Design av fiskale målestasjoner m.h.p. kost / nytte i en livstid syklus

En produktleverandørs syn

Kan verifiserings rutinene forenkles?

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INNHOLD

Teknologi

- DP celle eller turbinmeter teknologi har vært brukt i målesystemer over en lang periode, men ultralyd har tatt over mer og mer av dette markedet.
- Dette gjelder både gass og væske.
- Vi definerer allokerings måling og fiscal måling. Men er det egentlig forskjell.
- Vår kompetanse og erfaring er i stor grad rettet mot ultralyd teknologi, i forhold til målestasjoner.
- Coriolis er også på vei inn i dette markedet, og som presentasjonene under NSFMW i fjor høst viste, med vekslende resultater.
- I denne presentasjonen ser vi først og fremst på ultralyd.

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Referanser

- Vi har sett på og hentet informasjon fra foredrag fra NSFMW 2009 og 2011
- Paper no. 19 2009 Hogendoorn, High Viscosity Hydrocarbon Flow Measurement - a Challenge for Ultrasonic Flow Meters?
- Paper no. 12 2011 Hogendoorn, How accurate are Ultrsonic Flow meters in practical conditions: Beyond the calibration.
- Paper no. 13 2011 Flølo, Operational experiance with Liquid Ultrasonic meters

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Standarder

- De forskjellige standarder definerer design, FAT, og oppstart av fiskale målesystemer
- Vi finner lite i de forskjellige standardene angående verifikasjon og verifikasjonsintervaller.
- Inntrykket vårt er at dette blir definert i hvert enkelt tilfelle i samarbeid mellom OD og selskap. Grunnlaget for disse rutinene har fra starten vært erfaringene med andre måleteknologier.
- Ultralyd målere har vært på markedet siden slutten av 90 tallet, og dermed opparbeidet erfaringer gjennom 10 – 15 år.
- Nye teknologier har måttet dokumentere og argumentere i forhold til kalibrerings rutiner basert på gammel teknologi. Dette ser vi også nå i forhold til Coriolis, som er en massestrøms måler, og som må kalibreres volumetrisk.

Design

- Praksisen i forbindelse med Ultralyd gass, ser ut til å være akseptert med to målere i serie, som verifiseres ved sammenligning og diagnostikk.
- Flere leverandører har sågar utviklet doble målere med to sett sensorer og to sett elektronikk.

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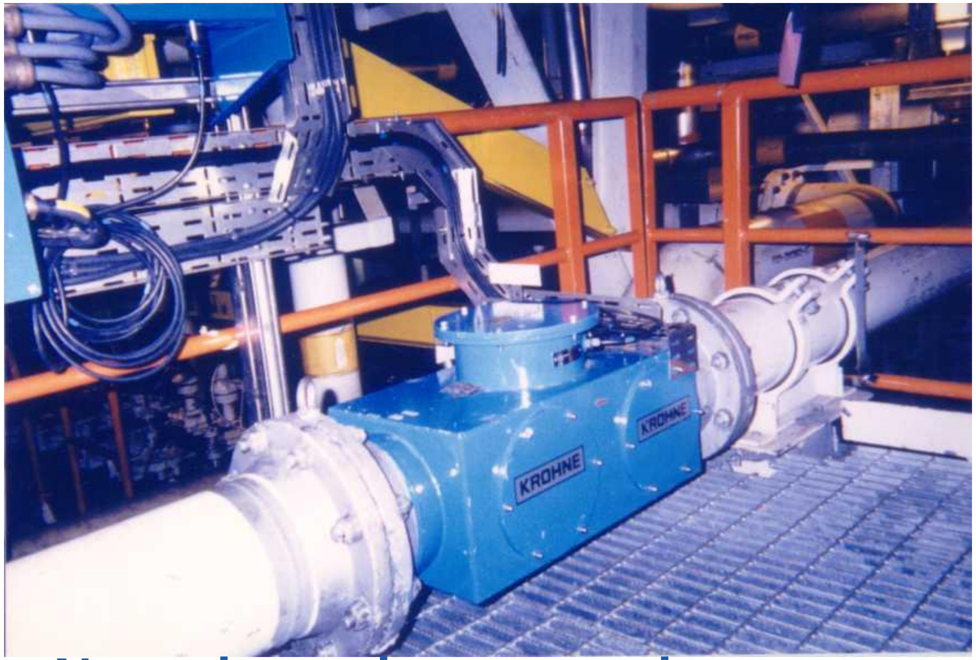
design

- Det samme design konseptet, bør etter hvert kunne overføres til væske systemene også.
- Hogendoorn demonstrerer langtids stabilitet i sitt foredrag fra NSFMW 2011
- Hogendorn demonstrerer sensor utvikling i forbindelse med høy viskositet i sitt foredrag fra NSFMW 2009.
- Fløløo tar for seg erfaringer fra forskjellige målestasjoner i sitt foredrag fra NSFMW 2011

ALTOSONIC V

Flow Metering Installation
Statoil Vigdis/Snorre Crossover



No major maintenance done since their installation in 1997

- Customer:
  Saga (nå Statoil)
- Application: Oil transfer between Snorre and Vigdis process trains
- 2 identical ALTOSONIC V
- Diameter: 8" - 300 lbs
- Installed 1997
- In operation since 98/99
- NPD acceptance for the metering solution

