

# Tilstandsovervåkning av ultralydmålere i et flerfase testanlegg

NFOGM fagdag, 2024-03-13

Christian Hågenvik

Equinor, K-lab

# Agenda

- Introduksjon til K-lab
- TESMA
- Overvåkning av ultralydmålere på gass
- Usikkerhet i beregnet lyd hastighet
- Oppsummering





## Technical specifications for the **SST** multiphase test loop

Pit dimensions: 13x15x20 (HxWxL)  
 Test section dimension: 12-16 inches (16" inlet)  
 Max gas flow rate: 13 000 m<sup>3</sup>/h  
 Liquid flow rate: 0-150 m<sup>3</sup>/h  
 Max. Op Press Liq/LP/HP: 140 / 140 / 190 bar  
 Temperature 10-60°C

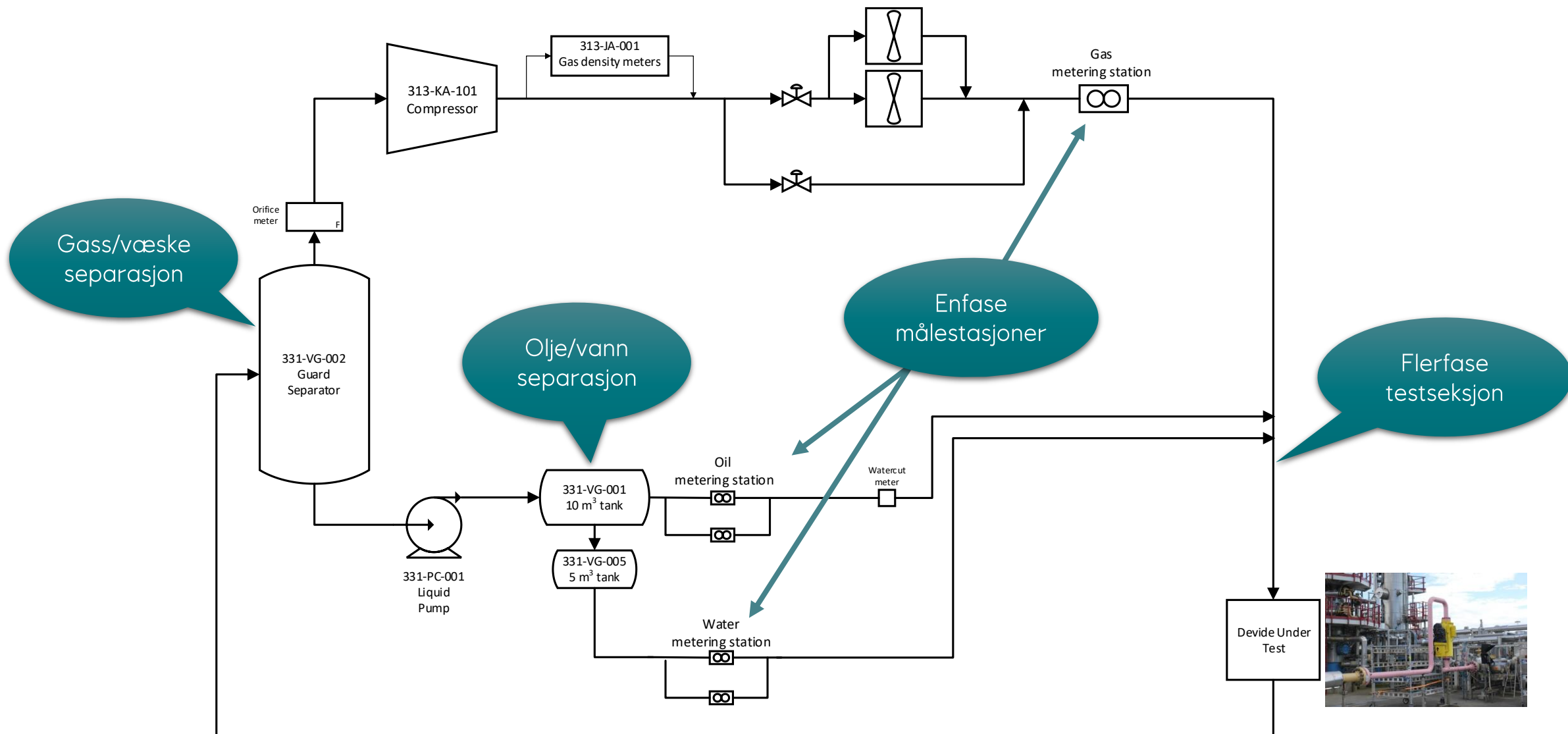


## Technical specifications for the **VGII** multiphase test loop

Test section dimension: 1-12 inches (8" inlet)  
 Gas flow rate: 20 – 3000 m<sup>3</sup>/h  
 Liquid flow rate: 0-150 m<sup>3</sup>/h  
 Operating pressure: 20-135 bar  
 Temperature 20-60°C



