The advantages of using a Turbine meter as a reference meter in a fiscal oil metering station.

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In chapter 4 of "The American Petroleum Institute Manual of Petroleum Measurement Standards" the reader is offered a guide for the design, installation, calibration, and operation of meter-proving systems that are commonly used by petroleum operators around the world. For those of you who have already read it I also assume you are familiar with the Norsok I-105, which will be the main source for this paper. In the API MPMS Chapter 4 we go deeper in the measurements standards covering 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 custody transfer applications.

When looking at the API recommendations they are specific in the types of equipment suggested for custody transfer application. Users have a choice of using displacement (ball prover), tank provers or a master meter to verify the accuracy of the duty metering devices.

One could ask one selves: Why is accurate metering so important? Well, for all the operators of the production facilities there is a significant cost savings involved with the accurate performance of the custody transfer meters. If we take a look at typical offshore oil production facility there will be produced around 110,000 bpd (barrels per day) and incurs an estimated $8-10 per barrel cost to extract the product. A meter with a read error of just 0.2% on total flow can cost the operator over $6MM in revenues assuming an oil price of $100 per barrel (today Brent Crude are $102,76). Given that a custody transfer metering station costs around $1.2MM, the payback for it is less than 2 months. This taken under consideration all these calculations are made by assumption that the meter is reading and performing accurately, and 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 production facility. With space at a premium one could clearly see that the best method available to producers will be the use of a master meter.

But first let us take a look at the traditionally accepted "proving" methods for offshore applications: Master Metering and Ball Provers where both of these methods are described in the API MPMS document. Today there has been developed a bidirectional prover by using a 4 way flow diverter valve (instead of the big and heavier earlier provers) which 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, but still far away from using a turbine meter as a master meter. And let us not forget that with SVP (Small Volume Provers) this only works if the duty meter has a uniform pulse output per revolution.

When come to thinking the accuracy of the prover relies on the proper functioning where all these mechanical parts are involved. Any leakage in the valve seats, stem packing or any damage to the internals of the valve, coating or scale buildup will affect the accuracy and performance of the prover. Regular scheduled maintenance is required in order to ensure the proper functioning of the prover, which is both a labor intensive operation and can be time consuming. Given the space constraints in offshore processing platforms, manufacturers are continually trying to reduce the overall footprint and size of the prover. SVP's 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. According to API MPMS 4.2 chap 4.284.3, we have an influence of pulse train stability on accuracy of the measurement. The pulse stability for turbine meters is in range of 0,006 – 0,015. Regarding this, we can calculate the minimum number of pulses and estimate error due to non uniform meter pulse spacing. To skip all the formulas and get straight to the point one could calculate the minimum of pulses for a 10” TZN turbine meter to 85 pulses to follow API MPMS 4.2 and still obtain a good uncertainty and accuracy. That is why SVP’s are having large difficulties on larger meters, where the selection a turbine meter as a master meter would be a much better solution.

A second option outlined by API MPMS Chapter 4 is the use of a master meter to verify the operation of the duty meters. When looking at Norsok I-105 section **5.2.3.4 Master meter**, it states that the same requirements shall apply as in section 5.2.2.3 for turbine meters: Turbine meters shall be according to API MPMS Chap. 5.3 and the repeatability shall be better than 0,04 % (band) within linear range on water and product when the method "5 successive repeats" is used. To achieve this a master flow meter is installed in series with the duty meter 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.

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 time can be substantially longer using a larger volume and therefore more pulses from the units which eliminates the problems with SVP’s and results in a more accurate calibration of the duty meters. 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 the issue of viscosity effects on the turbine meters can be eliminated. 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 “common-mode” errors in the past which have generally limited the use of standard turbines in these applications.

Main advantages:

1. Compact design with less overall space compared to a prover and therefore ideal for offshore application such as all offshore installations and tankers.
2. The master meter can be periodically removed and sent back to a calibration facility to be checked and recalibrated if necessary.
3. This ensures that the system is running at optimum performance for the operator.
4. High turndown.
5. Less maintenance due to fewer mechanical parts
6. Can be used as a duty meter if necessary in times of peak production or during maintenance of duty meters.
7. Gives a better pulse stability.
8. Lower purchase cost.

Conclusion

As listed above there are significant advantages to offshore production facilities by using the master meter method of proving production flow meters, and in many cases I think the election of a helical blade turbine meter is the most reasonable and best solution. When using a turbine meter 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. Given the fact that a spare master meter are significantly cheaper and less space demanding, I would say this is an ideal choice for all offshore applications it can be used on.