Lang tids stabilitet

Metering Configuration
Vigdis / Snorre Crossover
ALTOSONIC V

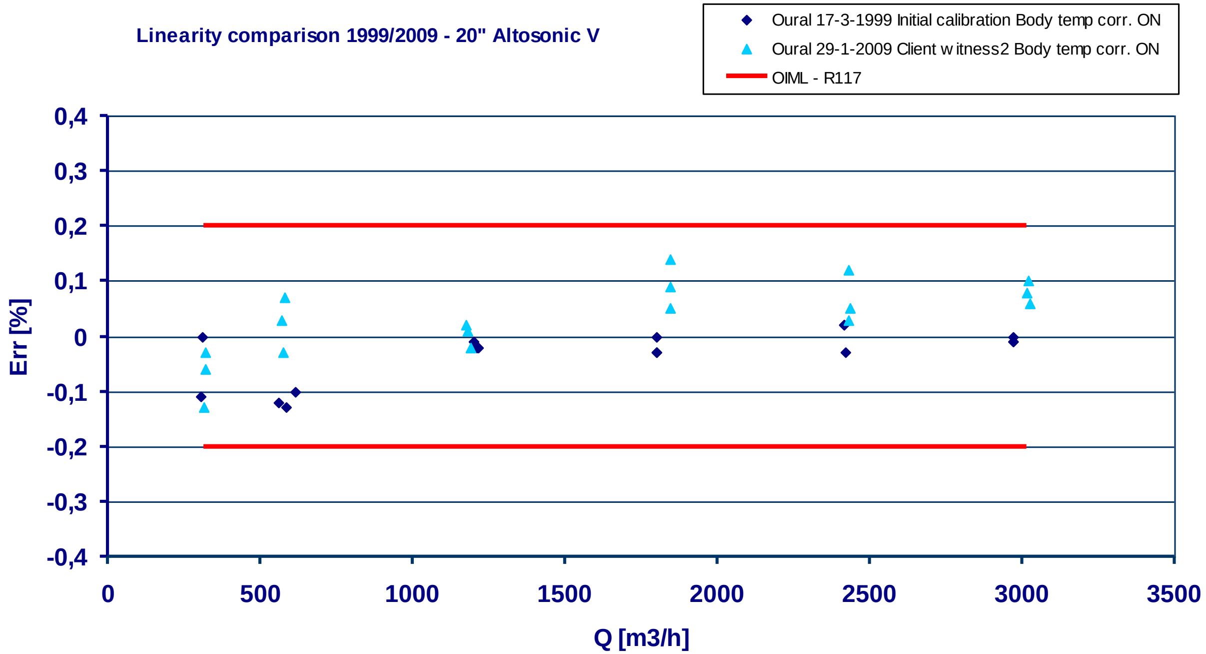
Results

- **“Excellent Experience History”**
- **Both ALTOSONIC V showed similar linearity curve**
- **Recent provings (2009) by the customer showed that the k-factor is within 0.05% compared to the k-factor established after start-up**
- **No major maintenance has been done on these meters since 1997!!**

Ultrasonic Custody Transfer and Master Metering

Long-term stability ALTOSONIC V

- Conditions:
- 20” ALTOSONIC V
- Period of 10 years
- No maintenance
- Verification on Oural (5cSt)
- Difference 1999 – 2009: 0.08%



Introduction

Flowmeter type and design

Initial measuring performance
- Linearity
- Repeatability
- Reproducibility
- Long term stability

Flowmeter sensitivity to
- Process related factors
- Installation related factors
- Environmental factors
- Replacement of components

Overall Measuring Uncertainty

External Factors

Process related factors
- Temperature
- Pressure
- Fluid properties
- Non-single phase
- Non-Newtonian
- Fouling

Installation related factors
- Flow profile
- Wiring
- Connectors
- Power supply

Environmental factors
- Temperature
- Humidity
- Vibration
- Aging

Replacement of components
- Converters
- Processor

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Total Uncertainty Calculation

Total Uncertainty Calculation:

- So far, all parameters or actions that might affect the flow meter uncertainty have been discussed and quantified
- Uncertainty caused by individual sources can depend on diameter and flow speed!
- Overall Uncertainty calculated as:

$$\Delta Q_{total} = \sqrt{\left(\Delta Q_{sys,1} + \Delta Q_{sys,2} + \ldots\right)^2 + \Delta Q_{rand,1}{}^2 + \Delta Q_{rand,2}{}^2 + \Delta Q_{rand,3}{}^2 + (\ldots)^2}$$

Contribution	*Value*		*Remarks*
Linearity	**0.10**	**%**	**Random**
Repeatability	**0.03**	**%**	**Random**
Long term stability	**0.08**	**%**	**Random**
Temperature effects	**0.03**	**%**	**Random (after correction for systematic part)**
Pressure effects	**0.006**	**%**	**Random (after correction for systematic part)**
Installation effects	**0.10**	**%**	**Random**
Calibration facilities	**0.04**	**%**	**Random**
Replacement	**0.01**	**%**	**Random**
TOTAL	**0.17**	**%**	**Total uncertainty in volumetric flow rate**

