Calibration and Verification of Multiphase Meters for Allocation Metering of the Urd Field

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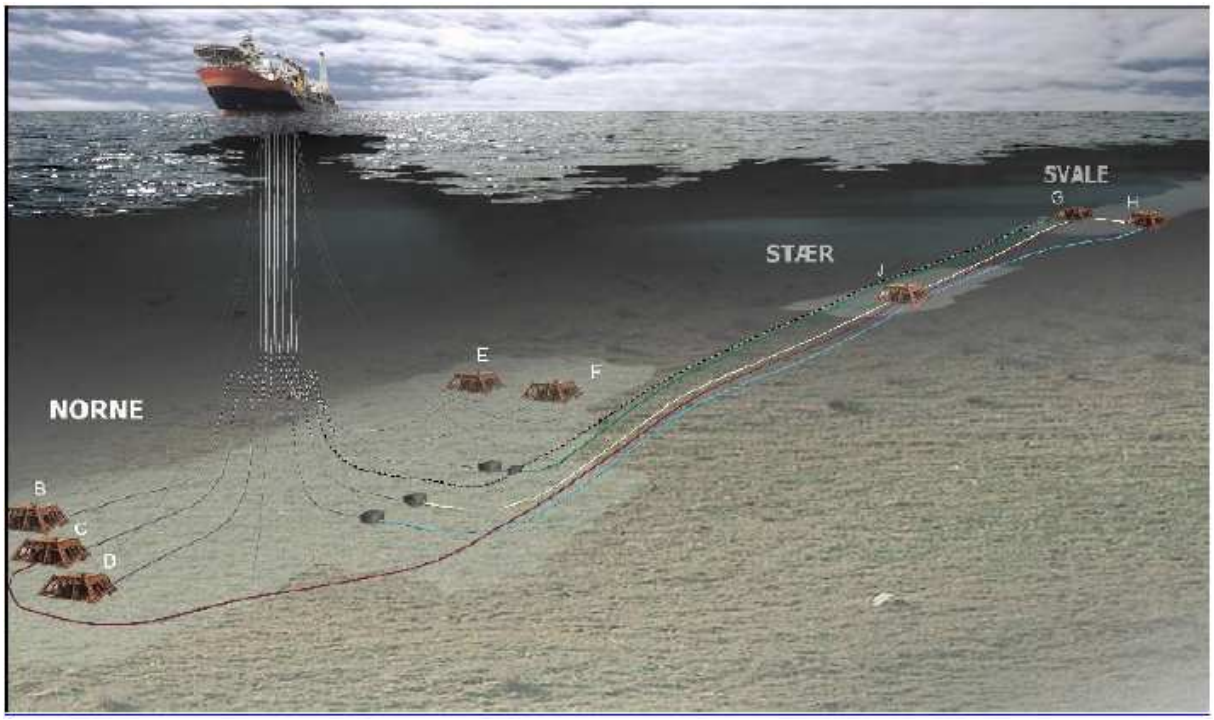
1. INTRODUCTION

This paper presents the history and current status of multiphase metering of the production from the five sub sea wells of the Urd field. The Urd field is a satellite field to the Norne FPSO and the Urd stream is processed onboard Norne. The production from the Urd field was started in November 2005.

The Urd field consists of two sub sea templates, "Svale" and Stær", and the distance to the Norne FPSO is respectively nine and five kilometres. Each of the five production wells is equipped with a multiphase meter and the total Urd stream is measured in a topside multiphase meter at Norne. Furthermore it is possible to route the Urd stream through a test separator with state of the art metering equipment.

The oil from the "Svale" skid has high density and viscosity whereas the oil from the "Stær" is lighter and quite similar to the oil from the Norne field.



2. URD CALIBRATION PHILOSOPHY

Due to the fact that all of the three measuring points (sub sea, topside and test separator) will have different operating conditions it was agreed upon that the main comparison should be in total hydrocarbon mass. From the sub sea meters only the measured flow rates at line conditions are used for further calculations.

