North Sea FLOW Measurement Workshop

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Paper 6.1

Multiphase Flow Metering: An Authority Perspective

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1 INTRODUCTION

The technological development in the oil and gas industry over the past 25 years has lead to a continuously stronger need for multiphase meters. This development is driven from both technical and commercial reasons and it covers both the need for accurate well testing (Improved Oil Recovery) and the need for accurate ownership and well allocation.

2 HISTORICAL OVERVIEW

From our viewpoint the North Sea Flow Measurement Workshop (NSFMW) has been in the lead of presenting new concepts within the multiphase metering area from the very beginning.

In 1987, some presentations on multiphase meters were done at the NSFMW. This was really simple presentations and not very useful from a practical point of view for doing flow measurement.

Most of the concepts at this time involved partial separation, which inevitable will lead to large and clumsy meters.

At the NSFMW in 1989, the concept for what should be the MFI/Fluenta/Roxar meter was presented (a small integrated meter with no need for additional separation).

Later this meter and meters from other vendors have been presented at several occasions.

It is no doubt that many leading personnel in oil companies and elsewhere at this time (and later) wished to use multiphase meters without recognising the technical complexity and the challenge it is to get them to work properly.

2.1 The Value of Real Test Data

Some vendors have disappeared and many new concepts have come. The technology and the knowledge have moved gradually forward. In 1997, all meters from the Norwegian manufacturers were tested at the Norsk Hydro test facilities in Porsgrunn. It was a positive event as it brought new knowledge about the meters and their behaviour, from an independent test lab which up to that was difficult to achieve. It made test data available which of course for all metering equipment is a key for verification of various vendor statements.

Some of the vendors got really surprises when they experienced how their equipment worked under real flow conditions.

It again proved the necessity of doing tests at “real” conditions, even though we all have to admit that to test multiphase meters to all operating conditions is not realistic. We have to live with some simpler solutions.

2.2 Standardisation

It is strengthening all technical devices to have an international standard to refer to. It gives the equipment credibility and users get faith in the equipment. For the multiphase meters several positive steps have been taken during the recent 15 years.

In 1995, the Norwegian Society for Oil and Gas Measurement (NFOGM) issued a handbook for multiphase meters:” The multiphase metering handbook”, which was a good tool to establish a common language or vocabulary related to multiphase meters. This handbook

was updated in 2003, as a consequence of the technical development. In 2005, American Petroleum Institute (API) took up the "glove" and issued the document API Recommended practice for Measurement of Multiphase Flow." (API recommended practice 86, September 2005). In addition to this the ISO document :"Natural Gas – Upstream area – Allocation of gas and condensate" (July 2005), could also be a useful document.

3 NPD REQUIREMENTS FOR MULTIPHASE METERS

The Norwegian Petroleum Directorate (NPD) has the following requirements for accepting installation of multiphase meters under the scope of the measurement regulations.

- The operator (oil company) shall handle the case formally against ourselves. The Guideline for the Plan for Development and Operation (PDO), item 3.4.4., states that the plan shall contain the following information:
- Principle of measurement.
- Estimation of expected measurement uncertainty.
- Cost/benefit analysis of selected concept.
- NORSOK I-104, Annex C, gives recommended method for cost/benefit analysis.
- The Measurement regulations section 4: " When technology or methods not described in recognised standards are used, criteria for development, testing and operation are required to be produced."
- Further comments are also given in the comments to the section 4. Any dispensation is just necessary for any deviation from the requirements which are not identified in the PDO.
- When the multiphase meters are installed on an installation they should be easily calibrated/checked against the test separator equipped with improved metering equipment. The multiphase meters should also be easily accessible for maintenance or repair if that is regarded as necessary.
- If the multiphase meters are installed sub sea the above requirements are difficult to meet. Sub sea installation for fiscal purposes should just be evaluated if close to equality in ownership exists and/or other alternatives are regarded as absolutely impossible.

