A field comparison of a fiscal USM gas metering station with a conventional orifice metering station

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1 INTRODUCTION

Norway and UK has a long common borderline which separates the two continental shelfs. During the first 35 years of petroleum activity the interaction between the activity on the two sides of the borderline was limited to the Ekofisk-Teesside oil line, Heimdal condensate to Brae and the activity naturally generated from trans - median developments, Frigg, Statfjord and Murchison.

In 2005, however, a new momentum in the cross border cooperation came up. A Frame Agreement between Norway and UK was signed. "Framework Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland concerning Cross-Boundary Petroleum Co-operation". As a consequence also the Memorandum of Understanding between Norway and UK related to measurement issues (dated 23.6.1998) was updated with a new Supplement document (dated september 2006).

This leads to several new developments crossing the border line. Among them the development which is the topic of this presentation the Statfjord gas export into the SEGAL pipeline system.

2 Where we are in the world

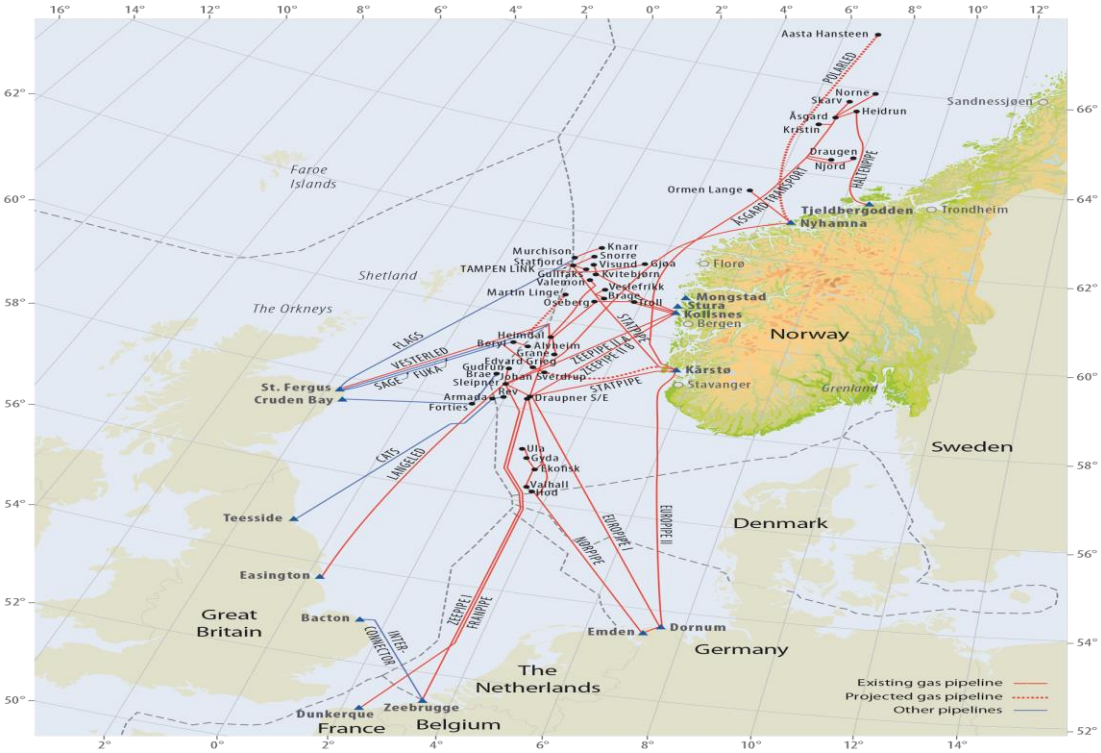


Figure 1. Pipeline map for the Norwegian Continental Shelf

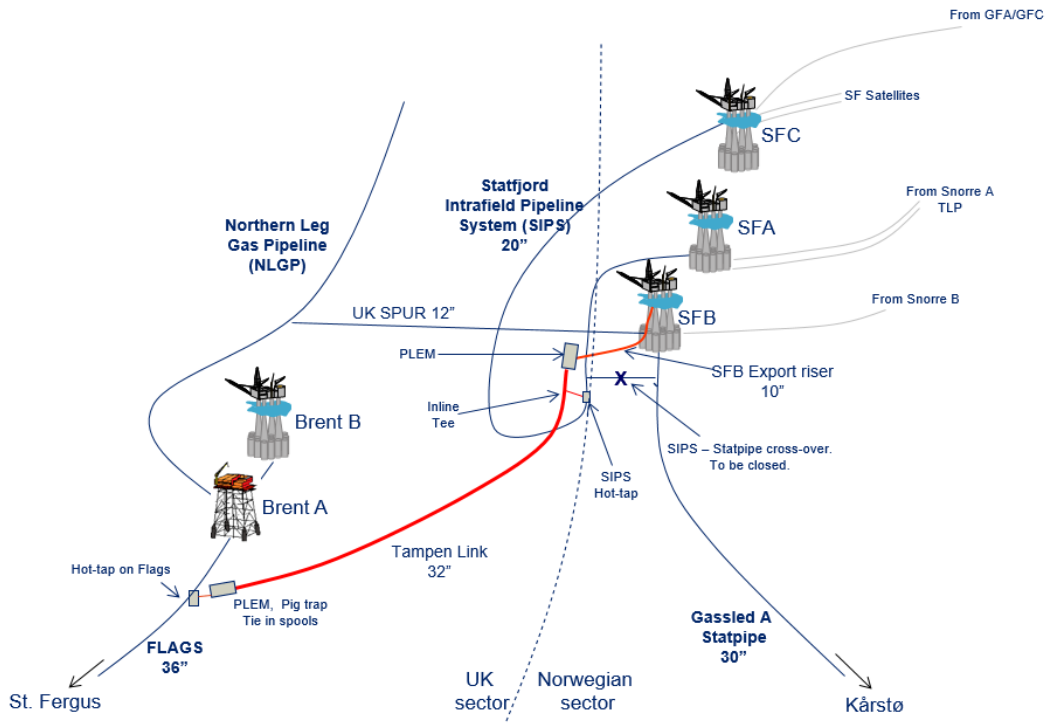


Figure 2. The Statfjord tie in to the SEGAL/FLAGS gas pipeline

3 Requirements to be met for the Stalfjord gas export

The original UK offtake measurement station had start up autumn 1985 and is equipped with tradional orifice plates according to ISO 5167. This station should take off the UK gas owner part from the Statfjord Field.

The technical standard was the same for the Statpipe gas export stations, one on each platform. The only special remark that should be done is that on Statfjord B, the gas to Statpipe and to UK Flags was not measured separately. The Statpipe station was first and then the offtake to UK, so that the Statpipe amount was determined as a deduction of total measured minus UK offtake.

