Proving for Measurement Verification

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Flow Management Devices

Summary
While meters measure flow, they require calibration to ensure accurate measurement. Provers are used to verify flow meter uncertainty by comparing their known volume with the measured volume of a flow meter. Various methods of proving are used globally to ensure meter accuracy and this paper will explain provers used for liquids, in particular oil and liquified gas. It will cover methodology, types of provers, proving best practices, and proving for liquified gasses.

Methodology
A meter prover is a device used to verify flow meter uncertainty to establish the following:

- Meter Factor
    - As shown in Equation 1, the Meter Factor is the metered volume divided by the prover volume after correction to standard units. The meter factor is then used to correct the original meter factor or a previous meter factor to the proving process conditions. An original meter factor is also typically referred to as a K-Factor.
- Linearity
    - An analysis of Meter Factors over time will present trends to the system user. Some shift in Meter Factor can be seen with varying process conditions, but excessive shifts are indicative of measurement problems. Linearity or correspondence to the process conditions should be able to be identified through proving.
- Repeatability
    - There is repeatability within the meter prove runs themselves and between consecutive meter proves. The repeatability requirements vary with the proving run configuration in the flow computer, but all correspond to the American Petroleum Institute (API) uncertainty requirement as per Table 1.
- Detect Measurement Issues
    - Through the analysis of the Meter Factor and its linearity along with the repeatability, it enables the system user to detect measurement issues. At times these issues may have nothing to do with the meter or prover but lead to system investigations that uncover other issues and improve overall measurement accuracy for the user.

$$Meter\ Factor = \frac{Metered\ Volume}{Prover\ Valome}$$

Equation 1: Meter Factor

From API MPMS Chapter 4.8 Runs at proving repeatability to meet ± 0.00027 uncertainty of Meter Factor		
Proving Runs	Repeatability Limit	**Meter Factor Uncertainty**
3	0.02	0.00027
4	0.03	0.00027
5	0.05	0.00027
6	0.06	0.00027
7	0.08	0.00027
8	0.09	0.00027
9	0.10	0.00027
10	0.12	0.00027
11	0.13	0.00027
12	0.14	0.00027
13	0.15	0.00027
14	0.16	0.00027
15	0.17	0.00027
16	0.18	0.00027
17	0.19	0.00027
18	0.20	0.00027
19	0.21	0.00027
20	0.22	0.00027

Table 1: Proving Runs and Repeatability Corresponding to API Uncertainty Requirements

Financial Purpose:
In addition to proving for the detection of measurement issues, there is also typically a higher level of accuracy and lower uncertainty when direct proving. Other methods include master meter calibrations or simply not proving and measuring off a factory meter factor. When comparing to a standard meter accuracy of 0.05% and assuming a typical under process condition proving (in-situ) accuracy of 0.02%, the financial advantage becomes clear following the example and Figure 1 below.

Example:
Consider a pipeline flowing 2,000 BPH (24 hours a day, 7 days a week) with a meter accuracy of 0.05% versus a proving accuracy of 0.02%. Following Equation 2 below with the meter accuracy yields a potential yearly loss of $438,000. Following Equation 2 below with the proving accuracy yields a potential yearly loss of $175,200. The difference between the two ultimately yields a difference of $262,800 which should also be considered as the potential yearly saving by proving in this application.

Furthermore, this data along with varying flowrate and unit cost as it relates to a 0.02% accuracy versus 0.05% accuracy was plotted in Figure 1. This along with ability to detect measurement issues should now make the financial purpose of a prover clear.

$$Potential\ Losses = Flow\ Rate\ \times Unit\ Cost\ \times Accuracy$$

Equation 2: Potential Losses Relation to Accuracy

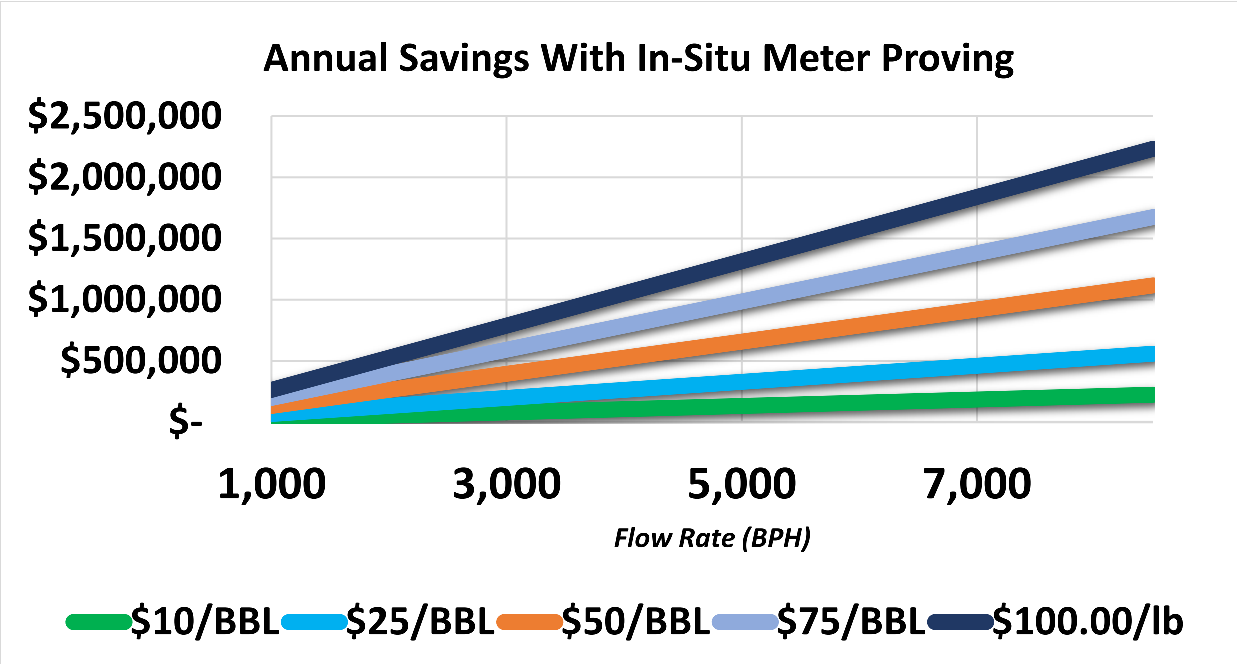

Figure 1: Difference in Potential Losses Of 0.02% Accuracy Versus 0.05% (Proving Versus Not Proving)

Types of Provers

There are many different types of provers and they are at the highest level organized or termed as static or dynamic. The difference between static and dynamic applies to the way the standard is compared with the reading of the flow meter under test.

