Paper 19

Metering
- the Challenges of Satellite Developments

Rosalind Rowe, Mike Carnegie,
Shell U.K. Exploration and Production

Metering Challenges of Satellite Developments

by Mike Carnegie and Rosalind Rowe

Shell U.K. Exploration and Production[1]

Summary

This paper is an overview of experience gained and the challenges met in the use of modern metering techniques across a range of satellite developments in the U.K. North Sea. The techniques reviewed include multiphase meters, wet gas venturis and geochemical fingerprinting. Lessons learned using these techniques for fiscal and allocation metering and reservoir management are presented including a number of operational challenges including the challenges of subsea installations. It is concluded that a move towards goal setting is required to bring together the new and conventional technologies to form an effective measurement system to meet the needs of evolving assets.

1. Introduction

Metering requirements have changed since the first platforms were installed in the North Sea in the 1970's, technology has also developed resulting in modern metering techniques becoming available. Shell Expro deploys a number of these modern metering techniques. A wide range of meters have been installed in a variety of configurations and combinations, providing considerable experience, this experience has been mixed both in terms of performance and operability. Many additional fields have been developed as tie-ins to existing installations. Installations have had to evolve to operate as host facilities for satellite developments whilst also adapting to low cost operating philosophies required in later field life, this has often necessitated changes to the metering philosophy.

2. Overview of each Installation

In this section a brief overview will be given of some of the satellite developments using what we are calling modern metering techniques in this paper. Not all of the techniques are currently in use or being actively used but they have all been used at some time.

2.1 Anasuria

Anasuria is an FPSO which was originally designed to produce the three satellite developments Guillemot, Teal South and Teal fields, it now also processes fluid from the third party Cook field. The vessel was designed for a twenty-year service life, it is currently projected that the vessel will remain on location for at least ten years before returning inshore for a major survey and inspection. Production commenced 5th October 1996 and the Cook field started producing through Anasuria in 1999.

A Fluenta multiphase meter was installed on the Anasuria FPSO in place of a test separator for well testing purposes. The saving to the project resulting from using a multiphase meter in place of a test separator was £4M in Capex. The multiphase meter was seen as a means of introducing the latest metering as a cost-effective option on a state of the art vessel. At the time the multiphase meter was installed on Anasuria, the technology was very new. The meter was common to each flowline, capable of being manifolded to it via

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[1] Shell U.K. Exploration and Production (Shell Expro) is operator in the U.K. sector of the North Sea on behalf of Shell, ExxonMobil and co-venturers.

the test header. However, as Teal South could only be routed up the test header and this was the only access route to the multiphase meter, it was necessary to close in Teal South and sustain a deferment if individual wells were to be tested. The only alternative was testing by difference with Teal South. In this configuration the multiphase meter was never used in earnest due to a number of operational issues and problems with the meter (see ref 2 for full details). Also each well could be tested using the platform separators, transferring production between the two separators and testing by difference.

In 1999, another satellite development, the Cook field was brought on line and processed on Anasuria. As shown in figure 1 in order to process these fluids one of the first stage separators was dedicated to Cook, with all of the Shell/Esso wells producing through the other first stage separator (i.e. Teal, Teal South, Guillemot P1, P2 and P4). As a result a method was required to manage the Shell Esso wells. The multiphase meter together with geochemical fingerprinting was used to manage the wells. The wells produced through Anasuria have very different production rates and some with a very high water cut which proved to be too demanding for one multiphase. Geochemical fingerprinting was used to provide a percentage split of the wells by mass. Anasuria was the first installation to use a combination of geochemical fingerprinting and a multiphase meter for reservoir management.

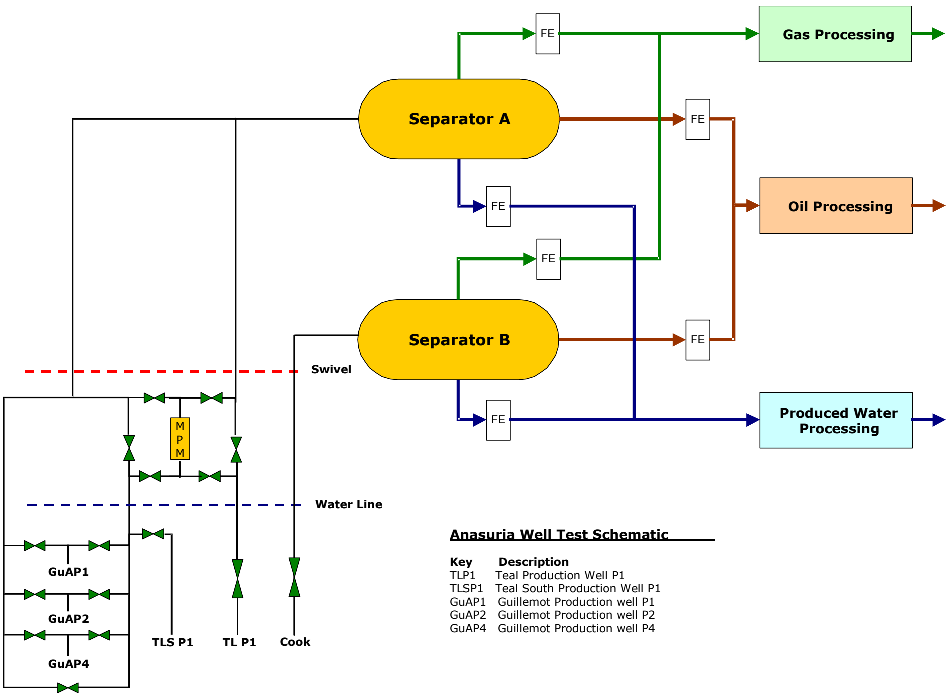

Figure 1. Schematic of Anasuria (post Cook)