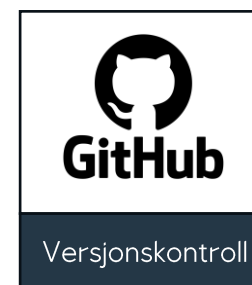
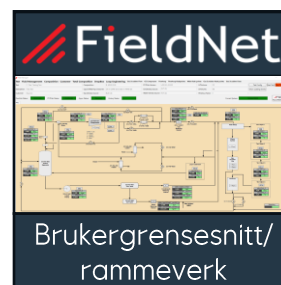
# K-lab VGII flerfase flowloop



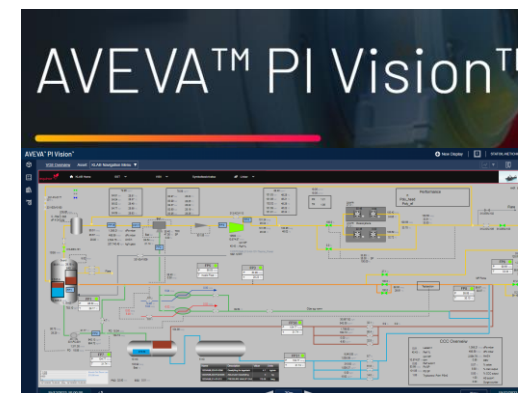
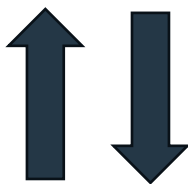
# TESMA: K-lab Test Management system

Live termodynamiske og måletekniske beregninger

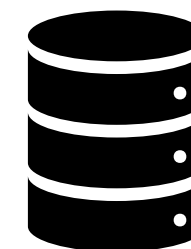
PVT engines



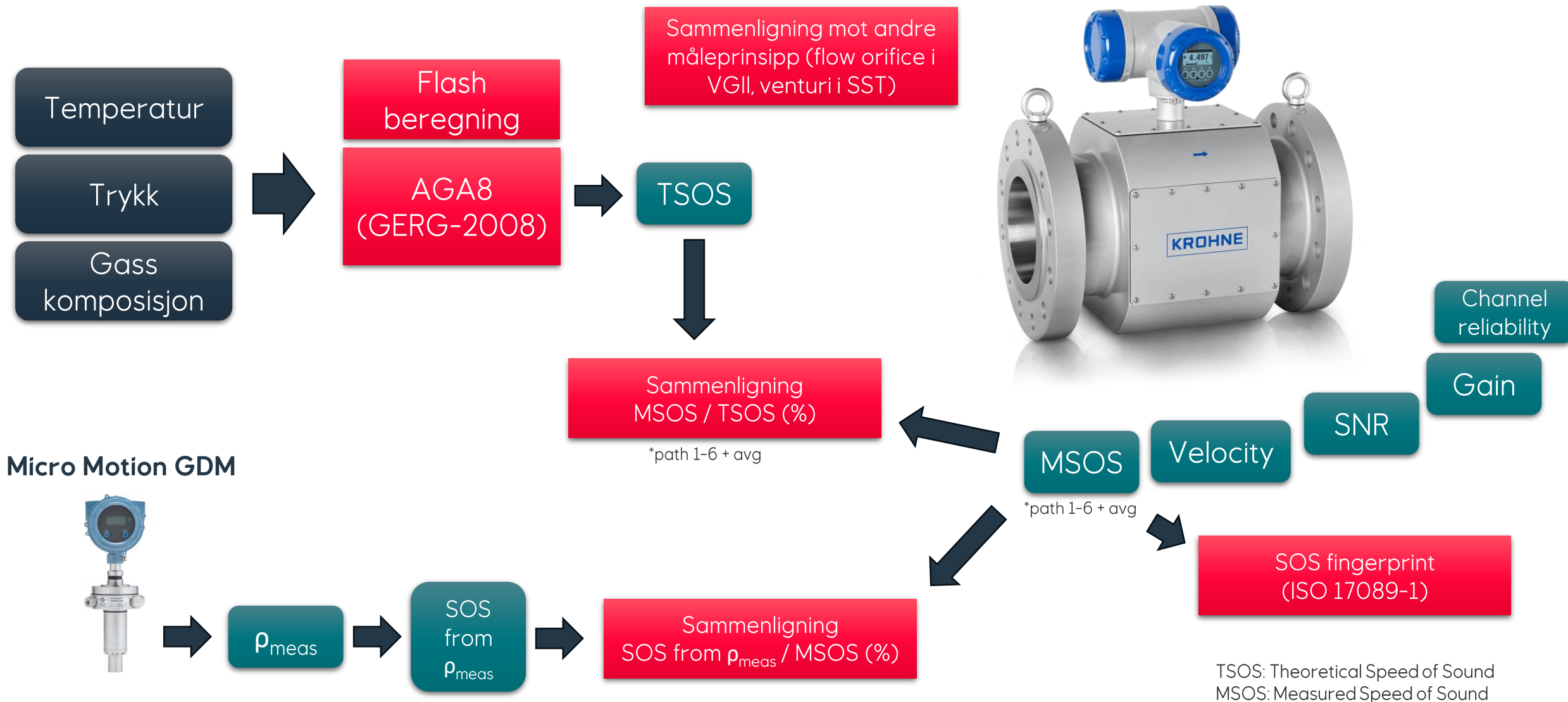
1 sekund oppløsning  
38 000 resultater per sekund  
9000 tag lagres i PI