It is often used the term "fiscal requirements". It is quite clear that for multiphase meters it is not possible to develop such a term which shall be valid for all meters. When multiphase meters are used under the scope of the measurement regulations, it is the acceptance of bullet point 4 (the cost/benefit analysis) from all involved parties which lay down the fiscal requirement for that particular development.

The term "fiscal" refers to a meter`s service, not to its quality.

From our perspective all developments in this area are unique and would thereby have to be treated individually.

4 GENERAL VIEWS ON VARIOUS ASPECTS OF MULTIPHASE MEASUREMENT

4.1 The Need For Monitoring Flow Changes

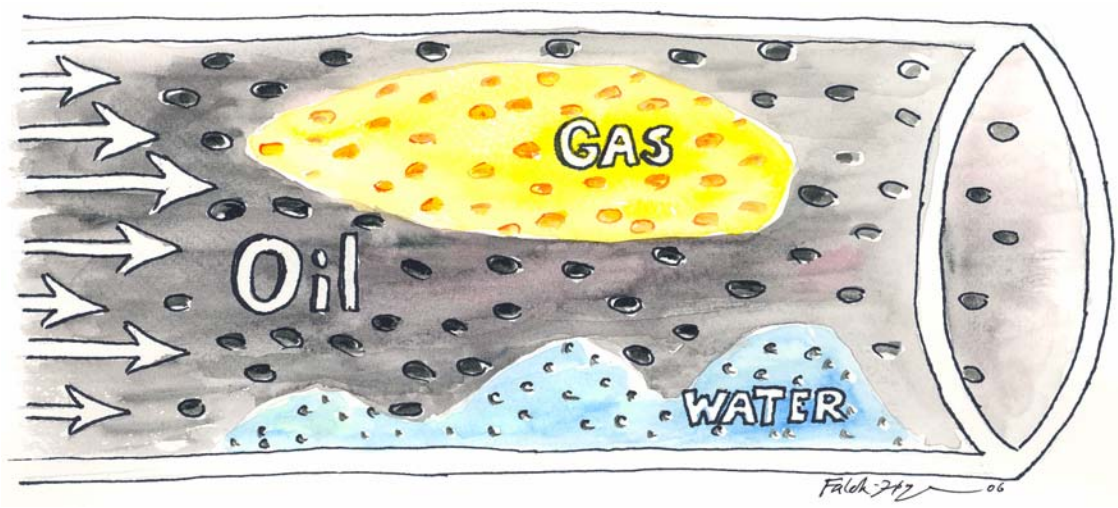

Fig 1

As shown in an artistic way in figure 1, the multiphase flow is a rather complex dynamic situation. It consists of the three phases oil, gas and water which can be present in all sorts of different percentages. The three phases will normally be "polluted" in different ways which makes accurate measurement even more complicated. As it is a large variation in the density between the three different phases, the velocity in the pipe will be quite different. Slip between the phases.

The Gas Volume Fraction (GVF) (The gas volume flow rate relative to the multiphase volume flow rate, at the pressure and temperature prevailing in that section. The GVF is normally expressed as a fraction or percentage).

The GVF is used to characterize the flow. The GVF is normally divided in four areas:

Low GVF: 0% - 25%
Moderate GVF: 25% - 85% (the multiphase meter`s sweet spot)
High GVF: 85% - 95%
Very high GVF: 95% - 100%

By "sweet spot" it is meant the range where the multiphase meters have their optimal performance. While the the two highest is more a wet gas application.

The flow from a hydrocarbon well can from the planning phase to the production phase be difficult to predict. Also in the production phase the the flow can vary significantly. Flow charts based on GVF will have to be developed for each meter and carefully examined during the lifetime of the meter. If you are outside the range of the meter you have to be prepared for changing metering equipment. This is something the operator have to be aware of and follow closely up. Otherwise he can easily end up with a metering equipment which is far out of range and thereby will deliver poor metering data. To be able achieve this goal it is necessary that the multiphase meters are easily accessible.

