Paper 15

Experiences with a Fiscal Metering System using Coriolis Meters

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EXPERIENCES WITH FISCAL METERING SYSTEM USING CORIOLIS METER

AS NORSKE

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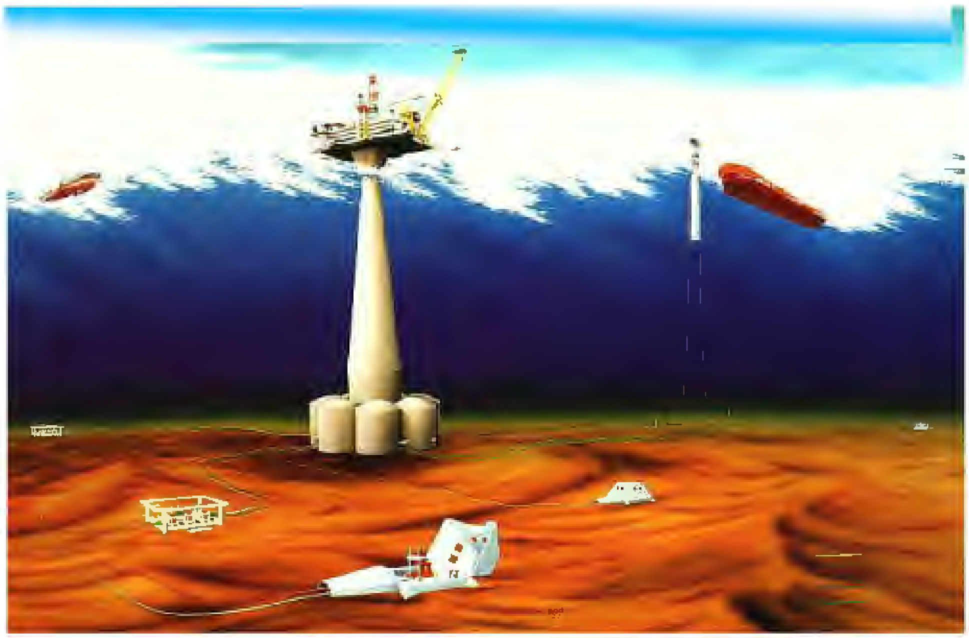
Vestfold Telemark Metering



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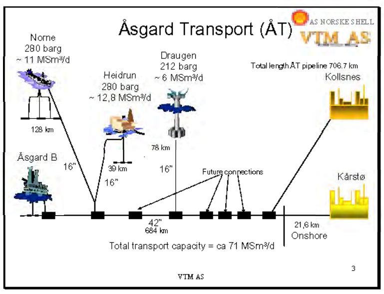
EXPERIENCES WITH FISCAL METERING SYSTEM USING CORIOLIS METER

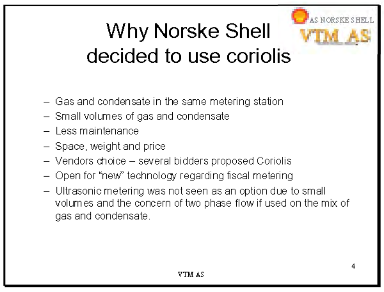
This paper will focus on challenges and results we had on Draugen Coriolis fiscal metering station from start-up summer 2000 until this day.

AGENDA

1. Gas transport system
2. Draugen gas export overview
3. Draugen experiences
4. Conclusions

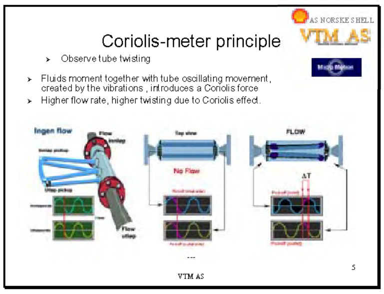


The slide is just to give you an idea of the Åsgard pipeline and the amount of gas exported from the different producers.
Noted pressures and volumes on the slide are design pressure and nominal capacity.