In the static scenario the fluid is collected in a test vessel and compared to the gross delivered amount of the meter under test. This is normally an open system and will require interruption of the flow process to perform the meter factor verification.

In the dynamic scenario the fluid remains in a closed system whereby the pulse registration of the meter under test and the pulse registration of the standard prover used are compared directly. There is no interruption of the normal flow process during this verification of the meter factor.

Equipment used for Proving:

There are three types of measurement equipment used for verification in the petroleum industry today, test measure tank provers, volume displacement provers, and master meters. Decisions for which type of equipment should be used are based on accuracy requirements, testing flow rates, measurement turndown requirements, environment, cost to install, cost to maintain, and in some cases local agency approvals.

Prior to the development of the volume displacement prover, the volumetric test measure tank prover was the only product available for volume measurement verification and has been around since the turn of the 20th century. The volume tank prover may be used for the calibration of liquid flow meters; and is also approved for performing a volumetric water draw calibration of volume displacement provers per API MPMS Chapter 4.9.

The master meter prover has unlimited applications for proving and is noted in the API MPMS Chapter 4.5. Although used in the industry for some time, it does not have total acceptance for custody transfer approval or for use in weights and measures type applications by all local or regional agencies. The required verification of the master meter's accuracy can be established by using a displacement type or a volumetric tank prover. This should be completed prior to the start of any transfer when product characteristics (products, temperature, pressure, density, viscosity) have changed since last master meter use.

The petroleum industry and American Petroleum Institute (API) have accepted the use of volume displacement provers in two categories. The conventional pipe prover is a displacement prover with sufficient reference volume to accumulate 10,000 whole pulses in a single pass; and the captive displacement or small volume prover (SVP) is a displacement prover with insufficient reference volume to accumulate 10,000 pulses in a single pass and uses pulse interpolation software). In both cases, it will require multiply passes for a proving and to establish as new meter factor. The conventional provers have been utilized for meter proving since the early 1950's and the captive displacement prover entered the market in the mid 1970's after the acceptance of the double chronometry or pulse interpolation (techniques which whole meter is counted between detector switch one and detector switch two and any remaining fraction of a pulse in calculated) as identified in API MPMS Chapter 4.6.

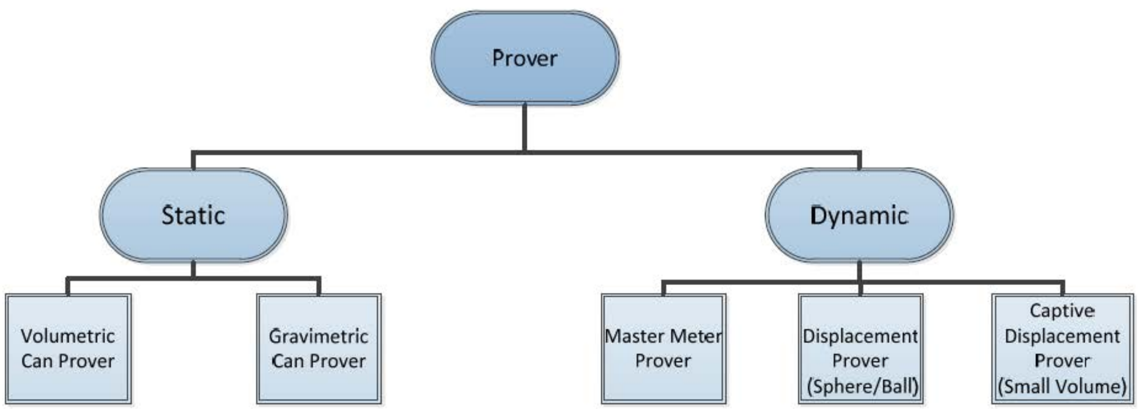

Figure 2: Proving Equipment Type Classifications

Key Components and General Operation:
The volumetric test measure tank prover is covered in the API MPMS Chapter 4.4 and was the first product to gain acceptance in the industry for meter accuracy verification in the field. This device is mechanical in design and is the simplest to use and operate. The primary tank prover consists of a certified volume tank or test measure (sized by the required amount of fluid delivered in 1 minute at the actual maximum flow rate) with graduated neck and a gauge glass and scale (scale is designed for +/- 0.5 percent of tank certified volume) on the top and possibly the bottom of the tank to measure the tank zero start and stop volume position respectively. There will be temperature measurement locations on an open or closed type system. On a closed tank system, pressure measurement is added as well as inlet/outlet flow connections and drain valve, vapor recovery or release system, overlapping tank side site glasses, and many other components as illustrated in API MPMS Chapter 4.3. When moving from a stationary tank prover to a portable system the additional components needed are a vehicle or trailer, leveling equipment, hoses and connectors, and possibly a small liquid pump-off system.

The use of a tank prover is simple in operation; the most important part is selecting the correct size tank for the meter flow rate(s) to be calibrated. Once all piping connections are established and tank is verified as empty the inlet flow to the prover begins and fills the tank to the appropriate level. When the tank has reached the upper neck gauge glass and the fill line falls within determined tank volume scales, the flow is stopped. The technician reads the scale for the exact gross volume measurement in the tank and this volume has a direct relationship with the registered volume of the meter under test. These values are then used to calculate a new meter factor. A verification proving is then required to assure that any changes applied had the desired result.

