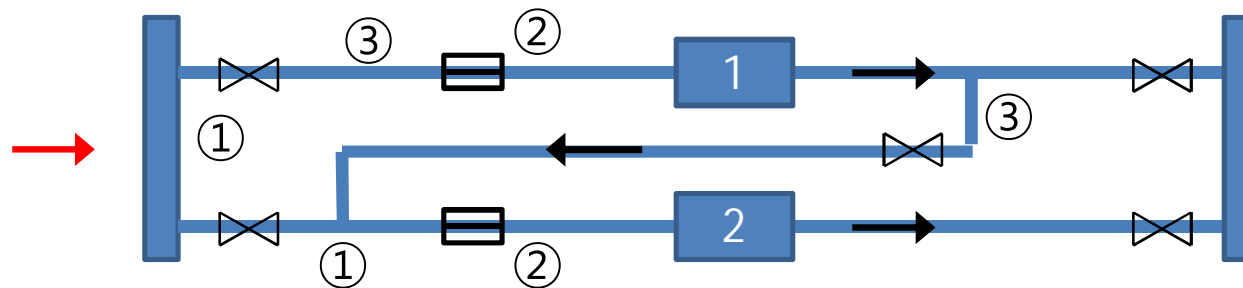
Extrapolation



Z configurations



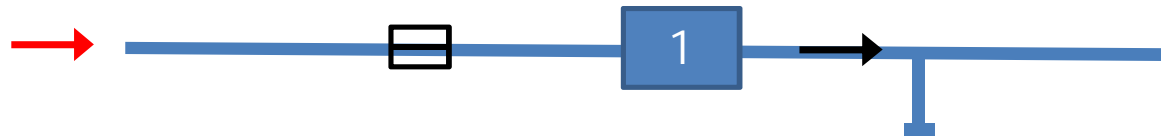
- Parallel use
- Serial comparison



- Points of attention
 - Flow disturbances and flow conditioning ①
 - Noise ② (100 dB(A))
 - Pulsations caused by closed side branches ③

Z configurations

- Separate calibration of two meters



- 0.5% difference with or without side branch
- → Recommendation: test the entire configuration
- Example
 - Hilko den Hollander, EFMWS 2015, Noordwijk
 - Calibration of a complete Z skid and its functionality

