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Allocation - The Howe Measurement Challenges.

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1-Abstract

The Howe Field is located in the Central North Sea Block 22/12a approximately 160km east of Aberdeen in a water depth of 85m. The reservoir lies some 12 km east of the Shell operated Nelson Platform, which is situated in adjacent Block 22/11.

The Howe project was initiated by Shell Exploration and Production to augment the operating life and production capacity of the Nelson platform, involving the development of an additional subset infrastructure and the installation of topside facilities. The owners of the Howe Field are Enterprise Oil PLC , Intrepid Energy and OMV .

The Howe well fluids are commingled with Nelson fluids. Therefore, it is required to measure the Howe well fluids to differentiate between the fields and to determine how much money each partner is allocated. The commercial agreements have stipulated that the measurements of Howe fluids are required to be measured within an accuracy of +/- 5% of reading.

In addition to accuracy constraints, it was important to minimise capex to ensure the development was economically viable. Given this, multiphase metering was considered to be a solution for allocation between the different ownerships, as opposed to traditional separator metering.

This paper will present the journey of the project activity through the selection criteria, flow loop test, installation, commissioning and the first 3 months of operation of the MPFM including verification with the Nelson test separator. Detailing with careful management and engineering support how to succeed with this type of application.

2. Background

Introduction.

The Howe development is the first of a new generation of sub sea tiebacks that benefit from government tax relief to encourage marginal field developments. Enterprise Oil discovered the field in 1987. The field is an under-saturated oil field and appraised by a further well in 2001. The reservoir is located at a depth of approximately 10,000 feet with a pressure of 455 bar and a temperature of 135 C. The tieback distance to the Nelson platform is 12 km in the easterly direction.

The Howe field has been developed by a single 14,650 feet (MD) production well, with the trajectory of the 2500 feet horizontal section being optimized by drilling a pilot-hole and through the use of geo-steering technologies.

The pipeline tie-in structure consists of an 8” pipe-in-pipe production flow line with a 3” piggy back gas lift line and multifunctional control umbilical. Oil is exported from Nelson to a Pipeline System to Grangemouth and gas exported via a Gas Line to St Fergus.

The co-venturers in Howe are Enterprise Oil. OMV (U.K.) LTD and Petro Summit Investment UK. The equities split for Howe is between Shell Intrepid and OMV . The Operator is Shell Exploration and Production.

Schematics of the process layout is shown in Figure 1.

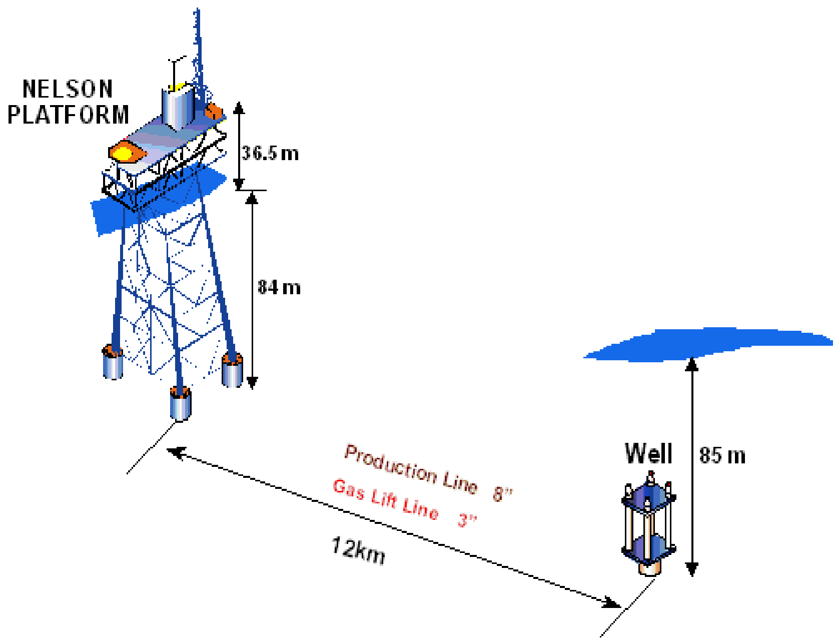

Figure 1 Process layout for Howe tieback to the Nelson Platform

Note: Howe being a marginal field has the following associated constraints:

- It will be produced without pressure support.
- It will have one production well.
- The reservoir pressure will decline rapidly.
- Nelson gas and oil are determined by difference.

3. Process Overview.

Howe Flow Line and Reception Facilities.

The Howe currently produces 11,000mstbd. The method of operating the well is to use both the subsea and topsides chokes, with the subsea choke being utilised to control the production and the topside choke being utilised to maintain the gas volume fraction (GVF) at 85%. The Multiphase Flow Meter (MPFM) is located upstream of the topsides choke valve. Downstream of the MPFM is the flowline which is connected to the 36” production header and the 10” test header. Production is normally routed to the production header and production separator V-1010.

When verification of the MPM is required the production is diverted to the test header and test separator V-1000. A schematic layout of the setup is shown in Figure 2.