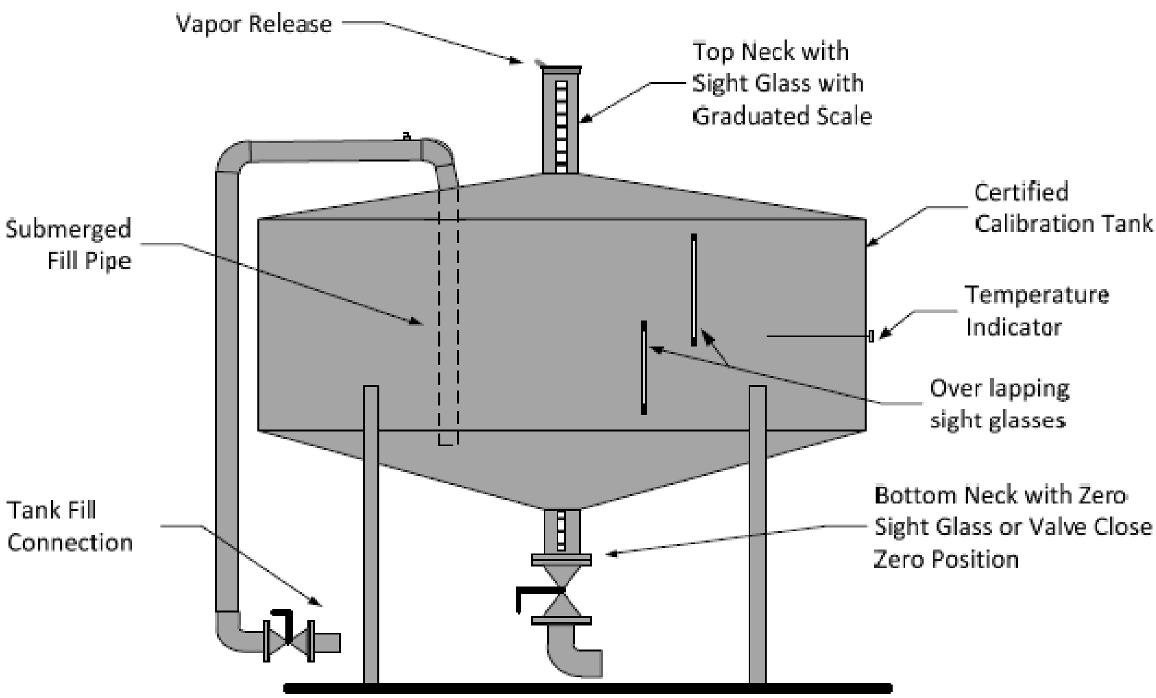

Figure 3: Components of Normal Tank Type Prover

Critical Characteristics of Tank Type Provers

- Using the one minute of flow rule for tank size, prover tank can become very large and difficult to maneuver and use.
- The can needs to be drained after each proving – in some cases product will have to be pumped to a sump-tank resulting in considerable product loss.
- If used on a loading bay it can stop truck loading for long period of time.
- Particle or heavy viscous product build-up can cause volume changes.
- Well maintained tanks require little maintenance costs.

The gravimetric test measure tank prover is accepted for use in meter verification but not approved by API as a proving device. When using a gravimetric tank prover, the most significant component is the certified weights used to calibrate the scale and the scale(s) itself. The scale is used to weigh the tank empty to establish tare weight, and also verify the weight of the product in the tank once a quantity is measured through the meter and into the scale tank. The volume amount is verified by the equipment mass weight on the scale. Once the weight of the product is determined, the product density must be verified and used to convert the mass measurement to a volumetric measurement for comparison to the meters registered volume.

Gravimetric test measure tank proving in a test lab environment is one way that displacement type prover's manufacturers use to verify the volume of the measurement area of each size prover. When completing a water draw certification for a displacement prover, the weighed amount is determined by the amount of fluid registered between detector switch one and detector switch two. Once the weight of the distilled water is found, the temperature and pressure of the water in the prover body is used to convert to a certified volume amount. (Refer to API MPMS Chapters, 4.9.4, Chapter 12.2.4).

Figure 4: ISO 17025 Certified Gravimetric Water Draw Test Stand – Flow MD – Phoenix, AZ

Critical Characteristics of Gravimetric Type Provers

- Scales and tank can become very large and difficult to maneuver and use.
- Scales is a mass device and requires precise temperature and density to convert to volume.
- The can needs to be drained after each proving – in some cases product will have to be pumped to a sump-tank resulting in considerable product loss.
- Normally used on water test verification or refined equipment.

- Particle or heavy viscous product build-up can cause volume changes.
- Well maintained tanks require little maintenance costs.

The master meter prover is covered in the API MPMS Chapter 4.5 and has been used in the industry for many years. Master meter proving requires the use of a higher accuracy meter (preferable 10 times more accurate meter being verified) installed in series on the pipeline along with the meter being verified. There will be a pulse counter system that allows the user to gather flow information over a greater time intervals and allows the user to gather as many pulses as they desire. The master meter register volume is then compared with the test meter volume and a new meter factor will be calculated. A verification proving is then required to assure that any changes applied had the desired result.

Figure 5: Master Meter Cart and Trailer Designs

Critical Characteristics of Master Meter Prover

- A proving device should preferably be 10 times more accurate than the device being proved.
- Avoid using an equally or less-accuracy device to "prove" a similar, less-accuracy device.
- Measurement errors form normal operation of the master meter will be transferred to the test meter.
- The Master Meter accuracy could be effected by liquid viscosity, flow rate, temperature or pressure.
- Master Meters are usually designed for a specific fluid type and can't be used on a range of fluid.

The conventional pipe prover (ball / sphere type) is covered in API MPMS Chapter 4, Section 2 and can be designed for unidirectional or bidirectional operation. The pipe prover was designed for all levels of flow, but gained the greatest acceptance in the industry in larger pipelines where other prover types were unable to handle the higher flow rates. Despite involving a much larger footprint than other types of provers, the pipe prover is very simple design. The criterion for a unidirectional pipe prover is a minimum sphere velocity of 1 foot /second and maximum sphere velocity of 5 feet/second. The bidirectional pipe prover design sphere velocity must be between 0.5 feet per second and 10 feet per second, but in either design the prover must allow for the counter to accumulate of 10,000 pulses between the two required detector switches. (Check API MPMS Chapter 4.2, Appendix B). Pipe provers come in multiple sizes and designs, flow rates, and sphere velocity calculations that affect the overall footprint of the individual device.