Pressure dependency – 1

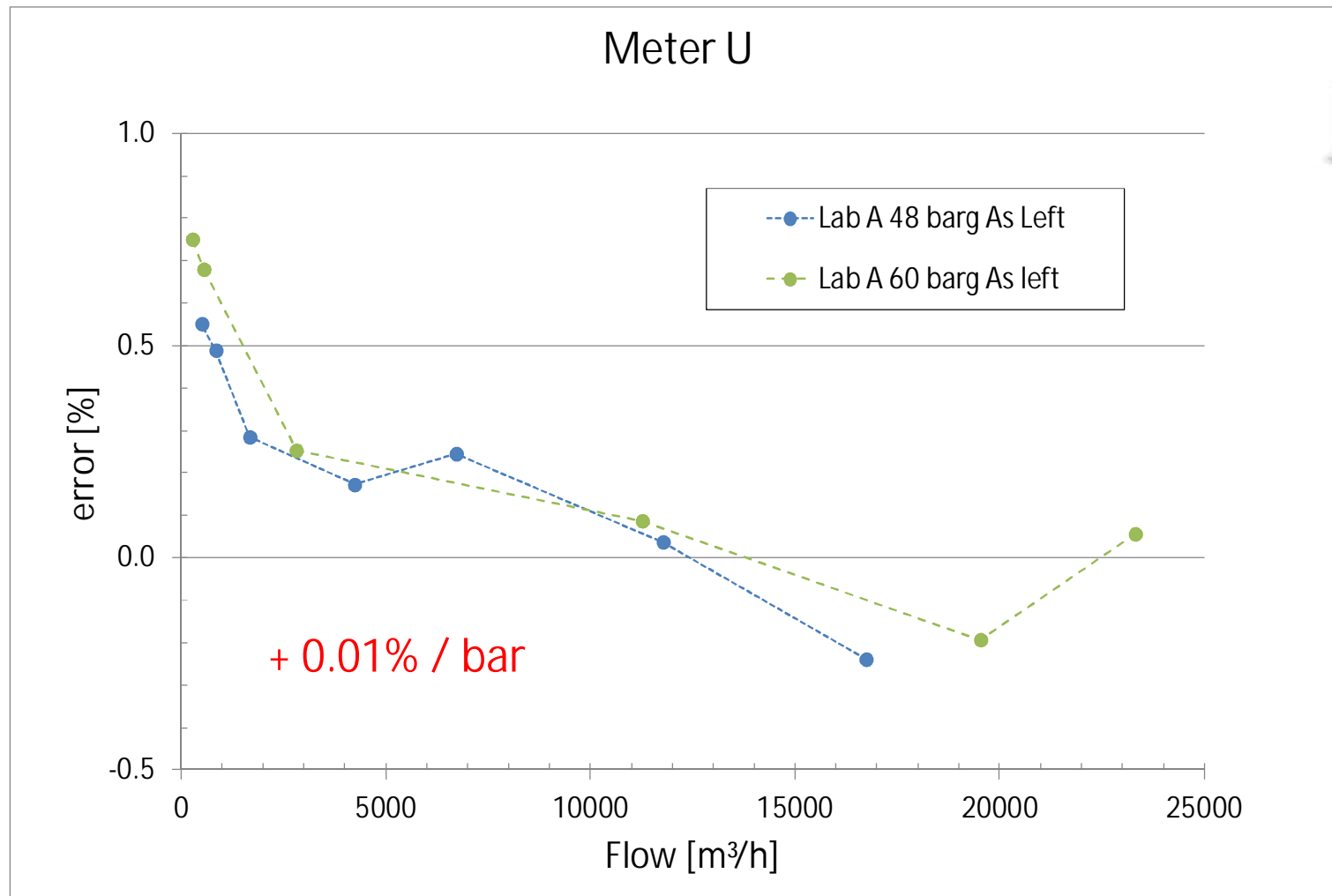


Claim

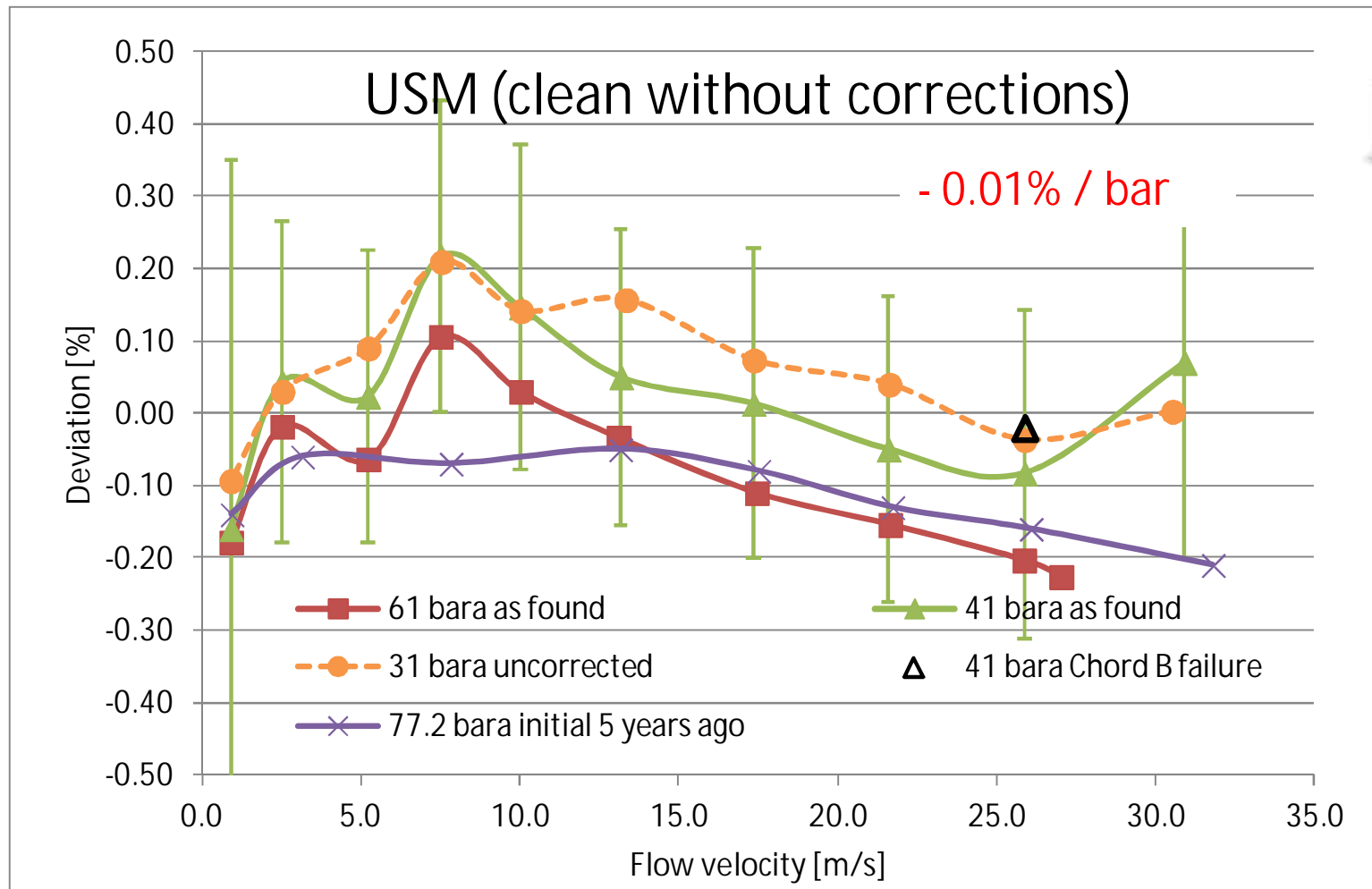
- Calibrations @ 50 bar are cheaper than @ 60 bar
- So even when operating conditions are 60 bar we order a 50 bar calibration
- There will be not that much difference ?
- Pressure dependency



Pressure dependency – 2



Pressure dependency – 3



How to deal with statements?



- No recalibration necessary?
 - Only for meters on the scrap yard
 - Change or damage to the meter → recalibrate
 - End of recalibration period → recalibrate
- Innovative declarations issued by notified bodies
 - Made on request of manufacturers
- So ask the manufacturer for
 - Magnitude of the change → additional uncertainty
 - Systematic proof, not just one case
 - Publications in the open literature
 - Results of studies and tests
preferably conducted by an independent third party

Conclusions and recommendations



- Metrological principle
 - Change anything on the meter and the calibration certificate will become void
- Legal metrology
 - Some modifications are possible without jeopardizing the performance with respect to legal tolerances
 - Use acceptance criteria smaller than legal tolerances
 - However legal metrology tolerances are too wide for industrial applications (TSOs)
- Systematic testing and reporting required

Cases

Δe

- Air calibration 0.9%
 - High-pressure air, not documented yet
 - How to scale the meter curve? Meter principle?
- Forward calibration – reverse adjustment > 0.1%
 - Newer meters perform better
- No recalibration with two meters in series ~ 1%
- Extrapolation > 0.1%
- Z configuration > 0.5%
- Pressure dependency + or - 0.01% / bar

Conclusions and recommendations



Currently

- Urban legends have always been there
- Alternative facts / fact-free reporting

Future

- Well documented test results → Transparency
- Transparency → Confidence
- Confidence → Trust