2.2 Gannet

Gannet, although one asset, processes fluid from seven different fields, six of which are satellite subsea developments with a total of 19 subsea wells. The Gannet installation has been developed over a period of 11 years and required modern metering and allocation techniques to be employed in order to manage and optimise the wells.

In 1997 two Roxar multiphase meters were installed on the Gannet platform, to provide additional flow measurement for reservoir management of Gannet A to F fields, following the installation of two new tiebacks, Gannet E and F. The original Gannet design allowed for an individual separator for each field (A to D fields) in addition to a test separator, however, project economics for the new tiebacks showed that this philosophy could not be supported and a change to the existing duty of the separators was required. As a result the configuration was changed with A&D Fields commingled into separator V1010, B field into V2010 and V2110, C&F fields into V1110 and E field into V1210 (figure 2). The effect of this change was for production from the B, D, E &F fields to be measured directly and production from the A & C fields to be determined "by difference".

Prior to installation of the multiphase meters, extensive testing was carried out within the predicted working range of the meters, both onshore at NEL and Norske-Hydro, Porsgrunn, and on the Gannet platform using the test separator as a reference. These trials confirmed the performance of the meters under known conditions (onshore tests) and familiarised operational personnel with the operation and capabilities of the meters (offshore tests). The offshore tests also compared the performance of the meters with reference to the existing test separator metering, and demonstrated that in some cases it performed better than the test separator.

Subsequent additional tiebacks, have resulted in further changes to the field configurations, resulting in a change of use for these multiphase meters. The multiphase meters no longer measure complete fields but, are used for multi-rate well testing, optimisation and surveillance.

Gannet also has a number of gas lift meters installed subsea, both venturi and orifice plate, however there are a number of operational problems associated with these.

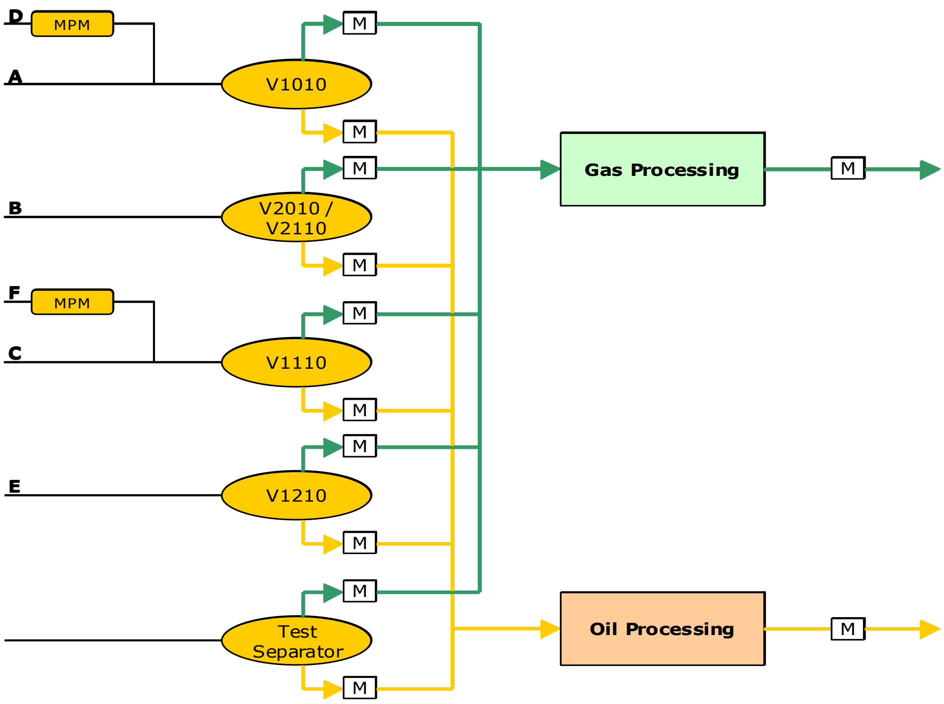

Figure 2. Schematic of Gannet

2.3 Halley

Halley is a tieback to Fulmar Alpha host platform, where its fluids are processed. Fluids produced from Halley enter the Fulmar processing facilities at the inlet to the A-train production separator, VE210. There are two first stage production separators, one on each of the A and B production trains. Halley fluids are measured using a multiphase flow meter, prior to entering the A-train separator, VE210, where they are co-mingled with Fulmar fluids (figure 3). Flow meters have been installed on each of the oil, gas and water outlets of the A train separator to enable calibration of the Halley multiphase meter. The B-train separator, VE220, is used to process Fulmar production.