When the opening for direct rich gas export from Norway to UK came as mentioned in item 1, the Statfjord gas should be exported no longer to the Statpipe but to the SEGAL pipeline.

The gas amounts from Statfjord was increasing. Much of the previously injected gas should now be produced and new measurement station had to be built on Statfjord B. It was deceided that it should be a USM station with two parallel 10" Daniel USM meters. The official start up date was 12.10.2007.

The various international standards relevant for orifice metering stations and for USM metering stations have been implemented, as well as OGA and NPD requirements.

The commercial agreements between Shell (SEGAL) and Equinor (Statoil) required 6 monthly laboratory calibration of the USMs. As compact flanges is used on the skid Equinor (Statoil) immidiately realized that they needed a platform shut down to be able to fulfill a requirement for USM laboratory calibration. And as a platform shut down is just taking place with an interval of several years, this would be difficult. The challenge was discussed between Shell and Equinor where also Norwegian (NPD) and UK (OGA) measurement authorities participated.

4. The benchmark test Orifice station in series with a USM station

To make life easier a discussion took place between Equinor and NPD to utilize the special metering design on Statfjord B for a serial test between the Statpipe Orifice station and the Tampen Link USM station. A bit of special planning was needed to be able to do the job but as a check on regular intervals it was possible to conduct. So from 2009 this test has been done on bi-annual basis and the results have been distributed and dicussed among the involverd parties.

