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PRESENT & FUTURE OIL COMPANY NEEDS IN THE AREA OF FLOW MEASUREMENT.

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1 INTRODUCTION

The purpose of this presentation is to put forward some operator-viewpoints-on needs for improvements within the area of flow metering.

The focus of this paper is mainly on fiscal metering; both for existing and future offshore platforms.

Fiscal metering in this respect includes export metering of oil and gas, plus the ownership allocation metering; i.e. metering of hydrocarbon streams between field owners.

2 SUMMARY OF VIEWPOINTS ON PRESENT/FUTURE NEEDS

The essence of this paper regarding the needs within the area of flow metering can be summarised as follows:

- Need of an "un-manned" fiscal oil metering and water fraction concept with a lower frequency of repair and intervention than conventional concepts.
- Need of lighter, smaller oil metering systems with known uncertainty.
- Need of metering systems proven to operate accurately for oil at the bubble point.
- Need of performance data from multiphase meters working in a real system.
- Need of further development of ultrasonic meters (USM) within a number of areas.

3 GENERAL

When planning a new metering system there are always one or more of the areas listed below where particular needs are highlighted:

- Weight
- Compactness
- Price
- Delivery time
- Accuracy
- Reliability
- Amount of maintenance and calibration
- Conformance with accepted standards and regulations

Which of the areas that has the strongest needs may vary from case to case.

You can never get a high score in all of these areas. If you want a system that is compact, light and inexpensive, you won't get the maximum score on high accuracy.

In the first phase of the North Sea oil and gas era, there was a strong emphasis on the areas of accuracy and conformance with standards and regulations. Today, however, it has become necessary to weigh needs in different areas against each other. This is because there has been a number of changes in the area of field economy and field development, some of these changes are reflected in the sections below.

4 UN-MANNING OF PLATFORMS

There is now more focus on un-manned platforms for marginal fields.

A typical un-manned production platform will accomodate wellheads, a 1st stage separator and may have a need of fiscal metering of the oil and gas output streams. These two streams may after metering, be commingled in a multiphase pipeline or leave in separate multiphases pipelines to be brought into the processing plant of existing platform(s).

On this typical un-manned platform there may be no living quarter, no equipment that needs large amounts of power and equipment that needs frequent maintenance (and calibration) will be avoided.

The streams to be fiscally metered are "raw" streams, coming directly from the separator outlets. Pressures and temperatures may be high. A power consuming heat exchanger or other facilities to dry the gas before metering, is out of the question. So the gas has to be metered in a saturated or "wet" condition.

Further, there may be no power consuming, maintenance adding booster pump to provide back pressure for the oil stream to be metered. The oil stream will only get the pressure boosting available as hydrostatic head, typically a maximum of 5-10 metres.

Also, the oil may contain large fractions of free water.

The special needs of flow metering for such a platform include a number of the areas of the list in Section 3: Low weight,small size, high reliability, low frequency of maintenance and calibration. In addition, there are these extra needs:

- The oil, in spite of being on the verge of starting to form bubbles at the slightest pressure drop, must be metered with a reasonable uncertainty. This uncertainty must have a reasonable value which must be known and documented in such a way that all involved parties can agree on it.
- The gas is also on the verge of condensing at the slightest drop of pressure or temperature and has the same requirement to have a reasonable known and documented metering uncertainty.
- An automatic oil sampling system or water in oil meter which is reliable and accurate for monthly averaging of water content of the oil at 1st stage separator conditions. Automatic oil samplers are, however, not reliable. Water in oil meters need a bubble free stream after oil has passed through the static mixer which leads to a pressure drop which again may lead to bubble formation.

As stated above, it is not possible to find a system which have a high score for all of the areas of metering. In a typical case with an unmanned production platform for a marginal field, two sacrifices can normally be made:

- The price of the metering system is, within reasonable limits, not critical
- The accuracy requirements may in many cases be relaxed

There is however a problem when you leave the conventional concept of turbine meters and prover which has a lot of standards and history to back it up: you tend to end up with a system for which it is very difficult to document figures for uncertainty. If you cannot do that, it is impossible to make any cost/benefit evaluation that you will need to gain acceptance for such a system from partners, NPD and other "interested parties".

On the gas metering side, we are in a better position when it comes to meeting requirements for low weight, small size etc. and proven accuracy when gas is on the verge of condensing. The ultrasonic metering systems are now available as an accepted fiscal metering concept. It should be noted that further needs within ultrasonic gas metering is dealt with in one of the sections below.

