EXPERIENCES WITH THE PERMANENT SERIES CONNECTION OF USM IN GERMAN GAS MARKET

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FLOW SOLUTIONS

June 2017

AGENDA

- Motivation
- Legal aspects
- Metering line design
- Calibration, commissioning & verification
- Practical results
- Conclusion / summary

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MOTIVATION

- Design of metering stations
  - Station design varies greatly
  - One or two meters in series
  - Replacing existing installation or green field projects
  - Clean gas, custody transfer

- Benefits of ultrasonic measurement technology
  - High turn down & no pressure drop
  - Diagnostics

- Best practice in Germany
  - Common requirements for USM series connection established
  - Described by PTB (TR-G 18)
  - Benefits of series connection of two ultrasonic meters

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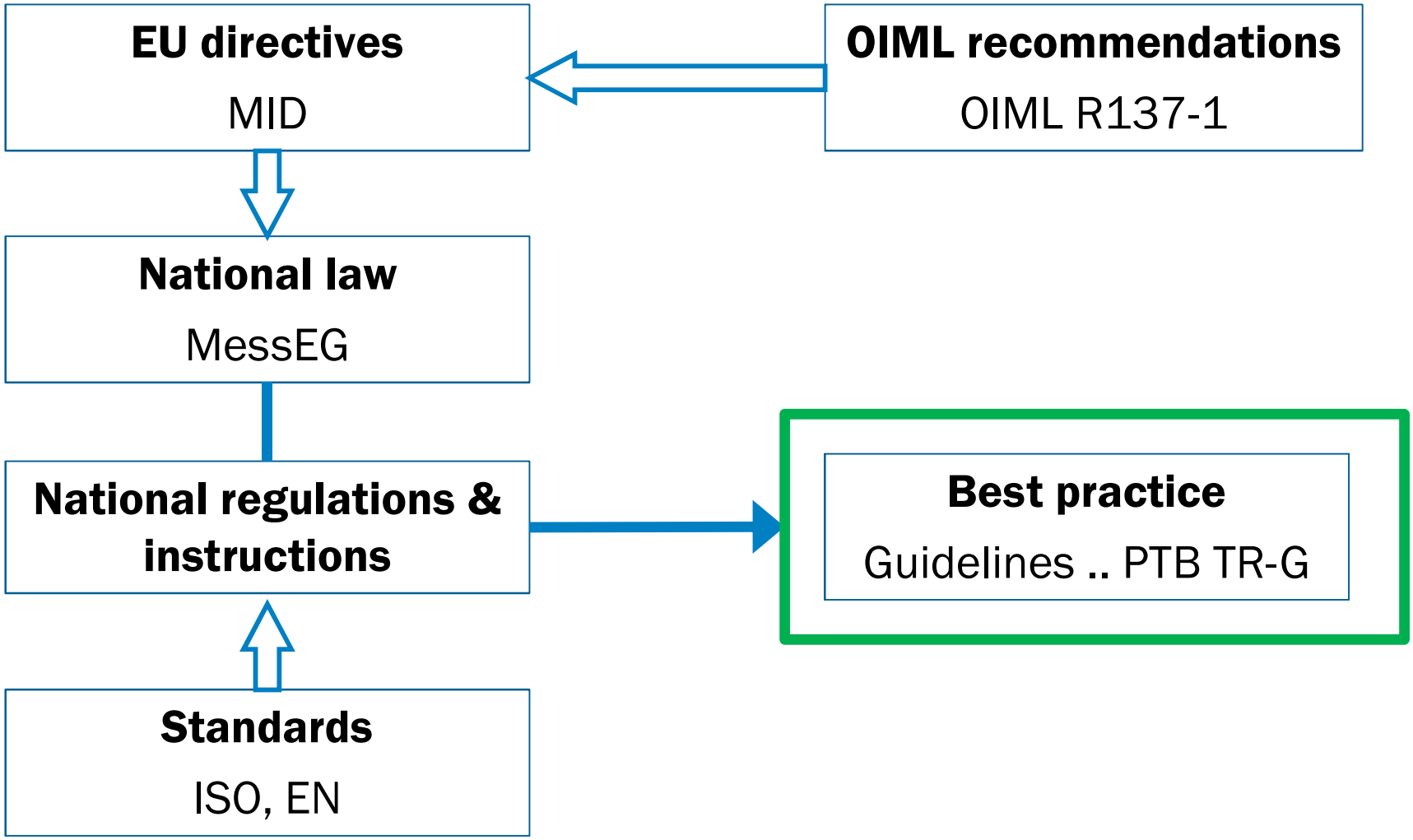
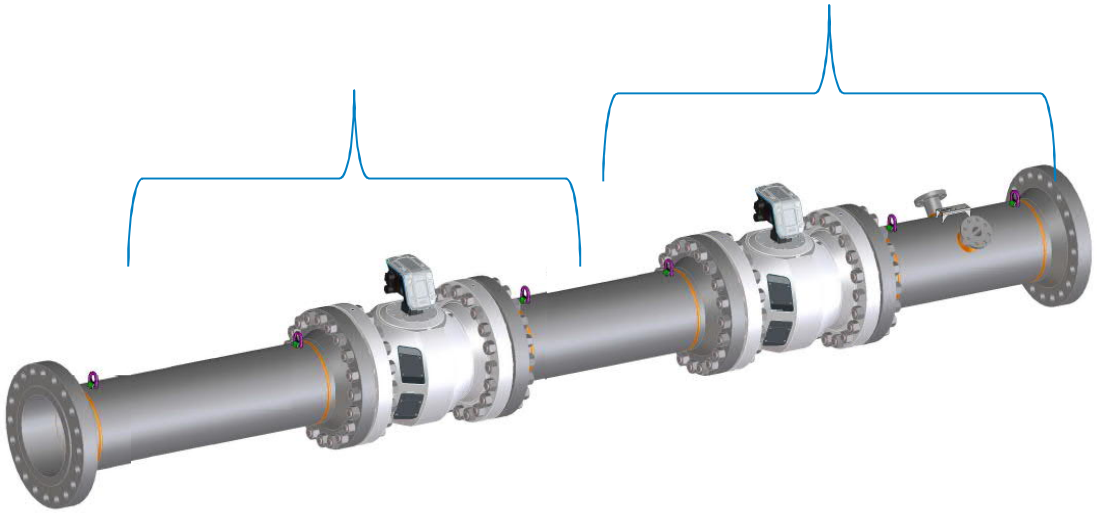
- Short overview and classification