The amount of oil exported from Halley is calculated using the oil measured by the multiphase meter corrected to export conditions (by the flow computer) and subsequently adjusted by the appropriate recovery factor. (A process model has been used to determine the Recovery Factors (RF's)). This value for oil exported from Halley is then subtracted from the total export oil for the Fulmar platform which is fiscally metered, to provide the amount of oil exported from the Fulmar field. Similar principles are followed for metering the gas from the Halley and Fulmar fields.

In order to minimise the uncertainty of the multi-phase meter it is necessary to calibrate the meter under operating conditions. Calibration involves flowing Halley fluids through the multi-phase meter and exclusively through separator VE210. This requires some Fulmar deferment, and leaves Fulmar fluids only flowing through separator VE220 and the test separator. Differences in flow rate between the multi-phase meter and the separator for each of the oil, water and gas phases are recorded and used to determine the meter K-factors (KFs). This test has been performed at a number of Halley production rates in order to determine the effect on the MPM due to changing flow rate.

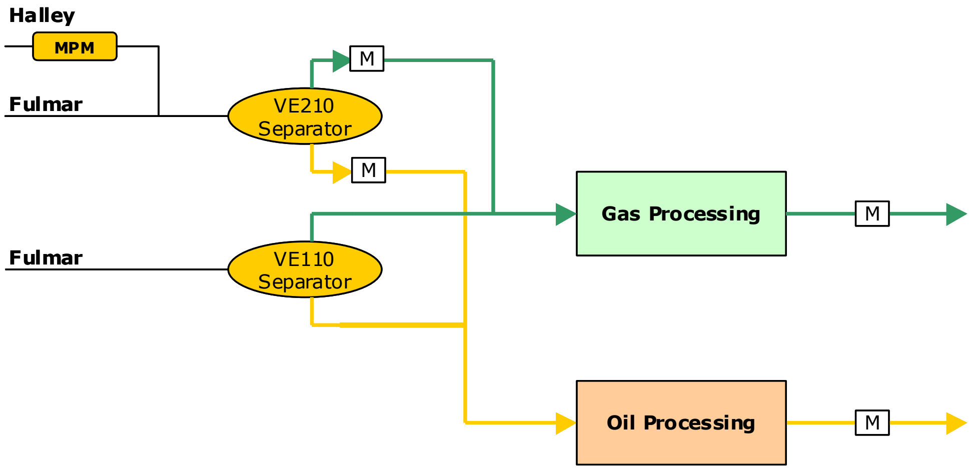

Figure 3. Schematic of Halley over Fulmar

2.4 Penguin

The Penguin field is a 55km subsea tieback to the Brent Charlie installation. Fluids from the Penguin reservoir are routed via a Severe Slug Suppression Device (S^3), which acts as a partial separator. Production from the Penguin field enters the Brent Charlie processing facilities at the inlet to the S^3. A 14" Solartron Dualstream II wet gas meter is installed on the gas outlet and a Framo MPM on the liquid outlet of the S^3. The liquid and gas streams from the S^3 are then commingled and processed with Brent Charlie production (figure 4). Production from the Brent Charlie field is calculated 'by difference', by subtracting the measured oil and gas, corrected for process conditions, from the Brent Charlie platform export.

The primary method of validation of the Penguin wetgas and multiphase meters is to periodically flow production from the Penguin wells through the Brent Charlie test separator. Comparison of the results from the two systems will be used to determine the need for any corrections. In addition to these topside meters, which are primarily used to determine field production, further metering equipment exists both subsea and downhole for reservoir management. This reservoir metering consists of Schlumberger downhole FloWatchers in each well and Venturis on each well flowline, which are being used to establish further development of the Penguin cluster. The flowline venturis are to be calibrated against the FloWatchers to provide best possible information in the event that the FloWatchers fail. The algorithms used by the downhole and subsea venturi meters and the way in which they are correlated is still being enhanced.