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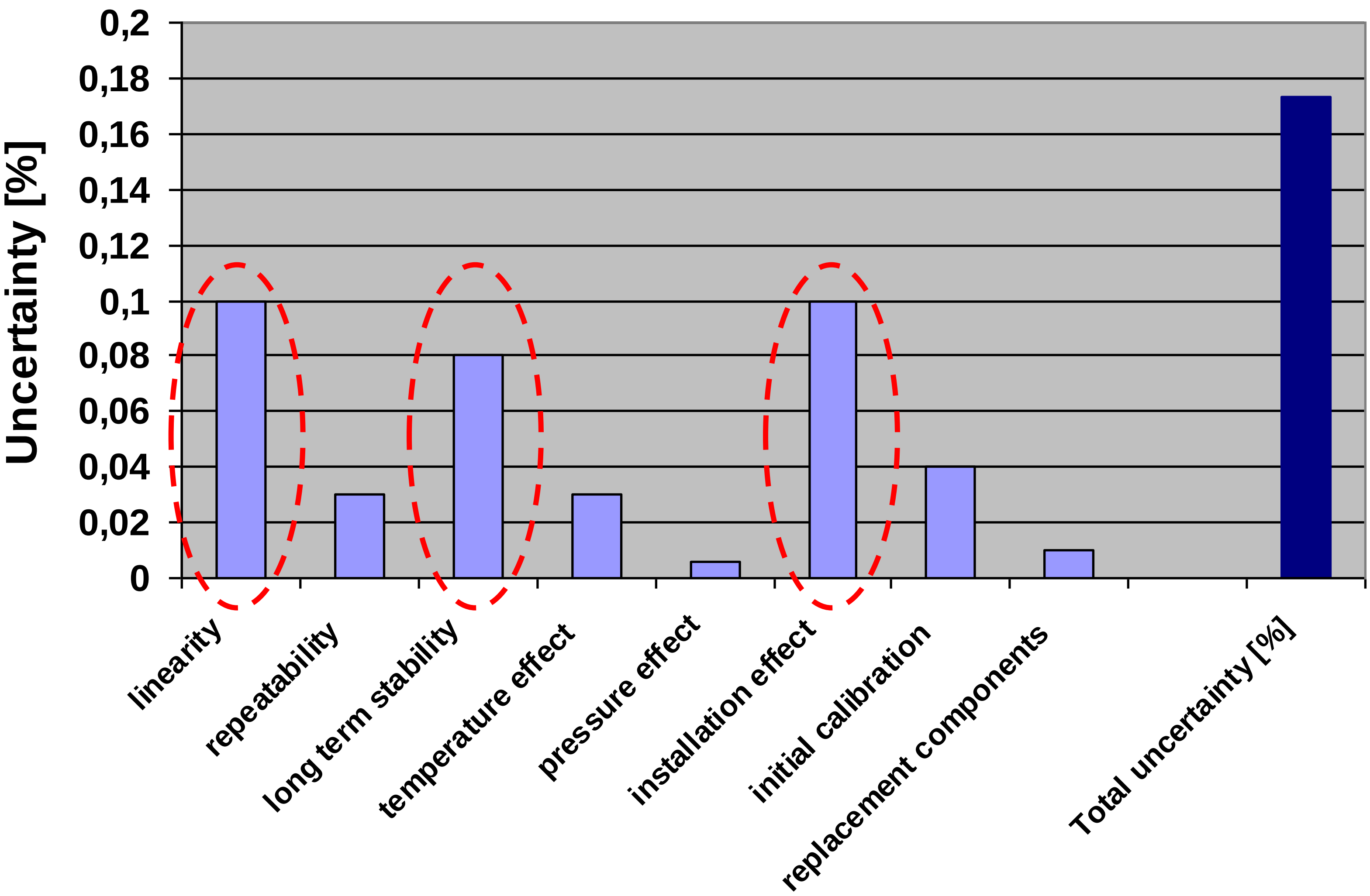
Total Uncertainty Calculation



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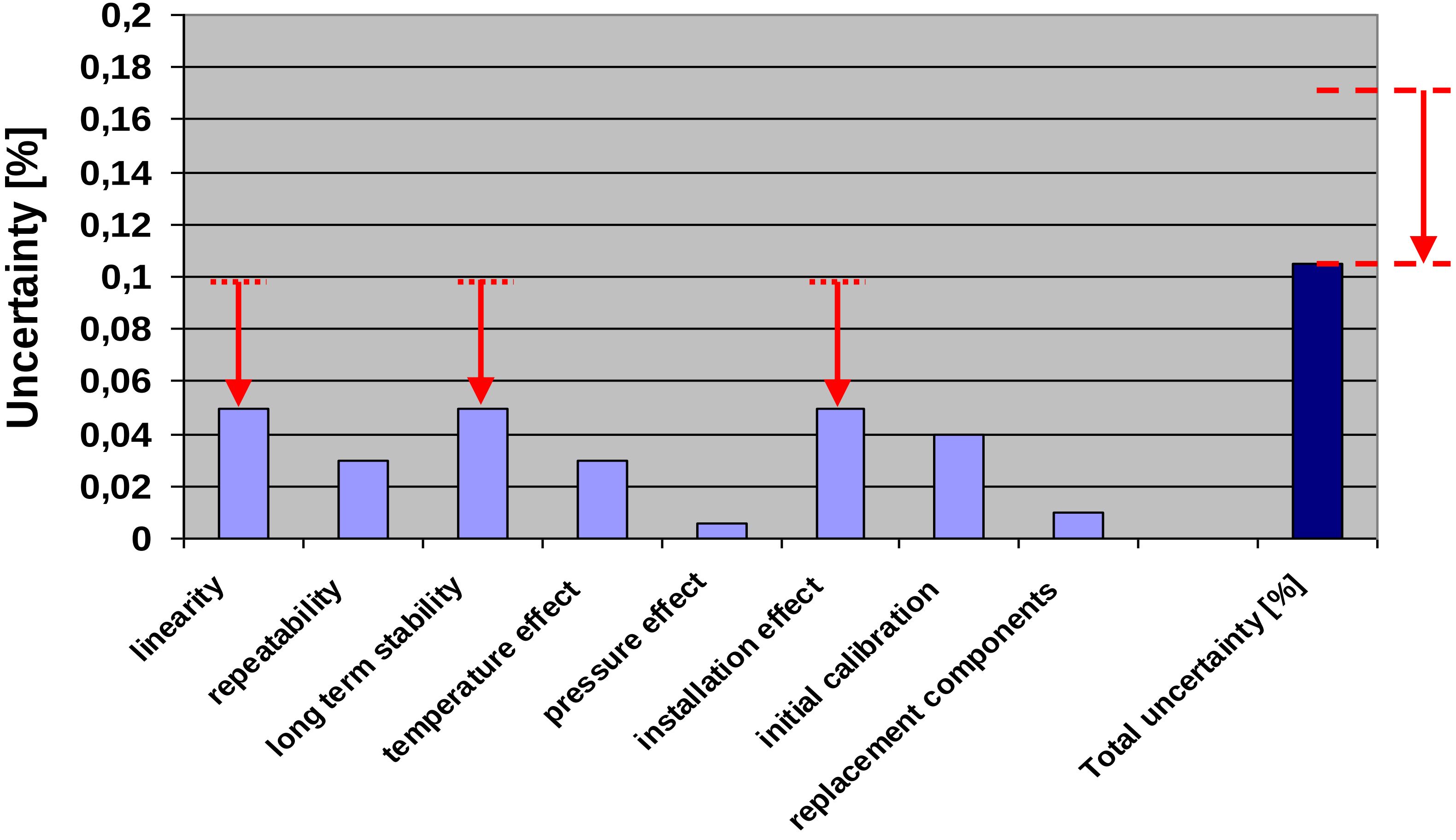
Total Uncertainty Calculation

