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WET GAS WELL TESTING

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Abstract: *Testing wells, which produce 1-2% liquid in the presence of 99-98% gas volume, is very difficult. The mixture is far from homogeneous, and task is similar to looking for a needle in a haystack. Yet, in the case of condensates, the dollar value of the liquid may equal that of the gas. Biggest economic justification is the case of Gas Lift, where proper gas injection control can make a significant contribution to the profitability of the operation. If the gas contains water, the treatment is very expensive, so knowledge of the exact nature of the produced fluid is essential for proper reservoir control and optimization. In gas wells applications for example, it is crucial to measure the small amounts of liquid to the highest degree of accuracy, since this data is necessary to monitor and control hydrate formation. The difficulty is in the accurate measurement of 2% of the total flow. For 5% accuracy of reading of the liquid flow rate, one requires 0.02x0.05= 0.001, or 0.1% accuracy of the total flow. Moreover, additional knowledge is required to know the water content of the condensates. In the case of multi-layered production, this knowledge contributes a lot to profitability.*

The difficulty in achieving this high degree of accuracy is compounded by the nature of the flow. Since the liquid tends to stick to the pipe walls, and is being dragged behind the gas, which is flowing at high velocity in the center of the pipe (Annular Flow). The gas is also carrying with it liquid droplets torn from the walls. Due to uneven terrain or vertical risers, pockets of liquid form at the lowest points, which are shot out in the form of slugs flowing at near the velocity of the gas. Knowledge of these slugs flow helps the design of compressors, slug-catchers, etc.

Field experience with Multi-Phase Flow Meters which operate at Gas lift and Wet gas applications is described in this paper.

Keywords: AGAR, Multi-phase flow metering, High GOR, FLOMEKO 2000, Wet Gas Metering, Flow Meters, Multi-phase, Three Phase Flow

1 INTRODUCTION

The need for an accurate wet gas meter has long been recognized by major oil and gas companies (1). Accurate measurement at GVF of 98% and 99% has long been a challenge for test separators and multiphase meters yet, many applications exist for such a meter. Among them are well testing in artificial-lift operations, well testing in gas fields, and Hydrate control and monitoring. The Agar MPFM 400 has been tested in both 3rd-party independent test facilities (2) and in field tests (3) and was proven to provide accurate measurement at the said range.

2 HIGH GVF WELL TESTING

High GVF (Gas void fraction) wells can be categorized as 1. High GLR wells, common applications- Artificial-lift operations and Gas fields (gas condensate). 2. Moderate GLR wells tested at low pressure. Well testing in high GVF operations (90 - 99.5% GVF) has been recognized as a specialized task that conventional multiphase meters can not address to the desired accuracy. A gas lift well that is averaging 90-95% GVF is more then likely to reach 98%, 99%, and 100% gas in instantaneous fluctuations such as gas surges/slugs. Slugs of liquid and gas are very typical for such an operation.

Accurate account of the oil, water and gas flow rates at that range is crucial for fiscal, diagnostics, and optimization reasons (4).
Since the Dollar value of the oil in such well, can be equal to that of the gas, an accurate account is necessary at the well head for "cost-allocation" purposes. Also, such a meter can be used as an operation-diagnostics tool for production optimization. Artificial-lift operations are from their nature very costly. Every malfunction such a leak between the casing and tubing or a faulty valve, must be observed and treated in a matter of minutes. Only a meter that can accurately operate at the said range and provide real time continuous data can be used for such a task. Such a meter provides this application a viable alternative to test separators that are by their nature non-real time averaging devices that "smooth" slugs. Test separators also suffer from inaccurate readings due to bad separation (e.g. liquid carry over in the gas leg and gas carry under in the liquid leg), size limitations, etc. Such a wet gas meter is also proving to be an optimization tool when it's output is used to chart the optimum pressure operation point on an IPR curve.

2.1 Hydrates control and monitoring

Hydrate control and monitoring has been recognized as an area in which accurate wet gas metering is a necessity. Hydrate control is crucial for Topside production facilities and pipelines, Subsea production facilities and pipelines, and Gas processing facilities. Hydrates are formed in natural gas streams at the presence of hydrocarbon and water. They form a solid in the presence of pressured gas and temperatures above 32®F. For an example; a gas field with a GVF of 97-99.5%, 3,000 PSIA, and temperature of 36 deg.F is expected to form hydrates. Hydrates have been known to plug pipelines, valves, etc. Hydrate formations at such venues are posing a safety threat and sever economical ramifications. In order to prevent such an occurrence the common industry practice is the use of "Hydrate Inhibitors" such as Methanol. Those methods have proven to work with one major draw back - the high cost of the treating product even in re-circulation usage. An accurate account for the liquid and water in the gas stream is necessary in order to determine and optimize in real time the exact amount of needed inhibitor.