3. METERING EQUIPMENT

Test Separator
The Norne test separator has the following instrumentation:

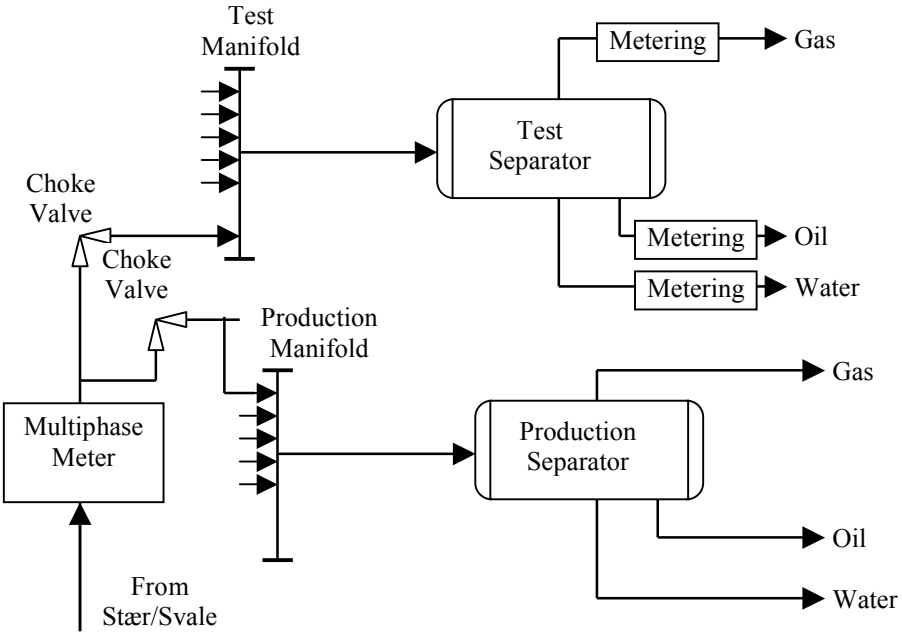
- Gas metering: V-cone, split range using 8”- and 16” meters
- Oil metering: 5-path ultrasonic (Krohne Altosonic V) Foure Herman turbine meter as back up
- Water-in-oil; Water Cut Meter (Roxar)
- Oil Density; Densitometer (Solartron)
- Water metering Electromagnetic (Krohne)

Sub sea MPFM
One MPFM on each production well, all of the same size, 52 mm venturi diameter.

Top side MPFM
One MPFM placed on the turret on the Norne FPSO, 12” venturi diameter.

Metering computers
The Urd metering system including the test separator is connected via separate flow computers to a supervisory system for further data analysis and where also the PVT calculations are performed.

Sketch of the Urd / Norne top side metering and production system



Normally the Urd production is routed to the production separator. The composition of the fluid arriving top side is determined by the flow measured by the sub sea MPFMs.

4. URD FLUID PROPERTIES

As previously described the Urd field consists of the Stær and Svale templates and the fluid properties are quite different.

