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Technical Paper

Blind testing of non-radioactive multiphase metering systems by the Joint Operator User Group on MPFM

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1 INTRODUCTION

One of the initiatives from the JOUG is the organization of joint testing project to assess the operability and understanding the performance of MPFMs. In November 2017, the first joint testing project was ran at DNV-GL flow loop in Groningen.

Three non-gamma multiphase flow or water cut meters have been tested during a period of two weeks. The following paragraphs will describe the philosophy, the organization and the conclusions from this project.

From the operator point of view, we see that impartial testing under suitable conditions run by operators is required in order to improve the confidence to flow loop testing and subsequent metering behavior and to avoid having to rely on testing performed by vendors, test labs, or non-operators.

2 CHOOSING THE TECHNOLOGIES TO BE TESTED

In 2016, the Joint Operator User Group was initiated. The objective was to share experiences between Oil & Gas operators and to join efforts to improve multiphase flow meters technologies.

The first workshops were to discuss to discuss the status and sharing the lessons learned from the three companies' experiences in subsea multiphase metering and at identifying technology gaps where a cooperation with technology providers could be interesting.

One of the technology gaps identified by the JOUG is for typical onshore applications [1].

The number of wells may be more significant than in subsea system and the common practice of installing one MPFM per well would lead to relatively high costs. Moreover, the use of permanent gamma sources may limit large deployment due to the requirement of authorization, training and follow-up for safety and security reasons.

Therefore the need for cheaper metering solutions has been addressed and several solutions can be envisaged:

- Simplified multiphase solutions that could provide just enough information for production optimization and reservoir monitoring (water fraction meter for water breakthrough follow up, WFM…)
- Low cost MPFMs (like non gamma technologies) which may have sufficient performance for reservoir monitoring

This first Joint Testing Project (JTP1) focus was on low cost technologies. Two commercial non-gamma MPFM and one water fraction meter were tested.

3 PHILOSOPHY OF THE JTP

This joint testing project is an initiative taken by Shell, Equinor and Total to jointly evaluate flow meter technologies. The operators will be leading testing of multiphase meters to ensure objective results that are comparable between different needs for different projects.

The objective is not to perform any qualifications but more for E&P users to get a better understanding of the flowmeters, how to operate them and the performance that should be expected.

A common philosophy between the three Oil & Gas operators has been defined: this JTP shouldn't aim at only testing commercially available technologies, but it should also be an opportunity to identify new technologies or that could need some support to boost their development. The JTP is also a tool for smaller vendors to present their technology, test data on more suitable realistic conditions can be collected with a limited amount of resources.

The main philosophy of this project can be summarized:

- Different maturity levels of the technologies can be tested: the aim is not only to evaluate commercially available technologies but also to identify future technologies that could be of interest for specific or general applications.
- The project will focus on what the meters can realistically achieve under the prevailing conditions. (It is not a technology comparison exercise)
- There will be a special attention put on the understanding of the technologies: how does the different systems behave? How to use them?
- There is no acceptance criteria.

4 DESCRIPTION OF THE TEST

This Joint Testing Project has been performed in December 2017 in DNV-GL facilities in Groningen.

The test matrix has been defined by the 3 operators leading the JTP. However, for practical reasons, complementary support has been provided by DNV-GL in order to optimize the number of test points (optimum set up based on the kind and number of meters to be tested, to get the best possible configuration for each meter and to optimize the number of test points) but also to deal with the different calibration requirements of the technologies tested.

4.1 Definition and preparation of the experimental set up

The preparation of the experimental set up has been an important phase. The input and requirements of each technology had to be taken into account and the interference of one meter to another had to be minimize.

Especially some discussions have raised on the best configuration for the testing. 2 set ups have been evaluated: testing of the meters in series or in parallel.

The first set up (meters in series) allowed more test points to be run but it required consideration of the total pressure drop of the test section that was more important and the impact of each meter on the following one. A special effort has been done in order limit the effect on the flow meters on the following ones and to ensure that all the meters will get the same conditions. A mixing valve has been installed 5 meters upstream the first meter. This mixing valve wasa request from the MPFM1 provider to mimic a field condition where oil and water are usually well-mixed. During the testing, some reproducibility tests have been conducted with this mixing valve open and partially closed in order to better understand its utility. Some optical windows were also installed to check the flow regime going through in all the flow meters.

