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Oil and Gas Flow Rate Measurement: It's Not That Simple

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1. Brief Introduction to the Letton Hall Group

The Letton Hall Group is comprised of experts in measurement of the flow of oil, gas, and multiphase flow at various points in its production. Its members and associates come from many E&P and service companies in the industry, such as Schlumberger, ExxonMobil, and BP. It has extensive experience in measurement innovation, meter selection, and problem solving, and has often been utilized in dispute resolution.

2. Introduction to Oil and Gas Flow Metering

The measurement of flow rates, constituents, and quantities is an area that is extremely important in the world of oil and gas, but of which there is little truly expert knowledge. Its importance is based on two primary facts: (1) almost all transactions, such as production sales or allocation, are based on measurement, and (2) decisions on how to properly manage hydrocarbon reserves require accurate and timely measurement.

Unfortunately, good measurement is neither straightforward to understand nor easy to perform. Measurement technology applied to the problem of oil and gas flow is highly complex; what is presented here is but an overview. We encourage the interested reader to use the references provided for further details.

In what follows, the basics of first liquid, then gas flow measurement as practiced are discussed. Detailed descriptions of the liquid and gas meters discussed here can be found in either of two excellent texts on flow measurement [Ref 7.1, 7.2]. Next is a very brief overview of multiphase meters, devices that measure both oil and gas flow in one instrument, without separation. Applications are then addressed in which financial transactions are based directly on measurements. Finally, examples of what can go wrong with the process, based on experience in the Real World, will be provided.

2.1. Common Liquid Flow Meters. There are numerous principles used in the oilfield for measurement of single-phase liquid flow, as well as various embodiments of each, offered by many vendor companies.

2.1.1. Positive Displacement (PD) Meters. Positive displacement (PD) flow meters measure the volumetric flow rate of a moving liquid by dividing the flow into fixed volumes and counting these over a measured period of time. An analogy often used is the so-called "bucket brigade" used in firefighting, where buckets of water are passed along a line of firemen to douse a fire; the flow rate of such a process would be the volume of liquid in a bucket multiplied by the number of buckets delivered, divided by the fixed period of time.

Because PD meters are by their very nature complex mechanical instruments, they are susceptible to any disturbance to the precision of their mechanical construction. They have found use in downstream applications where the liquids are pure, without solids or composed of more than a single liquid.

There are numerous embodiments of PD meters that have been offered commercially over many years. Because of this variety of design, standards for PD meters generally only address certain actions such as maintenance and calibration.

When properly calibrated and the fluids are compensated for pressure and temperature effects, PD meters can be a precise means of measuring *single-phase* flow rates. However for use in upstream measurement, PD meters are rarely used. Solid materials such as sand can have a particularly devastating effect on these devices, which can also be severely affected by deposits from the liquids, such as scale, paraffin, and hydrates.

2.1.2. Liquid Turbine Meters. A turbine meter uses a rotating, bladed element (rotor) secured inside a pipe; the force of liquid flow through the pipe against the blades causes rotation. For a given set of mechanical parameters – pipe size, number and pitch of blades, shape of blades, etc. – the turbine will rotate at a rate which is proportional to the volume rate of liquid flow through the pipe.

Like PD meters, liquid turbine meters are precision mechanical devices, and generally require clean liquids for both accuracy of measurement and long life. However turbine meters are simpler in design and construction than PD meters, hence generally less expensive and less prone to failure from impurities in the flow stream. For these reasons, turbines are often used in upstream applications, particularly on the liquid legs of separators.

As with PD meters, the commercial designs of turbine meters are numerous. Due to this variety of design, standards for turbine meters address only certain aspects, such as maintenance and calibration.

2.1.3. Coriolis Meters. Coriolis meters provide a relatively new method of liquid measurement – both turbine and PD meters have been around for more than 100 years – that has offered some distinct advantages over the technologies mentioned above. It is based on a force named after an 18th century French engineer, and overcomes some of the problems with turbine and PD meters.

To measure the flow rate, the liquid stream is diverted through a pipe section specially designed to sense the effect of the Coriolis force. The operating principle requires inducing vibration in the tubes through which the fluid passes, after which sensors monitor and analyze changes in frequency, phase, and amplitude of the vibrating flow tube signal. These changes directly indicate the mass flow rate and density of the fluid.

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