Calibration and Maintenance of Multiphase meters.

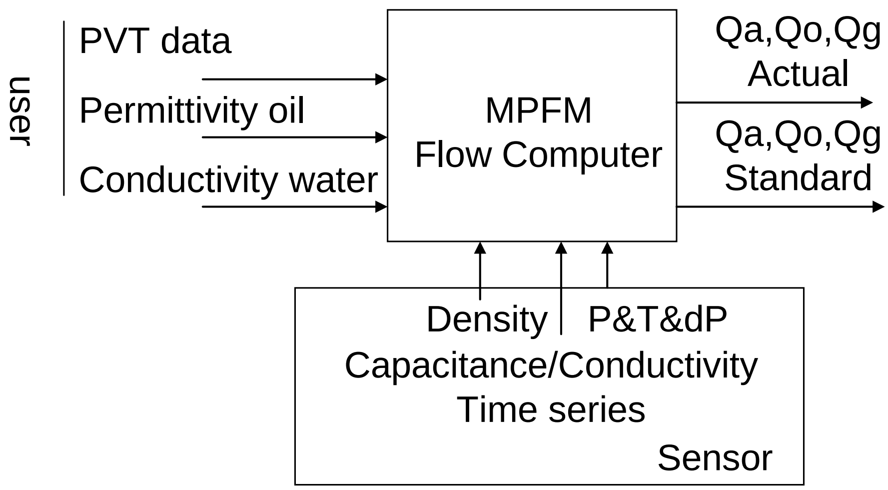
By Martijn Tol & Sverre Grimstad

Introduction

Multiphase meters are important instruments for oil- and gas producing companies. During the last ten years there has been made huge progress in technology and there is better understanding in the market about what can be expected from Multiphase meters, what their limitations are and how they should be taken care of in the field.

The use of Multiphase meters for a wide variety of type of applications make it even more important that there is a common understanding about what is needed for a multiphase meter to work. A MPFM, like any other type of measurement instrument, needs certain input to operate. Making sure that the basic input is accurate and up to date is one of the biggest challenges in operating multiphase meters.

The Roxar Multiphase Flow meter is such a MPFM. It depends on correct user input and on the right calibration of the sensors that provide the online and continuous measurements.



Picture 1) Diagram of a multiphase meter based on electrical impedance measurements, cross correlation, Venturi dP measurements and single high energy gamma ray density measurements

Factory Calibration

Although some of the multiphase meters are flow tested to assure that the meter operates within its performance criteria, the calibration is done mainly statically without flowing fluids. The gamma system is calibrated with two points, one with air and one with a liquid with a know density (normally water). The P, dP and T transmitters come with calibration certificates from the transmitter manufacturer. The capacitance and conductive measurement system are normally statically calibrated with single phase fluids with different densities and capacitive/conductive values. A flow calibration to determine the exact discharge value per meter, very common for single phase fiscal instruments, is not a common practice for topside multiphase meters. Reason for this is quite simple, the performance improvements for a volumetric based measurement principle that can be achieved by such calibration are not significant and do not weigh up to the costs in multiphase flow.

An important aspect during factory calibration is that the meter is "finger printed". This means that all calibration parameters are stored and should be kept available for use during future commissioning and for the regular check ups that the meters should undergo during its service life. This is an important tool to do "base line monitoring" of the sensors after it has been installed and to check the validity of the meter.

After installation
Even with a perfectly factory calibrated meter there are a wide variety of factors that can influence the performance of a multiphase meter in the field.

Drift of the sensors
Drift of the sensor is not very common but would generally be detected easy by base line monitoring. This could typically be checked during the yearly verification and calibration of the gamma system. Drift in the P,T and dP transmitters are minor with respect to the level of uncertainty of multiphase applications but if needed these can recalibrated or get a zero point trim. It is more important to check the dP and P readings for potential clogging of impulse lines regularly. The Gamma system is the only sensor part of the meter that really needs regular field verification/calibration due to the decay of the oscillator tube and gamma source that can not be predicted without errors. As a minimum this can be done when the meter is filled with gas/air only (empty pipe calibration) and /or with a liquid with a known density. During the yearly or bi-yearly service of the multiphase meter it is a great help if the different sensor data in static state can be checked against the calibration data from the factory calibration to detect any abnormalities.

Accuracy of input data
Some input data is more important than other. The diagram in figure 1 shows that the meter depends on PVT data, oil permittivity and water conductivity. Water conductivity as an input value is only of importance in water continuous flow since in oil- and gas- continuous flow the permittivity is measured using capacitance measurements. An additional probe could also be used to give this input. Another example from figure 1 is the oil permittivity; oil permittivity is only of any significance at very low WLR values in multiphase applications. At more than 10% WLR the mixture permittivity is so dominated by the presence of water that a rough default value for oil permittivity is more than enough in order to assure the meter to operate within the stated uncertainty specification.