Figure 6: Various Ball Prover Configurations

The key components of a pipe prover are the U shaped smooth lined uniform circumference pipe, the four way diverter valve system, the inflatable prover ball or displacer sphere, the ball launching chamber(s), the two detector switches and a meter pulse generating proving counter.

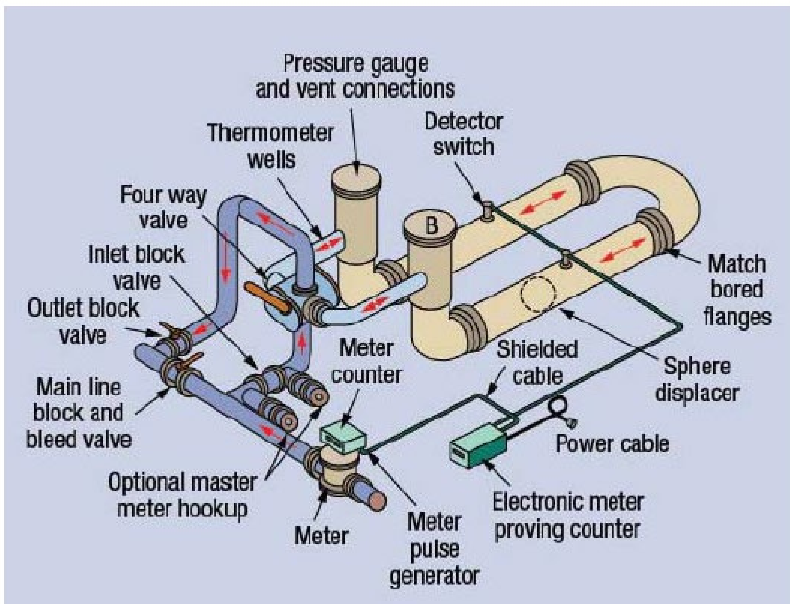

Figure 7: Ball Prover Components

Before the proving operation starts, a required proving flow rate must be established. The proving pass is started when the four way valve actuates to launch the prover sphere into the flow pipe. It then travels through the pre-run area until it reaches the u shape measuring section of the pipe. When the sphere contacts the first mechanically actuated detector switch, the counter is started and the sphere continues to travel until the second detector switch is activated, at which time the counter is stopped signaling a complete pass in a unidirectional prover. The sphere continues to travel until it reaches the other launch chamber where it remains until the start of the next proving pass. If bidirectional, the four way valve will again actuate to start the pass in the opposite direction and when concluded will be a single pass registration. The flow pulses accumulated from the test meter are then compared with the pulses generated from the accumulated volume between the detector switches on the prover. The proving passes are continued until sufficient passes are completed and the multiple pulse totals can be compared with sufficient repeatability to satisfy the requirements as specified in API MPMS Chapter 4.8, Chapter 9.3, and Chapter 13.2.

Critical Characteristics of Conventional Pipe Prover

- Ball provers requires launch and receive chambers and long pre-run distance.
- Possible high pressure drops with Ball Provers.
- More difficult calculations to correct for temperature and pressure.
- Appreciable uncertainties due to mechanically activated detection switches.
- Large in size and expensive to install.
- Sphere materials must be compatible with product, ball change with product change.
- Appreciable uncertainties due to mechanically activated detection switches and detector switch might be sensible to vibrations.
- Difficult to maintain and service.

The Captive Displacement or Small Volume Prover is a unidirectional device that is also covered in API MSMP Chapter 4.2. It has insufficient reference volume to accumulate 10,000 pulses in a single run and requires pulse interpolation software to calculate the 10,000 pulse requirement to satisfy a proving pass. One of the most significant design changes compared to a pipe prover was relocating the detector switches to the outside of the measurement pipe and installing them on a switch bar. This allows for higher quality switch activation and easier access for service. The most significant advantage of the design is the ability to verify meter accuracy faster over a larger flow range with an average 1200 to 1 turndown and considerably reduced footprint for installation. The major components of the small volume prover (SVP) are the prover body, prover frame, piston assembly, optic switches, puller assembly, drive system, drive shaft, and controller. For the complete proving operation there is also a need for a flow computer or proving software that takes in raw data from the prover and meter under test and per API MSMP Chapter 12.2 requirements calculates all data and generates a proving report automatically.