Uncertainty reduction by dedicated actions:

- Linearity:
  - **Taking entire Reynolds range into account leads to larger non-linearity**
  - **Non-linearity reduced by factor 2 when tailor made Reynolds range calibration is performed**
- Long term stability:
  - **Number shown before is result without any verification during over 10 years**
  - **Verification procedure: in-situ monitoring of long term stability**
  - **Result: reduction of uncertainty can be monitored in-situ and will result in reducing the long term stability significantly**
- Installation effect:
  - **Pay attention to upstream piping configuration**
  - **Flow conditioning measures**
  - **In-situ calibration could reduce the installation effects also (expensive on-site prover system or mobile prover)**

Reducing uncertainty by dedicated actions:

- Reducing the uncertainty in linearity to 0.05%, the long term stability to 0.04% and the installation effects to 0.05%,
- Total uncertainty reduces from 0.17% to 0.10%.

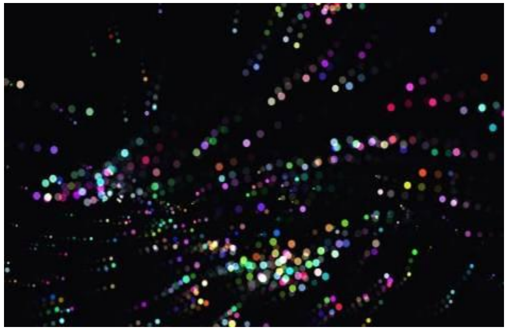


Process Related Factors – *Non-single phase*

Non-single phase flow:

- **Applications where the flowmeter has to deal with vapour bubbles, oil-in-water or solid particles**





Vapour bubbles:

- Flowmeter accuracy affected by content of gas/air in the liquid
- Rule of thumb: one-to-one relationship → e.g. ~0.1 Vol.% of vapour bubbles: ~0.1% over reading in volume flow measurement
- In practise a couple of percent of gas can be handled by the ultrasonic flowmeter
- Diagnostics module in the ALTOSONIC V creates alarm as soon as the fraction of path failures exceeds a predefined threshold
- Mechanical flow meters won't detect air/gas. Could lead to significant undetected errors.

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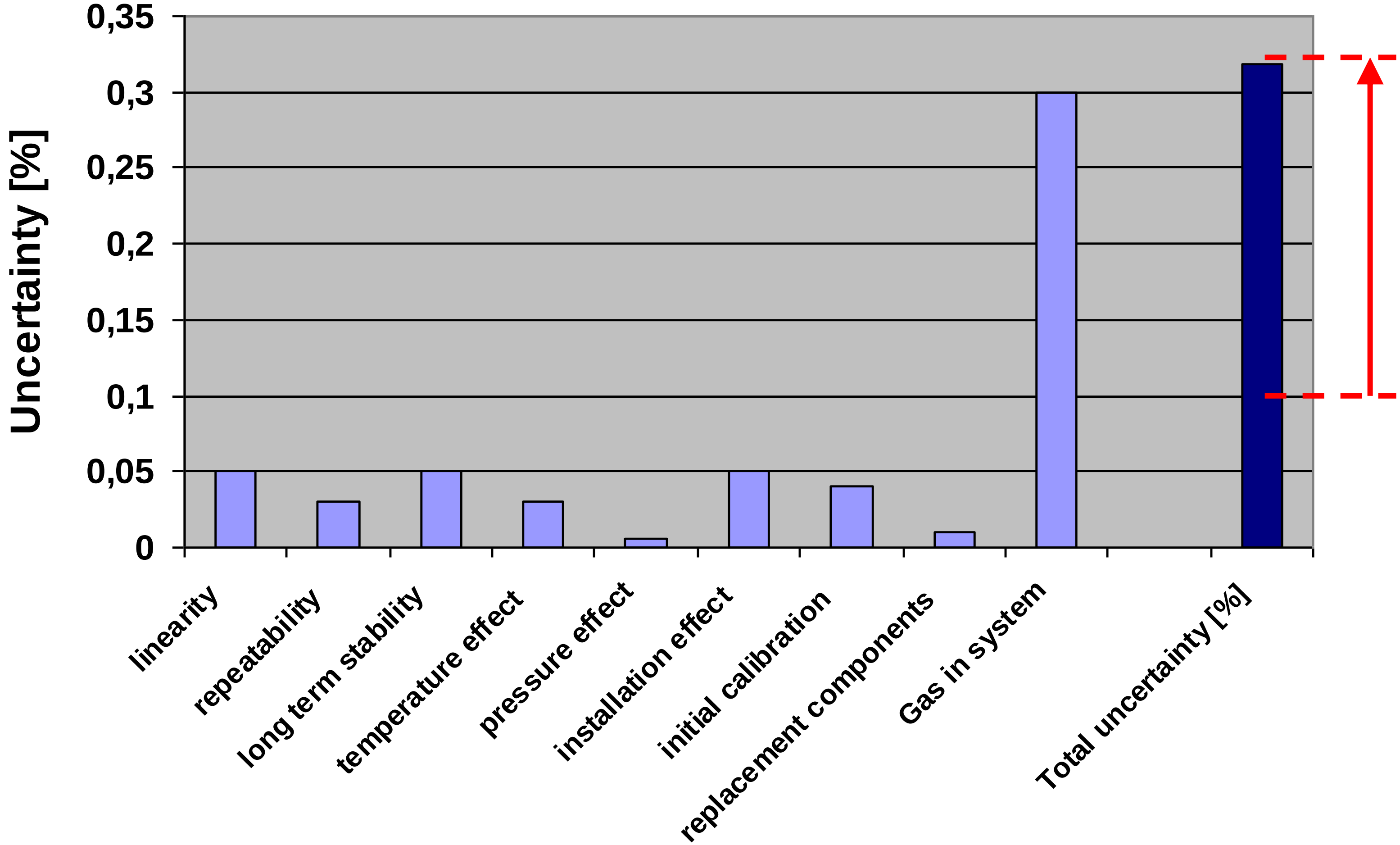
Total Uncertainty Calculation