LEGAL ASPECTS

- Metering line design & recalibration

EU Type approval



National regulations

Meter design

Piping

Series installation

Conformity

Verification limits

Recalibration

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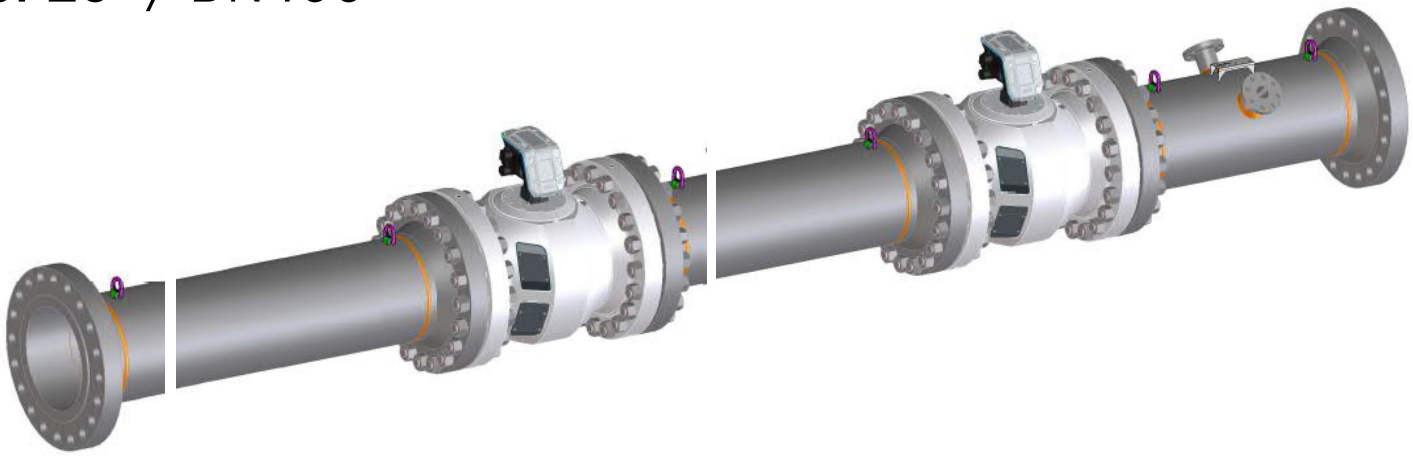
METERING LINE DESIGN

- Best practice examples in high volume gas metering applications
  - Network operators
  - Operators of gas terminals

METERING LINE DESIGN
TYPICAL INSTALLATIONS

- Two USM in series, no flow conditioner

  Size: 16” / DN400



20D USM1 10D USM2 3D

Example: Replacement of **Turbine meter – USM** installation with **USM – USM**

METERING LINE DESIGN
TYPICAL INSTALLATIONS

- Two USM in Back 2 Back configuration, no flow conditioner

  Size: 20” / DN500

30D USM1 – USM2 3D

- Full bore meter design
- Identical inlet and outlet diameter

Example: Replacement of **orifice meter** run in a gas terminal

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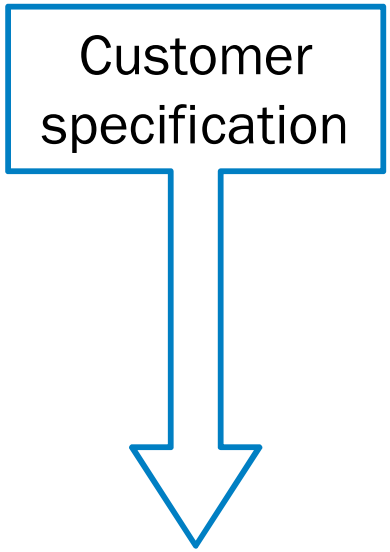
- **Standard requirements single meter calibration**
  - Meters calibrated individually with calibration lab piping
    - Inner diameter may differ up to 3%
  - Adjustment by constant factor or polynomial correction
  - **Meter** calibrated with lowest possible “as left” **error**