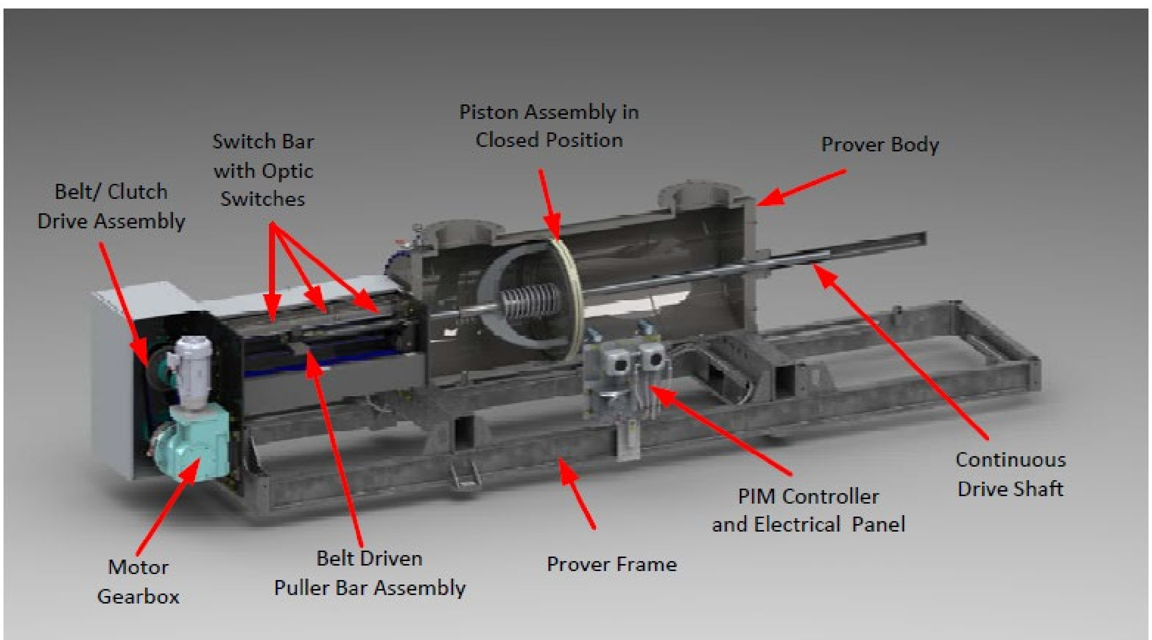

Figure 8: Flow MD SVP Components

The operation of the SVP is nearly fully automated. Once the valves are aligned to direct flow through the prover and the required flow rate is set, the flow computer sends a signal to the SVP controller to begin the proving. That signal will then start the drive system bringing the draw the piston back to the start pulling the piston shaft to the upstream position and in front of the first optical switch. Once the clutch releases the piston, the flow pressure will close the piston and begin the travel through the certified measurement portion of the prover flow tube. The certified measurement for calibration occurs when the optic flag mounted on the external portion or the drive shaft, activates the first optical switch and continues the travel downstream until the second optical switch is contacted signaling the end of the first pass. Simultaneously, when the first optical switch is contacted, a signal is sent to the flow computer to start both the interpolated signal prover counter and the counter for the meter under test. This begins the pulse accumulation from the meter and the controller. When the second optical switch is activated a signal is sent stopping the pulse counters, signifying the end of the next pass. This process continues until the set quantities of required passes are complete. During this process the flow computer is receiving pressure and temperature information from transmitters installed downstream as well as the temperature of the switch bar on the prover and also upstream by the meter in the pipe line. Once the multiple pass information is processed it will be compared for sufficient repeatability to satisfy the requirements as specified in API MPMS Chapter 4, Section 8; Chapter 9.3; and Chapter 13.2. The API proving reports can then be generated automatically as required.

Critical Characteristics of Uni-Directional Captive Displacement Prover

- Can be used in situations where it is possible to collect less than 10,000 meter pulses in a prover pass, by utilizing “Double Chronometry” or pulse interpolation.
- Designed with internal piston to displace the volume and externally mounted optical detector switches.
- Precise external optical switches are easily serviced.
- Small amount of liquid required for a volume water draw test.
- Piston and Poppet assemble is designed for fail safe operation not to disrupt flow.
- Prover allow for accurate measurement of flow meters with a wide variety of fluids.
- The repeatability of a prover will be better than 0.02% as stated in the API guidelines.
- Has a turndown ratio of 1200 to1 allowing for use for multiply size meters.
- SVP does not do any calculation itself, the pulse interpolation is completed in the flow computer or other type of computing devices that is part of the proving system.

Pulse Interpolation

With this introduction of pulse interpolation and the use of multi-pass runs, both defined within API Standards, has increase the ability for proving all size and types of meters using a SVP The Double Chronometry Pulse Interpolation is most widely used in the SVP, but is also used with the Conventional Ball or Pipe Prover with the 10,000 pulse counter requirement cannot be achieved.

The first action begins with a signal from the upstream detector switch, starting clock one (ET1, displacer elapsed travel time), next clock two starts with the detection of the first complete pulse (ET2 for the elapsed time to measure whole pulses). At the same time the accumulation of pulses (WP, whole meter pulses) from the meter being tested is also started. Clock one stops accumulating based on a signal from the downstream detector switch. Clock two stops accumulation based on the detection of the first whole pulse signal from the downstream detector switch which also stops the whole pulse accumulation. This method allows for the collection of (ET1) elapsed travel time of displacer, (ET2) elapsed time of whole pulse accumulation, (WP) whole pulse accumulation from meter and (DV) which is the already known displaced or calibrated volume for the prover. Taking these measurements multiple times within required repeatability values allows for the calculation of the new K-Factor.