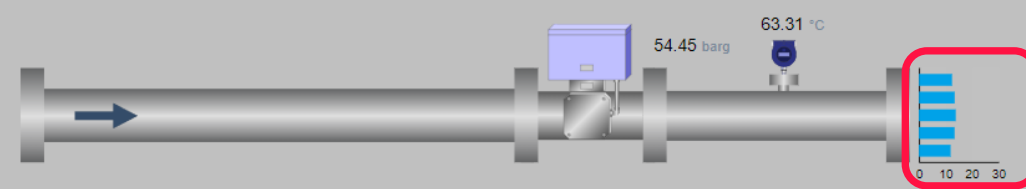
Tidsseriedatabase og  
visualisering



# Overvåkning av ultralydmåler



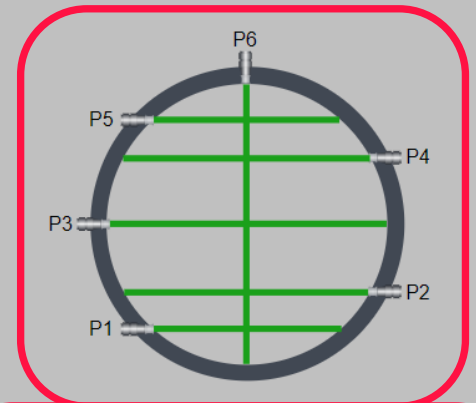
VGII - Krohne ALTOSONIC V12 8" Ultrasonic flowmeter



Liquid drop-out in USM (PVT)  
0.00000 % ●

### Comparing measured and calculated SOS

Calculated (AGA8: GERG-2008)	392.02 m/s
Measured (Altosonic V12)	392.33 m/s
Difference (%)	0.08 % <span style="color: green;">●</span>
Difference adjusted (%)	0.01 % <span style="color: green;">●</span>
Calculated from meas density (GDM)	392.83 m/s
Difference (%)	0.13 % <span style="color: green;">●</span>
Meas SOS max-min difference (%)	0.14 % <span style="color: green;">●</span>



Volume flowrate (uncorrected)	1,097.6 m³/h
Volume flowrate (PT corrected)	1,099.8 m³/h
Volume flowrate (linearized - final)	1,098.5 m³/h
Mass flowrate (linearized - final)	50,216.2 kg/h
Density (in use)	45.7 kg/m³
Velocity	13.1 m/s

	SNR		Gain [dB]	Ch reliability [%]	SOS [m/s]	Diff SOS [%]
Path 1	32.3 <span style="color: green;">●</span>	29.7 <span style="color: green;">●</span>	44.2 <span style="color: green;">●</span>	44.5 <span style="color: green;">●</span>	97.6 <span style="color: green;">●</span>	391.98 -0.01 <span style="color: green;">●</span>
Path 2	32.4 <span style="color: green;">●</span>	37.0 <span style="color: green;">●</span>	46.6 <span style="color: green;">●</span>	46.6 <span style="color: green;">●</span>	91.9 <span style="color: green;">●</span>	392.30 0.07 <span style="color: green;">●</span>
Path 3	27.1 <span style="color: green;">●</span>	29.1 <span style="color: green;">●</span>	51.4 <span style="color: green;">●</span>	52.2 <span style="color: green;">●</span>	89.0 <span style="color: green;">●</span>	392.53 0.13 <span style="color: green;">●</span>
Path 4	31.3 <span style="color: green;">●</span>	29.9 <span style="color: green;">●</span>	46.0 <span style="color: green;">●</span>	46.0 <span style="color: green;">●</span>	98.3 <span style="color: green;">●</span>	392.36 0.09 <span style="color: green;">●</span>
Path 5	29.3 <span style="color: green;">●</span>	31.4 <span style="color: green;">●</span>	45.8 <span style="color: green;">●</span>	46.7 <span style="color: green;">●</span>	86.8 <span style="color: green;">●</span>	392.23 0.05 <span style="color: green;">●</span>
Path 6	31.2 <span style="color: green;">●</span>	30.2 <span style="color: green;">●</span>	49.0 <span style="color: green;">●</span>	49.2 <span style="color: green;">●</span>	98.7 <span style="color: green;">●</span>	392.44 0.11 <span style="color: green;">●</span>