5 TIE IN OF A SATELLITE FIELD'S SUBSEA WELLS TO AN EXISTING PRODUCTION PLATFORM

Instead of installing a wellhead platform with pipeline to the neighbouring platform, as described in the previous section, a new field may be produced by subsea wells with multiphase pipeline(s) to an existing platform. At the receiving platform, there are, mainly, two ways to deal with the incoming stream:

- The stream is lead into the 1st stage separator of the existing process plant. In such a case the only way to "meter" the quantities of oil and gas from the satellite field is to use a test separator for "flow sampling" or to combine the use of multiphase meters and testseparator. Use of the test separator in combination with well performance plots and wellhead pressure measurement is a rather rough method of fiscal metering. On the other hand, cost/benefit analyses using NPV of field reserves and differences in field ownership and royalty for the satellite field and the existing field, will often justify the risk of 5-10% metering error of a test separator metering scheme. The ideal situation would of course be to have accurate, well proven multiphase meters to perform continuous metering. However, we are waiting for more real life data from the new fields with such meters installed to demonstrate the present state of multiphase metering over a wide range of applications. The need for data from real life operation and other needs in connection with multiphase metering, is dealt with in a separate section of this paper.
- An alternative to let the satellite field's production enter the existing field's separator, is to install a dedicated 1st stage separator for the satellite field. As far as metering is concerned, we are then back to a similar situation to that of the unmanned platform of the previous section. There is a difference, however, that frequent maintenance and reliability is not such a big problem, since the platform is manned. The main need here is an oil metering system with lower weight and smaller size than a conventional system and with documented figures for the accuracy in real life use.

6 WEIGHT SENSITIVE PLATFORMS

The fields in the Norwegian sector have gradually moved from shallow to deeper water. The heavy concrete platforms with their large weight carrying capacity now seem to belong to history. The new platforms for deep waters are floaters, a lot of them are ship constructions. So far, weight and and size of topside equipment have not become a particular problem for this type of floater.

However, ship constructions are not always the optimum floater for production facilities. Where no storage facilities for oil is needed as part of the construction, floating platforms like the semi-submersible drilling platforms, seem to be preferred. The experience with such platforms, from a metering engineer's point of view, is that they seem to have a very high marginal cost per ton of topside equipment, compared to the old platforms.

In pre-engineering studies, marginal platform costs as high as 1000NOK per kg of topside equipment, has been used for concept optimisation. As a typical price level per kg for large conventional metering systems are of the order of 200-400 NOK/kg, this means that the building site costs may be up to 5 times the cost of the equipment itself.

From the trend of platform design it may be concluded that there is a very strong need to reduce weight of metering systems.

For a floating production platform which is now under construction, one gas meter run with two ultrasonic meters in series, will be installed as a fiscal export gas metering station. There will be a very strong need that this concept is proven in real life to be as accurate and reliable as a conventional multi-run orifice metering station, so that such a system becomes a generally accepted concept for fiscal gas metering.

7 CRUDE OIL METERING SYSTEMS FOR OFFSHORE TANKER LOADING FROM A MARGINAL FIELD

Traditionally, offshore measurement of crude oil batches to marine tankers have been made by metering packages with turbine meters and prover.

Such systems are very accurate and reliable. However, for smaller fields they may be far too big, too heavy and too expensive to maintain.

It was the "giant" oilfields of the seventies and eighties that set the standards for metering practices and governmental regulations in the North Sea. The enormous monetary value of the oil reserves in these fields could justify almost any level of cost of measurement.

As time went by the new oilfields got smaller and the oil companies had to pay more attention to the cost benefit ratio of using traditional measurement systems. Also the governmental regulations were amended so that it was easier to get acceptance of less expensive metering schemes if justified by cost/benefit evaluations.