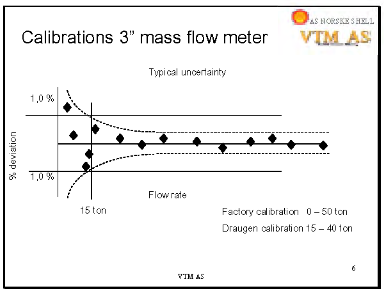


Why Norske Shell decided to use coriolis?

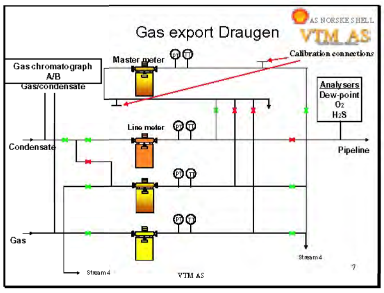
- Gas and condensate in the same metering station
- Small volumes of gas and condensate
- Less maintenance
- Space, weight and price
- Vendors choice – several bidders proposed Coriolis
- Open for "new" technology regarding fiscal metering
- Ultrasonic metering was not seen as an option due to small volumes and the concern of two phase flow if used on the mix of gas and condensate



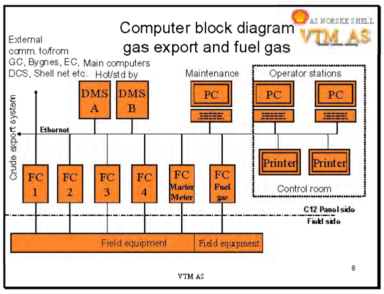
For those of you who are not familiar with the principal of the coriolimeter, this example should give you an idea of how it works. We are measuring the "phase shift" of the tube frequency on the inlet and outlet. No flow, no phase shift. Increasing flow gives greater "phase shift". Δt phase shift gives the mass flowrate.



This graph shows a typical calibration curve for a 3" coriolismeter. Coriolismeters on Draugen are calibrated from 15 to 40 tons/h and minimum flowrate is set to be 15 tons/h.



The fiscal gas metering system at Draugen consists of four operational 3" Micromotion Coriolis meters and a similar fifth 3" Micromotion Coriolis meter acting as a master meter.
Connection for calibration purpose is installed up and down-stream of the Mastermeter.
The input flow to the metering skid consists of one condensate line and one gas line. Downstream of the metering skid the two lines are commingled and enter the Åsgard Gas Pipeline.
Even though part of the flow through the station is in liquid phase, the station as a whole is by us regarded as a gas metering station and requirements for gas metering systems is applicable.
Analysers as Dew point, O2 and H2S are installed to ensure that the export quality is according to specifications.
2 chromatographs are installed and both are set up to be able to analyse both gas and condensate, However in normal operation they are analysing just one line each.
Normal operation parameters is:
Temp ~ 25 degC
Pressure ~ 130-180 BarG
Flow rate (each stream) ~ 15 -40 tons/h.
Mol weight for condensate is ~ 51 Kg/kmol,
Mol weight for gas ~28 Kg/kmol.

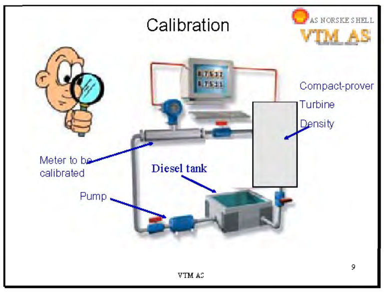


There is a dedicated computer system for the fiscal metering.
The system contains equipment for gas export, crude export and fuelgas measurement.
The gas system consists of one flowcomputer for each stream and one for the Mastermeter.
Operation interface is normally trough the operator stations placed in the control room.
Mass calculation is done by transferring pulses from each coriolismeter to the flow computer, where the pulses are divided by a k.factor to give the right mass flowrate.
Calibration of the meters is done by using the master meter as a reference.
The K-factor for the meter to be tested is determined as follows:

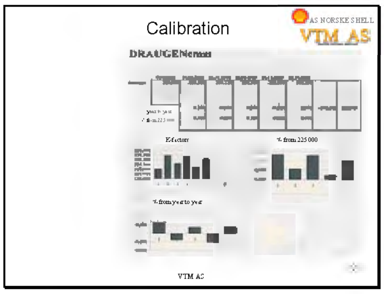
KFMUT = PF/PMM*KFMM

where:

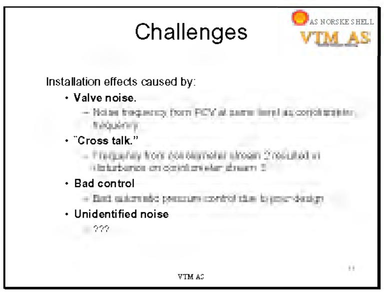
KFMUT is K-factor for the meter under test
PF is the fixed number of pulses counted from the meter under test
PMM is the number of pulses counted from the master meter
KFMM is the K-factor from the master meter.



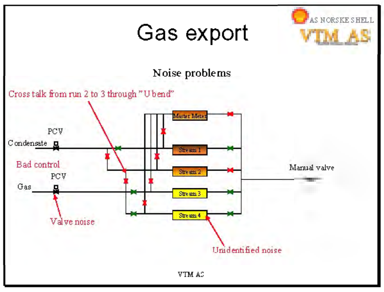
Calibration of the master meter is done by circulating diesel true a compact prover in series with the meter.
The compact prover is a volumetric reference and we are looking for mass. Samples are therefore taken during the whole calibration for determination of density.



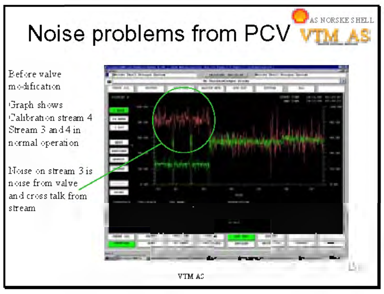
Calibrations done on Draugen from start-up indicate good performance of the master meter.
Max deviation from original factory K-factor is 0.13 %.
Repeatability all 5 calibrations is 0,11 %.



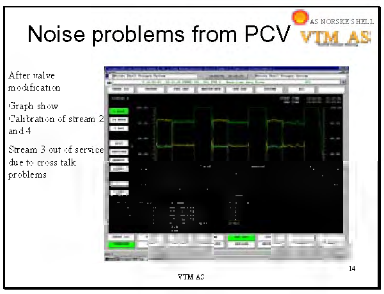
We have had some challenges since start-up.
Valve noise, Cross talk, pressure control problems and some unidentified noise.



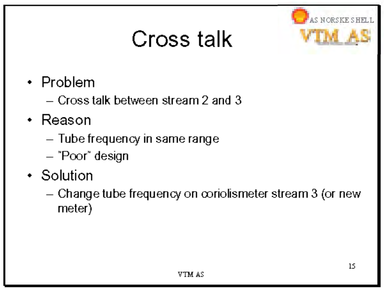
On this graph you can see where we have discovered problems.
Valve noise, Cross talk, control problems and some unindetified noise.



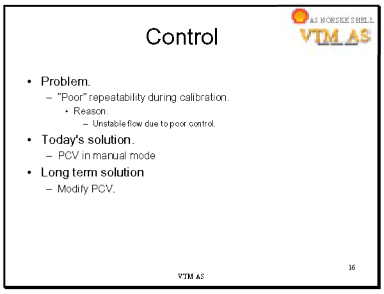
Graph shows situation before any modifications were made to the valve. All streams are more or less affected by noise. Stream 3 (red line) is picking up significantly more noise than the other streams, due to cross talk from stream 2 (green line).



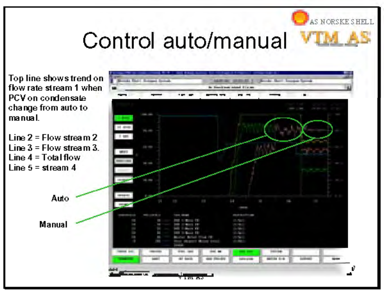
The result of the modification made on the valve clearly shows that it had a major effect.
Stream 3 still had a problem with noise due to cross talk and is therefore out of service.
The change in flowrate is due to meters taken in and out of calibration (there is no flowcontrol on the station).