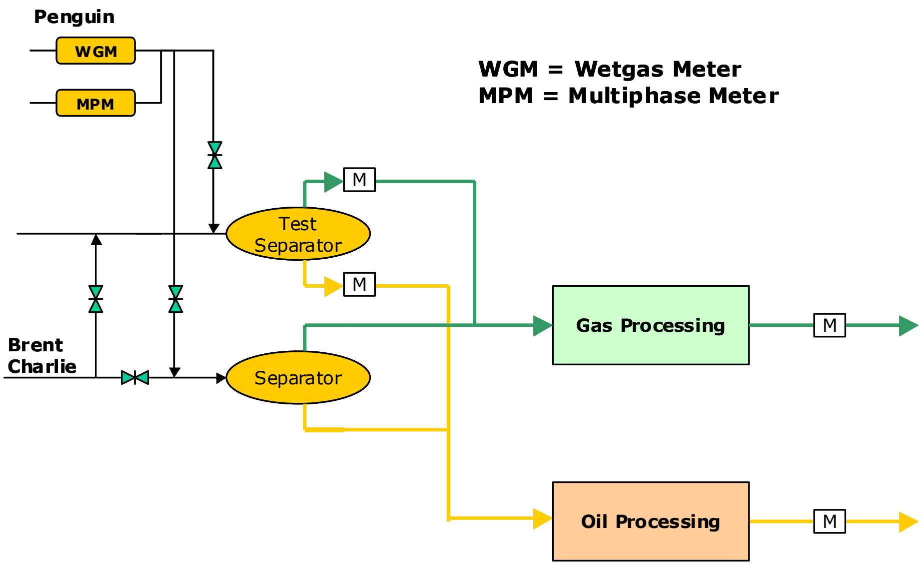

Figure 4. Schematic of Penguin over Brent

2.5 Scoter (Future)

Shearwater is a high pressure/high temperature (HP/HT) field development in the Central Graben area in the U.K. sector of the North Sea. Production flows, via multiple wells, into a first stage separator V-1010, a test separator V-1110 is provided for testing the Shearwater wells (figure 5). The Scoter development comprises a number of subsea production wells, which will be tied back to the Shearwater platform. Allocation metering for the Scoter fluids will be carried out on Shearwater.

In order to process fluids from the Scoter reservoir, amendments to the existing Shearwater topsides processing and metering facilities are required. Scoter fluids will be measured using a wet gas meter prior to entering the Shearwater test or production separators. The test separator metering will be used to periodically calibrate and validate the Scoter wet gas meter. The wet gas is measured using a venturi, the gas metered is corrected for overreading due to the entrained liquid (using De Leeuw correlation) and will be used to allocate hydrocarbon production to the Scoter reservoir.

Two options were considered for allocation of the Scoter production. The first was allocation of Scoter / Shearwater product by a pro-rata arrangement against the fiscal exports. The second option was allocation by difference. Exposure calculations have demonstrated that the 'by difference' option provides the most cost effective solution, whilst the pro-rata arrangement offered little benefit in terms of accuracy. Allocation of Shearwater production will be determined from the difference between the fiscal export meters and the measured Scoter flows, corrected for process conditions.

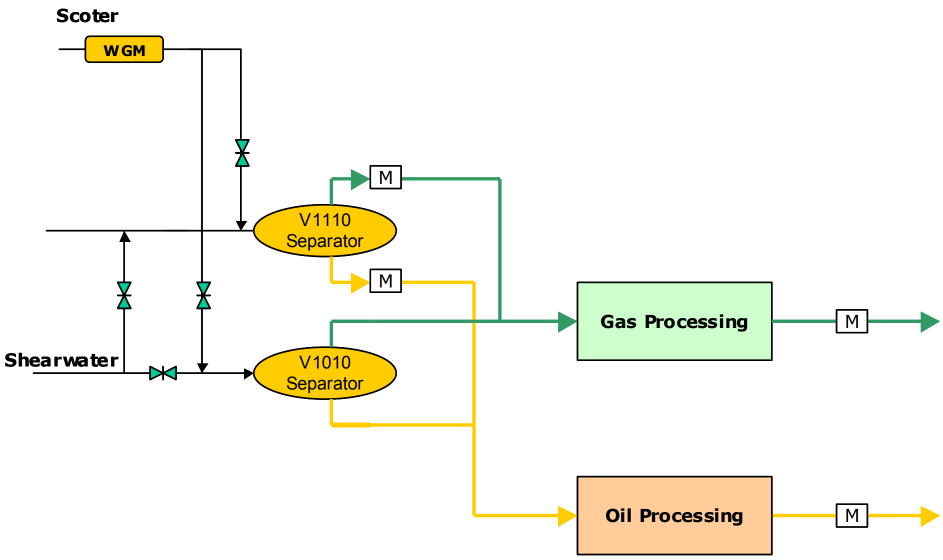

Figure 5. Schematic of Scoter over Shearwater

2.6 Otter

The Otter field is a subsea tieback to the Eider Alpha installation. Production from each field shares the separators on the Eider platform. Otter production is approximately 90+% of the total export flow from Eider for the first three years of commingling and has a separate metering system. Production from the Eider field does not have a dedicated metering system, it is calculated by difference using the Eider export meter. The Otter metering system has an uncertainty of +/-5 % and calculating the low volume of Eider field production by difference could give errors of +/-50% or more. To reduce the uncertainty of the Eider contribution, geochemical fingerprinting using the Multiple Dimensional Gas Chromatographic (MDGC) fingerprinting technique is used to verify production allocation, this reduces the uncertainty to within the range of +/-25%.