2.2 The Accuracy Challenge at High GVF

Accurate measurement of a liquid portion in high GVF such as 98%, is a noticeable challenge. Accuracy of 5% for such a liquid phase would be considered a definite achievement, as it is actually 0.1% accuracy for the total flow. (0.05 - accuracy for liquid, 0.02 - liquid fraction, 0.05*0.02=0.001= 0.1%). The difficulty in achieving such accuracy is being compounded by the nature of the flow. At such high GVF Annular flow in a vertical pipe is very common as the liquid is sticking to the pipe wall and the gas, at higher velocity, is traveling at the pipe center. In some case the liquid momentum would be to low and liquid and gas would travel at opposite direction in an annular bi-directional flow. In such flow patterns the gas may also carry some liquid droplets in the middle of the pipe. A meter that would be able to present the desired accuracy at those conditions will be suitable for the said application. Needles to say, such a meter can not saturate at 95% or 90% GVF, rather, work the entire range of 0-99.9% GVF. Artificial-lift Fields that average 98% GVF, are more then likely to incur liquid slugs of 100% liquid.

2.3 The Agar MPFM 400 Design

The AGAR MPFM-400 Series extends the dynamic range of the gas and void fraction capacity of the patented AGAR MPFM-300 Series multi-phase flow meters by adding a Fluidic Flow Diverter (FFD™) Device and gas bypass loop.

The MPFM-300 is compounded of 4 major subsystems:

2.3.1 The Volumetric Flow Meter is a positive displacement meter that accurately measures the total flow (gas and liquid). This meter is selected from a range of commercially available products with proven field records. The volumetric flow data is fed into the MPFM Data Analysis System (DAS) who performs calculations for the multi-phase measurement.

2.3.2 The AGAR Momentum Meter uses a unique dual venturi configuration to establish the gas volume fraction of the flow stream. Data from the momentum meter is fed into the MPFM DAS.

2.3.3 The AGAR Watercut Meter (OW-201) is a microwave-based oil/water monitor. The OW-201 uses a microwave transmitter broadcasting at over 2 Gigahertz and receivers to measure bulk electrical properties of the fluid. Engineering advances allow the OW-201 to measure water content accurately over the full range of 0-100% water in either oil or water-continuous phases. Accuracy is independent of changes in velocity, salinity, pH, viscosity, temperature or density. Watercut data is fed into the MPFM DAS.

2.3.4 The AGAR Data Analysis System (DAS) performs on-line analysis of data acquired from the above subsystems to determine the oil, water, gas, and total fluid flow rates.

The MPFM 400 consists of all components of the 300 design with the addition of the FFD™ and the gas bypass loop. The FFD™ Device uses the difference in flow momentum of the gas and the liquid to divert most of the free gas in the stream into a secondary measurement loop around the core MPFM-300. The remaining fluids flow through the core MPFM-300 Series system. The gas in the bypass loop is metered and added to the oil, water and gas discharged from the MPFM-300 core uni

By reducing the amount of gas flowing through the MPFM-300 Series core unit, the MPFM-400 Series often allows the use of smaller MPFM-300 units. This arrangement can reduce the cost of measuring flow streams where gas is the dominant component of the flow.

The FFD™ comprises of a cyclone style Diverter device which significantly increase the velocity of the fluid. Centrifugal forces created inside this first section of the FFD™ force the liquid molecules to coalesce and gravity settle towards the bottom of the cyclone. Since gas moves with higher velocity relative to liquid, mostly gas with small amounts of entrapped liquids divert towards the top and leave this cyclone device through a pipe which loops over the skid of the 301 section. There is one more diversion device for coalescing and further removal of entrapped liquid before final measurement of gas in the vortex meter.