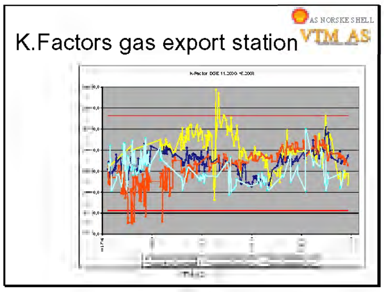
The reason for cross talk problem was more due to a misunderstanding than bad design.
From the start of the project, the supplier of the coriolismeters was aware of the potential problems with cross talk. Therefore the meters on stream 3 and 4 (gas) were chosen with different resonance frequency. Stream 2 was seen as a"condensate" meter and the only consideration regarding cross talk was taken against meter on line 1 (condensate).
On this configuration, stream 2 is used as s spare for gas and condensate. Resonance frequency was very close to line 3 and cross talk was a fact. Problem was solved by changing the meter.



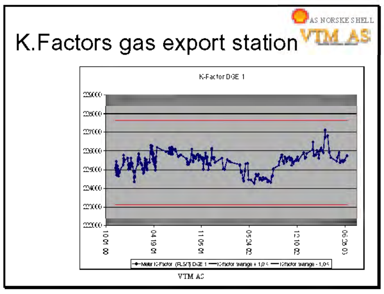
The PCV do not have an ideal set-up concerning fiscal metering. Due to oscillating flow the repeatability was slightly poorer.
Repeatability in stable conditions was normally below 0.2 %. With unstable conditions between 0.2 to 0.4%.
This was good enough to meet the NPD reguirement. It was however decided to set the PCV in manual mode in calibration situations.



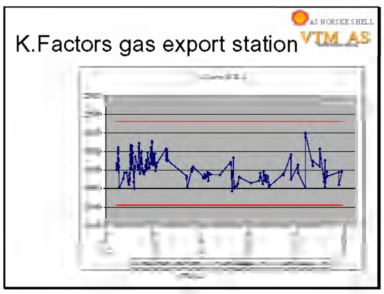
The graph shows the effect on flow stability with the PCV in automatic and manual.



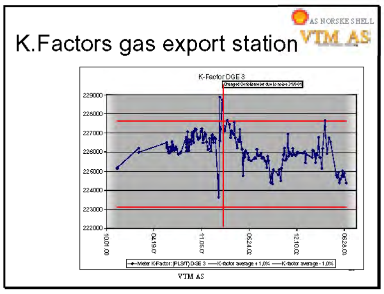
Here we can see ALL **910** calibrations done on all lines from start-up until June 2003.
Red lines shows +/- 1% from total average K.factors.



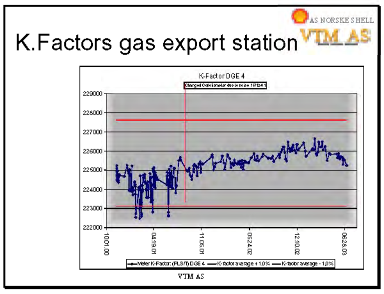
This shows K.factors on stream 1 (condensate) with limits +/- 1 % of average K.factor from present stream.



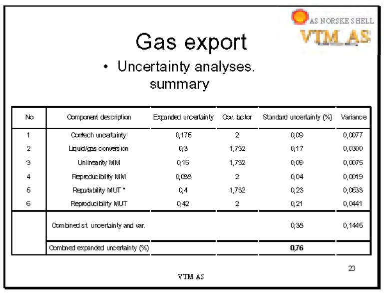
This shows K.factors on stream 2 (both gas and condensate) with limits +/- 1 % of average K.factor from present stream.



Stream 3 is the meter where we had cross talk problems etc. The meter was changed in June.2001.
limits +/- 1 % of average K.factor from present stream.



Meter on stream 4 picked up some “unidentified” noise and was changed in Desember.2001 with a meter with different frequency.
The old meter was returned to supplier for check, but no faults were found on the meter.
The noise picked up from meter on stream 4 was never identified.