The MDGC fingerprinting technique is a quantitative analysis of the aromatic compounds between C_8 and C_{10} of an oil sample. Each reservoir normally has a unique fingerprint, this is usually displayed graphically as compound ratios in a star plot which provides a simple visual evaluation of the different oil samples. If two oils with different star plots are mixed together the resultant star plot is intermediate to the two individual star plots (reference 1). A series of laboratory mixtures of the two oils are made and mixing lines are generated for the various compound ratios. The mixing lines are then used to quantitatively calculate the relative amounts of end-member contributions in commingled production from the Otter and Eider fields. The benefit of this technique over allocation by difference, for this particular development, is that the fingerprinting technique is a direct measurement tool on the commingled oil

3. Implementation of Modern metering

3.1 Historical Approach

Historically a new field development was achieved by setting up a project team comprising Shell and contract personnel responsible for the design, construction and commissioning. Knowledge of the brown field or green field was often limited, generally at conceptual design phase the team would comprise new personnel who hadn't worked on the asset before. When the project moved to the detailed design stage an operations representative would form part of the team, if the project was a modification to an existing platform the representative would be from the platform. In addition, the team normally had minimal specialist knowledge in the area of metering and allocation and hence relied on the respective departments within Shell for support. Project guidelines were used by the project team to ensure all aspects of the project were covered.

Project teams need clear prescriptive guidance, they are typically bound and driven by timescales and budgets, hence it is critical that the metering and allocation requirements are clear from an early stage. However, at conceptual design, not all the necessary information is available to enable a good accurate budget to be developed for provision of the relevant metering systems. The data required to specify and design appropriate metering is given in Table 1, although this list is not exhaustive. In an ideal world a suite of "acceptable" designs would exist and the "best fit" could be adopted, but as the word implies "best fit" is not necessarily good enough or fit for purpose. Historically within Shell Expro, corporate design documents existed, however these were for the design and installation of fiscal standard single phase gas (orifice) and liquid (turbine meter) export systems. With the advent of new technologies such as ultrasonic, coriolis, multiphase and wetgas, the decision was taken to remove these corporate documents and rely on international standards where applicable. *Note: These international standards often require specialists to interpret them appropriately.*

A result of removing corporate standards is to raise the importance of good communication with the specialist metering group. There is also a need for: detailed roles and responsibilities: clearly defined deliverables; and agreed delivery times between project team and support groups. Typical metering deliverables for a development project are given in Table 2.

Production profiles and field life
Process conditions – Slugging, composition,
Co-mingled production or separate train
Potential export routes
3rd party owners or Shell - new field
3rd party owners or Shell - existing field
Commercial agreements – impact on –need for new agreements
Standard of metering required
Maintenance requirements

Table 1. Typical Data Required for design

Measurement Philosophy
Uncertainty / Exposure Calculations
Allocation Philosophy
Allocation Software
DTI /Partner Submission
Maintenance / Calibration Principles
Commissioning Procedures
RTMS / PI Data Hand Off
New Log Books
Responsibility Matrix

Table 2. Typical Metering Deliverables

3.2 Goal Setting Approach

Off the shelf designs are becoming less acceptable and very few traditional fiscal standard single-phase metering systems are being installed. Many new developments are over existing brown field sites, they are often small tiebacks and subsequently generate less value. These small tiebacks normally need to be installed within the boundaries of existing real estate, they typically have to utilise existing plant (i.e. separators, manifolds etc) and are often subject to slugging and process related problems. In addition, such tiebacks are normally commingled with product from the existing plant. This can create a challenge for existing metering systems that may need to be upgraded or have additional new techniques incorporated in order to bring the metering up to the required accuracy. The resultant commingling of products creates the potential for equity leakage between the various fields (owners) concerned. It is important that this potential for equity leakage is considered in the prospect development stage, especially when several evacuation routes are being evaluated so that the exposure can be minimised.

All developments require a number of metering systems each with different requirements depending on the user of the data. These may include: metering of each well for reservoir management: allocation metering to allocate between fields; and fiscal metering for tax and equity purposes. These requirements need to be considered as a whole in order to get an integrated metering system.

The potential for revenue leakage is directly related to the metering and product allocation uncertainty, which is expressed in percentage terms of the quantities that are to be measured. For marginal developments, metering is often less than full fiscal standard, to help reduce costs to make the development economically viable. However, it is very important that when making such decisions the business risk plus resultant economic consequence, is properly evaluated in the prospect development screening process so that appropriate options are selected for further development. Currently, although such metering screening is included in the prospect development plan (see fig.7), it is not always carried out at this stage and may be completed during the conceptual and/or the detail design phase of the project, which may be too late to optimise and/or change to the appropriate technical metering solution. It is often assumed that metering uncertainties are random and will cancel out over time. This is not necessarily the case. Proper evaluation of propagation of errors through the system is often not carried out. The consequence of this is that, in some instances, a different evacuation route may have been more appropriate or it could even make the development economically unviable, as the potential reward may not justify the risk.

To redress this it is recommended that, when new prospects are being considered, as well as the usual economic screening, the potential for equity leakage as a direct result of metering and allocation uncertainty is also evaluated for each evacuation route being considered, over field life in terms of net present value (NPV). It will then be possible to specify the product metering and allocation uncertainty target that will have to be achieved to make it viable for each evacuation route. Furthermore, the level of exposure determined will also yield the amount of money available to effect an appropriate “fit for purpose” metering and allocation solution. Normally 10% of the NPV exposure is budgeted to reduce or eliminate the metering uncertainty. If a metering solution can’t be found to deliver the target metering uncertainty with the budget available, then the proposed development needs to be reconsidered as it may present too great a risk for the reward available (figure 6).