### Meter status

Alarm: 0 All OK ●

Overall reliability 97.9 % ●

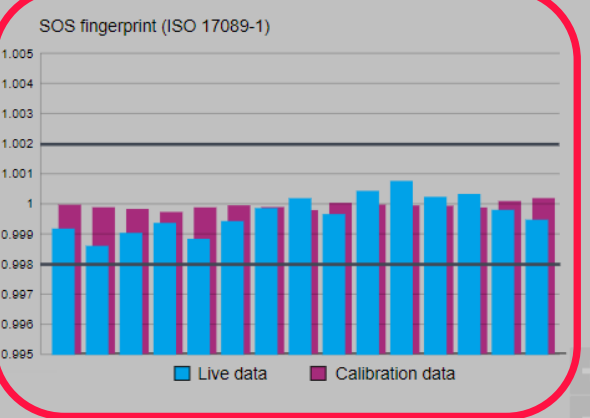
Pressure correction 0.00 %

Temperature correction 0.21 %

Linearization 0.12 %

Comparing massflow between USM and orifice Invalid Float %

\*Only calculated when 0177 and 0049 is closed





# Eksempel: Baner faller ut på lavt trykk og høye hastigheter

AVEVA™ PI Vision™

VGII-USM Asset: KLAB Navigation Menu

STATOIL-NETCHHAG

equinor KLAB Home SST VGII Symbolbeskrivelse Linker

### VGII - Krohne ALTOSONIC V12 8" Ultrasonic flowmeter

Liquid drop-out in USM (PVT) 0.00391 %

Volume flowrate (uncorrected) 2,514.2 m³/h

Volume flowrate (PT corrected) 2,515.0 m³/h

Volume flowrate (linearized - final) 2,511.7 m³/h

Mass flowrate (linearized - final) 57,406.8 kg/h

Density (in use) 22.9 kg/m³

Velocity 29.2 m/s

#### Comparing measured and calculated SOS

Calculated (AGA8: GERG-2008)	392.03 m/s
Measured (Altosonic V12)	391.68 m/s
Difference (%)	-0.09 %
Difference adjusted (%)	-0.16 %
Calculated from meas density (GDM)	392.05 m/s
Difference (%)	0.09 %
Meas SOS max-min difference (%)	0.54 %

	SNR		Gain [dB]		Ch reliability [%]	SOS [m/s]	Diff SOS [%]
Path 1	21.5	22.5	55.0	57.9	19.4	391.68	-0.09
Path 2	12.1	11.6	55.9	56.8	15.6	391.91	-0.03
Path 3	20.0	16.8	61.0	63.8	9.6	392.04	0.00
Path 4	21.8	23.3	56.4	58.5	69.7	392.03	0.00
Path 5	20.0	10.3	58.4	60.2	20.3	389.92	-0.54
Path 6	26.4	14.3	57.9	57.9	93.0	392.02	0.00

#### Meter status

Alarm: 2 Some paths failed - unreliable

Overall reliability 27.0 %

Pressure correction -0.02 %

Temperature correction 0.05 %

Linearization 0.13 %

Comparing massflow between USM and orifice -0.19 %

\*Only calculated when 0177 and 0049 is closed

#### SOS fingerprint (ISO 17089-1)

12/12/2023 09:41:00 3m 12/12/2023 09:44:00

# ISO 17089-1

## Measurement of fluid flow in closed conduits – Ultrasonic meters for gas

“The MSOS to TSOS comparison is acceptable when the differences are  $\leq 0,25\%$ » (< 120 bar og -8 til 62°C)”

1. Hva er usikkerheten i beregnet lyd hastighet?
2. Er kravet realistisk å oppnå for alle typer gasser?

Table 6 — Relational diagnostic diagram

Relational diagnostic	Per path					
	Signal Acceptance	Automatic gain control	S/N	MSOS	Flow velocity	Standard Deviation
Transducer failure	x	x	—	x	x	x
Detection problems	x	x	x	x	x	x
Ultrasonic noise	x	x	x	—	—	—
Process conditions pressure	—	x	x	—	—	—
Process conditions temperature	—	—	—	x	—	—
Fouling	x	x	x	x	x	x
Changes in the flow profile	—	—	—	—	x	x
High velocity	x	x	x	—	—	x

ISO 17089-1:2019, side 50

Usikkerhet i beregnet lyd hastighet

Usikkerhet i målt trykk og temperatur

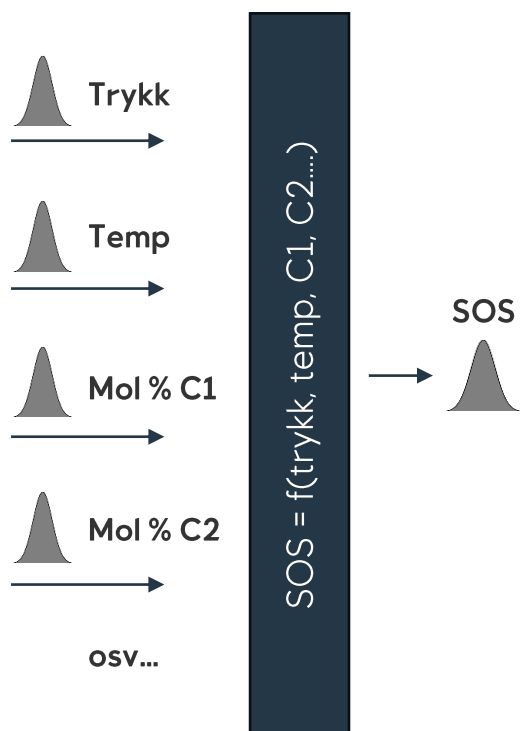
Usikkerhet i komposisjon (GC)