Increase in Uncertainty:

- Gas in the system
- e.g. 0.3 Vol.-% of gas → additional uncertainty of 0.3%.



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Paper no 13 2011, Flølo

Erfaringene fra Flølo sine referanser, gjør at han konkluderer følgende:

- As claimed by the manufacturer there are no sign of K-factor drift for any of the meters evaluated in this paper.
- As claimed by the manufacturer the long time reliability of the meters seems to be superior and no hardware failure of any of the meters are recorded.

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Paper no 13 2011, Flølo

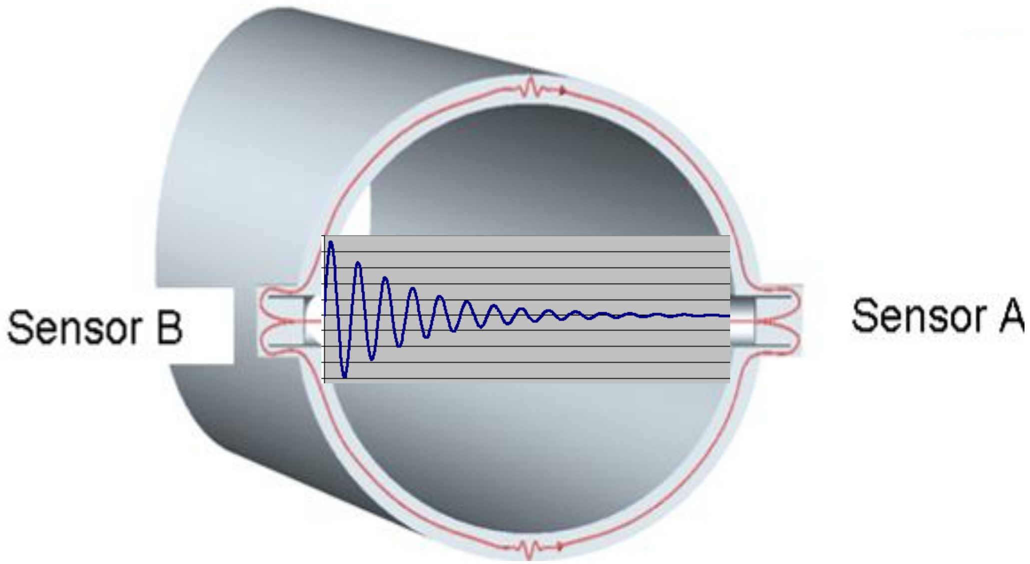
- Men Fløl sine referanser viser også at høy viskositet er en utfordring.
- Dette viser seg kraftigst i det laminære flow regimet, samt overgangen fra turbulent til laminær flow.
- I ettertid av leveransene til referanse prosjektene, har sensor teknologien hatt en utvikling.

Critical Factors

Major issues leading to measurement uncertainty of ultrasonic meters are:

- Attenuation of the transmitted acoustic signal
- Increasing cross-talk due to attenuation

Critical Factor: Attenuation of Transmitted Acoustic Signal



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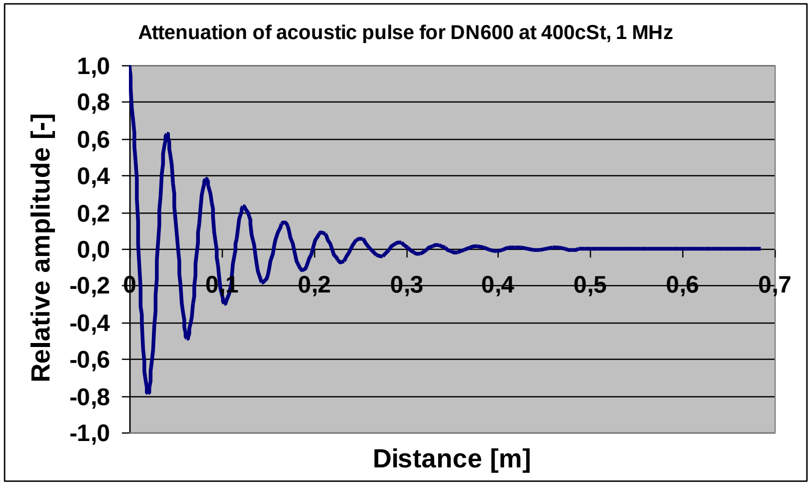
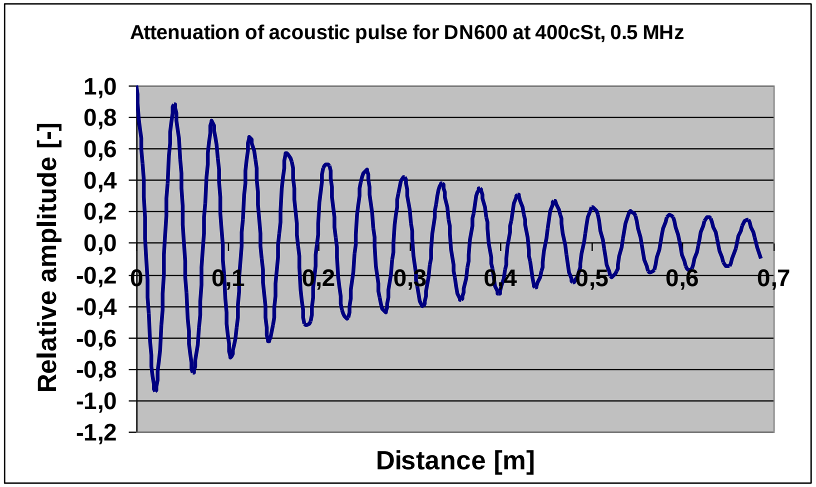
Critical Factor: Attenuation of Transmitted Acoustic Signal