As has been adopted in safety standards, a prescriptive approach has been replaced by risk assessment and demonstration of the capability to meet customer requirements. In metering terms this can be seen as the result of a combination of exposure analysis, resultant available revenue for development and available measurement technology. An example of this is the metering development for Eider, which utilised this goal setting approach.

3.3 Satellite Development

As previously discussed, many of the new field developments are small satellite tiebacks to existing installations. These often present new challenges in terms of distance from the host installation, location and cost drivers. In order to meet the commercial targets and reduce the operational demands, these often necessitate the need for subsea development. Subsea developments still require the same if not more monitoring for management of the asset.

To enable reservoir engineers to optimise and manage the wells, a measurement philosophy needs to be developed in which the detail from individual well through to field is addressed. Each individual well will require measurements for production and gaslift/water injection as appropriate. Depending on the complexity of the development the measurements may need to be subsea. For a simple one well tieback the measurements may be made topsides. However, increasingly satellite developments are becoming more complex requiring production, water injection or gas lift metering to be subsea. In addition, these developments can only be developed now with the advances in technology, which have reduced the overall development costs.

A subsea development is achieved by installation of a standard subsea tree. Frame agreements are in place to ensure that tight timescales can be achieved for development and installation, within the tree design standard metering is provided for water injection and gas lift as required. These meters are sized before the well is flowing when little is known about production. Venturi meters are used for both gas lift and water injection with a turndown of typically 3:1. The aim with a subsea installation is fit and forget, but with installed instrumentation providing the relevant measurement data reliably and consistently. Maintenance is not normally carried out but inspection will be carried out to ensure integrity is maintained.

For example the Penguin field when fully developed will comprise 8 wells arranged in pairs with each pair feeding a common manifold. A downhole meter is installed on each well, this provides three measurements of both pressure and temperature. The pressure and temperature readings are then sent onshore for manipulation and to provide flow measurement. Down hole meters have had a history of failing in infancy, to ensure the reservoir engineer is provided with well data, a venturi meter has also been installed for each well. However, algorithms for these venturi meters are still being developed.

