

# Liquid Meter Proving Techniques

by Harry James 

Producers and shippers are becoming more and more aware of the importance of accurate measurement. Their bottom line depends on it. Not only does this relate to the actual product value, but in relation to environmental considerations it also has implications associated with regulatory compliance and integrity management.

As a result, measurement accuracy is being scrutinized more vigorously than in the past. Companies are being required by their clients and regulatory bodies to "Verify" their metering accuracy. Therefore it is essential that all procedures and auxiliary equipment be operated in a consistent, accurate and defensible manner.

Metering installations vary vastly in their installation and regular maintenance requirements subject to the severity of service they are subject to. The type of products being handled and the temperature and pressure at which they are operated all play into the requirements. Even meters in clean service (refined products) and normal pressures and temperatures will experience wear over time. To ensure meters give accurate results and to compensate for any wear, or changes to the environmental conditions, requires regular precision calibration by a meter prover operated by a competent individual.

Meter proving is the means by which meters are calibrated to provide a "meter factor" that can be applied to the meter indicated volume output that will result in a recorded volume that can be traced back to a regulated reference standard. This is accomplished by passing an identical volume of liquid through both the meter and the meter prover and then comparing the results. The meter prover is precisely calibrated during a withdraw calibration process using standards that in turn have been calibrated against nationally regulated reference standards.

## LIQUID METER PROVERS

There are a number of devices that can be used for proving of meters, however, in continuous service and for proving on-line there are basically two types of provers that are commonly employed.

1. Pipe Provers
  - Uni-directional
  - Bi-directional
2. Small Volume

Note: Small Volume provers are sometime called Ballistic or Double Pulse Chronometry provers.

These provers can be fixed or portable and are manufactured in various sizes according to requirements. The small volume prover is essentially a uni-directional prover with a significantly reduced volume that employs high speed clocking technology (chronometry) to provide equivalent or better calibration resolution than standard pipe provers.

## PLANNING AHEAD

Because there are a number of details that can affect the accuracy and precision of the proving, it is essential that a systematic procedure be in place and followed in a consistent manner.

Parameters such as ambient and product temperature, product pressure, density, viscosity, flow rate, meter wear etc. do not remain constant from proving to proving. As a result, meter factors can and usually will change from proving to proving. This will even occur proving the same meter multiple times back to back, although the difference in meter factor should be minimal.

Before proving the following should be determined:

- Is the flow rate within the design range of the meter?
- Is the prover suitable for the flow rate and pressure?
- Are the prover seals, o-rings, proving sphere, etc. compatible with the product?
- Are all prover temperature and pressure devices current in their calibration?
- Is the prover certification current?

If the above list of items is not in order, don't waste your time trying to prove the meter. Get these items in order before you attempt to prove.

It is also a good idea to ensure that all parties agree what criteria are going to be used in the proving before you begin.

## PRE PROVING ASSESSMENT

Once we know the meter and prover are suitable for the product and flow rate, the prover can be connected to the meter. Once connected, the pre-proving assessment can start.

The following items should be checked:

1. Is the flow rate constant? The flow rate should be adjusted to the same as the operational flow rate of the meter.
2. Check divert valve for sealing integrity.
3. Check all block & bleed valves to ensure there are no leaks or by-passing.
4. Check all flanges and fittings on the prover for evidence of leakage.
5. Ensure all temperature and pressure devices are operational.
6. Operate the divert valve to verify operation.
7. Identify where the prover ball/displacer is.
8. Cycle the prover several times ensuring the ball enters the launch tube before reversing the flow. This helps stabilize the temperature and removes the product from a previous proving.
9. There should be venting points at the high points of the prover, bleed product off these locations to ensure there is no air or vapor retained in the prover.
10. Check wiring connections to ensure they are secure and will not vibrate loose during operation.
11. Check operation of switches and triggering of the prover counter.
12. Record position of the ball or displacer.
13. Operate the pulse check on the prover counter to ensure it is counting all pulses.
14. Record prover data on the proving report.

## OPERATING THE PROVER (Bi-directional)

1. Launch the ball and compute the flow rate on the first pass.
2. Record the inlet and outlet temperatures and pressures.
3. Obtain a sample of the product being sampled and determine its density/specific gravity/API Gravity as required.
4. When the ball has passed the second prover switch, record the number of pulses on the prover counter.
5. Check the Temperatures and Pressures to ensure they have remained stable.
6. After the ball has entered the launch chamber, reverse the divert valve to launch the ball in the reverse direction.
7. When the Ball has completed the reverse pass and the counter has stopped counting, record the round-trip total.
8. Reset the prover counter.
9. Repeat the sequence, recording the inlet and outlet temperature and pressure for each round trip.
10. The sequence should be repeated until the required number of runs within the required tolerance is achieved.
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## OPERATING THE PROVER (Uni-directional)

1. Launch the ball/displacer and compute the flow rate on the first pass.
2. Record the inlet and outlet temperatures and pressures.
3. Obtain a sample of the product being sampled and determine its density/specific gravity/API Gravity as required.
4. When the ball/displacer has passed the second prover switch, record the number of pulses on the prover counter.
5. Check the Temperatures and Pressures to ensure they have remained stable.
6. Reset the prover counter.
7. Repeat the sequence, recording the inlet and outlet temperature and pressure for each round trip.
8. The sequence should be repeated until the required number of runs within the required tolerance is achieved.