As the objective for the testing was not to do a comparison of the different technologies, but to assess what the meters can realistically achieve under the prevailing condition, the slight difference in temperature and pressure at the flow meters due to the configuration in series was not a concern.

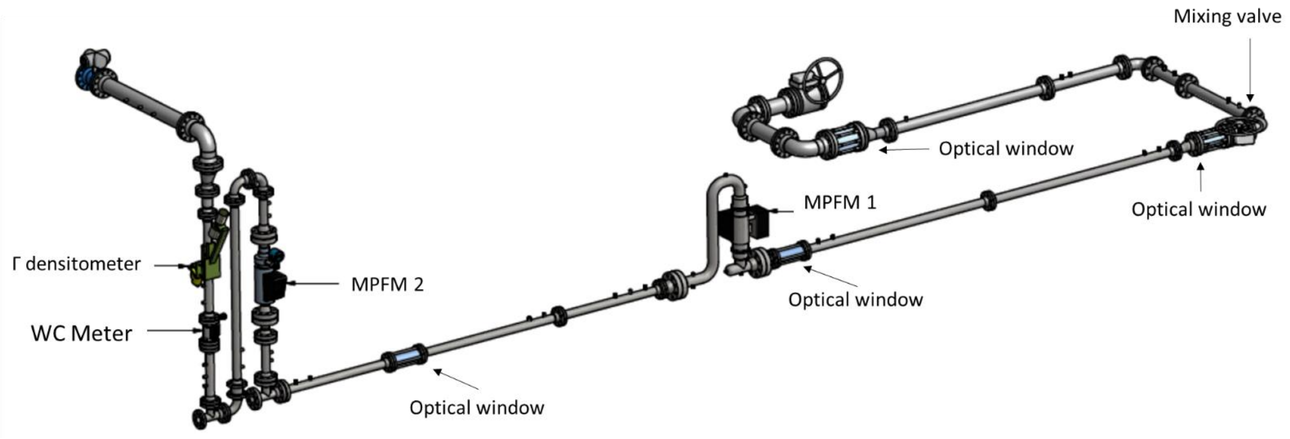

Fig. 1 Flow loop configuration - DNV-GL facility

The advantages of second set up (meters in parallel) was that all the meters were independent, and that the same conditions could be assured for each meter. In the other hands, the inconvenience was that all the test points needed to be run twice therefore it was discarded.

4.2 Building the test matrix – running the testing

The test matrix did not necessarily stay within the technology operating envelope. For each technology a diagnostic status could be provided based on their analysis. Each vendor got the opportunity to label their own data set without available references data to green, orange (slight concern on the data validity) or red (out of range).

The reproducibility of the MPFMs was another important aspect that needed to be addressed. Therefore, some points of the test matrix have been repeated.
During the test, the data from the meters were made available, and the possibility to witness was offered to everyone.

The objective of that JTP being to focus on what the meters can realistically achieved, no meter 'tuning' was allowed prior and during the testing. However, some calibration has been required and authorized during the testing. All those additional calibrations have been documented. The objective once again was to get useful results and therefore this has been accepted to avoid having non exploitable results.

If some big deviation was observed by DNV-GL showing that something was definitely wrong and needed update, the technology provider was informed – the objective still being to get useful information, and not to waste days of testing when obvious deviations are identified. Input data for each technology was requested before the test and the settings couldn't be changed nor updated during the test.

Each test point was logged for approximately 5 minutes and one test result represents the average data over the logging period. This had to be standardized, otherwise too much consideration could be needed on a case by case basis leading to a challenge as several units are being tested at the same time. The logging of the test point was starting after all the meters were stabilized. Once again, the objective was to get constructive and understandable results and not to challenge the technologies.

Before the test, the following information have been provided to the technology providers to set up their meters:

- Fluids used during for the test
- Approximate Information on the test matrix :
    - Minimum and maximum flowrates
    - Minimum and maximum WLR & GVF
- Flow loop uncertainties
- Installation set up schematics
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At the end of the test, for each technologies, all the other information have been provided including the detailed test matrix, the actual gas, oil and water volumetric at meter under test at each test point, the specific flow loop uncertainties and the pressure / temperature measurements for inlet and outlet conditions. This allowed the vendors to comment on the end results.