- **Requirements series meter installation**
  - Two meters reacting differently to flow disturbance
  - Both meters calibrated with customer piping
  - Calibration at the same lab
  - whole skid at the same time
  - Increased number of test points
  - Adjustment by constant factor or polynomial correction
  - **Meter run** calibrated with lowest possible “as left” **difference**



COMMISSIONING

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- Commissioning
  - Initial fingerprint of both meters

FLOWSIC600 - Maintenance Report: ID_20161108171111

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Zählerdatum:	08.11.2016	(dd.mm.yyyy)
Zählerzeit:	17:11:11	(hh:mm:ss)
Log-Länge:	43	(Samples)
Letzter Test:	11.05.2016	(dd.mm.yyyy)

Zählername: Schiene 1 Techniker:

Prozessdaten Druck (Mittelwert): 56,08 bar(a) Temp. (Mittelwert): 6,45 °C Schallgeschw. (berechnet): 409,37 m/s

Innendurchm. Zähler:	0,36008 m	Firmwareversion:	3608	Schallgeschw. Mittel:	409,44 m/s
Innendurchm. Rohr:	0,37800 m	Firmware CRC:	0xCA22	Schallgeschw. Differenz:	0,02 %
Pfadanzahl:	4	Parameter CRC:	0x0E8F	Profilfaktor:	1,117
Impulsfaktor:	720 Impulse/m³	Eichrecht CRC:	0x0285	Symmetrie:	0,984
Impulsfaktor invers:	0,001389 m³/Impulse	Justage CRC:	0x1162	Durchfluss:	7354,00 m³/h
Signal Stacking:	nein	Justagemethode:	Polynom	Durchfluss (norm.):	725783,00 Nm³/h

Zählerdiagnose (Pfade & Wandler)

VOG

VOG [m/s]	Mittelwert	Maximum	Minimum
Pfad 1	17,861	18,683	17,395
Pfad 2	20,181	21,098	[illegible],792
Pfad 3	20,28[illegible]	[illegible]	[illegible],681
Pfad 4	18,363	19,070	[illegible],799
Mittelwert	18,203	18,860	17,820

SOS

SOS [m/s]	Mittelwert	Maximum	Minimum
Pfad 1	409,55	409,72	[illegible],34
Pfad 2	[illegible]	[illegible]	[illegible],19
Pfad 3	[illegible]	[illegible]	[illegible],16
Pfad 4	409,58	409,74	[illegible],39
Mittelwert	409,44	409,53	409,35

AGC / SNR

	AGC [dB]	SNR [dB]
Pfad 1 AB	36,7	35,7
Pfad 1 BA	35,6	36,0
Pfad 2 AB	[illegible]	34,9
Pfad 2 BA	40,7	34,4
Pfad 3 AB	40,9	34,4
Pfad 3 BA	[illegible]	[illegible]
Pfad 4 AB	[illegible]	[illegible]
Pfad 4 BA	35,4	35,9
AB (Mittel)	38,8	35,2
BA (Mittel)	38,0	35,2

VOG ratio

	Perform. Mittel [%]	Turbulenz Mittel [%]	Geschw. relativ	AGC Diff. AB - BA
Pfad 1	100	3,2	0,909	1,140
Pfad 2	100	[illegible]	[illegible]	0,116
Pfad 3	100	[illegible]	[illegible]	0,512
Pfad 4	100	2,9	0,935	1,302
Mittelwert	100	2,6	0,976	0,767

Zählerstände			
Volumen [m³]	Normal	Störvolumen	Total
Vorwärts	50628745,3	6635,5	50635585,7
Rückwärts	29,4	0,0	30,7

USM diagnostics

- Standardized report
- Automated creation
- Stored in Database

Zählervergleichsmessung Zeitgleiche MU-Prüfung

		ZMU - 2.2	ZMU - 2.1
Vb Ende	[m³]	3.466,1000	3.458,3300
Vb Anfang	[m³]	0,0000	0,0000
Vb Differenz	[m³]	3.466,1000	3.458,3300
Abweichung	[%]	0,22	

- Initial meter readings and SOS ratio
  - Applying PTB guideline TR-G 18

VOS - Betrachtung Mittelwert - Pfade

VOS - Mittelwert: 409,54

	VOS-Pfad 1	VOS-Pfad 2	VOS-Pfad 3	VOS-Pfad 4
Messwerte:	409,64	409,45	409,39	409,68
Abweichung zum Mittelwert:	0,1000	-0,0900	-0,1500	0,1400
rel. Abweichung:	0,02	-0,02	-0,04	0,03