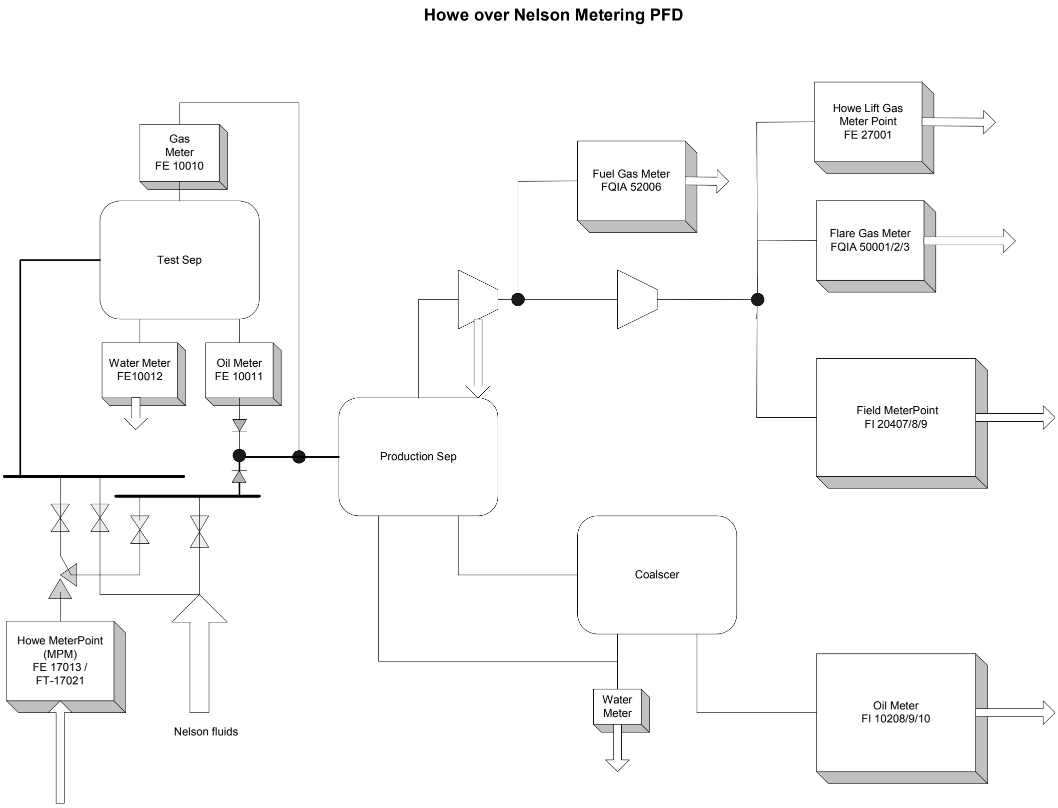

Figure 2 Schematic Howe over Nelson metering process flow.

Processing Howe Fluids.

The Howe fluids are commingled with Nelson fluids in the 36” production header and processed directly in the Production Separator V-1010. The Test separator V-1000 has a capacity of 25,000 BLPD and this separator is used for well testing and also for the verification of the MPM. The test separator is equipped with a Coriolis meter for oil measurement, a magflow meter for water and a V-Cone for the gas measurement. It also is equipped with a venturi meter for and if gas lift is required. Figure 2 visually illustrates the above text.

4. Design Requirements and Allocation Philosophy.

Design Requirements.

The main consideration of the metering design of the Howe project was the requirement to comply with the Nelson, Forties and Segal pipeline agreements. The Nelson agreements stipulated that the measurement of the Howe fluids should be 5% for oil, 5% for gas and 10% for water utilizing a MPFM or a similar device. The test separator requirements to enable this uncertainty to be verified accurately were determined as 3% for oil, 3% for gas and 10% for water.

Howe Production Meter.

To achieve the stated uncertainties the MPFM option and other measurement devices were investigated, i.e Wet Gas Meters (WGM), this also included the option of installing a production separator. The cost and size considerations immediately eliminated the separator option and it was quickly realised that a multiphase meter was the practical and feasible solution.

In later field life the GVF is expected to exceed 90%. Thus, it will be a requirement to revisit the MPFM uncertainties for this condition. A WGM has been accounted for in this case if the initially installed MPFM cannot meet the uncertainty requirements. The GVF is expected to increase as the well pressure decreases but for the initial production years a MPFM turned out to be the choice.

The other consideration is that the MPFM will benefit from being installed upstream the topside choke. To provide comfortable operating conditions for the MPFM and thus good uncertainty figures, the Howe fluids will be produced at 80% GVF at MPFM conditions. The GVF at MPFM conditions can to a certain degree be controlled if the topside choke is positioned downstream of the MPFM.

MPFM uncertainties are influenced by the accuracy of their input parameters. Hence it is important that good quality samples are obtained. Therefore, to ensure good quality samples of the fluid for analysis a fully engineered sampling point is required preferably not too far from the MPFM.

Allocation Philosophy:

The equity divisions of the Howe reservoir are different to the Nelson reservoir. Consequently, the requirement for a method for measuring and allocating Howe Field production volumes needed to be agreed between the Howe Field and Nelson Field owners. In addition, for the gas allocation, the gas purchaser also had to be included as a party to the agreement. Furthermore, approval of the allocation procedure to ensure the correct reporting of oil quantities for tariff purposes was required from the pipeline system operator.

The main allocation principle was to establish the rules for determining the Howe Field and Nelson Field production quantities. It was agreed that Nelson Field would be calculated "by difference"

Nelson Field Gas Production = Nelson Platform Gas -Howe Field Produced Gas and
Nelson Field Oil Production = Nelson Platform Oil Export - Howe Field Produced Oil
Nelson Field Water Production = Nelson Platform Water - Howe Field Produced Water

The Howe Field fluid is firstly measured by means of a MPFM to determine the quantity of oil, gas and water at the MPFM location. Based upon process modelling oil and gas recovery factors are calculated and applied to determine what these quantities will be at the export meter point. For the avoidance of doubt Howe Field will not use water injection.