Once all the data has been collected it must be recorded on a prover report. The repeatability should be checked to ensure it meets acceptable tolerance. The meter factor or K-Factor should then be computed and recorded.

All extraneous information obtained during the proving such as ambient temperature, time of day, clouds, humidity etc. should be recorded on the report even if it seems trivial

Once the report is completed, all interested persons witnessing the proving should sign the Proving Report.

## THINGS TO WATCH FOR

There are a number of things that can affect the results of an otherwise acceptable proving.

1. If the number of counts shows a continuous decline from run to run and the repeatability is still in the acceptable range, it is likely that the temperature of the steel in the prover has not yet stabilized. The same applies to a continuous rise in counts. This is particularly critical to a Small Volume Prover.
2. If there is trapped air in the prover, this can affect the ability of the prover to yield repeatability. This is due to the air expanding and contracting as the pressure fluctuates in the prover. The fluctuation operates almost like a spring or shock.
3. If the pressure of the system is not above the equilibrium vapour pressure of the liquid, repeatability will be hard to achieve. The pressure of the system should be at least 125% of the equilibrium vapour pressure. Product flashing into a vapor state will cause similar problems to the second point above.
4. If the sphere is not symmetrical or inflated improperly, repeatability will be hard to achieve.
5. In a bi-directional prover, if the ball is not allowed to travel all the way to the next launch/receive chamber before reversing the direction of the flow, the temperature in the prover can be different than the inlet or outlet temperature. It may also not provide enough time for the diverter valve to fully close. This may manifest as a lack of repeatability in the prover counts.
6. Has the flowrate remained constant? If not repeatability could be hard to achieve and a meter factor within 0.25% of the previous proving could be hard to achieve.
7. If the temperature or pressure is not stable, it is difficult to determine which correction factors to apply.
8. Inconsistent density and viscosity can affect repeatability.
9. If information revealed during a proving is not recorded, IT DIDN'T HAPPEN. Ensure all pertinent information is recorded when it happens. Memories become fuzzy with time.

If repeatability cannot be attained, the above list of items should be investigated and problems corrected before trying to reprove.

**NOTE:**

Temperature correction sensitivity is not fully appreciated by inexperienced measurement personnel. A simple set of 'rules of thumb' is:

For normal crudes 825 kg/m<sup>3</sup> (40 deg. API)  
- 0.1 % per degree C. MF differential of 1.0010, or 0.9990  
- 0.056 % per degree F.

For condensates 700 kg/m<sup>3</sup> (70 deg. API)  
- 0.2 % per degree C. MF of 1.0020 or 0.9980  
- 0.11 % per degree F.

For NGL's 575 kg/m<sup>3</sup>  
- 0.3% per degree C. MF differential of 1.0030 or 0.9970  
- 0.17% per degree F.

These are only approximations that show the relative sensitivity of temperature correction factors for different densities.

## COMMONLY ACCEPTED PRACTICES

Most companies have published Rules and Regulations that state the acceptable procedures, number of runs, repeatability etc. In many cases these reference API requirements.

Some commonly accepted criteria for number of runs and repeatability are:

- 5 runs with 0.05% repeatability
- 10 runs with 0.10% repeatability
- 15 runs with 0.17% repeatability

Commonly accepted criteria for rejection of a meter are:

- Inability to achieve acceptable repeatability.
- Failure to achieve a factor within 0.25% of the previous proving without a defensible reason unless it is a first proving, or first proving after a meter prover has been calibrated, although a similar shift in MF may be apparent.

The acceptability of criteria should be agreed to between interested parties before beginning the proving.

Track and chart your meter factors. Assigning error bars and having a visual representation of proving records make things quite obvious that may not have been when looking at proving reports. This could include:

- Gradual changes
- Seasonal shifts
- Product/viscosity differences
- Meter failure

## CONCLUSIONS

Good proving cannot be rushed. Care must be taken to ensure accurate and defensible results are obtained. Experience will allow a good operator to identify issues or potential issues before they become problems.

Proving requires attention to detail. The results of inattention are typically:

- Inability to get a good proving
- Questionable results
- Wasted time
- Reduced confidence in the prover operator
- Financial repercussions