VOS - Betrachtung Pfade zur Inbetriebnahme

rel. Abweichung	VOS-Pfad 1	VOS-Pfad 2	VOS-Pfad 3	VOS-Pfad 4

VERIFICATION
ACCORDING TR-G 18

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- Steps to prolong the re-calibration period

  - **Annual** check of **meters difference**
    (Vn = base condition (German ☺))
    - Continuous comparison
    - Typ. Deviation < 0.5%

  - **Annual diagnostic** comparison
    - SOS difference to theoretical value

  - Approval by Bureau of measures & weight “Eichamt”
    - Approval for another year

Zählervergleichsmessung — Zeitgleiche MU-Prüfung

		ZMU - 2.2	ZMU - 2.1
Vb Ende	[m³]	3.466,1000	3.458,3300
Vb Anfang	[m³]	0,0000	0,0000
Vb Differenz	[m³]	3.466,1000	3.458,3300
Abweichung	[%]	0,22	
Vn Ende	[m³]	225.203,2619	224.921,4832
Vn Anfang	[m³]	0,0000	0,0000
Vn Differenz	[m³]	225.203,262	224.921,483
korr. Abw.	[%]	**0,13**	
Belastung	[m³/h]	6932,2	6916,7
rel. Belastung	[%]	69,32	

VOS - Betrachtung Mittelwert - Pfade

VOS - Mittelwert: 409,54

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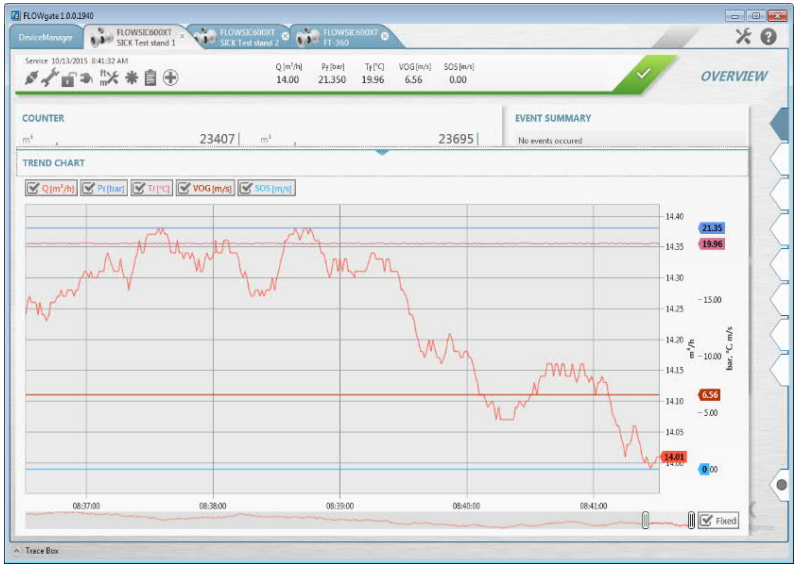
VOS - Betrachtung Pfade zur Inbetriebnahme

rel. Abweichung	VOS-Pfad 1	VOS-Pfad 2	VOS-Pfad 3	VOS-Pfad 4

VERIFICATION
RECOMMENDATION

- Additional considerations by TR-G 18
  - Use different transducer frequency to have different **noise sensitivity**
  - Track SOS difference of each path to average (>0.3% deviation allowed)
  - Compare avg. **SOS to theoretical value**

- Additional recommendations by manufacturer
  - Set meters to different measurement rates → **detection of pulsation**
  - Make use of diagnostic comparison:
    - Annual fingerprint recording
    - AGC, SNR
    - Turbulence, path ration and symmetry
    - Trend analysis