5 Findings from the JTP / Debriefing

5.1 Test matrix presentation

As described earlier, the test matrix has been defined by the E&P companies some fine tuning by DNV-GL in order to take into account the limitations of the flow loop but also the operational constraints and to optimize the number of points.

330 test points have been run in two weeks, including several reproducibility tests. Each test point was logged for 5 minutes, after the loop had stabilized. For a few points with GVF higher than 80%, the points have been run for 10 minutes when observed instabilities.

The test conditions have been the following:

- Pressure : [16 ; 33] bara
- Temperature : [16-21] °C
- Flowrate :
  - Liquid flowrate : [10-90] m3/h
  - GVF : [5-85] %
  - WLR :[5-95] %
- Fluids
  - Gas : Natural gas
  - Oil : Exxsol D120 (density [810-820] kg/m3, viscosity [3.1-4.6] cP)
  - Water: Salt water (density [1015-1040] kg/m3, salinity [2.7; 5.8] wt%)
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The blind test has been conducted during 2 weeks following the experimental matrix defined by the E&P operators with the assistance of DNV-GL. One of the constraints has the specific operation procedure for the Meter 1. This is detailed just below.

5.2 Meters calibration requirements

The different flow meters tested had different calibration requirements. Each meter requirements is detailed below.

5.2.1 Meter 1

It requires the WLR at regular calibration points. A recalibration was required each time the change in flowrate, pressure, temperature, GVF or WLR would be higher than 15%. This lead to a rather high number of calibration which were performed inline. Out of the 332 test points, 32 calibration points have been required.

The following graph shows an illustration of the calibration points required for that meter. The squares are the calibration points, the full dots the test points within the envelop of each calibration point and the empty dots, the one out of the envelop of each calibration point. The dashed rectangle shows the inversion area.