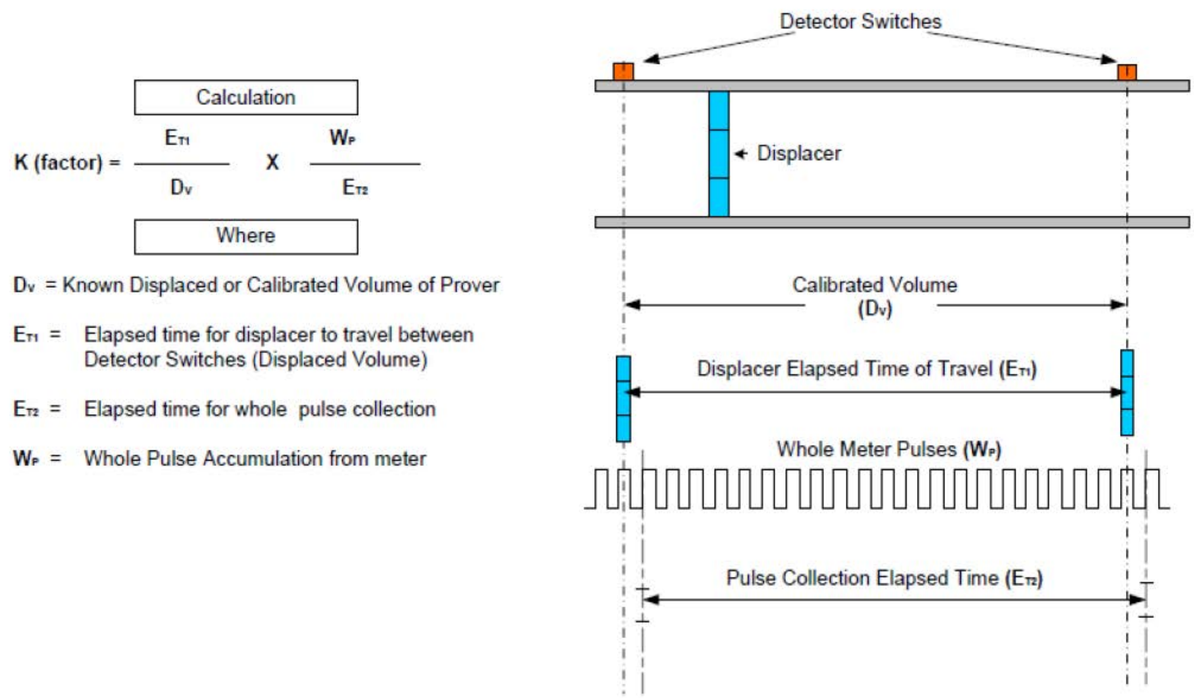

Figure 9: Double Chronometry Pulse Interpolation Formula and Diagram

Industry acceptance of multi-pass runs for proving allows for adjustment in repeatability limits while still meeting ± 0.0027% uncertainty helped tremendously in allowing for use of the SVP when using the newer technologies like Coriolis and Ultrasonic and their manufactured pulse signals. (API Chapter 4, Section 8, Appendix A and Chapter 12, Section 2, Part 3 address the issue of multi-pass uncertainty limits.) All meter models and sizes can now be easily verified by the SVP to an acceptable repeatability value more efficiently and faster than using a bidirectional pipe/ball prover. Allowing pipeline operators the opportunity to make multiple proving passes while increasing the limits of repeatability while still maintaining the ± 0.027% uncertainty level required in the industry.

Small Volume Prover Sizing

As previously explained small volume provers work with all meter technologies. However, when pairing a meter and a prover, the methodology for sizing varies with the selected meter technology. In addition to the meter technology the system characteristics such as fluid dynamics through piping, valves, and pressure control devices also all play into the system optimization. The following sizing methodologies provide a basis for sizing but ultimately a thorough review of the system should be conducted with both the meter and prover manufacturer to verify sizing.

In order to understand the various sizing methods, several terms must also be discussed. Figure 10 represents a typical flow rate chart during a SVP sequence and also helps explain some of these terms. Various manufactures may reference other terms such as total prove time (TPT), runs required, or prove time – these are all further calculations based off the terms below. While okay to consider these other terms it must also be understood that they do not take actual process conditions into to account and are only guidelines or predications of proving time or passes, not expected results.

Pre-Run Time

- The time from the initiation of the piston traveling downstream to the first detector switch.
- Flow disturbance needs to be processed by meter/transmitter before first detector switch is seen and during this time.
- Time is a factor of both flow rate and poppet closing speed.

Flight Time

- The time between detector switches or the time meter pulses are being recorded by the flow computer.
- Need to achieve the recommended number of meter pulses as recommended by the meter manufacturer.
- Time is a factor of flow rate and prover volume.

$$Flight\ Time = \frac{Base\ Prover\ Volume\ (BPV)}{Flow\ Rate}$$

Equation 3: Flight Time

Meter Tube Velocity

- Flowing velocity of the fluid traveling through the meter.
- This a factor of flow rate and meter tube design.

Figure 10: Pre-Run and Flight Time During SVP Sequence

Traditional Turbine Sizing:

Typically, small volume prover rated flow rates or published flow rates are stated under the assumption that a traditional tubing meter will be used. This sizing is based on the allowable velocity through the meter and the mechanical design of the prover. SVP manufacturers also typically consider a piston velocity between 5 ft/sec and 10 ft/sec for use with the meters.

If parameters lead to times less than the below, further consolation with the meter and prover manufacturer should be completed.

- Shortest flight time is typically 0.5 sec
- Min pre-run time is typically 0.25 sec

PD Meter Sizing:

PD meters follow the same velocity principles as traditional turbine meter sizing, with one major exception. If a PD meter is configured with whole barrel gearing, it must be paired with an SVP that has a calibrated volume that is also in whole barrels.

If parameters lead to times less than the below or a non-whole barrel SVP, further consolation with the meter and prover manufacturer should be completed.

- Shortest flight time is typically 0.5 sec
- Min pre-run time is typically 0.25 sec
- PD meters in whole barrel gearing must be paired with a whole barrel prover

Helical Turbine Meter Sizing:
A helical turbine meter will output a relatively number of pulses per pass compares to a traditional turbine meter. 25-35 meter pulses per pass is a relatively good role of thumb. This can vary based on the helical turbine's pulses/unit volume (K factor). Pulse stability will also affect this: process conditions, number of meter runs and flow control. If a prover and helical turbine meter combination produce less pulses per pass than 25-35 pulses, further consultation should be done with the meter and prover manufacturer.

Coriolis Meter Sizing:
Field testing has shown down to 0.8 second flight time can work with most Coriolis meters. This can require pass averaging and factors such as flow stability and the number of meter runs all play into the compatibility. 0.8 second flight time is a typical industry minimum while 1.0 second and greater flight time is ideal for fewer runs and the potential for adverse flow conditions. Consultation should be done with both the meter manufacturer and prover manufacturer along with analyzing the metering layout.

Ultrasonic Meter Sizing:
Varied results based on ultrasonic meter manufacturer and turbulence conditions as shown in Figure 11. In all meter proving situation you want laminar flow, but this is even more critical in ultrasonics. In general anything below a 1.0 second flight time should be further analyzed. As shown, in Figure 11 various properties of the ultrasonic such as number of beams, bore reduction, and flow conditioning all have major effects on deviation or repeatability.