4.2 Follow Up Of Multiphase Meters

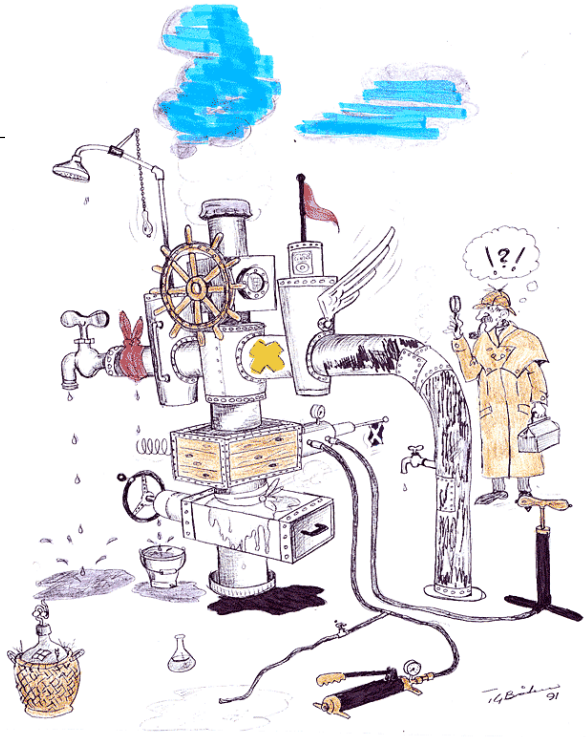

Figure 2 Manual follow up and inspection

Follow up according to previous picture number 2, is no longer possible for any system and especially not for a multiphase meter. The multiphase meter need an expert system which require online data connection and possible intervention if parameters slip outside a preset limit. The system will have to be set up as an interaction between platform, onshore responsible engineer and vendor service engineer. We have seen a tendency in direction of dedicated service contracts.

A typical configuration of multiphase meters could be as shown in figure 3, with meters on each sub sea template (on each well is also possible) and then multiphase metering on the host platform. The borderline between UK and Norway is also shown here, and that complicates of course the picture even more when it comes to taxation and ownership allocation.