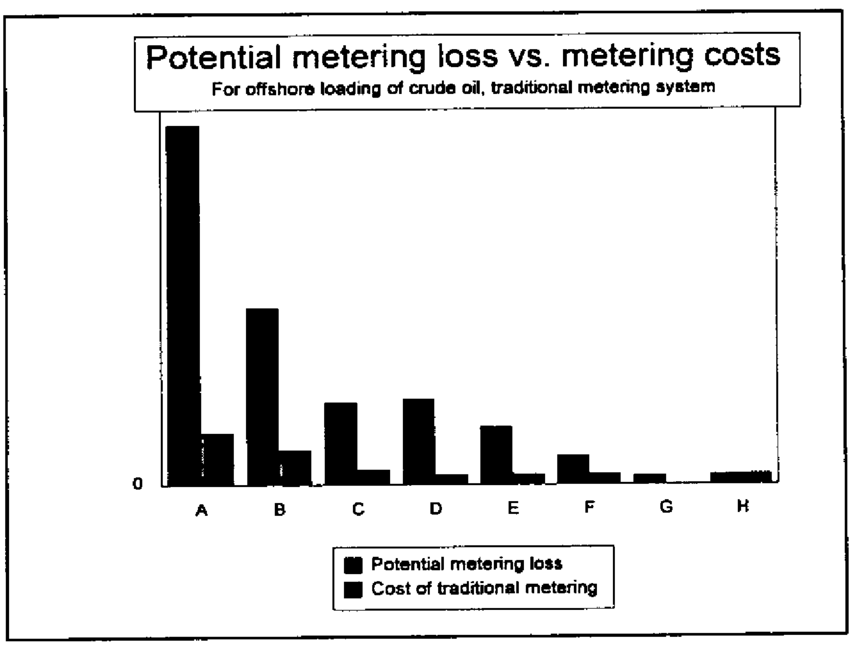

Figure 1 - Cost/benefit relationship

Figure 1 illustrates the cost/benefit relationship for traditional oil metering packages for some offshore loading oil fields in the North Sea. The chart shows the NPV of 0.5% of the platform's export quantity during its lifetime (dark bar) together with the total lifecycle costs for a traditional metering package (grey bar).

The value of 0.5% is used here as a potential metering loss when there is no measurement made at the exporting platform. It should be noted that this figure has been chosen as a parameter in the cost/benefit evaluations of crude oil measurement systems because 0.5% is very often used as a maximum deviation limit in crude oil transactions. It is not based on any data beyond this.

The two fields, A and B, in the left part of the chart, belong to the "giant" category of oilfields of the early eighties. As we move to the right in the chart, we find some of the fields that has been developed during the late eighties and the nineties.

Fields C, D and E have a reasonable margin between metering costs and a potential metering loss of 0.5%.

Field G delivers all of its export oil to a terminal which has a traditional turbine meter/prover measurement system, operated and maintained in accordance the offshore measurement regulations. Based on this, it was accepted that no fiscal measurement needed to be made at the platform.

For field H, the cost of its traditional metering system, marginally outweighs the value of a potential metering loss of 0.5%. This fact was acknowledged at the time when the technical concept of the field development was settled, but for a number of reasons it was not possible to get all involved parties to agree on a less expensive metering scheme.

The main reasons for this were probably as follows:

In the "world of the North Sea flow measurement" there is presently only one undisputable standard for crude oil fiscal measurement. This standard is represented by the traditional equipment, of turbine meters and prover, calibrated, maintained and operated at high costs with specialised personell.

For situations where there is a need of a less expensive fiscal metering scheme, we have not yet managed to establish a standard for 2nd class of fiscal oil measurement which is acceptable to all people involved in the production, transport, sale and purchase of crude oil.

In the authors' opinion, the following is needed to establish such a standard:

- More real life, operating experience with alternative metering systems, for example liquid ultrasonic meters schemes, with the emphasis on long term stability and reproducibility from laboratory conditions to field use.

- Open presentation of all such operating experience by the users, including both positive experience and negative experience.

- A written standard for this 2nd class of fiscal oil measurement, known to be based on real life experience, with technical details and specific figures for measurement uncertainty.

8 FISCAL GAS MEASUREMENT

8.1 General

In traditional systems up to the early nineties, orifice "technology" for several reasons, has been the dominant concept for fiscal gas metering. In purely dry gas service, on sales-metering onshore; gas turbine meters are however in use.

Traditionally; orifice metering systems have been quite large, heavy and a lot of capital and maintenance effort have been put into these systems. In order to achieve sufficient straight pipe on the Ekofisk 2/4-S riser platform, the gas metering station was the controlling equipment for the plattform length!

To be able to meet the field and pipeline development requirements for more compact and cheaper systems; at least two concepts have been in focus for fiscal use the last 5 – 10 years. The first one is orifice with flow straightener in combination with extended beta ratio and higher delta p, and the second is ultrasonic meters (USM).