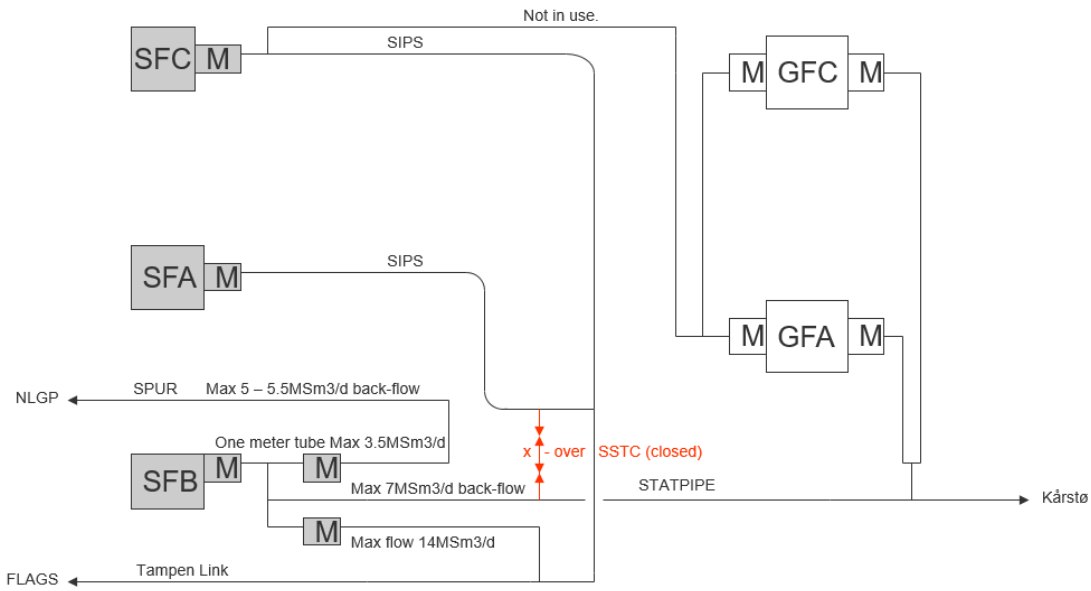


Figure 3 is the lay out of the area and the pipelines involved and the metering stations involved in the serial test on Statfjord B.

5. Serial test of Statpipe/Tampen Link measurement stations

It is an obvious challenging integity issue related to such an serial check. All involved valves will have to be properly closed and hopefully without any leak. Relevant ESV valves should also be closed.

Typical test sequence:

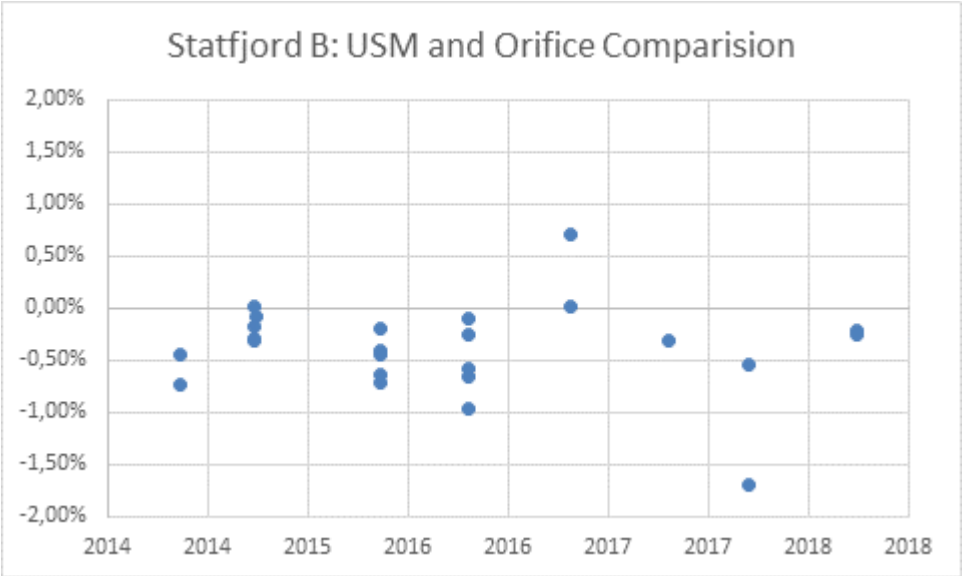
- Close UK offtake. Close Statpipe from Stat B.
- Statpipe line 1 test in series with FLAGS line 1.
- Statpipe line 1 test in series with FLAGS line 2.
- Statpipe line 2 test in series with FLAGS line 1.
- Statpipe line 2 test in series with FLAGS line 2.