Gas export

- Uncertainty analyses. summary

No	Component description	Expanded uncertainty	Cov. factor	Standard uncertainty (%)	Variance
1	Contech uncertainty	0,175	2	0,09	0,0077
2	Liquid/gas conversion	0,3	1,732	0,17	0,0300
3	Unlinearity MM	0,15	1,732	0,09	0,0075
4	Reproducibility MM	0,088	2	0,04	0,0019
5	Repatability MUT *	0,4	1,732	0,23	0,0533
6	Reproducibility MUT	0,42	2	0,21	0,0441
	Combined st. uncertainty and var.			0,38	0,1445
	Combned expanded uncertainty (%)			**0,76**	

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This shows the final uncertainty analyses done autumn 2001 by Metro Partner.
Combined expanded uncertainty is stated to be 0.76 %.
The Regulation relating to fiscal measurement of oil and gas etc. issued by NPD requires as follows: “The total gas metering uncertainty shall, for the operating flow range, be below ±1.0 % (mass metering).

Uncertainty contributing elements

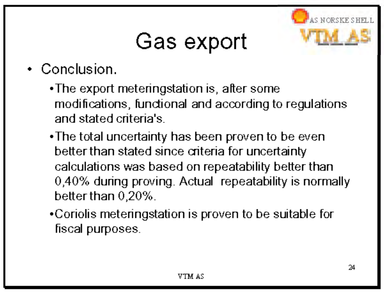
Given the calibration chain briefly described the following elements are expected to contribute to the overall uncertainty of the metered result.

Uncertainty:

- from the reference meter brought to the platform. Given by the calibration company.
- of MM due to uncertainty in the KFMM by going from liquid (by which it is calibrated) to gas (which is used when calibrating the gas flow meters). Determined from qualification tests prior to the installation at the platform.
- of the MM due to uncertainty in the KFMM due to unlinearity in KFFMM over the measuring range. Observed from the calibration results.
- of the MM due to uncertainty in KFMM due to drift between two consecutive calibration. Observed from actual results of two

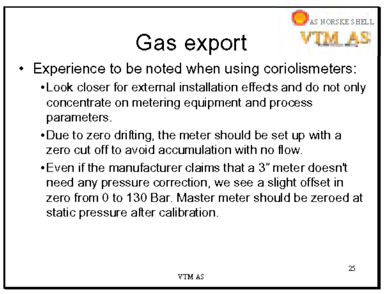
consecutive calibrations offshore with 4 months interval.

- due to uncertainty in calculation of the KFMUT as an average based on a number of individual KFs between which there is a spread.
- in MUT due to uncertainty in the KFMUT due to drift between consecutive calibrations. Observed from actual results of a lot of consecutive calibrations with hours or a few days interval.



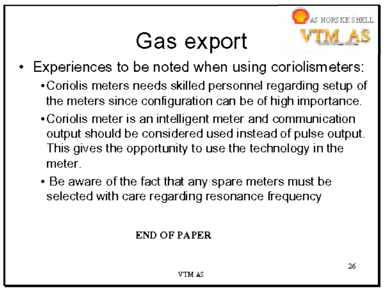
Conclusion.

- The export metering station is, after some modifications, functional and according to regulations and stated criteria's.
- The total uncertainty has been proven to be even better than stated, since criteria for uncertainty calculations was based on repeatability better than 0.40 % during proving. Actual repeatability is normally better than 0.20 %.
- Coriolis meteringstation is proven to be suitable for fiscal purposes.



Experience to be noted when using coriolismeters:

- Look closer for external installation effects and do not only concentrate at metering equipment and process parameters.
- Due to zerodrifting, the meter should be set up with a zero cut off to avoid accumulation with no flow.
- Even if the manufacturer claims that a 3" meter doesn't need any pressure correction, we see a slight offset in zero from 0 to 130 Bar. Master meter should be zeroed at static pressure after calibration.



Experiences to be noted when using coriolismeters:

- Coriolismeters needs skilled personnel regarding setup of the meters since configuration can be of high importance.
- Coriolis meter is an intelligent meter and communication output should be considered used instead of pulse output. This gives the opportunity to use the technology in the meter.
- Be aware of the fact that any spare meters must be selected with care regarding resonance frequency.