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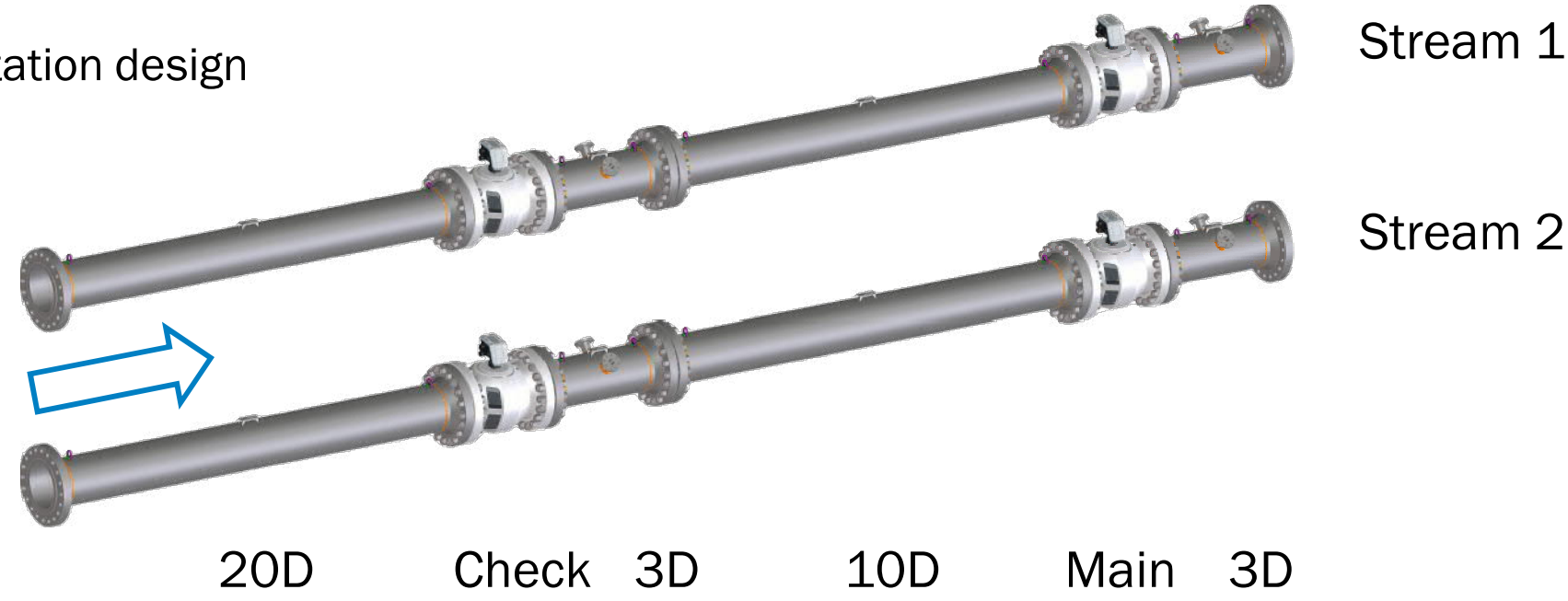
- Example of **two** metering stations
  - Each station with two metering lines 16-inch
  - USM of two vendors
  - Allowed differences: +/- 0.5%
  - Station design



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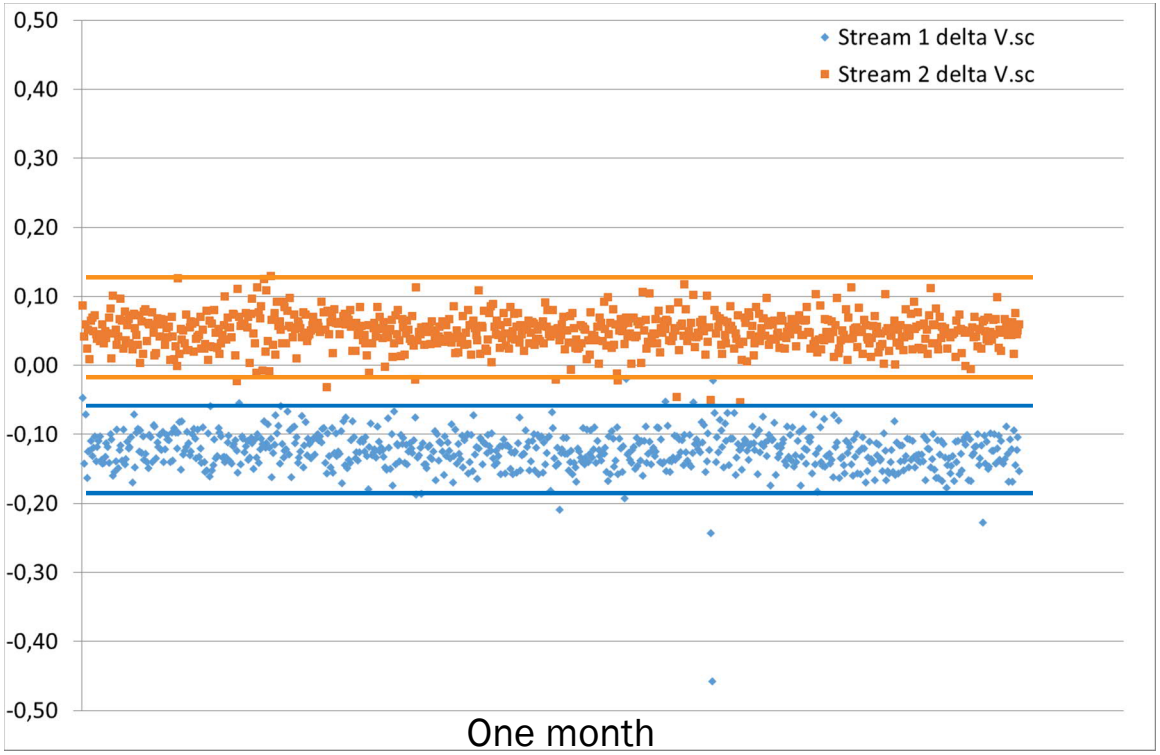
- **Station 1** - Monthly data
  - Difference between base volume of Main and Check meter