Trends are based on accumulated sums. The difference between the two metering stations for the tested period. Ie. one point pr. test.

The typical time for a test is 2 consecutive hours. Then the relevant accumulated mass values for the two hours are logged.

The percent difference between Statpipe/FLAGS : (Statpipe/FLAGS – 1)*100.

A plot (figure 4) of historical results are given underneath:



6. Design details of Statpipe/Tampen Link measurement stations

The Statpipe metering station is a conventional orifice metering station with two parallel 10” pipes. Density measurement in each pipe. Also equipped with online GC. The upstream straight pipe is 30,25 D while the downstream straight pipe is 7,25 D. The calculation routines are upgraded to ISO 5167 (1991).

The FLAGS metering station is conventional metering station with two 10” Daniel

4 path Senior Sonic USMs in parallel pipes. Two online GCs for calculation of density. The upstream straight length is 21,1 D and the downstream length is 17,9 D.

Two pictures will illustrate the standard of the two measurement stations:

The USM station on top and the orifice station bottom (figure 5 and 6).
The pipe distance between the two stations is ca 83m. They are almost on the same level (hight) but in different modules.

An overview of the equipment on the Gas metring equipment on Statfjord A/B/C.

FMC control system . FMC 207 flow computers with one FCM 217 fiscal server on each installation.

Statfjord A:
Gas export. 2*10" orifice station with densitometer in each line. 2 GCs, 2 H2S analyzers and 2 H2O analyzers.

Statfjord B:
Gas export:
Statpipe (Statfjord B). 2*12" orifice station with densitomer in each line. 1 GC, 1 H2S and 1 H2O analyzer.
UK offtake (SPUR to NLGP) 2*10" orifice station dual densitometers I each line. 1 GC, 1 H2S and 1 H2O analyzer.
FLAGS (Tampen Link). 2*10" ultrasonic with densitometer in each line. AGA 8 calculated density. 2 GCs, 2 H2S and 2 H2O analyzers.

Statfjord C:
Gas export: 2*12" orifice station with densitometer in each line. 2 GCs, 2 H2S ans 2 H2O analyzers.

7. The results of the Statpipe-FLAGS serial testing

We have to be aware that these two metering stations are located 83 meter away
from each other so the integrity of the system is very important.
The timing of the start/stop of the test as well as the calculation sequences will have to be syncronized to hopefully achieve a result with as little bias as possible.
We clearly saw some challeges here but the serial operation has been more routine now as it has been repeated several times.

- Previous series tests (discrepancy is for hourly reports):

2016, discrepancy in mass ranging between 0,69 to -0,85 %

2015, discrepancy in mass ranging between 0,56 to -0,75 %

2014, discrepancy in mass ranging between -0,33 to -0,73 %

2013, discrepancy in mass ranging between 0,48 to -0,99 %

2012, discrepancy in mass ranging between -0,67 to -1.1 %

2011, discrepancy in mass ranging between -1,03 to -1.36 %

2010, discrepancy in mass ranging between -1,11 to -2.13 %

2009, discrepancy in mass ranging between -0,64 to -1,34 %

Figure 7

Minus in this table means that the USM has the highest value.

The first years the timing issue was a challenge and the calculation of density. In 2010, the results had the highest deviation. The reason was the orifice seal ring on Statpipe which was identified as a leaking point.

As you see from 2013 and onwards the results have had a significantly lower bias and some results also show "positive" results. That means highest volume measured on the Statpipe orifice station.