The commercial framework for the metering and allocation rules is included in two main agreements covering oil and gas separately.

Allocation Principles – Outputs

The allocation outputs are:

a) The determination of the Howe Field and Nelson Field production quantities
b) The allocation of the fuel gas and flare gas utilised on the Nelson Platform
c) The allocation of the gas export quantity between the Howe Field and Nelson Field to meet the reporting requirement of the Segal Operator i.e. gas disposal system
d) The allocation of the oil export quantity between the Howe Field and Nelson Field to meet the reporting requirement of the Pipeline Operator i.e. oil disposal system

5. Meter Selection.

Howe Production Meter.

The choices of meters were limited. It was known that in the first year of production a 3 phase flow measurement would be required. This narrowed the possible selection to multiphase meters. There were not many MPFMs available for this application providing an uncertainty of 5% for oil and gas, with a GVF of approximately 80%.

In later field life when pressure drops and GVF increases above 90%, the uncertainties of the MPFM will be revisited and compared with alternative metering devices.

Further criteria for selecting a MPFM make were track record, uncertainty specifications, operational experience and level of support. Using these selection criteria across a range of MPFMs it was decided that the Framo/Schlumberger PhaseWatcher Vx was the prefered choice.

It later became known, that the PhaseWatcher technology has been further developed so it can be utilized for high GVF applications by changing software. This has to be assessed for the Howe fluids when the pressure drops in the future. The consequence is that it might not be necessary to install a dedicated WGM for late field life.

The selected vendor has been producing MPFMs since beginning of the 1990s and has continuously developed the technology. On the UK sector several MPFMs are installed and feedback from the market is positive. In addition, an attractive characteristic of selected technology is that it is based on fluid physical properties and well known physical relations and thus does not need dynamic flow calibration. This point is important as it has a bearing on how to validate, setup and to do commissioning of the MPFM.

Another point to consider is whether or not the MPFM is flow regime dependent. The selected MPFM is not. The flow regime independence is obtained by using a blind tee immediately upstream the measurement section as a part of the MPFM design. Prior to entering the measurement section of the meter the fluids are conditioned into a predictable flow pattern by the blind tee.

The working principle of the selected MPFM is comprised of a venturi and a dual energy spectral nuclear detector. The total flow is measured by the venturi and the split between the phases is indirectly measured by a gamma ray detector. From these data sources the flow rates of each phase through the meter are calculated. A cutaway schematic of the MPFM is shown in Figure 3.

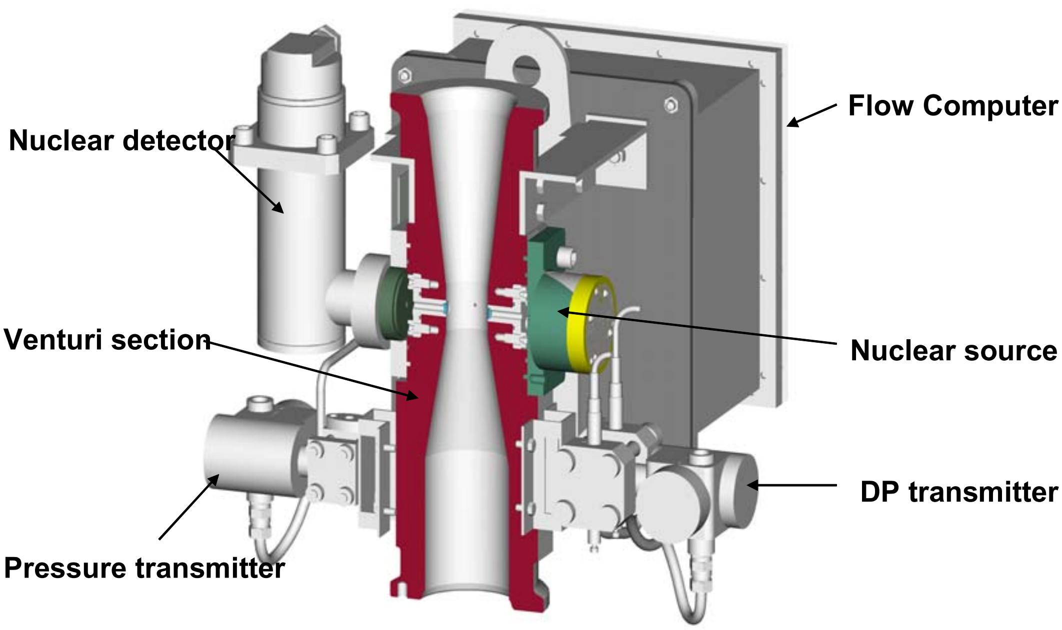

Figure 3 Cutaway schematics of the selected PhaseWatcher Vx.

As for all multiphase flow meters it is important to get a good understanding of the required input parameters. For meters utilizing the selected technology it is necessary to provide PVT data of the fluid. It is recommended that PVT information is derived from a sample taken at line conditions and analysed at a laboratory that can produce the correct analysis for uploading into the MPFM.

