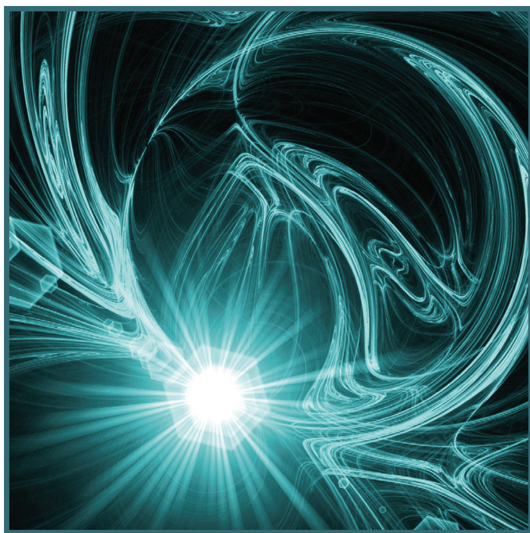

Advantages of Master Metering Method of Proving Custody Transfer Flows

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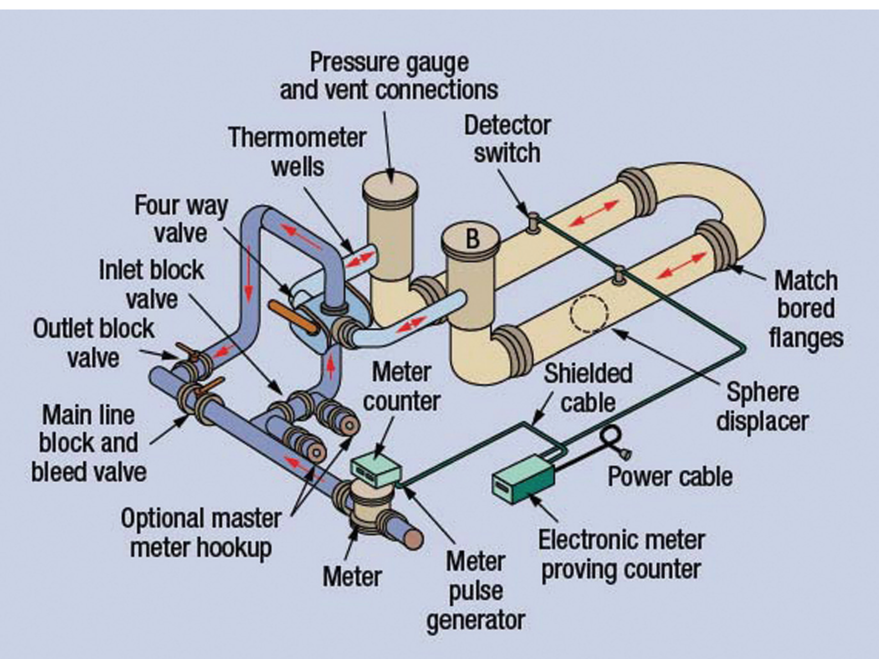
Chapter 4 of "The American Petroleum Institute Manual of Petroleum Measurement Standards" offers a guide for the design, installation, calibration, and operation of meter-proving systems that are commonly used by petroleum operators around the world. The chapter covers Displacement and Tank provers as well as the use of Master Meters to validate measurement systems for custody transfer. The purpose of this paper is to discuss the advantages of the Master Meter proving method in today's offshore and onshore custody transfer applications.



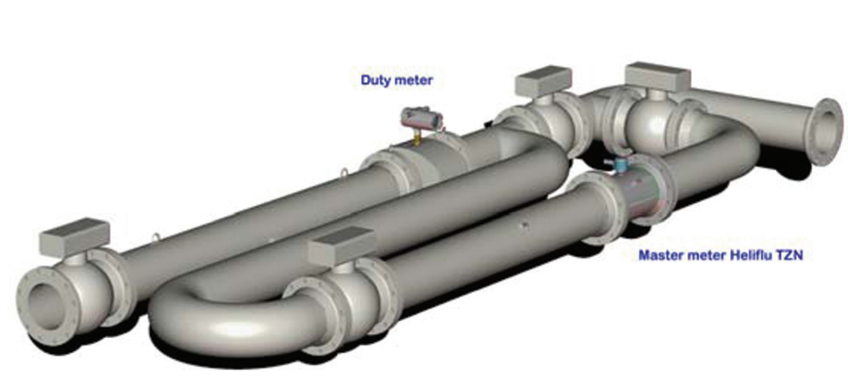
In any Greenfield construction project and specially those that are located offshore, space comes at a premium. However, when it comes to custody transfer applications where petroleum product ownership changes hands, operators have limited options as to the type of equipment that can be employed for the verification and proving of flow measurement systems. The API recommendations are specific in the types of equipment suggested for this application. Users have a choice of either Displacement (ball prover), Tank provers or using a master meter to verify the accuracy of the production metering devices.