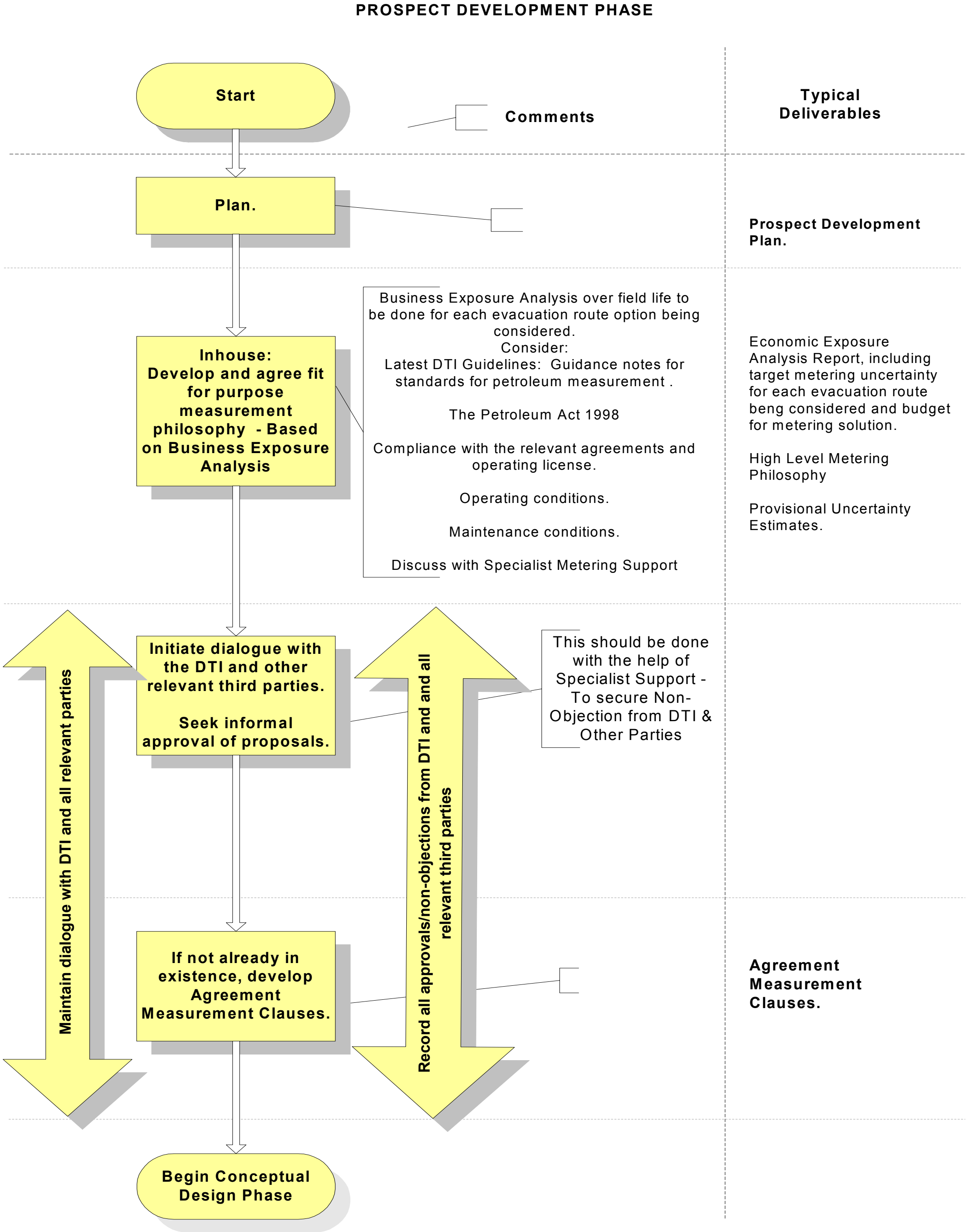

Figure 6. Flowchart for prospect development phase.

4. Operational Challenges

In section 2 a brief summary of each of the assets has been given where modern metering techniques have been used. Section 3 described the change in projects when addressing metering issues from a prescriptive approach to goal setting. The development of marginal fields and the availability of new measurement techniques has brought challenges both technically and operationally in providing metering systems that are fit for purpose for reservoir management, allocation and fiscal measurement. A number of specific operational challenges experienced will be addressed in this section.

4.1 Meeting Expectations?

4.1.1 New Technology

New technology, by its nature, implies new techniques, learning and knowledge, standards are not in place and need to be developed following experience. Installing a new technology, which is in its infancy, will often have teething problems. Although the technology may have been tested extensively, this will normally be on a test rig, field conditions will normally be more demanding. An example of this was the installation of an MPM on Anasuria, this is described in reference 2.

On the Penguin development, the host and satellite fields are under different tax regimes so there is a drive for the metering system to achieve an accuracy of +/-5% for gas and oil measurement. Following the start-up of Penguin in January 2003 it was observed that the readings from the wetgas meter, were not within the specifications of +/-5% for gas and +/-10% for liquids for the meter. An investigation into why the meter was not working within specification, established that the meter used for research and testing had been a considerably smaller meter. In order to achieve reasonable results from the Dualstream II, the meter was initially used as a conventional wet gas venturi (Dualstream I). During this period test separator measurements were used to determine the gas mass fraction and entered into the flow computers. To resolve the Dualstream II issues another 14" meter was tested in late April in order to enable enhancement of the flow computer algorithms so that the Dualstream II meter can achieve the original specification of +/-5% on gas and +/-10% on liquids. This is an example of the limitations of using predicted performance based on test rig data, and thereby requiring further development work when the unit is installed in the field.

Implementation and installation of a new technology needs to address the requirements for isolation and bypass facilities and whether any redundancy or contingency is required if the installation is not immediately successful. In addition, verification and confidence will need to be gained before the item can be used in earnest. On the development described above the facility to test and verify the Dualstream II meter has been included and has been paramount in resolving the initial teething problems described.

Manufacturer's recommendations for initial installation, commissioning and calibration, may be valid, however they still rely on the operator recognising the importance of good process data for setting up algorithms used in calculating the outputs which in turn impacts the success of the technology. An example is the validity and accuracy of available PVT data to the operating conditions actually experienced rather than the predicted operating conditions, especially if this is used to set-up the technology.

4.1.2 Resource Implications

Modern metering can assist new projects to meet and often exceed the minimum requirements needed to successfully manage small field developments, whilst helping to reduce CAPEX. These systems as previously discussed may bring new problems. Although there is a reduction in CAPEX, there is likely to be an initial increase in OPEX when additional resource is required to manage and verify data to gain confidence in the technique. However, newer projects are beginning to recognise these additional resource requirements.

Post installation issues invariably occur during or shortly after commissioning. Once commissioned the project team is dispersed, together with the limited expertise If the new technology subsequently fails to meet expectations, there is a need for detailed analysis, requiring extensive resource and expertise.

New techniques provide an abundance of data, which can be useful to a range of people including reservoir engineers, production technologists, metering and allocation engineers and hydrocarbon accountants. Each of the disciplines will require different data however, one person will need to have the complete overview to ensure that it is consistent and provides the correct end values. It is important that each user is able to define their data requirements, to use it effectively. The user also needs to establish whether the data can be used, or whether better use could be made of it for example for flow assurance/surveillance. These questions can only be answered if the full process is understood and there is consistency in the end to end data. In some cases data may only be required for trend analysis, in other cases the absolute value may be required. In addition some data may be useful for a short period of time, for example in Penguin start-up, data for reservoir management was crucial to establish phase 2 requirements. Some data will not be required all of the time but may be needed during specific phases, such as change in operational regime, faultfinding or routine verification. It is important that the relevant data is maintained at the appropriate level. As a consequence of obtaining extra and often-valuable information, there is a corresponding increase in workload to manage, analyse and use the data. The new Penguin development currently has one person working full-time managing the data.