Although no dynamic calibration is required a static calibration on an empty meter must be allowed for before production starts. The vendor will acquire data on an empty meter and use that as a baseline reference. Since this meter will be used for allocation it will be written into the commercial agreement, and compared against a test separator from time to time.

6. Testing Requirements.

A critical part of the Howe metering project was the functional acceptance testing of the selected meter to prove that it can achieve the stated accuracy.
Ideally the MPFM should be tested at conditions as close to the operation envelop as reasonably practicable. This can cause difficulties in selecting a testing facility that can simulate the pressure, flow, temperature and phase conditions.

It was initially planned to send the PhaseWatcher to a laboratory that was specialised in testing equipment for gas metering and could be operated under realistic conditions. The other alternative was to utilise the Framo multi phase test facility at Flatoy. This facility did have the equipment to conduct the test over the GVF and WLR range, however, it did not have the capability to simulate the pressure range that the MPFM would be exposed to at start up as the maximum pressure the flow loop could operate at was 9.0 bar.

After assurances from Framo, that the meter could perform to expectations and to the uncertainties expected, the decision was made to proceed with the Framo flow loop. The multiphase flow loop test of the PWVx was being performed in a closed loop on Exxol D80, fresh water and nitrogen. The flow loop test set-up, see Figure 4, includes a large horizontal three-phase separator from where single-phase streams of oil, water and gas are drawn, boosted and measured individually. Flow rates of the single-phase oil, water and gas streams are adjusted by means of remotely operated control valves before being commingled into a multiphase oil-water-gas stream. The multiphase stream is routed through the PWVx and back to the separator via a remotely operated control valve, which is used to adjust the operating pressure.

Single-phase flow measurements will serve as references for the PWVx. Single-phase flow rate measurements are found by measuring differential pressures over KEMETMA V-cone flow meters. In addition, pressure and temperature will be measured on the multiphase stream immediately upstream and downstream the PWVx, and in the separator for process control purposes. Also a secondary measurement is done both on the gas and the liquids in order to quality check the primary measurement. For the gas, a Venturi meter is used as secondary measurement and on the liquid a Micromotion Coriolis meter is used.

Key engineering variables such as pressure, temperature, total volumetric flow rate, gas volume fraction and water cut at PWVx inlet conditions were calculated by the flow loop control system and displayed on a computerized flow diagram. The control system comprises built in alarms and emergency shutdown (ESD) functions in case of system failure.

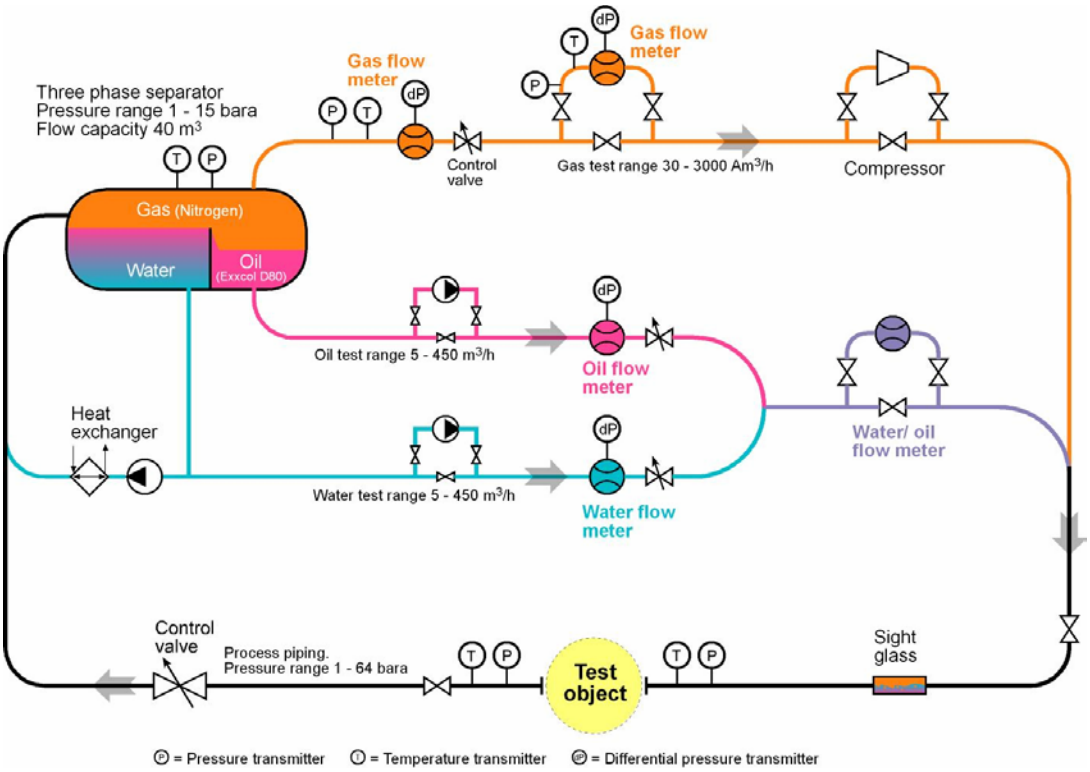

Figure 4 Framo multi phase test loop facility schematics.

The Results.