Why is accurate metering so important? For the operators of the production facilities, there is a significant cost savings involved with the accurate performance of the custody transfer meters. If a typical offshore oil production facility produces 100,000 bpd (barrels per day) and incurs an estimated $8 (random) per barrel cost to extract the product, a meter that has a read error of just .2% on total flow can cost the operator over $3MM in revenues assuming an oil price of $50 per barrel (at today's price of $70+ per barrel, the cost is over $4.5MM). Given that a custody transfer metering station costs around $1.2MM, the payback for it is less than 4 months. While these numbers are eye opening, the primary reason for offshore metering is to measure the output of a facility at its source to avoid disagreements between production partners and tax authorities. However, in all these calculations, the assumption is made that the meter is reading and performing accurately. The only way to verify this is to periodically check the meter against a reference standard. The most cost effective way to do this is to have that reference standard on board the vessel. With space at a premium, what is the best method available to producers that will fit into the smallest possible footprint to verify the accuracy of the flow measurement.

The traditionally accepted "proving" methods for offshore applications are Master Metering and Ball Provers. Both of these methods are described in the API MPMS document, Chapter 4. A ball or pipe prover procedure involves using a sphere that has a close tolerance fit inside a u-shaped pipe loop (to avoid product flowing past the ball instead of pushing it). This is then pushed along by the oil flow in series with the meter under test. The ball passes detectors mounted in the pipe wall that start a timer. Combining an accurate time measurement with an accurately calibrated internal volume of the pipe provides an accurate measurement of average flow rate when repeated several times. This average is then used to calculate the meter factor which in turn is used to calibrate the meter. The physical size and weight of the early provers was an issue for offshore platforms. This resulted in the development of a bidirectional prover. Using a 4 way flow diverter valve, a bidirectional prover allows the ball to travel in both directions combining forward and reverse volumes into a single proving cycle. The benefit of this approach is that it reduces the overall calibrated length of the prover and limits possible hysteresis errors in the ball detectors. Another innovation was the use of pulse interpolation techniques for small volume piston provers. This procedure estimates the part of a full meter pulse that is usually lost at the end of the ball movement. The result is a reduction in the size of the overall prover. This only works however if the duty meter has a uniform pulse output per revolution. This is the case with all turbine meters unless they are damaged or worn in some way. A schematic of a bidirectional prover is shown below.

From the drawing, the one thing that stands out is the number of mechanical parts involved in the product. The accuracy of the prover relies on the proper functioning of all these mechanical parts. Any leakage in the valve seats, stem packing or any damage to the internals of the valve will affect the accuracy and performance of the prover. Also, any coating or scale buildup in the pipe sections will result in a change to the calibrated volume of the unit and therefore the overall accuracy of the system. In order to ensure the proper functioning of the prover, regular scheduled maintenance is required to make sure the system is in perfect working order. This is a labor intensive operation and can be time consuming. Also, how does an operator verify the accuracy of the prover system? If issues are noted (scale, leakage etc) and cleaning or repairs are done, what processes are followed to ensure the system is back and operating accurately? Given the space constraints in offshore processing platforms, manufacturer's are continually trying to reduce the overall footprint and size of the prover. Small volume provers are available at marginally reduced overall acquisition costs but the issue with these devices is that there is insufficient volume on larger size meters to generate the 10,000 pulses needed for a "good" calibration run.

A second option outlined by API MPMS Chapter 4 is the use of a master meter to verify the operation of the duty meters. A flow meter is installed in series with the duty meters and isolated by block valves. When the accuracy of the duty meters needs to be verified, the valves are opened and flow is allowed across the master units. The outputs of the 2 units are then compared and the duty meter factor is changed if necessary to ensure that the volumetric output is in agreement with the master meter. A picture showing a master meter installation is below.



The overall installation is significantly more simple and the result is an overall cost reduction in the metering skid of up to 40%. Since the unit is in series with the production meters, the proving run can time can be substantially longer using a larger volume and therefore more pulses from the units. This results in a more accurate calibration of the duty meters. Also, many of the mechanical moving parts are eliminated reducing potential wear points (and subsequent inaccuracies) and substantially reducing the maintenance requirements of the overall system. In times of peak production, the overall capacity of the system can be increased by using the master meter as a duty meter for limited operational time or during maintenance of the duty meters, the master meters can be used as a spare line. Using a helical blade turbine meter in this application eliminates the issue of viscosity effects on the turbine meters. Using a K-factor calibration on a helical turbine meter eliminates viscosity effects over a wide range of products. This has typically been the source of "commonmode" errors in the past which have generally limited the use of standard turbines in these applications.

The 2 major advantages of a system using a master meter are:

1. The master meter can be periodically removed and sent back to a calibration facility to be checked and recalibrated if necessary. This ensures that the system is running at optimum performance for the operator.

2. The overall size of the metering skid is significantly reduced. In an environment where space is at a premium, having an accurate measurement system that fits into a small footprint is of great value.

Conclusion

The master meter method of proving production flow meters offers significant advantages to offshore production facilities without compromising overall accuracy and performance of the custody transfer metering systems. The helical blade turbine meter is immune to viscosity effects and offers extremely accurate and repeatable measurement of process flows. When used as a master meter, the unit reduces the overall size requirement, reduces overall maintenance of the metering skid and provides an easy way for producers to verify metering skid accuracy. Also, due to the relatively compact design of the helical turbine units, a spare master meter can be stored on site to offer complete system redundancy.