8.2 Ultrasonic meters (USM)

The need of more compact systems compared to orifice, was obvious; and earlier studies ref (1) indicated space savings in the order of 80-90 % and weight savings in the order of 50-60% using USM. For a particular project it has been found "site" cost reductions of approx. 90% utilizing USM technology compared to traditional orifice meters.

Besides, it looks like the orifice meter has, for many years, been at the end of the road with respect to improvements of accuracy. The USM however is still in its youth with a high potential for further improvements.

The benefits given below is commonly accepted for an USM system:

- reduced costs (capital, maintenance & operational) compared to orifice systems.
- improved turndown.
- improved selfdiagnostic.
- improved understanding of metering installations' flow profile and swirl.

However, even if the USM technology is accepted by NPD, they give no "standard" permission to utilize a USM without spare meter tube. Full redundancy is not achieved for two meters in series before we are able to perform full transducer changeout on one meter; while keeping the other in service. This fact forces the operators to continiously collect experience data with regard to long term stability and reliability.

With respect to USM improvements it should be focus on the following key topics:

- improve the ultrasonic technology in respect of:
  high temperature range (100 - 130(C)
  high pressury (>200 bar)
- generally improve the documentation to establish the effect of upstream disturbances.
- noisy conditions; generated in the flow/pressure control valves.
- further move towards wet gas metering.
- extended use of "raw" data from the meter ie performance monitoring, density measurement, liquid fraction metering etc.
- intelligent meters with built in methods for indicating if actual flow profile is within acceptable limits.
- establish well proven methods with respect to how to verify that the meter output is still valid after typical 5 years in service without recalibration.

9 MULTIPHASE FLOW METERING

Accurate metering of unseparated well streams is of vital importance in subsea satelite field development projects, but the technique also provides significant benefits in standard platform-based production cases. Application for multiphase flow metering include well monitoring, reservoir management, production well allocation and process control

Utilizing the multiphase metering technique will add value in the following ways:

- reduce the need of subsea test lines from remote wellheads
- reduce time needed for well testing
- release test separator for low pressure production

- immediate detection of changes in well performance (gas/ water breakthrough)
- optimize process plant performance

The following items indicate some forthcoming challenges with respect to multiphase metering. It is assumed that a lot of work still must continue from where we are at the moment

- Increased field experience for topside and specially subsea real use of the meters output data. The experience with topside meters is limited and it is not known any published experience data for subsea meters.
- General meter improvements in co-operation with the manufacturer. There will still be needs of further optimizing the meters. It is reason to believe that real life experiences will lead to revised meter software. Also the meter's dependancy on fluid properties is very attractive to reduce.
- Optimize meter calibration method in order to further improvement of meters performance. In order to establish well proven calibration methods a lot of details regarding well composition, fluid data, flow regime, reference meter performance etc. must be under "control". In order to be able to control and understand the MFM performance, it will be essentiall to establish the complete "uncertainty" budget for this kind of metering system.
- Developing alternative calibration methods and optimize systems for a limited flow regime envelope. In order to reduce the need of a test separator it is also very attactive to establish the MFM performance (i.e. calibration factor) on a more cost effective basis. It is believed to be a realistic goal to be able to put MFM in service (topside or subsea), leave them and use the results for allocation purposes.
- Utilizing MFM system for fiscal use for marginal fields. There are very high expectations among operators for using the MFM as a fully recongized metering system. The meter is assumed to cover all needs regarding reservoir control, well monitoring, plant optimizing, production reporting, well allocation and ownership allocation. An improved metering concept selection process covering all aspects in the design and operational phase is essential.

10 OTHER TRENDS

Further on there are several good reasons to believe that there will be strong needs to improve todays metering solutions with respect to the following subjects.

- need for various metering concepts; detailed analysis may conclude that for marginal fields there is a need of simpler metering concepts as well as more flexible and tailor made systems.
- measure "secondary" parameters due to demand of A) quality control and B) fluid characterization & modelling. (CO_2-content, dew point, water content)
- increased need for mass-flow figures; specially for calibration of multiphase meters.
- further development of condition based maintenance methods.
- extended use of existing metering equipment.

At the bottom line there will always be a need of highly and relevant qualified personell during concept, selection, design, engineering, construction, commisioning, maintenance and operation of a metering system.

Finally there is a continiuos need for sharing of relevant information and experience between the oil companies, the suppliers, manufactorers, contractors and R&D environment.

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