In July 2017 and in december 2017 tests were done and results underneath:

Station 1	Station 2	Start time	Stop time	Discrepancy % accumulated mass
STP1	FLAGS 1	07:55	10:05	-0,30
STP1	FLAGS 2	10:50	13:05	-0,28

Station 1	Station 2	Start time	Stop time	Discrepancy % accumulated mass
STP1	FLAGS 1	11.12.17 8:18	11.12.17 10:18	-1,67 %
STP1	FLAGS 2	11.12.17 10:40	11.12.17 12:40	-0,51 %

In the summer 2018, 1 USM was calibrated at FORCE during the Statfjord B summer turnaround and mounted back in the line. The meter from line 2 was sent to FORCE for calibration. Then sent back and mounted in line 1. In line 2, the meter which was calibrated in 2015 was installed (had been in warehouse in the meantime).

The serial check was done immediately after and the results were:

Comparison start:	14.07.2018 08:30			Comparison start:	14.07.2018 12:00	
Comparision end:	14.07.2018 11:00			Comparision end:	14.07.2018 14:30	

Discrepancy:	-0,214 %			Discrepancy:	-0,258 %	
Totals:	1477003	1480177			1462536	1466326
	Orifice	**USM**			**Orifice**	**USM**
Timestamp	**STP Line1 (ton/h)**	**Flags Line 1 (ton/h)**		**Timestamp**	**STP Line2 (ton/h)**	**Flags Line 1 (ton/h)**

Figure 8

As is shown in the table the USM figures are slightly higher than the orifice but on the same level as has been reported in laboratory tests, see reference 7 & 8.

It was the intention also to run the comparison check on FLAGS line 2, but due to technical problems with that meter it was not possible this time. Emerson is doing error investigation.

8. Summary

The serial test was first discussed between Mr. Fosse,NPD and Mr. Hjorteland, Equinor. The plan was to establish a benchmark test which could be used together with traditional CBM to achieve acceptance for a longer calibration interval for the USMs. As the serial test could be done on Statfjord B without too much work it was regarded as a good idea.

As the results started to come in 2009 and the discussions thereafter it was may be not such a brilliant idea. But we have learnt a lot and from a metering point of view it has absolutely been worth while.

Important issues to check during such a test:

- The flow range has to be defined
- Separate GC and density measurement
- Timing to fully syncronize the test
- All leakage points should be identified and eliminated
- The calculation of density should be equal
- Seal ring on orifice plate should be in proper shape
- All valves involved should have no leaks

It is quite clear that this is not a laboratory test and therefore you can not expect to achieve the figures which had been reported in references 7 & 8.

The big challenge which is influencing the results is obviously the flow regime. Even though both the orifice station and the USM station is designed according to the valid standards, the upstream pipe work and the header configuration is often making things complicated. The flow regime is disturbed. This without that you are able to exactly quantify it.

Figure 4, is giving the summary of the results. The avarage deviation is 0,4%.
But we have to bear in in mind that we are comparing towards ISO 5167 (1991).

A comparison towards the valid orifice standard ISO 5167 (2003) would have increased the average bias to 0,6%. The results reported in reference 7, the serial tests in Emden is within 0,25%.

One result from december 2017 has a significantly higher deviation than the rest (1,7%). It is no explanation from CBM or other parameters.

The work to use the experience from the serial tests to extend the calibration interval for the USMs are still ongoing.

9 REFERENCES

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(2) Technical dossiers from Trond Hjorteland, Statoil/Equinor

(3) Technical dossiers from John Frey, Statoil/Equinor

(4) Technical dossiers from Martin Lillo, Statoil/Equinor

(5) Technical dossiers from Leif Jarle Vikshåland, Statoil/Equinor

(6) Technical dossiers from Asle Hvidsten, Statoil/Equinor

(7) Reidar Sakariassen, Statoil/Wolfgang Sdun, Statoil/Frederic Vulovic, GdF, Detlef Vieth, Ruhrgas: Long term comparison of an ultrasonic and a turbine meter with an orifice meter at EMS test loop. NSFMW 2000.

(8) A.Niazi, BG Technology, Building confidence with multi path ultrasonic meters, NSFMW 2000.