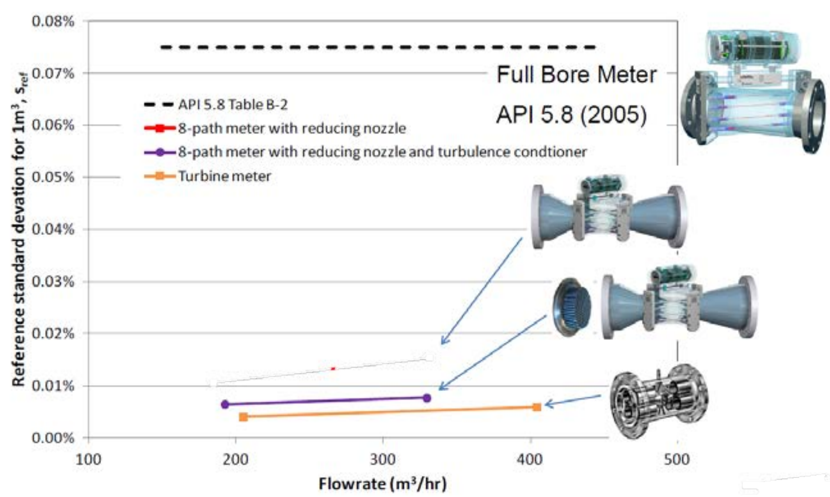

Figure 11: Ultrasonic Meter Sizing

Mass Proving and Proving Liquified Gasses
Becoming ever more popular in the world today are the liquification of gasses for transport. Liquefying gasses requires either extremely high pressure or low temperature of the gas for it be maintained in a liquid state. The technology now exists to prove these liquified gasses in pressures up to 1500# and cryogenic temperatures down to -265 degrees Fahrenheit. Liquified gasses are also typically measured

by mass or under a mass flowrate and associated with Coriolis meters. When flowing with a mass flowrate, the prover volume must also then be converted to a mass.

Coriolis Meters are not a direct volume measurement device and use the Coriolis effect on a vibrating tube of the liquid or gases flowing to measure mass direct. Any prover is volumetric device and requires either the Coriolis meter to be converted to a volume or the prover volume to be converted to a mass. For this reason the density of the fluid musty be verified and this is typically done with a density meter and pycnometer as shown in Figure 12. In this setup the densitometer reads live density while proving and the pycnometer is used for manual density verification before proving in which the fluid is weighed on a scale to verify density.

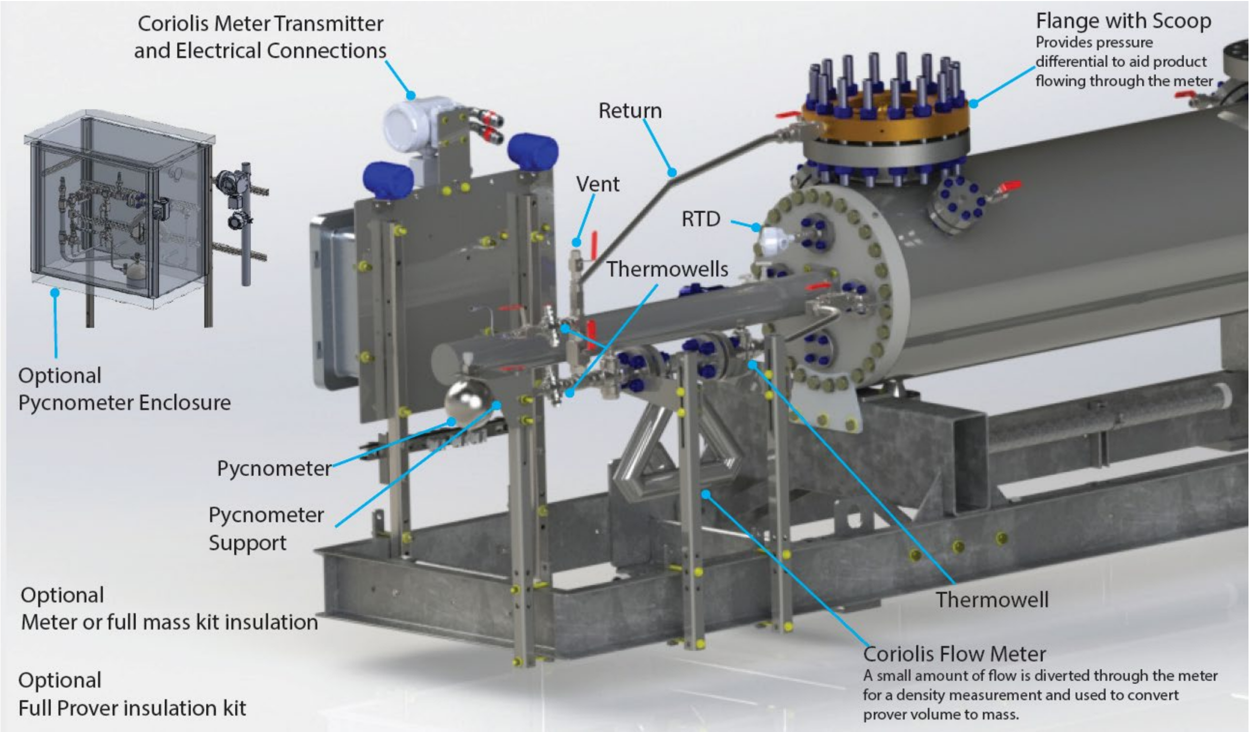

Figure 12: Mass Prover Setup that Includes a Densitometer and Pycnometer

Some general installation recommendations of the mass prover setup include Installing the densitometer and pycnometer downstream of prover (not between meter and prover) to limit the leak points and not cause adverse flow conditions. It is also recommended to have a valve between the density loop outlet and the return manifold back to the main process. This valve placement is shown in the P&ID in Figure 13 below. The valve placement as per this allows for a slight closure of the valve to help force flow through the density loop and obtain the recommend flow rate through the densitometer.