Stream 2

Stream 1

  - Both streams perform well within +/- 0.10 % difference in measurement

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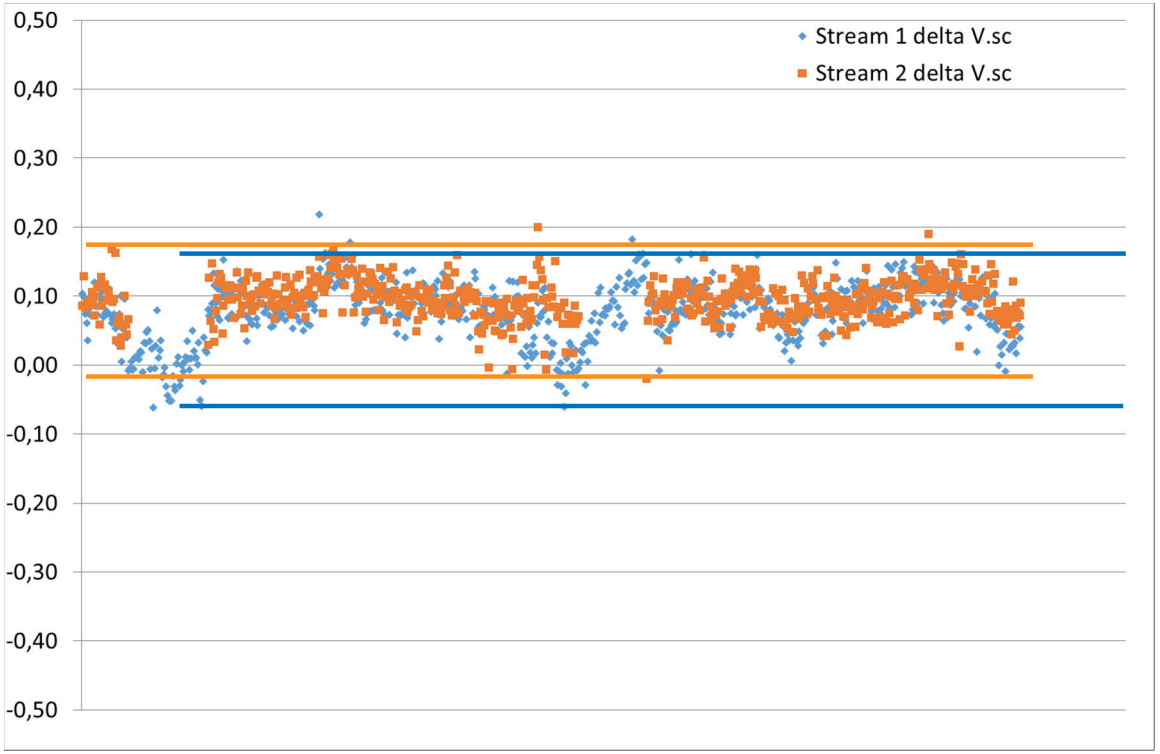
- **Station 2** - Monthly data
  - Difference between base volume of Main and Check meter



Stream 2

Stream 1

  - Stream 1 performs within +/- 0.15% difference in measurement
  - Stream 2 performs within +/- 0.10% difference in measurement

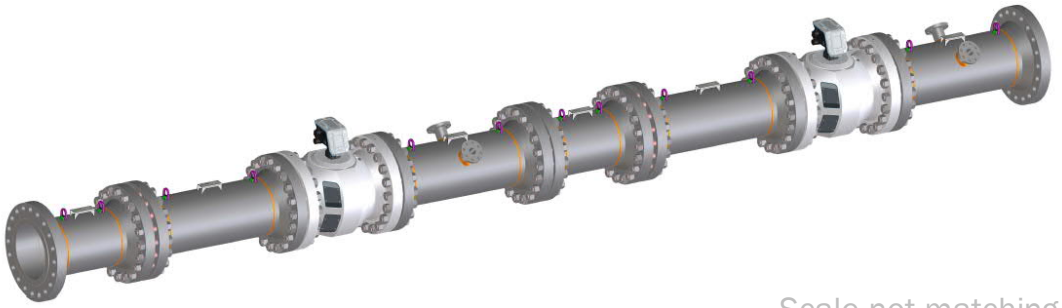
PRACTICAL RESULTS
CUSTOMER B: POWER PLANT

- Metering line
  - Replacement of existing turbine meter installation
  - USM of same brand
    Allowed difference: +/-0.5%