Enquiry – change of opinion



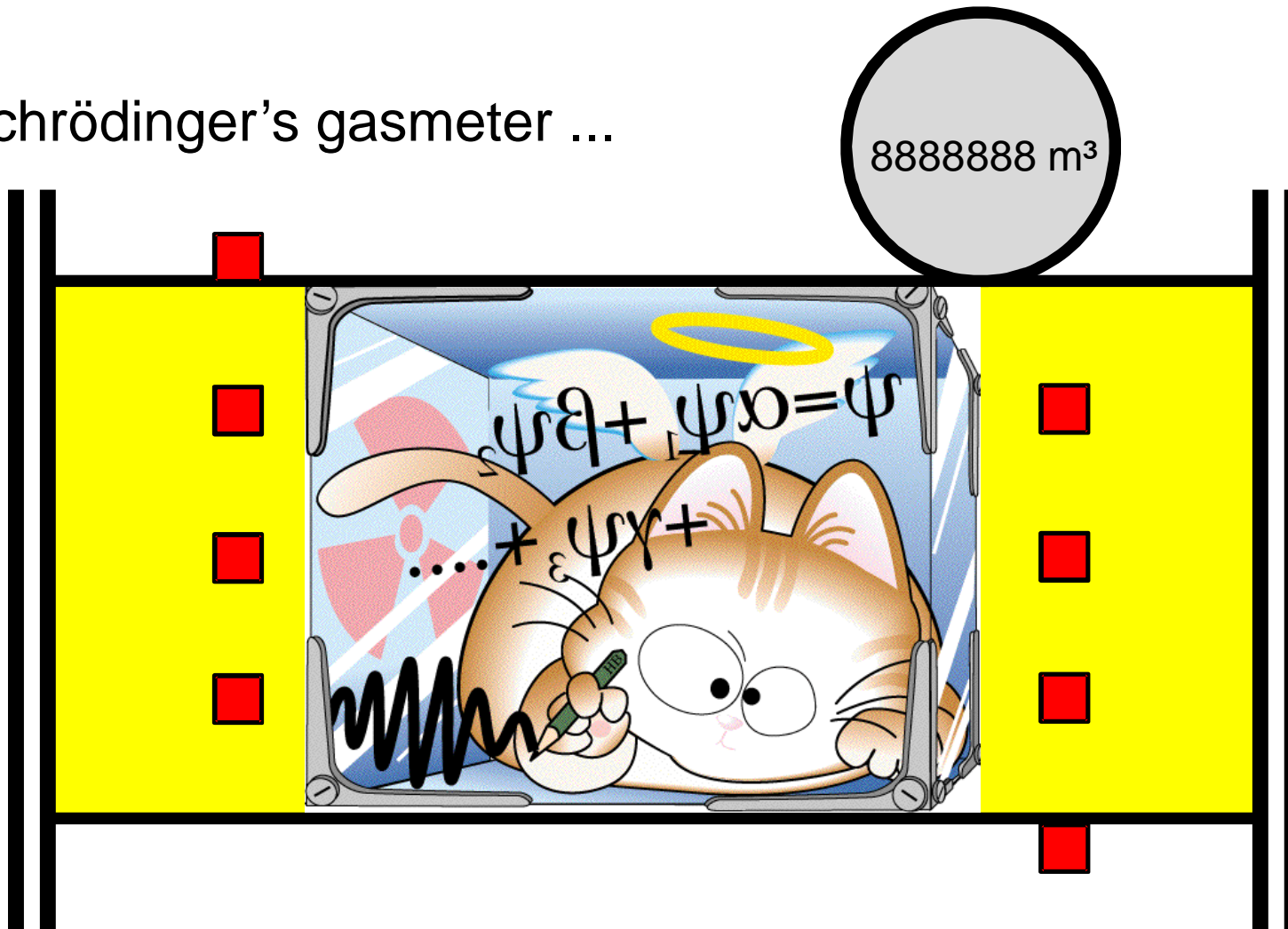
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 - Did you change your opinion? Yes / No

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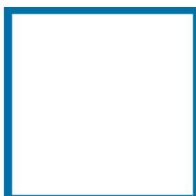
- Your gasmeter can measure accurately without re-calibration.
 - Did you change your opinion? Yes / No

Questions?

- Schrödinger's gasmeter ...



The only way to know is to re-calibrate !!



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