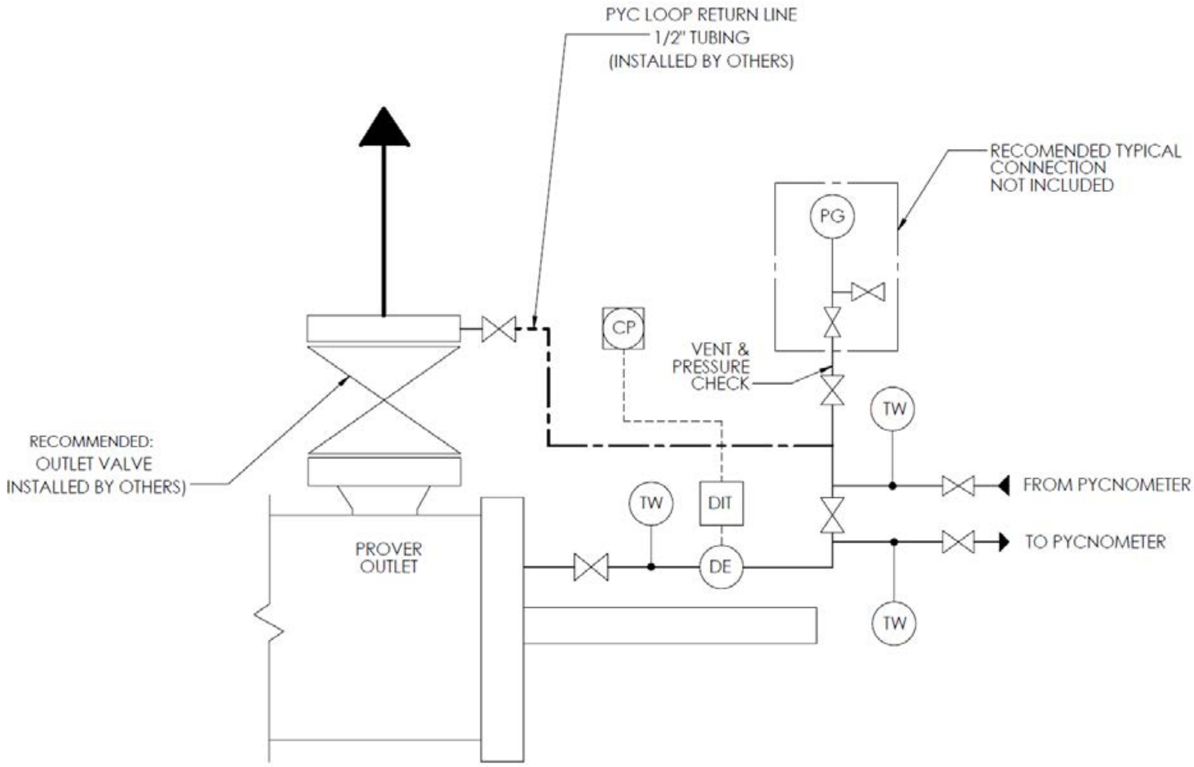

Figure 13: Mass Prover Density P&ID

Low Temperate Proving:
As mentioned previously, the technology now exists to prove cryogenic liquids with temperatures down to -265 degrees Fahrenheit. SVPs are the ideal proving choice for these fluid characteristics with their compact design and ability to custom fit them with attributes required for low temperature.

Due to the extreme low temperate and to prevent frost build up on parts, a nitrogen purge coverset or blanket is recommended for cryogenics. This is recommended for any application with a process temperature below -50 degrees Fahrenheit The details of this purge coverset are shown in Figure 14. Standard insulation is also applied over the flow tube and any piping with the recommendation of low temperature bolting as well.

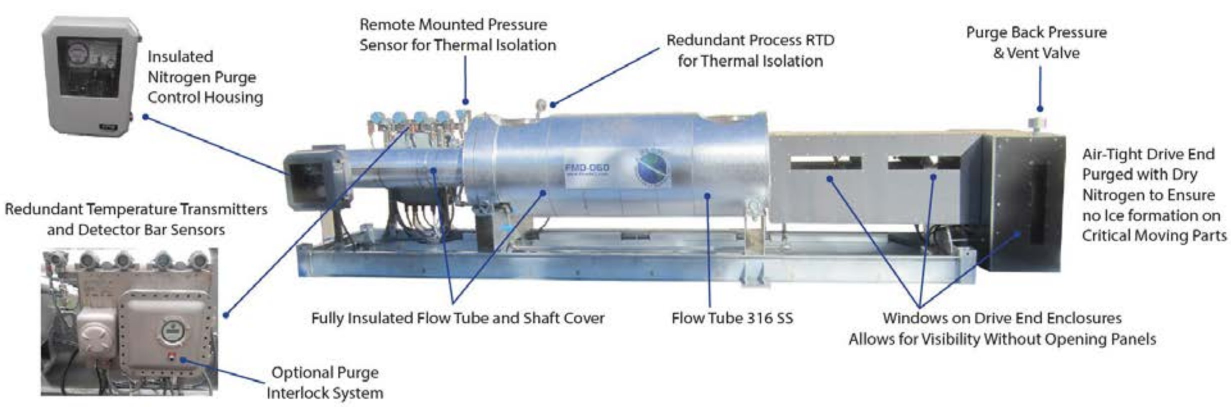

Figure 14: Purge Coverset Details on an SVP

Groups and Agencies that Govern the Proving Processes:
The American Petroleum Institute (API), International Organization of Legal Metrology (OIML), and National Institute of Standards and Technologies (NIST) oversee the meter proving process generally. There are global requirements and regional requirements to be aware of and the specific regulations or standards for each country, providence, state or city where measurement equipment and measurement verification devices are used must be taken into account. Noted below in the reference sections are documents that should be evaluated when proving meters and for the operation and design of verification equipment and systems.

Summary:
The best way to minimize losses and maximize profitability for a liquid metering application is periodic meter verification or proving. This includes evaluating the accuracy and repeatability of the system through the complete flow range. There are many options for using a proving device and all influences like accuracy, flow rates, measurement turndown, environment, installation and operational costs, local agency acceptance should be part of that decision. There are applications for every type of proving device and the information provided here offers guidance for proving devices.

References:

American Petroleum Institute, “Manual of Petroleum Measurement Standards,” Chapter 4, “Proving Systems”, Section 1, “Introduction”, Section 2, “Displacement Provers”, Section 4, “Tank Provers” Section 5, “Master-meter Provers”, Section 6, “Pulse Interpolation”, Section 7, “Field-standard Test Measures”, Section 8, “Operation of Proving Systems”Section 9, “Calibration of Provers”.

American Petroleum Institute, “Manual of Petroleum Measurement Standards Chapter 9—“Density Determination”, Section 3—“Standard Test Method for Density, Relative Density, and API Gravity of Crude Petroleum and Liquid Petroleum Products by Thermohydrometer Method”

American Petroleum Institute, “Manual of Petroleum Measurement Standards Chapter” 12 “Calculation of Petroleum Quantities”, Section 2—“Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors “, Part 4—Calculation of Base Prover Volumes by the Waterdraw Method”.

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