To understand the test results one has to understand how the MPFM works and how the corresponding uncertainties are specified. The uncertainties are specified in GVF ranges. That is, at lower GVFs the MPFM will perform better than at higher GVFs. This is due to the inherent nature of dual energy gamma ray venturi meters. The GVF range from 0 to 100% is usually split into 3 or 4 ranges for which the uncertainties are specified. In addition, the uncertainties are specified differently at lower pressure than at higher pressure. The pressure ranges is usually split between lower and higher pressure. Higher pressure usually means higher than 20 barg and higher GVFs usually means above 80% GVF. Our stipulations were for a 5 % uncertainty on oil and gas for the Howe conditions. Howe conditions cover both high and low GVFs but at higher pressures. Framos expectation for the flow loop conditions were 10% uncertainty for the gas flow rate measured by the PWVx + 1.5% uncertainty for the gas as measured by the flow loop, however, it was stated that the meter would perform better than this.

The test results showed that up to 60% GVF the Shell Howe requirements were met as shown in Table 1. The pressure during the test was 8 bara. The units are m3/h at MPFM conditions. Above 60% GVF the MPFM met Shell requirements were met for oil and water but not for the gas. Although the vendor specifications were met this was not satisfactorily to Shell. A graphical visualization of the gas flow comparison is shown in Figure 5. The red horizontal lines show the Shell expectations; whereas the grey horizontal lines represent the Shell expectation added to the flow loop uncertainty. On the y-axis is plotted the difference between the flow loop reference system and the MPFM readings. The x-axis represents the tested GVF. The rest of the test results are summarized in Table 1.

	Reference			PhaseWatcher Vx Measurements						
FP Id	Qliq	Qgas	WLR	Qliq	rel.dev%	Qgas	rel.dev%	WLR	abs dev. %	GVF %
FP001	79.46	36.89	40.22	78.70	-0.95	35.87	-2.74	39.88	-0.34	31.03
FP002	79.09	37.95	70.43	79.57	0.60	36.74	-3.19	69.15	-1.28	31.38
FP003	81.35	49.55	40.12	80.92	-0.54	48.17	-2.79	40.54	0.42	36.80
FP004	79.10	48.44	70.10	79.19	0.11	47.51	-1.92	69.69	-0.40	37.13
FP005	88.97	71.84	29.92	88.08	-1.01	71.15	-0.96	30.27	0.35	44.14
FP006	88.49	70.12	60.19	87.81	-0.77	68.54	-2.25	59.84	-0.35	43.18
FP007	85.22	98.93	20.72	85.45	0.27	98.70	-0.23	21.26	0.54	52.76
FP008	84.70	99.85	60.26	83.89	-0.95	97.58	-2.28	60.96	0.70	52.73
FP009	82.86	154.40	20.59	81.82	-1.25	147.30	-4.60	21.04	0.45	63.34

Table 1 Flatøy test results at low pressure.

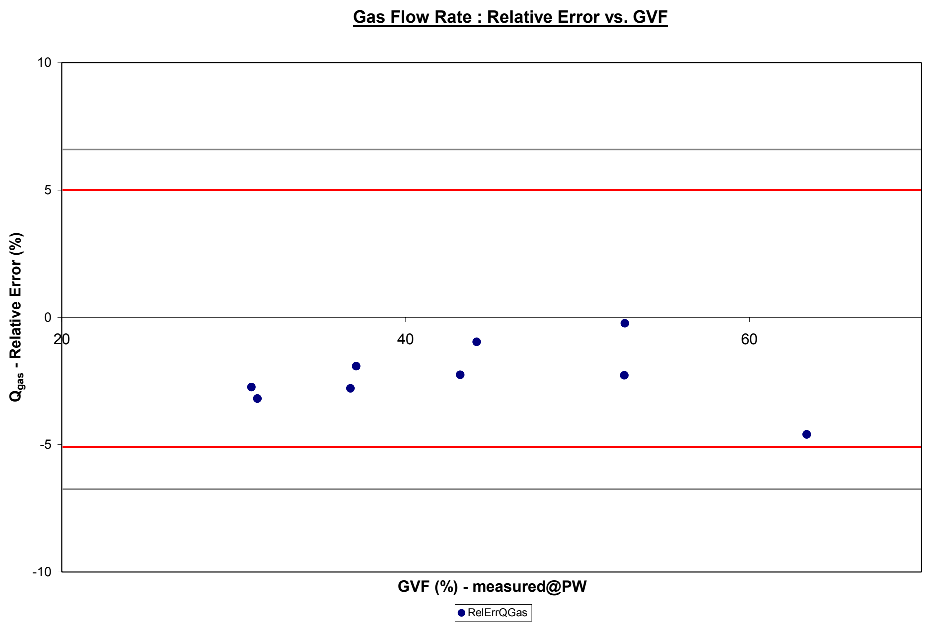

Figure 5 Flatøy test results, gas flow rate.

To verify the MPFM at a higher pressure the option was either to remove the meter to a specialised facility or design a flow loop at Flatøy to operate at the expected operating pressure of the meter. The first option was to utilise a specialised facility as the flow loop could operate at higher pressures. Obtaining a test week however proved difficult and it was then that Framo, as their flow loop had not an alternative, engineered a solution. They modified the existing facility to accommodate one of their multiphase pumps that could deliver 25 barg. The only restriction with this was that the 3 phase measurement would be reduced to 2 phase (water and N2). However, according to Table 1, the WLR uncertainty does not seem to be an issue at all and the proposal was accepted. Figure 6 shows the modified test loop schematics with the multiphase pump. With the pump the GVF test range was set to 60 to 95% GVF.