Solution:

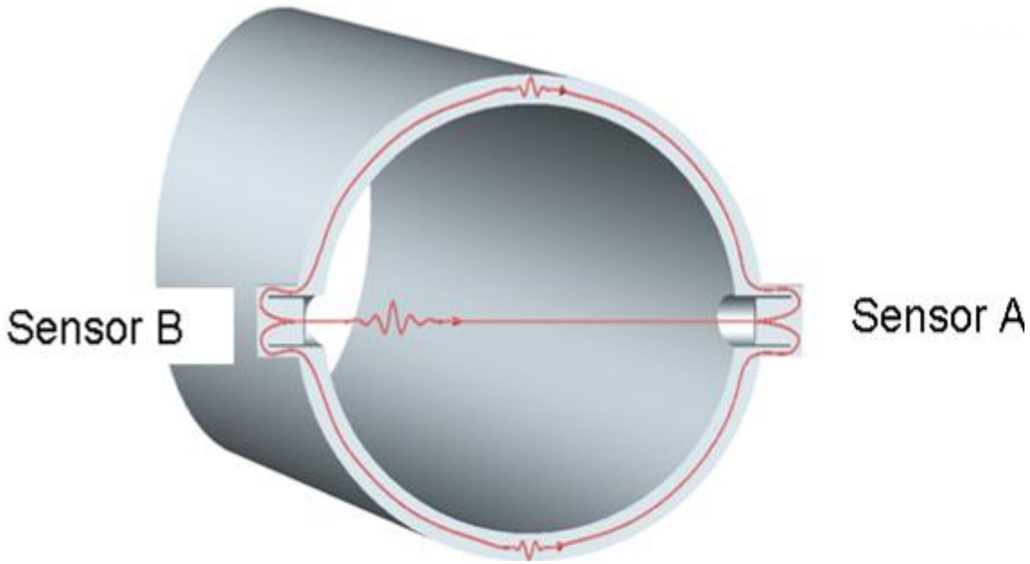
- Reduction of path length
- Conical measuring section (reduced bore)

- Reduction of frequency
- From 1 MHz down to 0.5 MHz





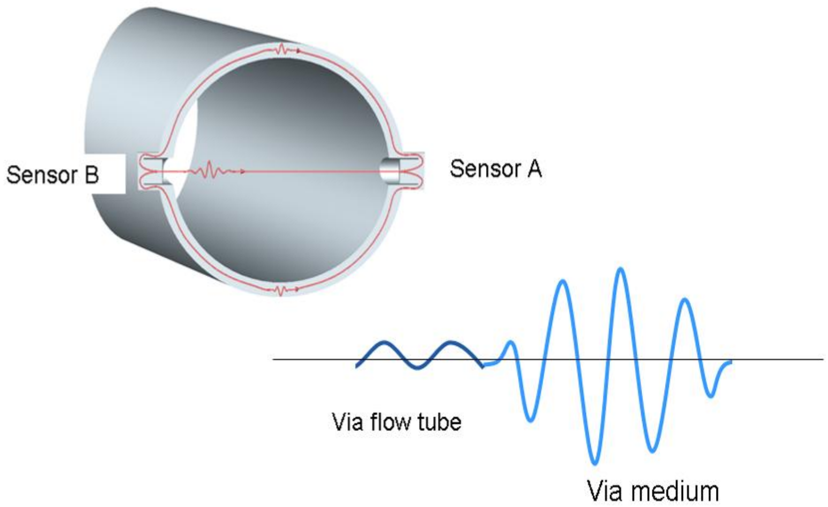
Critical Factor: Increasing Cross-talk due to Attenuation



Critical Factor: Increasing Cross-talk due to Attenuation

Cross talk

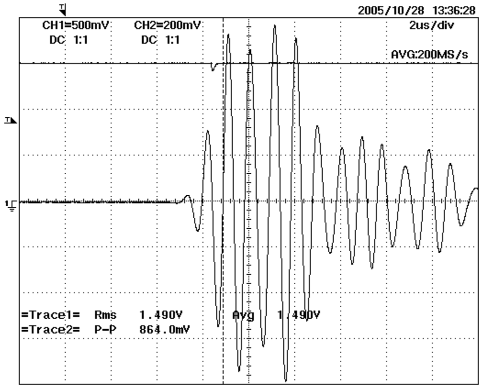
- Ultrasonic acoustic signal transported via pipeline wall
- Higher viscosity: stronger cross talk signal compared to the received signal
- Significant effect on overall uncertainty