  - **Meter 1**
    - 8-path meter
    - 200 kHz transducer type

  - **Meter 2**
    - 4-path meter
    - 300 kHz transducer type

- Calibration
  - In one piece



Scale not matching

PRACTICAL RESULTS
CUSTOMER B: POWER PLANT

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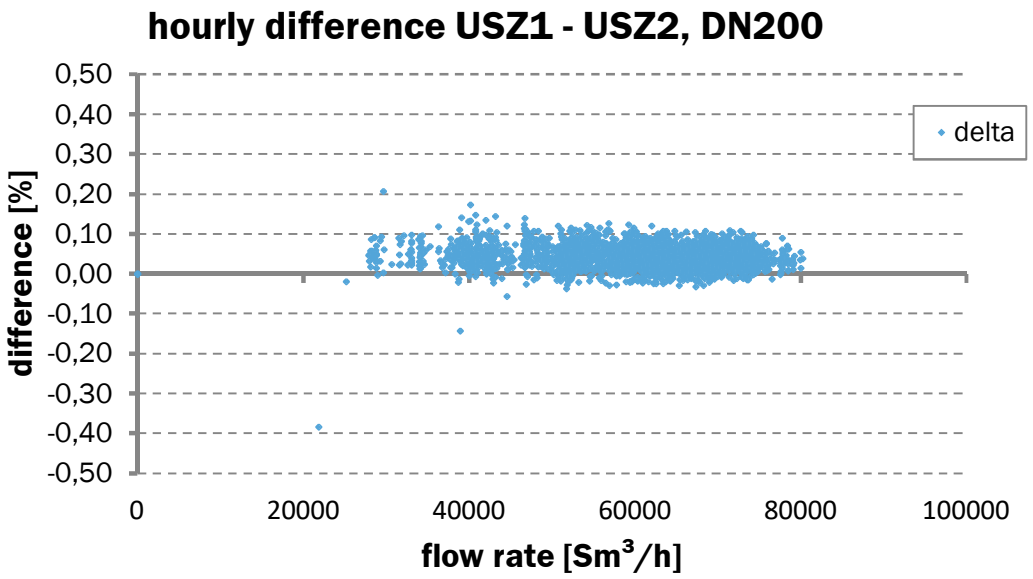
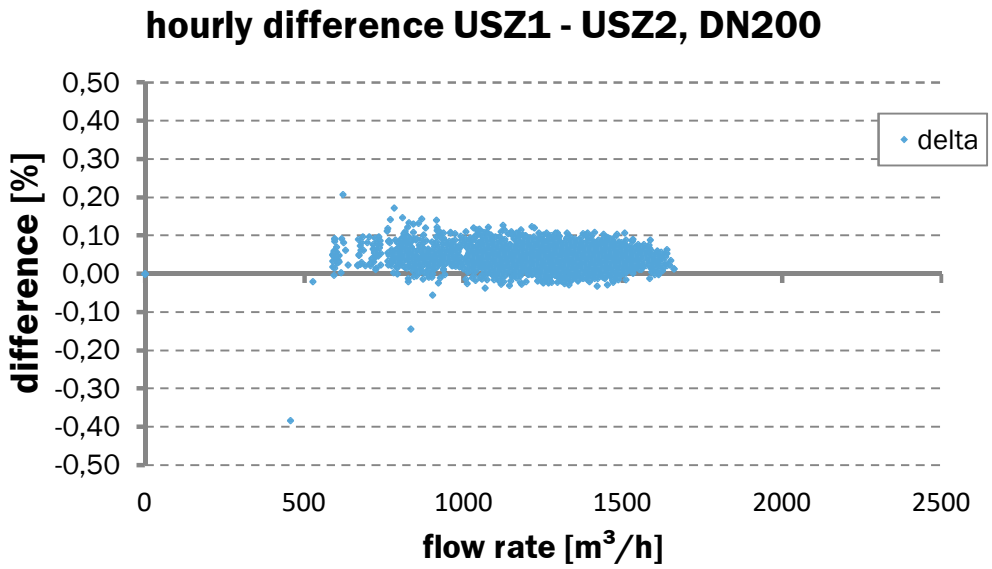
- Hourly comparison over **four month**
  - USM2 (Main) – USM1 (Check)