Usikkerhet i modell/ligning AGA8 (DETAIL eller GERG-2008)

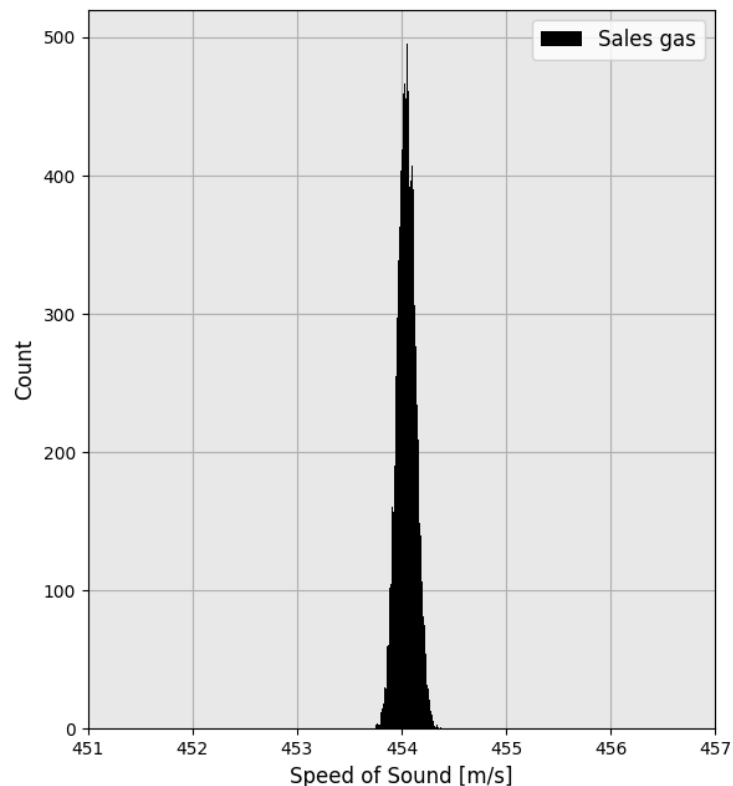
AGA8: «the uncertainties in density and speed of sound are **generally** within 0.1 % or less”

# Usikkerhet i kalkulert lydshastighet fra usikkerhet i trykk, temperatur og komposisjon

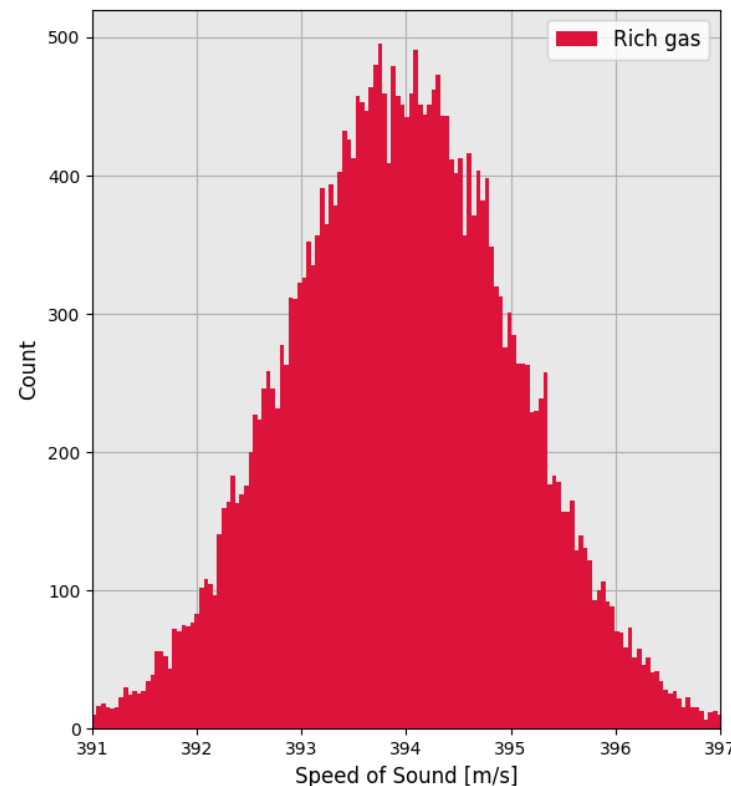
Estimert usikkerhet basert på Monte Carlo (trykk, temperatur og komposisjon) for hhv salgsgass og rikgass



Monte Carlo results: Distribution of Speed of Sound at 60.0bara and 80.0°C for rich gas and sales gas