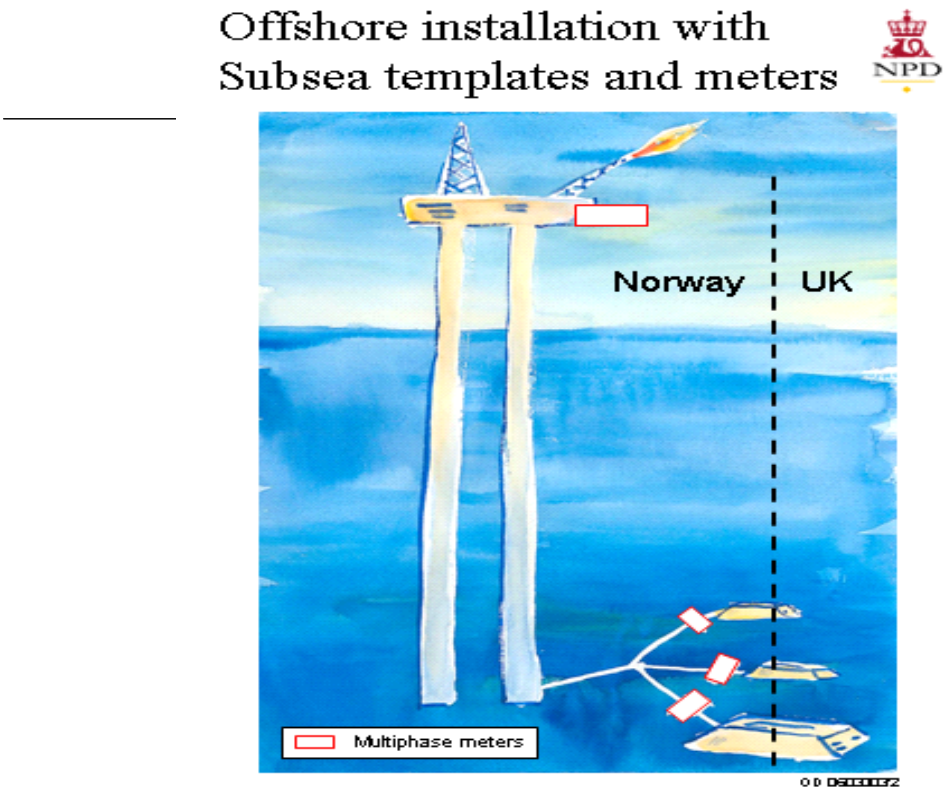

Figure 3

The interaction between the platform/sub sea equipment and personnel onshore is shown on figure 4. The data security is an aspect which always will have to be addressed and the drawing has included fire walls some places as an illustration.

The importance of establishing an efficient and good relationship between offshore personnel, onshore engineer and the vendor engineer must be emphasised. The relationship should ideally be based on trust and be established so that all participants will gain from it if the relationship is successful and the meters operate to the satisfaction all parties involved.

To understand the behaviour of a multiphase meter will have to include an understanding of flow conditions. The various flow conditions as bubble, slug, chum, finely dispersed bubbles, plug, stratified, wave, mist and annular are defined relevant flowcharts. What can complicate the situation is a tendency to hydrate formation which also have to be considered.

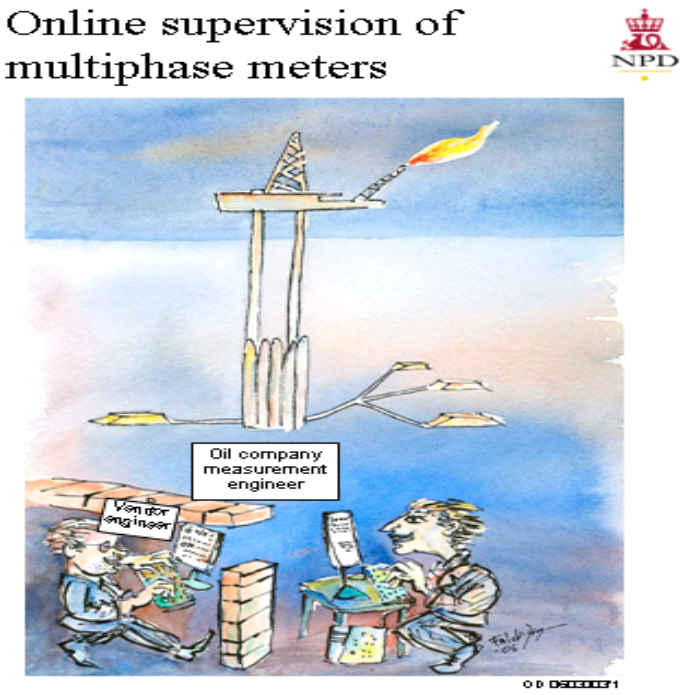

Figure 4

Sub sea equipment is generally difficult and costly to maintain. As we have to admit that we can not expect immediate action to repair a sub sea multiphase meter, it is extremely important that the design is robust and that any parts which can fail is duplicated. If a break down happen or regular maintenance will take place, then the sub sea meter will have to be disconnected and brought to the surface. It is then important that the equipment is designed so that this operation can be done in an efficient and cost effective manner. Figure 5, is giving an illustration.

The amount of technical support from the locals on the sea bed could be limited even though they in this case are equipped with helmet and tools.

The multiphase meters will have to undergo proper testing both mechanically and with respect to flow before installation.

In addition a maintenance strategy should be in place when installation takes place. That means that for example any need for recalibration or change out should be defined.