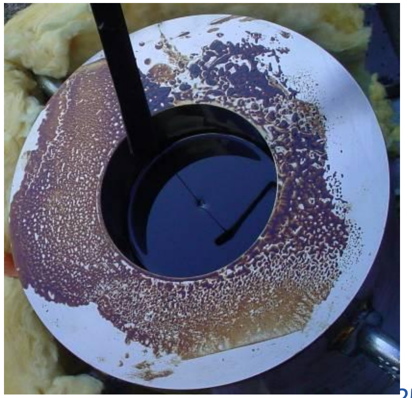


Critical Factor: Increasing Cross-talk due to Attenuation

Solution:

- Improved transducer decoupling
- Isolating transducers from meter tube, reducing direct metallic contact
- Tests performed on a flow meter tube using crude oil with a viscosity of 1,500 cSt
- R&D test results prove that the signal to noise (cross talk) ratio is significantly better for the new decoupled transducer design



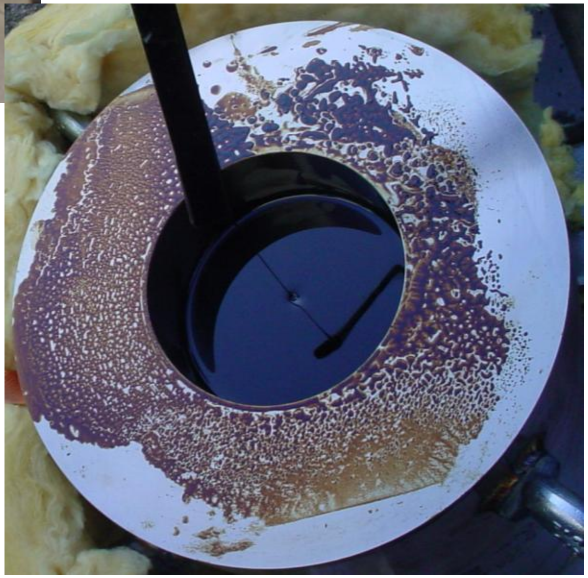


ALTOSONIC V

Custody Transfer of High Viscosity Hydrocarbons

Flowmeter Design and Tests:

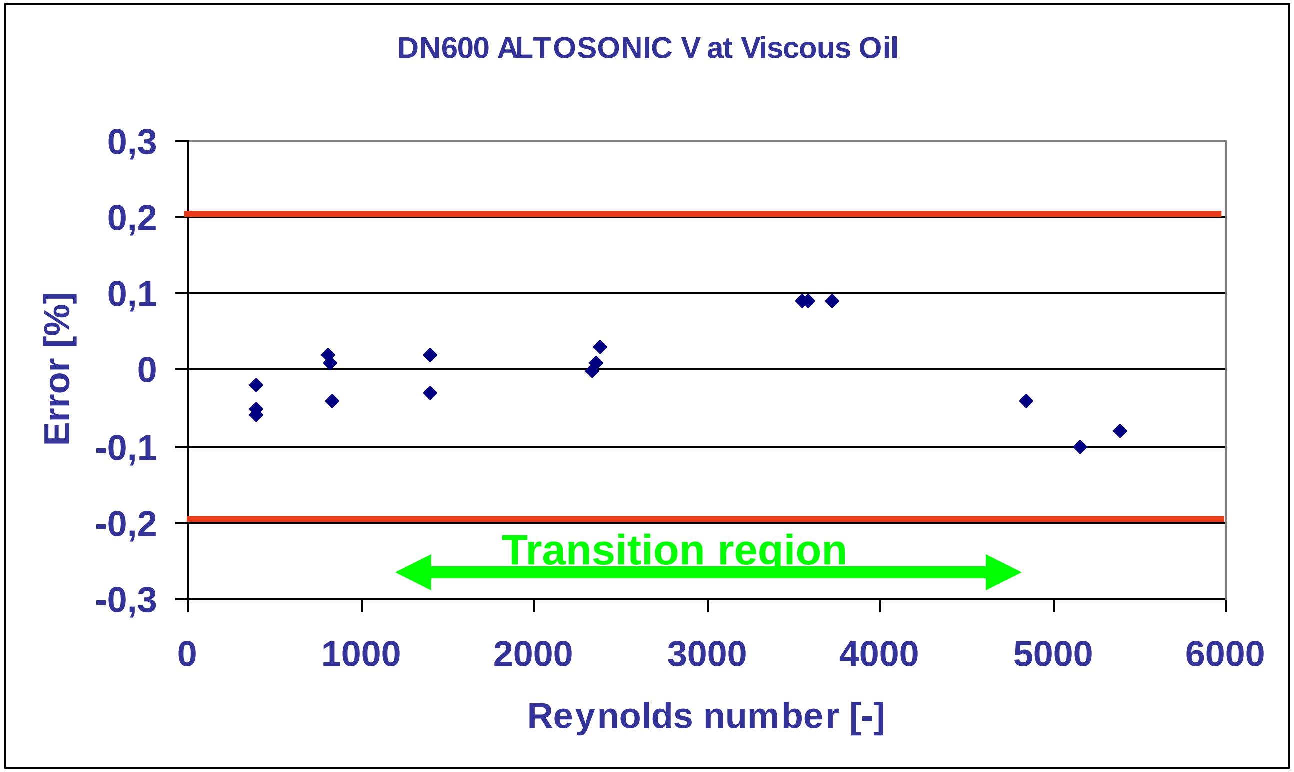
- Special Transducer Design
- Accuracy: ± 0.20% of MV
- Repeatability: ± 0.06%
- Certified up to 400 cSt
- Viscosities up to 1500 cSt
- Compliant with:
  - OIML R117
  - MI-005
  - NPD
  - API