Mean [m/s]	454.0
2σ [m/s]	0.17
2σ [%]	0.04



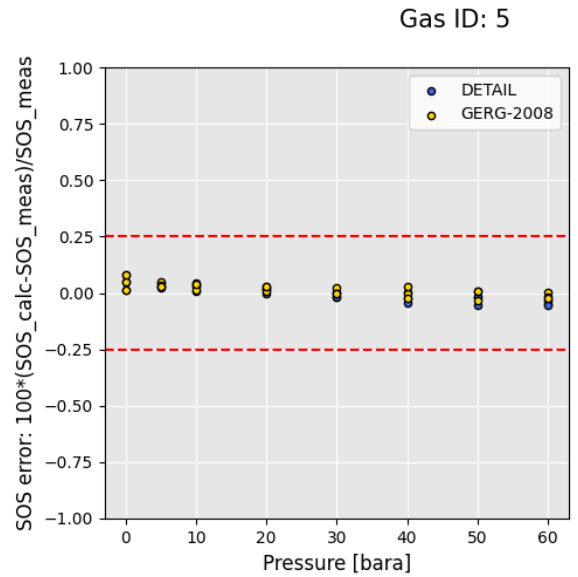
Mean [m/s]	394.0
2σ [m/s]	2.16
2σ [%]	0.55

Estimert usikkerhet fra Monte Carlo oppgitt som 2 standardavvik ( $\sigma$ ), 95 % konfidensintervall

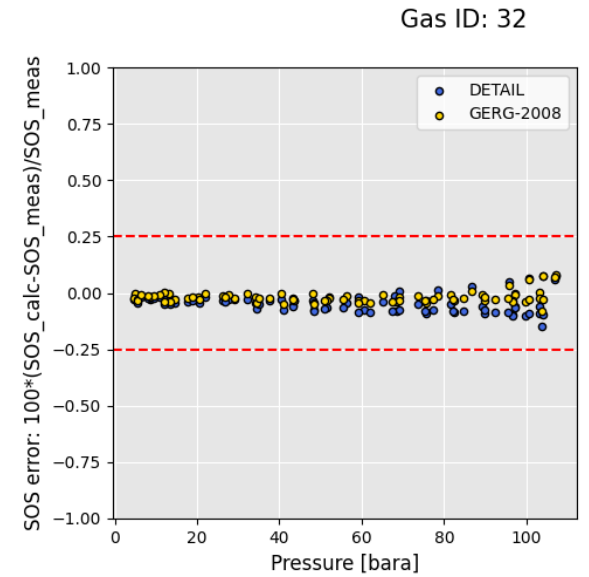
# Usikkerhet i modell? (AGA8: DETAIL og GERG-2008)

## Sammenligning av beregnet og målt lydshastighet for kjente gasser

«Tørrgass» / «salgsgass»

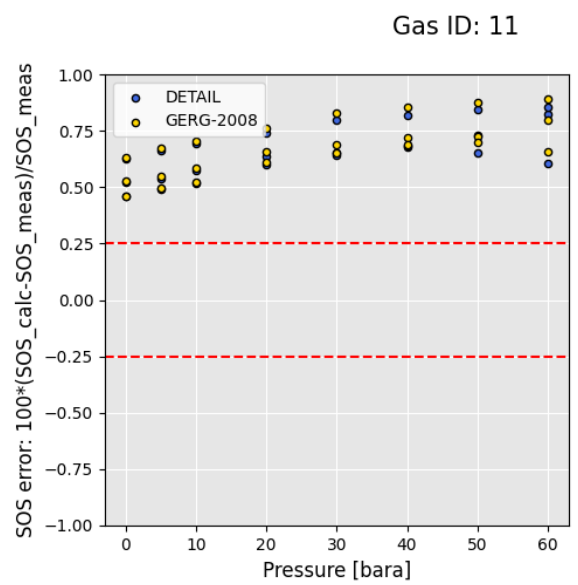


Mole Percentage	
C1	81.216
N2	17.103
CO2	0.493
C2	1.05
C3	0.039
nC4	0.007
iC4	0.009
nC5	0.006
iC5	0.002
nC6	0.003
nC7	0.001
nC8	0.0
nC9	0.0
nC10	0.0
H2	0.0
O2	0.0
CO	0.0
H2O	0.0
H2S	0.0
He	0.07
Ar	0.0