Sample Field Well Formation		**Crude oil Svale 6608/10-6 MDT Lower Åre**	**Crude oil Stær 6608/10-8 MDT Tilje**	**Crude oil Norne 6608/10-3 DST 1 Åre**
Statoil Fluid Ref no.		2000-205	2002-300	94.110
Biodegraded		Yes	No	No
Weight % C_{10+} fraction		98.95	90.29	89.02
Weight % C_{20+} fraction		70.71	55.08	52.00
Molecular weight oil (g/mole)		315	237	228
Molecular weight C_{10+} (g/mole)		323	273	282
Molecular weight C_{20+} (g/mole)		428	403	415
Density oil (g/cc)		0.915	0,865	0.861
Density C_{10+} (g/cc)		0.918	0.877	0.876
Density C_{20+} (g/cc)		0.935	0.896	0.898
Wax content (wt%)	Not purified	2.8	5.7	10.0
	Purified	1.7	5.0	7.8
Pentane insolubles (wt%)	Precipitated 1 X	0.29	0,54	0.19
	Precipitated 2 X	0.17	0,10	0.08
Total acid number, mg KOH/g		0.67	0.05	0.03
Sulphur (wt%)		0.33	0.19	0.18
Pour point (°C)	Maximum	<-38	+22	+20
	Minimum	<-38	+16	+10
WAT by microscopy. (°C) WAT by NIR (°C)		<25 -	40.9 42.6	38.5 -
Wax dissolution temp. (°C)		-	53	47
Viscosity (cp) (shear rate 100 s-1)	80 °C	7.51	2.31	2.33
	50 °C	20.0	4.21	3.88
	20 °C	90.0	43.7	32.4
	10 °C	182	242	172
	5 °C	280	-	326
	0 °C	405	557	500

5. TEST RESULTS

The first proper flow test was performed with two Stær – and one Svale wells in operation. The reason for this was that Norne had problems separating the Svale fluid and this was the only Urd mix that could be properly separated and hence giving proper measurements downstream the test separator. In all the following result tables the MPFMs performance are compared to the test separator. It should be noted that no calibrations or tuning has been done to the sub sea MPFM during the period of operation.

There are of course more tests performed than the three tests described in this paper, but the included tests are very typical for the meters. For all the tests the stable period exceeds 6 hours and the Urd production has been run stable for at least 12 hours prior to the test period.

The average GVF is approximately 80 in all tests.

Test #1, june 2006

Metering	Sub Sea	Topside
Total HC Mass	0,4 %	14,0 %
Water (Mass)	-16,8%	-41,5 %

In March 2007 it was planned to perform a calibration of the topside MPFM, but due to problems with the supervisory system it was not possible to perform a complete calibration. It was however discovered quite heavy slugging thorough the topside MPFM with the dp varying from 200 – 600 mbar and 40 cycles in 15 minutes.

The next successful (?) test was performed in May 2007 after some attempts to calibrate/tune the topside MPFM had been undertaken and this time the entire Urd production was measured. It should be noted that the flow signals from the sub sea MPFM indicate quite heavy slugging in at least one of the wells giving dp-readings from zero to approx. 600 mbar.

Test #2, May 2007

Metering	Sub Sea	Topside
Total HC Mass	3,2 %	17,8 %
Water (Mass)	-15,5 %	-26,1 %

After some further attempts to tune the topside MPFM another test was performed in September 2007.

Test #3, September 2007

Metering	Sub Sea	Topside
Total HC Mass	-3,5 %	6,2 %
Water	-11,5 %	6,2 %

6. CONCLUSIONS AND LESSONS LEARNED SO FAR

It is likely to believe that slugging has a detrimental influence on the performance of the MPFMs and according to the StatoilHydro experts on slug control the observed slugging must be regarded as a “normal” flow situation for the Urd production stream. However the performance guarantee given by the manufacturer does not take this into consideration. The topside MPFM was installed in order to be the main allocation meter but so far only the sub sea MPFMs have been used for this purpose. Due to the large size of the top side MPFM it was not possible to conduct flow tests (FAT) on the meter prior to installation and based on the lessons learned so far we may conclude that is was a very brave decision to install an untested MPFM.

Although it seems like we still have quite a way to go before the top side MPFM can be used as the main allocation meter StatoilHydro will continue to challenge the manufacturer in order to get acceptable performance of the meter.

Regarding the sub sea MPFMs some work need to be done in order to evaluate the performance of each of the meters. We do however believe that the main cause for the deviation from the test separator is the slug flow in one of the wells. The deviation in water production rate may also to some extent be explained by the long production line from Urd to the Norne FPSO, i.e. water accumulation in the flow line and subsequent water slugs arriving topside.

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.