ALTOSONIC V High Viscosity Design (up to DN600)

Test Results at SPSE France

- **Linearity and repeatability as function of Reynolds number**



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Many Applications running

- **Stable measurement results**
- **Satisfied Customers !**

- **Feedback from one of our Customers:**

Meter size	No drift observed over a period of
6 inch	23 months
6 inch	9 months
6 inch	20 months
12 inch	8 months
24 inch	46 months

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Integrated Diagnostics

Several self tests performed

- Memory checks
- Parameter validity check
- Plausibility checks on individual measurements
- Validity check of measured values
- Sound velocity check i.e. comparison between 5 beams
- And more …

Diagnostics of direct environment

Combination of data like

- Flow velocity per path
- Sound velocity per path
- Signal strength
- Signal-to-noise ratio

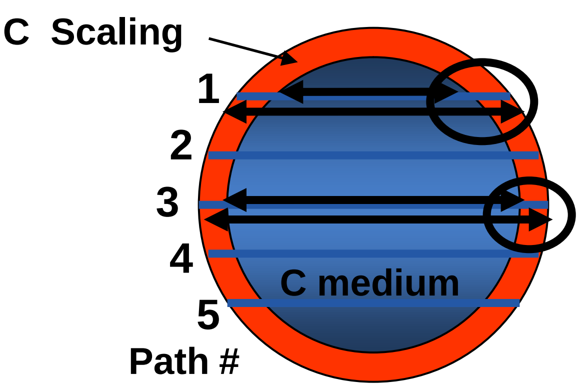
Provide indication of

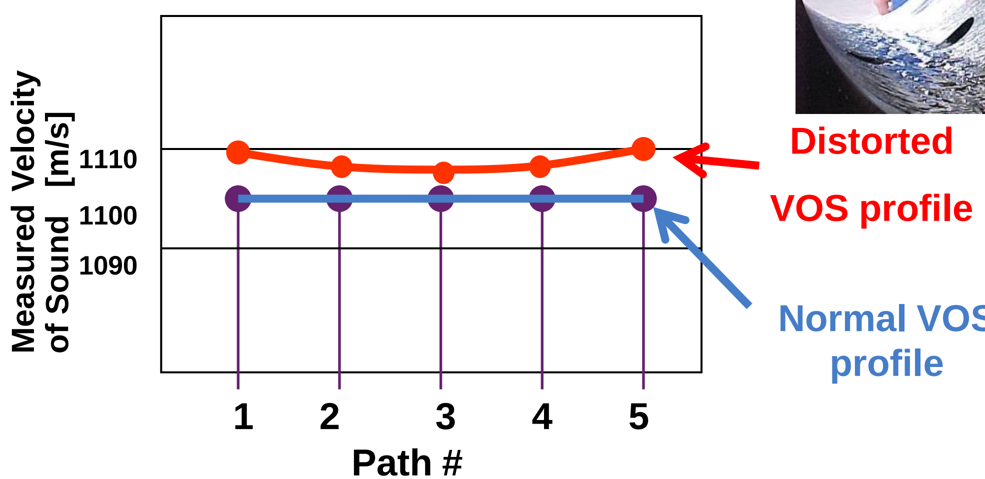
- Scaling
- Presence of higher viscosities, entrained air, gas or wax
- Warning that measurements may not be within specified accuracy class (measurement continues!)

Integrated Diagnostics

Fouling:

- Dependent on the process and type of fluid, fouling might occur (Scaling, Wax formation, ..)
- Could also occur in flowmeter
- Acoustical properties (density, speed of sound, attenuation) of the fouling layer differs from the properties of the liquid
- Speed of sound at 5 different paths: very thin layers of fouling can be detected → alarm can be created
- In addition: check by using the procedure as described later on





Diagnostics: Other Examples

Indication of

- Too high contents of solids or particles
- Too high gas contents e.g. resulting cavitations

Observation

- Transmitted signal from one sensor not correctly received by the other sensor.

Alarm: Path failure

- Automatically an alarm is generated
- Real time correction of missing values based on historical data

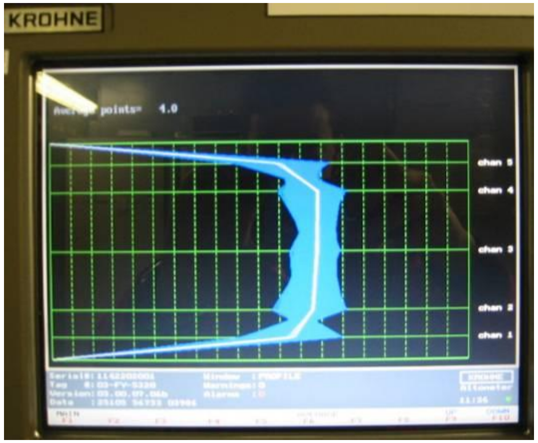
Indication of

- Obstruction in the flow
- Damaged valve

Observation

- Velocity profile disturbances

Diagnostic feature: Visualization of the Flow Profile



Konklusjon

- Langtids stabilitet er demonstrert suveren.
- Ultralyd væske målere gjennomgår kontinuerlig videreutvikling
- Diagnose funksjonene utvikles kontinuerlig, og er fullt på høyde med gass målerne
- Sensor teknologien utvikles kontinuerlig
- Vår erfaring er at det er flere målere som blir ”skrudd i filler” ved kalibrering på land, enn det oppdages drift.
- Og de kommende årene vil gi enda bedre utviklede målere enn dem vi ser som er 10 – 15 år gamle.
- Vi bør ha større fokus på bygge prosess slik at måleren får stabile væsker å måle på. Gass i væsken gir større utslag i måleusikkerhet, enn målerens egen oppførsel over tid.


Takk for oppmerksomheten
achieve more