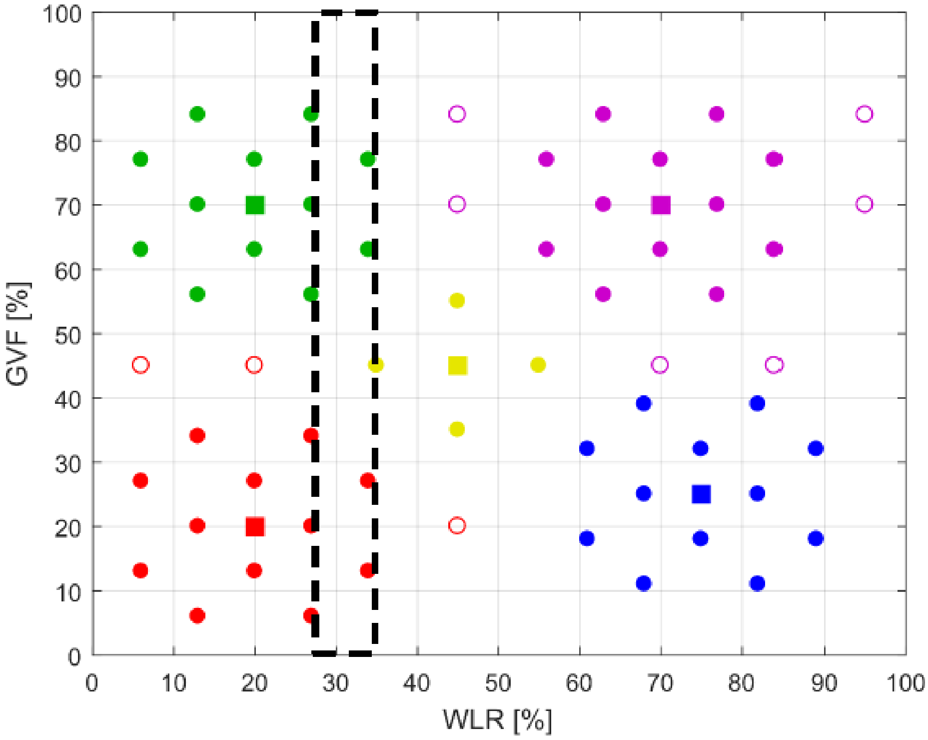


Fig. 2 Meter 1 - Calibration requirement

5.2.2 Meter 2 – Water cut meter

This meter didn't need any configuration data from the flow loop. A challenging part has been to determine how to evaluate its results: the test facility could only provide flow rates data and therefore some reprocessing was required to define the reference data for the water volume fraction.
During the testing, the data had to be reprocessed by the technology provider with a pressure correction. However, this was done before the reference data had been sent to the vendor. A technical note has been provided, explaining the problem.
This technology hasn't the same maturity level than the 2 other ones. This kind of problem could be expected due to lower TRL of this technology.
In addition for 3 points some issues were identified in the software and appropriate correction have been performed.

5.2.3 Meter 3

The meter 3 requires the following configuration parameters:

Table 1 – Meter 3 configuration parameters

Standard Configuration Parameter	Sampling Condition
Oil permittivity	Sample taken from oil line
Oil density	Sample taken from oil line
Water conductivity	Sample taken from water line
Water density	Sample taken from water line
Gas specific gravity	Provided by DNV-GL

In addition to those parameters, the technology provider requested a mixing valve upstream the meter to mimic field conditions were water and oil are usually dispersed.
During the testing, no additional calibration was required. However, after the salinity change, the water conductivity measured by the meter 3 was too high. DNV-GL and the E&P operators decided then to provide the measured conductivity value to the meter 3 engineer to adjust the set up. However, during the test results analysis, meter 3 specialists encountered an offset in their results. The value provided by DNV-GL for the conductivity has been investigated and a lower value was actually recalculated. The meter 3 results have then be reprocessed.

5.3 Analysis of the results

As explained in the description of the methodology, the technology providers had the opportunity to provide a diagnostic based on their meters reading. The test points could be labelled red (invalid), yellow (doubtful) or green (valid). This exercise has been performed before the reference data were made available in order to ensure that this validation was purely based on meter readings.

The following table shows the number of test point on each category for the 3 meters.

Table 2 Results analysis - diagnostic

	Meter 1	Meter 2	Meter 3
Red	30 (9%)	11 (3%)	11 (3%)
Yellow	27 (8%)	0 (0%)	9 (3%)
Green	275 (83%)	321 (97%)	312 (94%)

The number of red points is quite small and more that 90% (or 80% for one of the technology) of the test points have been classified as valid. This shows the efficiency of the testing and reinforce the interest of this blind testing. The operation of meter 1 required a specific procedure involving regular inline calibration as explained earlier. This explained the higher number of points noted as red or yellow. Part of those points were slightly out of a calibration point operating envelop.

There are several reasons why some test points have been considered as invalid but some common (and expected) concerns are about points in the inversion area. The reasons behind the red and yellow labels have obviously been explained and discussed.