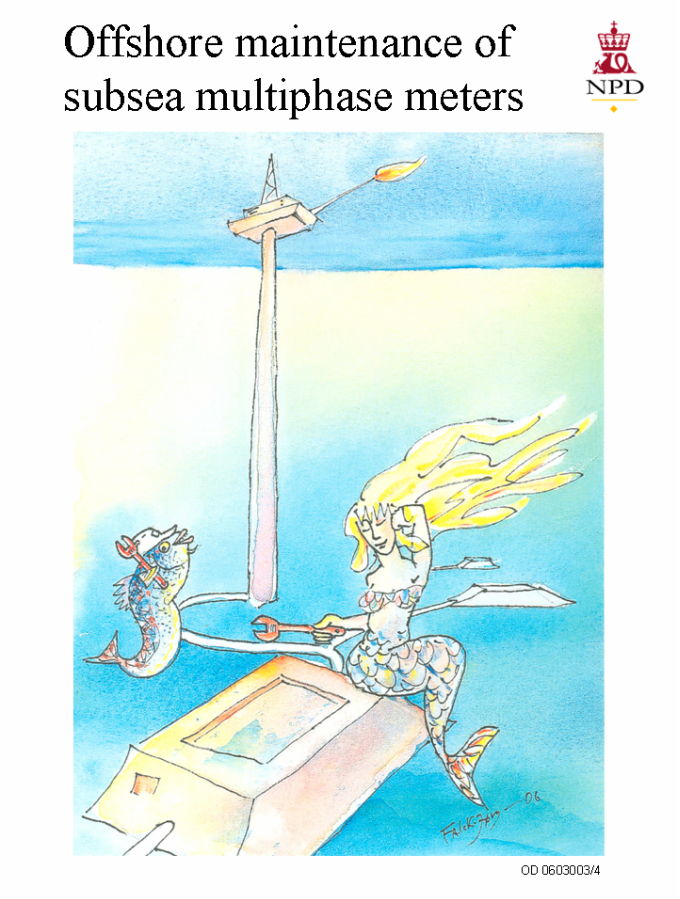

Figure 5

5 MEASUREMENT RANGE, OPERATIONAL REQUIREMENTS AND LIMITATIONS

Charts which is giving the Gas Volume Fraction (GVF) as a function of liquid flow rate and gas flow rate at actual conditions, should be examined to ensure that the multiphase meter operates inside its capabilities.

The following criterias should always be reviewed when a multiphase meter is put in service:

Measuring range: the range within which the MPFM operates according to its specification.

Rated operating conditions: the range that the measuring instrument parameters shall lie within.

Limiting conditions: conditions where the multiphase meter and its components can work, without failure or irreversible change in performance.

- Requirements concerning environmental, process and fluid conditions
- List over chemicals or gases which can or can not be used
- Check compatibility with other substances which could be present in the well stream (e.g. salt in produced water)

6 SAMPLING AND ANALYSIS

All Multiphase meters require for their successful operation a knowledge of the physical properties of the fluids passing through them. In fiscal applications, single-phase measurements are typically back allocated to individual wells or fields on basis of MPM data. Single phase and multiphase measurements are unlikely to be at same conditions (T,P), so a degree of phase change may be expected.

Phase change models using equation of state, which depend on knowledge of physical composition of fluids for their successful operation will have to be used.

Sampling an analysis is therefore a critical part of the process.

Sampling on multiphase streams is a technically challenging exercise so it is very important to analyse the situation and decide the right sampling strategy both from a technical and economical standpoint.