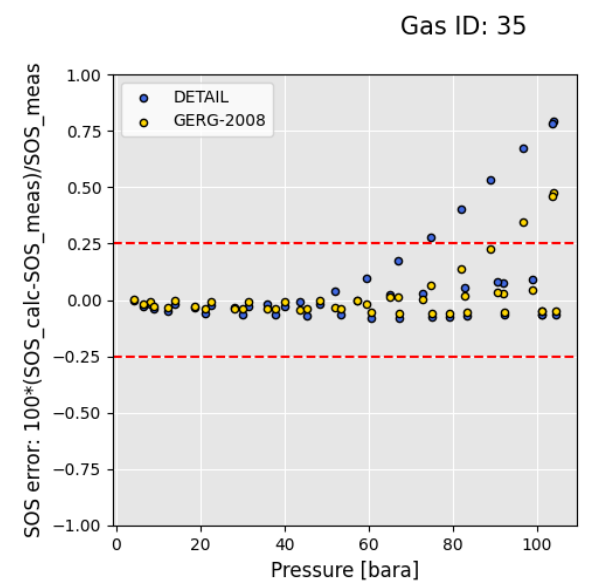


Mole Percentage	
C1	96.561
N2	0.262
CO2	0.597
C2	1.829
C3	0.41
nC4	0.098
iC4	0.098
nC5	0.032
iC5	0.046
nC6	0.067
nC7	0.0
nC8	0.0
nC9	0.0
nC10	0.0
H2	0.0
O2	0.0
CO	0.0
H2O	0.0
H2S	0.0
He	0.0
Ar	0.0

«Rikgass»



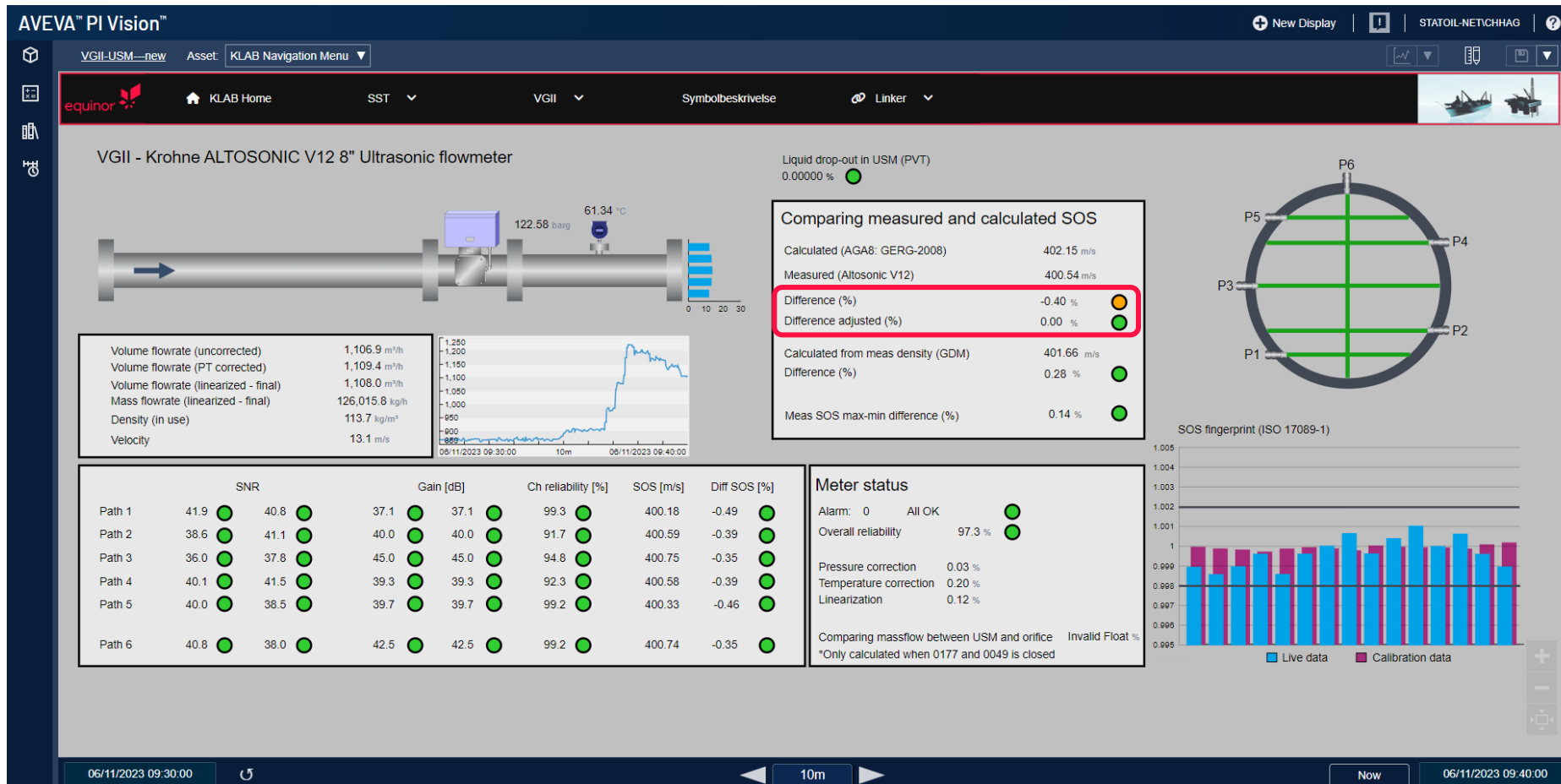
Mole Percentage	
C1	80.088
N2	7.909
CO2	3.53
C2	3.819
C3	3.039
nC4	0.902
iC4	0.435
nC5	0.127
iC5	0.125
nC6	0.026
nC7	0.0
nC8	0.0
nC9	0.0
nC10	0.0
H2	0.0
O2	0.0
CO	0.0
H2O	0.0
H2S	0.0
He	0.0
Ar	0.0