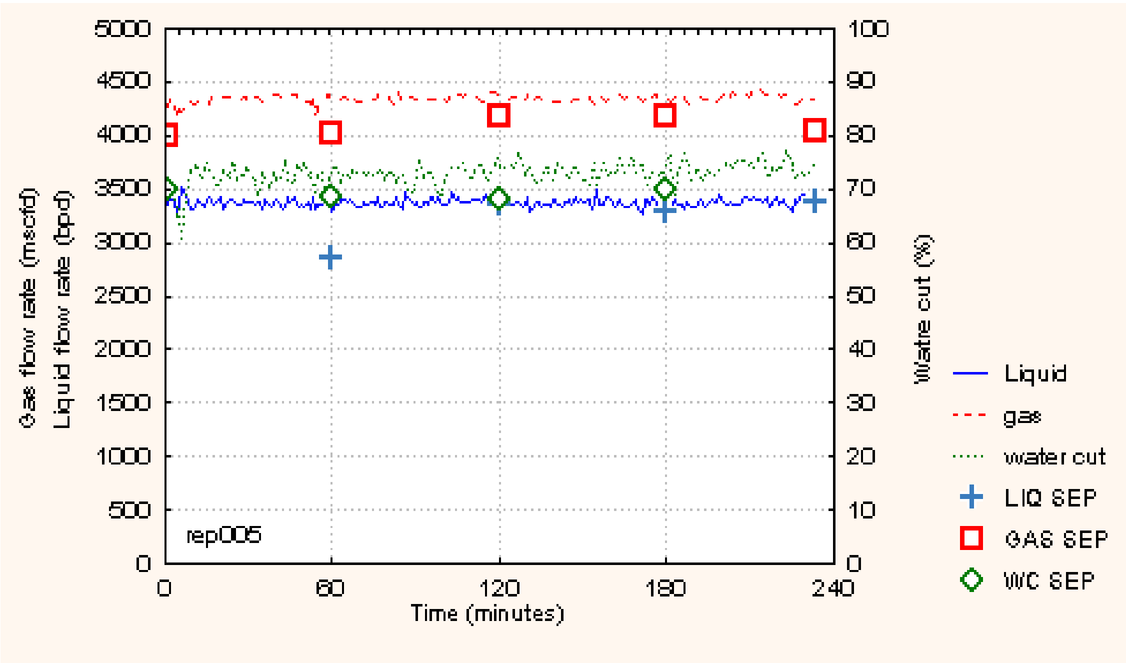

Figure # 1

Figure 1. The well shown above demonstrates a stable gas lift operation with production rates and injected gas rates appearing stable over the period of the test.

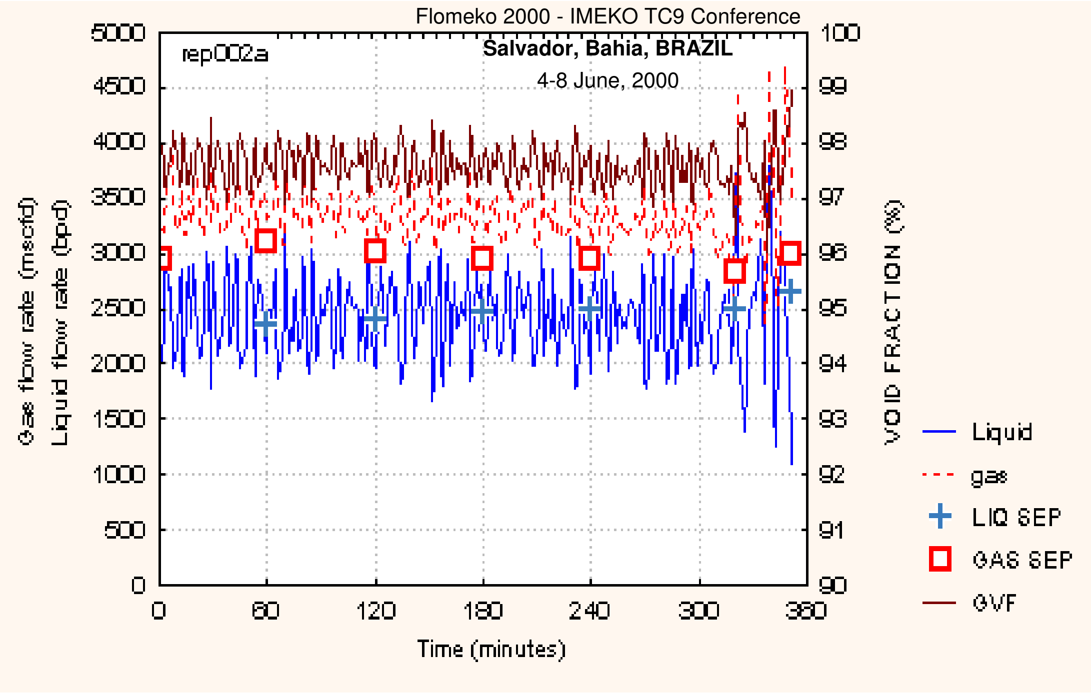

Figure #2

Figure #2 indicates a serious problem with the well operation. Notice the severe heading in liquid production and gas injection. The conclusion was that the well either had a bad gas lift design, a mechanical failure of the gas lift valves, or communication between the casing and tubing. This problem is easily shown by the Agar MPFM real-time data. This would have been virtually impossible to find using only a standard test report.

Figure # 3

Figure #3 Above shows an AGAR Series 400 Multi-phase flow meter installed on the platform where the above wells were tested. This unit has a large diameter gas loop and a small fluids section due to the high GOR characteristics of the wells of this field. As the injected gas has to be measured together with the gas produced, the sizing of the unit must take into consideration the total volume of the three phase flow to be metered at the preferred wellhead production pressure.

3 CONCLUSION

After a series of well documented tests and operations worldwide, a substantial number of companies depend on multi-phase metering as a diagnostic tool for optimization of field performance, diagnostic of gas lift efficiency, secondary recovery efficiency, diagnostic of failure of downhole and surface components and well service results to the point where the monthly required well production reporting takes a secondary place in the purpose of the instrument. The real time graphs produced are an important improvement over the information that can be obtained from test separators and the ease of operation where no calibration is required when switching from well to well, makes all previous well testing methods obsolete.

Note: Individual reports issued by many of the companies that have tested the above multi-phase meters are available from the Agar web site at http://www.agarcorp.com/

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