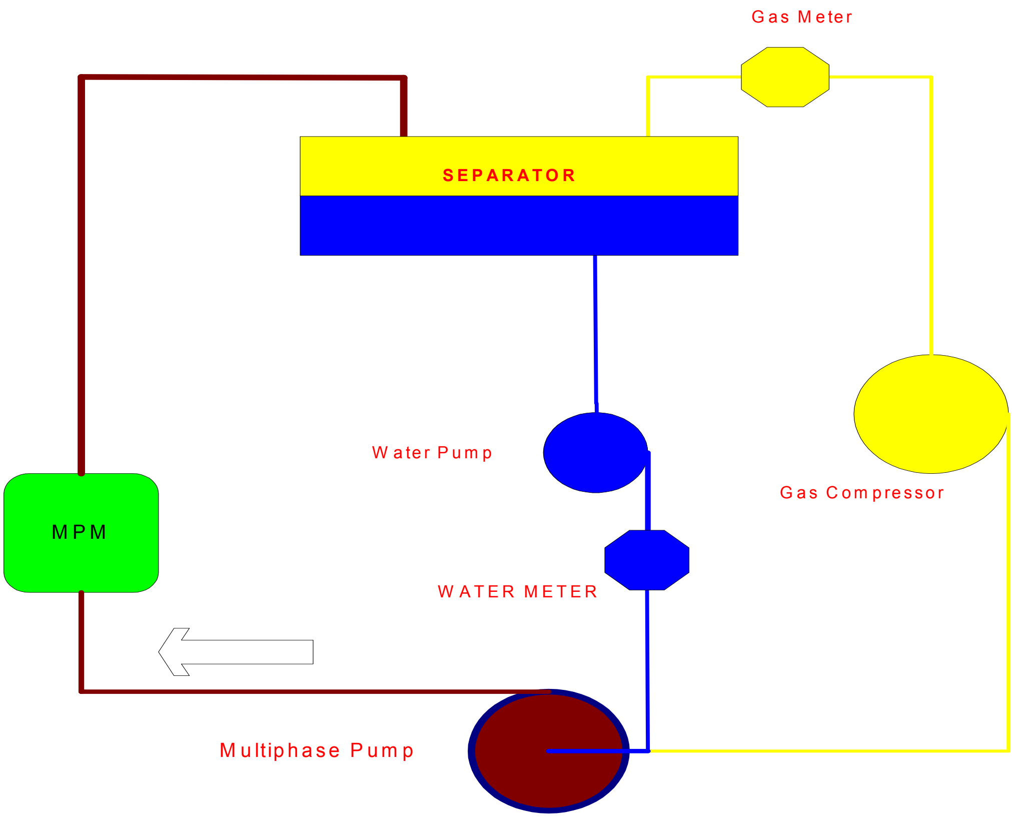

Figure 6 Framo multiphase test loop with a multiphase pump to boost the loop pressure.

The test results are shown in Table 2.

	Reference			PhaseWatcher Vx Measurements						
FP Id	Qliq	Qgas	WLR	Qliq	rel.dev%	Qgas	rel.dev%	WLR %	abs dev. %	GVF %
FP002	80.12	129.84	100.00	81.67	1.9%	123.47	-4.91	101.09	1.09	59.79
FP003	42.49	167.31	100.00	44.08	3.8%	161.52	-3.46	100.07	0.07	77.58
FP004	23.24	201.28	100.00	23.72	2.0%	196.61	-2.32	98.60	-1.40	88.92
FP005	12.78	245.19	100.00	12.94	1.3%	237.23	-3.25	102.20	2.20	94.32

Table 2 Flatøy test results at elevated pressure.

The test results showed a significant improvement due to higher pressure, as expected. All flow points are within stated limits for the Shell requirements.

Uncertainty

The uncertainty of the multiphase meter was an area that was defined prior to purchase of the meter. The results from the testing fell within the theoretical results.

The uncertainty of the facility at Flatøy was stated as:

- 1% relative of reading for the oil flow rate.
- 1% relative of reading for the water flow rate.
- 1.5% relative of reading for the gas flow rate.

Although all the test meters on the flow loop had traceable certification the flow loop itself only produced a functional test of the MPM. The flow loop is not an accredited facility, however, better documentation to substantiate the stated uncertainties would be preferable. On the other hand, the flow loops secondary instrumentation give a good indication of the measurement quality of the primary reference instruments. And above all, the MPFM passed the test within the MPFMs specifications. That is, the requirement is really MPFM spec + flow loop spec.

Therefore, it was considered proved that the uncertainty that was likely to be obtained once the meter was operational would be within the specified range for all three phases.

7. Commissioning.

The commissioning and set up of the MPFM once installed on the platform is critical to its success in measuring the fluids from Howe. Commissioning of the MPFM involves communication checks and set up of the MPFM configurations. This section will concentrate on the setup of the MPFM due to its significance for obtaining good quality measurements.

Required input data

The MPFM needs to be setup with fluid property data. The required input data for the MPFM are:

- Pressure,Volume and Temperature (PVT) data. Oil, water and gas densities at MPFM conditions. Typically tables for different temperatures and pressures around the expected operating temperature and pressure.
- Oil, water and gas compositions. Alternatively, oil and water samples and a gas compositional analysis.
- A baseline reference measurement.

For this MPFM there as basically two options for supplying PVT data. One can either choose:

- Generic black oil model which requires a limited number of input parameters
- Fluids ID model, which requires PVT data for the specific fluid at MPFM conditions as described above.