Base conditions

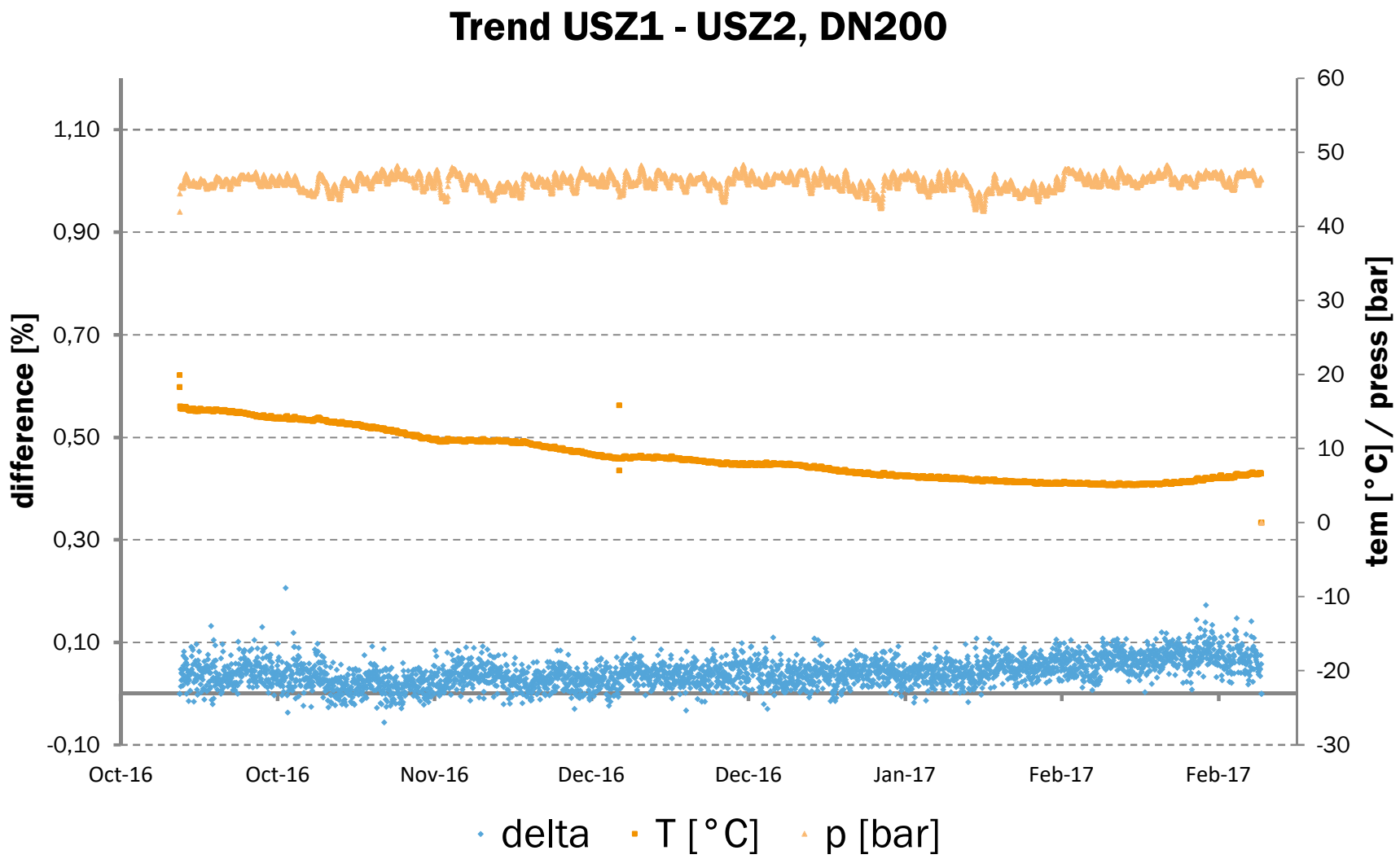


Actual conditions



- Metering line within observation limits

- Trend over 4 month



- SOS difference per meter to theoretical value and per path to avg.

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Innendurchm. Rohr:	0,37800 m	Firmware CRC:	0xCA22	Schallgeschw. Differenz:	0,02 %
Pfadanzahl:	4	Parameter CRC:	0x0E8F	Profilfaktor:	1,117
Impulsfaktor:	720 Impulse/m³	Eichrecht CRC:	0x0285	Symmetrie:	0,984
Impulsfaktor invers:	0,001389 m³/Impulse	Justage CRC:	0x1162	Durchfluss:	7354,00 m³/h
Signal Stacking:	nein	Justagemethode:	Polynom	Durchfluss (norm.):	725783,00 Nm³/h

- Trend data sets currently missing

SOS [m/s]	Mittelwert	Maximum	Minimum
Pfad 1	409,55	409,72	409,34
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CONCLUSIONS

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- Permanent series connection of two Ultrasonic meters
  - Accepted method by operators in Germany (TR-G 18)
  - Operators use **tighter specifications** in terms of design & calibration
  - Proven and accepted method to extend the recalibration cycle
  - Effective to observe the performance of the two USM
  - Effective to **identify possible issues** in the metering line
  - Method to detect **long-term drifts** / changes
  - Operators apply tighter observation limits as requested

CONCLUSIONS

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- General Recommendation
  - Calibration of the complete metering run
  - Use of Diagnostics in addition to **SOS and Volume** comparison
    - AGC, Path ratios, Turbulence etc.
    - Audit trail: Maintenance reports
  - Make use of **finger prints & trend analysis**
    - Comissioning fingerprint
    - Actual comparison
  - Define the allowed difference appropriately to the **line size**
    - Distinguish between small and large sizes
    - E.g. 4-inch = 0.5% vs. 24-inch = 0.4%

SUMMARY & OUTLOOK

- Ultrasonic meters in series connection for fiscal measurements
  - Is a proven way to extend anually the recalibration period
    →Potentially **unlimited calibration** period
  - Diagnostic allows detection of pulsations by using variable measuring rates
  - Use of different US frequencies provide different noise sensitivity
- We **encourage operators** to use the two meter in series concept and **share experience** with the community

MANY THANKS FOR YOUR ATTENTION.

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