7 FUTURE

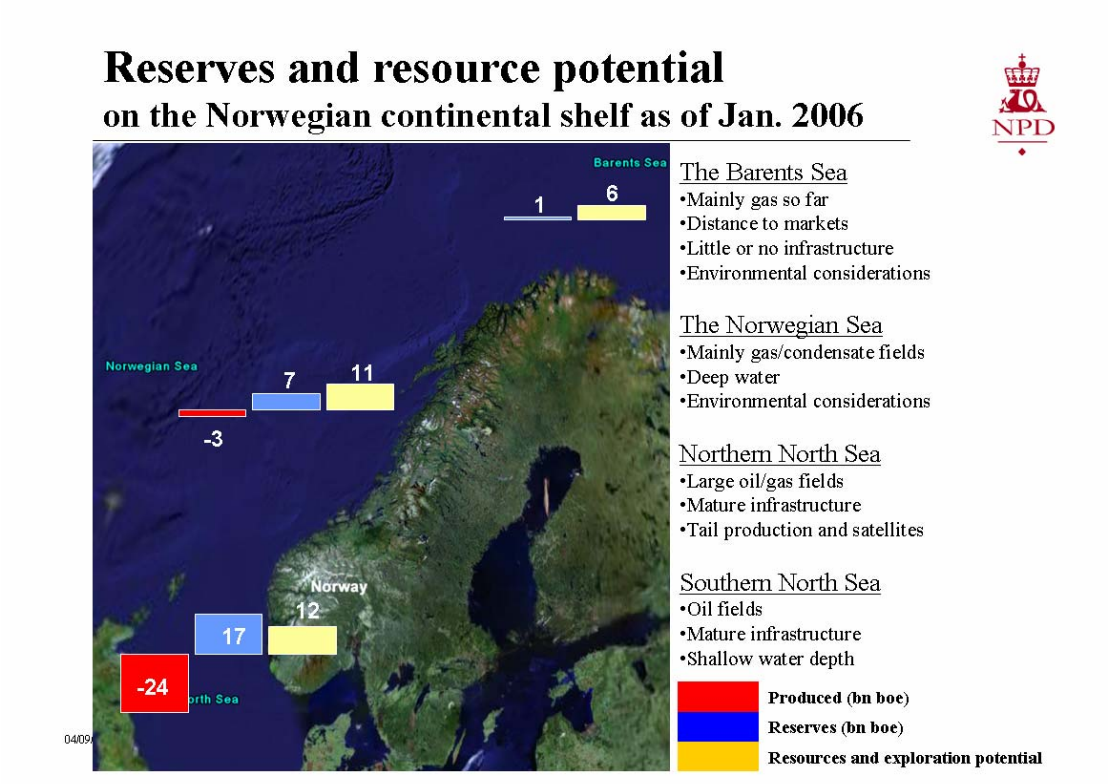

Figure 6

If we use the blue and the yellow column in picture 7 as a reference, it means that it is still a lot of hydrocarbons to be produced which often will need to be metered by multiphase meters.

I of course refer to the situation in Norway, but I would imagine that in principle the situation is very much the same in most mature oil provinces also in other countries.

Oil and gas discoveries are normally in clusters as picture 7, also shows. This increase the need and benefit of using multiphase meters when you tie new fields into existing fields for processing. The time frame can also be a factor for some projects, as they have to be developed when existing infrastructure is alive in the neighbourhood.

We anticipate that 10-15 developments will be processed during the next few years on the Norwegian continental shelf.

Until now about 210 meters (wet gas + multiphase) are sold for use on the Norwegian continental shelf.

The vendors expect to sell about 30 multiphase meters every year in the years to come (Norwegian market).

8 CONCLUSIONS

- All developments based on multiphase meters will have to be treated individually against the authority (tailor sewn). The economical impact on company economy and taxation will determine what solutions the authorities can accept.
- Multiphase metering is a technically challenging discipline. It is not an easy way to achieve fiscal data with fiscal quality. It will cost a significant engineering effort during the whole operation of the meters to achieve data with high quality.
- Experience from other projects, other oil companies, the vendor, standards and handbooks should be utilised to achieve the best possible result.
- It is extremely important to be able to operate within the specified range of the multiphase meter at all times.

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