For this application, the Fluids ID model was chosen for optimum accuracy since the MPFM is used for allocation. The need for PVT data is not unique for MPFMs and should not be of particular concern for MPFMs. PVT data is equally important to other flow measurement devices at a test separator.

A reference measurement is required for the nuclear system as a base line for the number of gamma photons acquired by the system when the MPFM is empty. If possible, the vendor recommends doing this on site after installation. The baseline reference recording requires that the MPFM is empty, that is, free of hydrocarbons.

The compositional data or physical samples are used to find the mass attenuation values for the fluid. The mass attenuation value for a fluid is a measure of how much the gamma photons are attenuated when they are passing through that fluid. Oil, water and gas have different mass attenuation values and they are a characteristic of the fluid in the same way as density The mass attenuation value is determined by the atomic composition of the fluid and can be found from published tables.

The mass attenuation values can be found in three ways, from a theoretical computation based on compositional data for that fluid, by filling the measurement section of the MPFM with a representative sample or finally by measuring the fluid sample with another fully tested MPFM. Filling the MPFM with a fluid one can measure the mass attenuation value directly for that fluid. If the sample is representative for the fluid and it is practically possible, the vendor preference is to measure the mass attenuation value with the actual MPFM. There is dedicated tool for doing this so the required amount fluid sample is about 0.5 litres.

The MPFM provides data for both line and standard conditions. The black oil model does not require further input to provide this information. The Fluids ID model require fluid specific data about shrinkage factors, gas in solution etc. This is standard information needed to convert flow rate data between line and standard conditions.

Howe MPFM setup

The goal was to use the MPFM to measure the well fluids from first oil and on. At the beginning limited fluid property data were available and the vendor was asked to use this data knowing that the setup would need to be updated when samples were taken and analysed.

The plan was to bring Howe on line to clear the impurities, and then complete an ESD check on the platform. Before restarting, pressurised samples were taken to update the MPFM with results from the sample analysis. Some samples were analysed offshore and other shipped to an onshore laboratory. The offshore analysis data would be an enhancement to the setup based on the limited data available before first oil. The offshore analysis was performed using a portable laboratory and software package (PVT express). This is an analytical service provided by Schlumberger. The final setup was based on the Pressure,Volume, and Temp analysis report from the onshore lab when that was available.

Further assurance can be attained, by diverting to the test separator until either a Howe fluid sample has been analysed or a full setup of the MPFM was performed. In addition to measuring the Howe fluids, the test separator can be used in series with the MPFM for comparison during the different setup stages outlined above.

Baseline reference: Prior to start up, we believe it is essential to have a representative from the manufacturer, mobilised to the platform to ensure that the meter was installed correctly and that communications with the meter to the data trending package (PI), distributed control system (DCS) and the service computer were functioning correctly. As it was practically possible the service engineer rechecked the air calibration of the gamma source i.e. to determine how many counts per second were received from the gamma source by the detector in air – this then provides the baseline reference.

PVT data and mass attenuations: The initial data for the mass attenuations and fluid PVT data were obtained from the on site analysis and input to the MPFM. The vendor did all the calculations and updating at this stage. The on site data were updated later when the onshore laboratory finished their analysis. The logistics in the North Sea is quite good and the laboratory provided a swift service. The experience is that, at least for North Sea applications, the time savings on doing on site analysis compared to shipping samples on-shore for analysis is not big. The last update was done by sending the onshore laboratory results to the vendor, which then did the appropriate calculations and updated the MPFM configuration file accordingly. The file was then sent offshore and downloaded to the MPFM.

8.Verification.

As soon as the meter calibration procedures were completed and the meter was once again brought on line, it was decided to compare the meter against an external source. The uncertainty requirements for the test separator were stated earlier as 3% for oil, 3% for gas and 10% for water. The operational plan was to use the test separator and MPFM in series to compare the measurements and establish confidence in using the MPFM.

A procedure had been developed to enable automatic verification. This was carried out by obtaining the data from PI for both the MPFM and the test separator instrumentation. This information was automatically transfered into a spreadsheet for direct comparison.

The start up performance against the test separator was based on the input from the on site fluid analysis. The sample analysed was taken after the clean up and ESD test.

The comparison showed that the gas results were extremely good; the deviation between the test separator and the MPFM was within 2%. The oil comparison showed a variation between 3 to 8%. It was also clear that the default input water properties could benefit from an update since traces of water were shown when in fact there should be no water produced. In interpreting these data one should consider the added uncertainties for both the MPFM and the test separator.

It later became apparent that the values read from the MPFM had shrinkage factors applied, whereas it was believed they had not. The consequence was that shrinkage factors were applied twice to the oil. This was rectified by the vendor since the MPFM can hand off both line and standard conditions data. It was decided to fetch only line condition data into the data trending package (PI) and do PVT conversion on a common basis for both the test separator and MPFM.

Since the production was very stable it was considered that the comparison was of good quality and further improvement could be obtained by updating the PVT data based on the on-shore laboratory PVT analysis.

The full laboratory analysis allowed for updating the oil, water and gas density. The results showed an improvement in performance and most results met the specifications, however, it was found that on two occasions the gas was out of specification and on one occasion the oil was out of specification. The cause was found to be that the PVT data range uploaded to the MPFM were not sufficiently large to incorporate the operating range required.