4.1.3 Logistics

Modern metering techniques tend to exist as "Black box" technology to the operations team and any queries or anomalies often need a more detailed technical knowledge to resolve. This knowledge does not necessarily reside with the operators and may require specialist skills, which are typically only available from the vendor. The majority of vendors supplying the new technologies operate with small service departments and hence small numbers of specialists, giving rise to resource constraints, when in need of assistance. As indicated earlier, there is normally minimum redundancy and hence the problem needs immediate resolution. The resulting logistical issues are often overlooked.

If adequate data from the new device is sent onshore, it can be reviewed and assistance may be provided for resolution of queries. The data can often be forwarded to the vendor, which may allow a faster response or reduce the need for an offshore trip. On at least one development, raw data is sent onshore and the flow algorithms reside on an individual's desktop computer.

Another example where logistics has had a considerable impact is in the use of geochemical fingerprinting. Following the work on Anasuria, where it proved to have considerable value as a validation tool, it was recognised that the technique could be developed further and was used for Otter and Eider allocation. However, the need for additional laboratory equipment and experienced personnel became more onerous. With limited facilities able to carry out the specialised analysis work and correlate the results, a backlog of work built up and set targets could not be met. This has resulted in the purchase of laboratory equipment and training of local in-house personnel to complete all the necessary analysis and data correlation.

4.1.4 Subsea Metering

A considerable number of new satellite developments utilise subsea or even downhole metering as part of the operating philosophy, whether they are used to measure production fluids, gas lift or even water injection.

Subsea assets in Shell Expro provide over 60% of the total production and this is increasing. New projects are generally satellite developments tying into existing installations, most of these are subsea developments. Reliability of the subsea equipment is critical to achieving the production targets and data provided by the subsea instrumentation is critical for optimising and managing the reservoir.

Subsea equipment provides a high uptime, in excess of 99.99% with failures being attributed to one off occurrences. Flowmeters are installed subsea for gas lift, water injection or production however, to date these subsea flowmeter installations have had a very poor success rate.

The first gas lift flowmeters installed were orifice plate meters for the Gannet D wells in 1992, there are a total of four orifice plate installations subsea for gas lift. Venturi meters are used for all other gas lift metering subsea. In total there are 32 venturi meters installed for gas lift metering subsea with 10 meters working. One of the problems with gas lift metering is that they are not used continuously and may only be required intermittently this means that problems are not picked up immediately so any alternative methods for metering will be used if available. The venturi meters are installed both horizontally and vertically although the success of operation does not appear to be dependent on the orientation of the meter. Failure of these meters, ranges from problems in design data, sizing, fabrication, installation, commissioning through to operation. Although some of these problems can be rectified following installation many would require diver intervention, which is not normally economically viable. Within Shell Expro we have carried out a full assessment of the problems with these gas lift meters and where they can be rectified without diver intervention these have been dealt with. Other issues such as leaks, hydrate formation in the impulse lines and delayed commissioning are currently being worked.

4.2 Changing Requirements

On many installations new tie backs lead to the requirement to change the process configuration, this in turn may result in a change in use of certain pieces of equipment. For example, on Gannet the original installation of MPMs allowed production from each field to be measured for reservoir management. Subsequently, the need to optimise production has resulted in further commingling of fields and individual wells from fields, and consequently changed the function of the MPMs.

A similar situation occurred on Anasuria where the introduction of a new field, reduced flexibility and increased reliance on the MPM for well testing.

It is important to recognise at the design stage that requirements may change through the life cycle and flexibility to adapt the use of equipment may be paramount for efficient and cost effective operation.

5. Conclusions

The use of new metering techniques within Shell Expro has enabled marginal fields to be developed that otherwise would have been uneconomical. There has been a considerable amount of learning for each of the new technologies and techniques.

Implementation of a new technology may require some development following installation, as the manufacturer's specification will be based on the results of testing on a test rig where the conditions are not as onerous as the field. This often requires the engineer to be persistent to achieve the full potential of the technology, this usually takes a longer period than initially envisaged. In order to gain confidence in the measurements provided, a means of verification is required and a backup in case of loss of data. The installation also needs to address the requirement for repair and isolation of faults.

Although the project will gain the benefit of reduced CAPEX which may enable the project to progress, there may be increased OPEX in managing the data, although more data will be available which provides the opportunity to know more about the asset. A significant recent development has been to move more data onshore. Improved data onshore, allows monitoring of the asset to be carried out more cost effectively, also this data may not be relevant to the operator but is required onshore for management of the asset.

Subsea metering is becoming more important with satellite developments. To date the meters installed for gas lift have had very poor success although those installed for water injection are considerably more reliable. Considerable effort is now being put into working the issues so that meters installed subsea together with RTMS data provide reliable and consistent data for production optimisation and control.

In conclusion, the requirements of an asset may change over field life e.g. with the introduction of satellite developments. The design engineer needs to be innovative in the use of existing equipment and how it can continue to provide the measurements required for optimisation of the asset. The approach adopted in Shell Expro has been a move towards goal setting, which is bringing together the new and conventional technologies to form an effective measurement system.

6. References

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