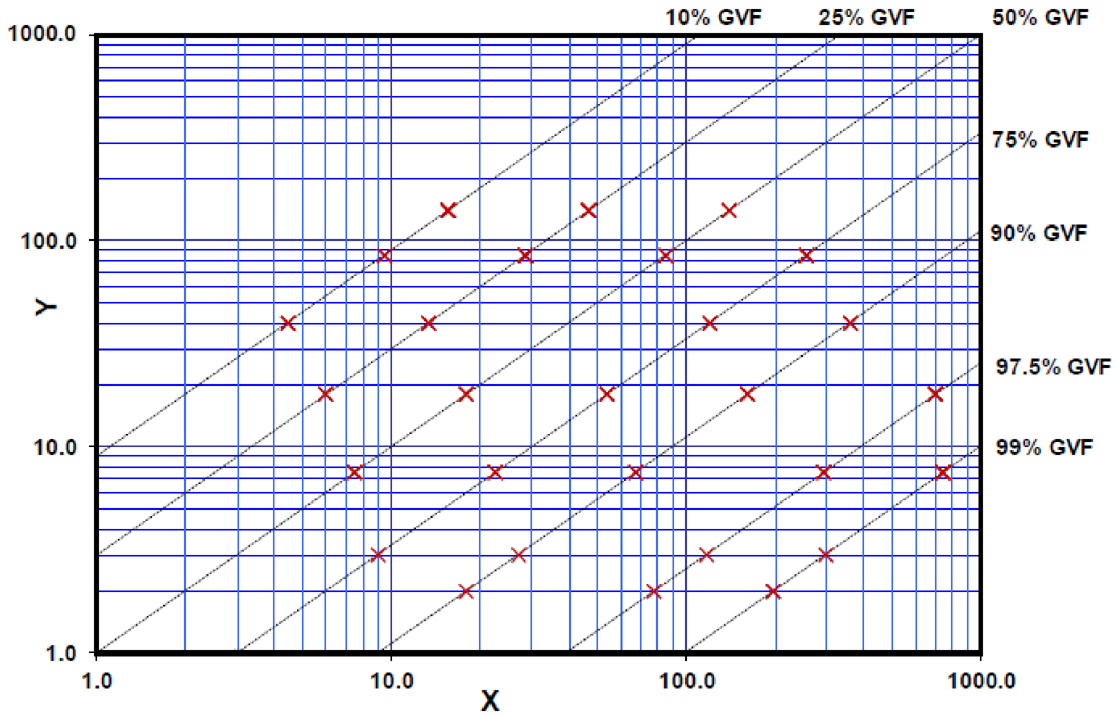
All the technology providers have been invited to provide their analysis of the results of their meter to the O&G partners of the JTP through both a report but also during a meeting. The objective of the JTP, once again, is not only to test the flowmeters but also to understand their operability and the feedback on the behavior of the different technologies during this test was a very important aspect.

The main deviations of the meters compared to the experimental points have been discussed and reviewed. The different technology providers had a chance to explain the behavior of their meters. This has been a very good exercise and helped the understanding of the operation of the different flow meters.

6 NEW ISO STANDARD : GUIDELINES ON PERFORMANCE TESTING

In order to ensure the sustainability of this kind of testing, the ongoing work on the updating of the ISO TR 21354 (Measurement of multiphase flow) will include blind tests as part of the methodologies.

The blind tests will be defined in order to standardize practices. The new ISO standard will propose some methodology to organize MPFM blind tests such as the conditions in which those tests should be organized, the information required from the vendors. It will also provide an example of a typical test matrix.



Key

X gas flow rate (m^3/hr) at actual conditions
Y liquid flow rate (m^3/hr) at actual conditions

Fig. 3 Example of test matrix

The new ISO standard defines that blind tests should be carried out in a third party multiphase flow loop by a group (or individual) of MPFM users through a Joint Testing Project. The flow loop should be able to provide traceable reference flow rates for all phases. The new ISO standard also precise the measurement uncertainty from the flow loop that should preferably not exceed one fifth (one third could be accepted) of the expected uncertainty of the meters under test.

It details the organization and running of the test, the data provided to the meters under tests and the expected results.

This new ISO TR 21354 has been updated to include blind testing.

7 CONCLUSION

The objective of the Oil & Gas operators through this Joint testing Project was to get a better understanding of the operation, performance and behavior of the different multiphase flow meters tested under prevailing conditions. Running a blind test was a way for the operators to assess the more real achievements of each flow meter under the prevailing conditions of the tests. Traceability and assessment of tests performed by different suppliers or other external parties is always complicated and therefore this testing was an efficient way to get a end user oriented assessment.

On an operator point of view, this project gives a good overview on the status, strengths and weaknesses of the different technology tested. It allows as well to better envisage the usage of each technology and what the expectations should be on a field installation. It also gives a better confidence on the capability of each technology as result of this impartial testing. This kind of testing is a win-win exercise for the operators as well as the technology provider. The aim is to get useful data for everyone, therefore during the testing special attention has to be put on unexpected meters deviation for example in order to identify them and to correct those kind of behavior as soon as possible to minimalize the number of test point that cannot be valorized. The assistance of the flow loop operators is here very important.

For a better sustainability of this kind of testing, members of the joined operator user group are working on the update of the new ISO in order to include blind testing in the methodology and to provide guidelines.

4 REFERENCES

[1] E.Åbro, JP.Couput, H.de Leeuw. Joining efforts between operators within multiphase metering technology, NSFMW2017.