After the final update of PVT data the comparison between the MPFM and test separator clearly demonstrated that the MPM performs to 5 % on oil and 5% on gas. The performance has now been verified over half a year. Figure 7 show comparison results from January to July 2005. The x-axis show when the comparisons are made and the y-axis show the relative difference between the test separator and the MPFM. Bear in mind that these comparisons are based on raw data from the MPFM and test separator, no adjustment factors have been applied to either measurement.

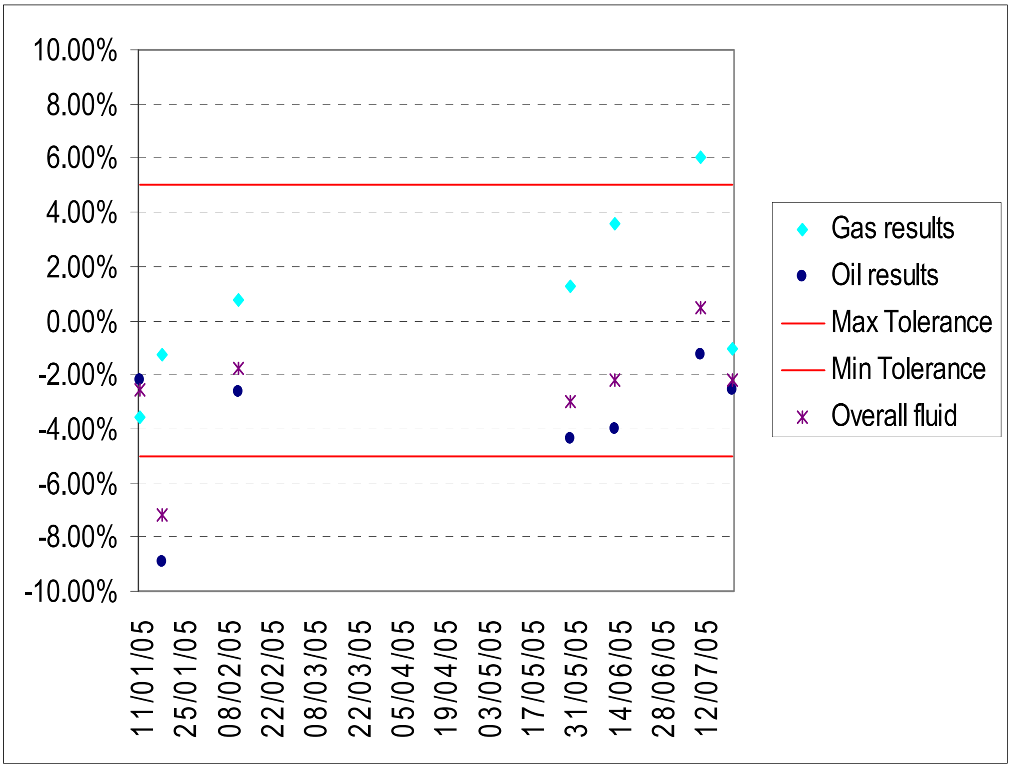

Figure 7 MPFM and test separator comparisons from January to July 2005.

9.0 Conclusion.

The overall performance of the meter, once set up with the correct PVT data has been exceptional. It should be remembered that this was a marginal field that was always under scrutiny and challenges from partners and owners alike. The data in section 8 proves without question that the performance of the meter achieves the +/-5% relative difference of reading for oil and gas that was promised to the operator for the Howe fluids.

In the first year that the MPM has operated, no failures or under performance has occurred. In the initial start up period and until the meter was correctly configured some issues did arise. They did not impact on the overall performance and reliability and were rectified by providing temporary shrinkage and expansion factors. It should also be realised that at no time was any doubt raised on the meters ability to measure the hydrocarbons, but only to the numerical values that were being handed off. The point that should be highlighted is that it is essential that the sampling and analysis regime are strictly adhered to. This will ensure that the meter can be uploaded with the correct PVT as and when the well conditions change.

As the well conditions change it should also be realised that the MPFM PVT data should be updated. The assumption that the performance of the meter will not be affected by a change in the PVT is incorrect. The sensitivity to a PVT change will depend on operating conditions and initial fluid properties. The MPFM is robust to changes in hydrocarbon compositions, however, the sensitivity can readily be calculated by the vendor for the field in question. Then, the allowed change in PVT data before an update is necessary can be advised. A sampling regime should be initiated from the start up of the field. The change in composition can be identified by comparing with previous PVT analysis or when the meter is verified against the test separator. The technicians should be made aware of the significance of a disagreement between the MPFM and test separator and the required remedial action. Then the accuracy of the MPFM will not be affected.

The other factor that is essential for good performance is the initial dry calibration and adherence to the set up procedures. This should be carried out in location at start up and preferably repeated at every shutdown. It is essential that this is performed by an experienced engineer, using the manufacturer procedures. To cover this requirement, consideration should be given to placing a contract with the manufacturer of the MPFM. Issues around personnel protection from the nuclear source and other HSE issues are then covered.

It should be noted that the success of this project was due to the close co-operation between Framo and Shell. In the initial production phases the engineering challenges that occurred were dealt with immediately and therefore removing any doubts on the validity of the measurements. The other key points were the constant analysis and surveillance that followed the commissioning of the meter.

It should be realised that it is essential that in-house specialist for MPFM support is available, as well as support from manufacturers.

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.