In accordance to the NFOGM handbook for multiphase metering vendors should make clear how inaccurate user input values impact the uncertainty of the meter by presenting results from a sensitivity analysis. In practice this means that these sensitivity analyses need to be made for various flow scenarios so it becomes clear what the significance is for each input value at the flow conditions where the meter is used.

The Roxar MPFM is also dependant on PVT data. First of all for the flow rate calculations of oil, water and gas at actual conditions. Secondly also for conversion of the actual measured volume flow rates to volume flow rates of the three phases at standard conditions.

So how important is PVT data?
To specify this question a bit more let's limit this to the importance for flow rate calculation at actual conditions. The calculation from actual- to standard conditions can be considered as a pure PVT conversion exercise and therefore be very dependant on how the operator has chosen to do this and quality of the PVT data, not so much on the performance of the MPFM. Most of the Wetgas meters (or multiphase meters in wetgas mode) operating at 95% or 98% GVF and higher often use a GOR value calculated from PVT to split the hydrocarbons in condensate and gas. This is done because it is normally much more accurate than a gas-liquid split calculated by the meter purely based on sensor input, for example by a gamma detector. With the current state of technology gamma detectors measure with an uncertainty between 1-4 kg/m3 if well calibrated. This is not enough to detect small traces of liquid at 98% GVF with a good relative accuracy since the impact of the liquid on the mixed density is so small with respect to the resolution of the gamma density gauge. This drives the use of two phase (HC mass flow and WVF) Wetgas meters that can give a three phase output with the help of PVT input data. Water volume fraction in Wetgas though can be measured online using microwave or electrical impedance based permittivity measurements with good accuracy and sensitivity.

PVT calculation based on a hydrocarbon composition data offers input information about the density of the three phases at the pressure and temperature of operation, and the phase behaviour of the fluids from the prevailing pressure to standard conditions. When doing full three phase fraction calculations it is clear that the dominant fraction needs the best possible input data to minimise the uncertainty of the meter. An error in gas density at 95% GVF will impact the uncertainty of the meter more than at 50% GVF. Again, a sensitivity analyses for input data for different flow scenarios will help the customer to asses what input value should in particular be most up to date in order to assure the best measurements by the MPFM.

A way to make the MPFM less dependant on PVT is to measure the properties of the single phase fluid at pressure and temperature. For example if a MPFM can "trap" a single phase under operating pressure and temperature (for example 100% gas) it is obvious that at such moment the system can be "calibrated". It can for example be used to measure the density and the permittivity of the gas and use that as a validated "user" input. In practice however such offline verification steps can have some practical drawbacks in for example for subsea applications. In addition the accuracy and drift of the sensor itself also should be taken into account.

Intelligent metering
The Roxar meter, as displayed in the schematic of figure 1 uses data from different type of sensors to measure the same characteristic of the multiphase flow. This makes the meter less dependant on one type of sensor, user input and flow regime.

Combining measurements from different sensors lead to a more robust system then what can be expected based a single sensor.

An example of this redundancy for the Roxar MFPM is the way flow velocity is calculated: Velocity is deducted both from the Venturi dP measurements as well as from cross correlation and this is used for internal flow verification and alarms. Another example of redundancy is subsea meters that are normally equipped with dual dP cells and multiple electrodes. Also, information about the gas - liquid split can be deducted from mixed density measurements using the gamma detector and also by using the variation in the permittivity measurements over time (non gamma algorithms).

An example of build to improve the performance of the meter is by using data gathered during short periods where the measurements are believed to be more accurate or representative. For example during a short period of a liquid slug it is better to determine the electrical properties of the liquid then at moments when there is a lot of gas present. The capability to measure in different cross sections of the pipe, for example using near wall measurement also increases the accuracy of the sensor input during for example in annular flow regimes when the liquid is pushed to the pipe wall. This technology is further developed in Roxar 3rd generation of meters based on Zector technology.

Conclusion

Multiphase meters depend on a correct calibration and input data. The Roxar MPFM needs a yearly or bi-yearly check up and empty pipe calibration. Base line monitoring of the meter throughout its life can increase the confidence in the meter and helps to detect any abnormalities in the meters performance.

The significance of PVT data is very clear but depends per type of application. 2-phase Wetgas meters depend on PVT data for the gas liquid split when operating in GVF >98% and multiphase meters need input from PVT about the density of the phases at the pressure and temperature of metering.