Mole Percentage	
C1	74.348
N2	0.537
CO2	1.028
C2	12.005
C3	8.251
nC4	3.026
iC4	0.0
nC5	0.575
iC5	0.0
nC6	0.23
nC7	0.0
nC8	0.0
nC9	0.0
nC10	0.0
H2	0.0
O2	0.0
CO	0.0
H2O	0.0
H2S	0.0
He	0.0
Ar	0.0

# Usikkerhet i beregnet lydshastighet vil variere med gass

- For rikgass vil et avvik på f.eks. 0.4 % kunne være normalt
- Hvis dette avviket dropper til 0 %, kan det betyr at noe er gale
- **Løsning:** Justeringsfaktor for avvik i lydshastighet



# Eksempel: Avvik i lydshastighet på rikgass

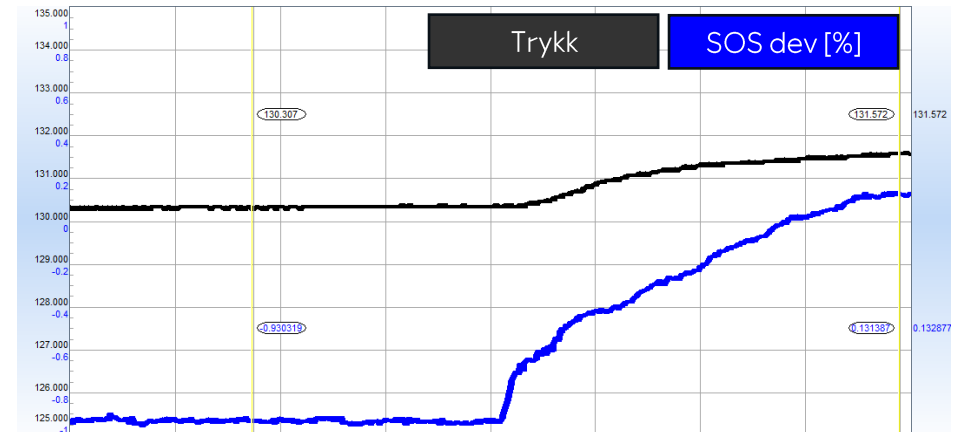
## September 2020 (før vi hadde TESMA)

- Rikgass
- Trykk: 130 barg
- Temperatur 36 °C
- Stabilt avvik på -0.9 % mellom målt og beregnet lydshastighet
- I forbindelse med justering av flow, endret avvik i lydshastighet seg fra -0.9 % til 0.1 %

### Årsak:

- Feilutkobling av varmekabel på tubing til trykktransmitter i forbindelse med en annen jobb
- Førte til hydrater i tubing til trykktransmitter

Utklipp fra gammelt system (AspenTech)



Normal drift

	SOS
Meas	403.6
Calc (GERG)	407.3
Dev [%]	-0.93

●

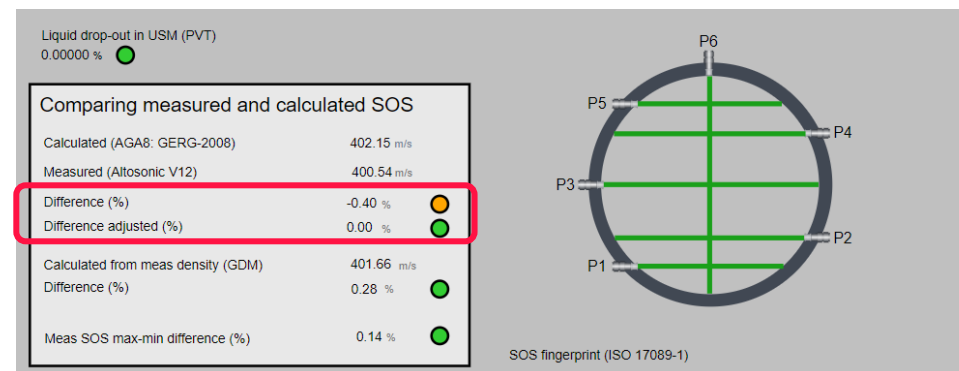
Hydrat i impulslinje

	SOS
Meas	408.4
Calc (GERG)	407.9
Dev [%]	0.12

●

# Oppsummering

- Ta vare på data fra ultralydmålere og bruk dataene best mulig
- Ulike problemstillinger vil påvirke ulike parametere i målerne
- Usikkerhet i beregnet lydshastighet vil variere med gasskomposisjon
- Noter ned avvik under normale betingelser. Avvik fra dette kan bety at noe er gale





equinor

Takk for oppmerksomheten  
Spørsmål?



Tilstandsovervåkning av ultralydmålere i et flerfase testanlegg

Christian Hågenvik, Equinor K-lab

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