Dynamic Liquid Measurement - Meter Proving Operations (Ch. 4)
What is Proving?

- Defining Proving involves explaining meters
  - Meters indicate flow based on the effect the fluid has on the “meter”
  - For some types it is change in pressure (orifice)
  - For some it is transfer of momentum (turbine)
  - For some it is linear velocity (ultrasonic)
  - In all cases, the function is not “purely” mathematical and some adjustment factor is required.
Metering and Proving – Two parts of the same operation

- Calibration and Proving are the same thing – “proving” is the word traditionally used in the metering standards
- Generally all meters require calibration
  - More precision requires more or more precise calibration
  - How often to calibrate is a function of desired precision, meter stability, tolerance of risk, value of the material, and cost
  - The best program considers all of these factors
Proving is a simple experiment

- Proving is a simple experiment to measure a known volume (or mass) with the meter
- Volume of the prover is established using defined, traceable protocols
  - Multiple runs that can vary within certain criteria
  - Data acceptance criteria or outlier tests
  - Averaging of results
  - Standardized reporting of results
- The procedure for proving is described in detail in MPMS 4.8
Provers take different forms but all represent a known volume

- Tank Provers
  - Simplest, direct volume container
- Displacement provers
  - Volume of a pipe
- Master Meters
  - Volume of a prover as transferred by the master meter

All the above methods have advantages and disadvantages, and can give acceptable results if done correctly and in the right service.
**Tank Provers**

- The most fundamental way to describe a fixed or known volume
- Slower to use and tends to generate more downgraded slop
- A traditional method but becoming less common as jurisdictions allow newer methods
- Generally sized to hold 2 minutes of flow, so can become unwieldy for larger flows
- Inherently requires starting and stopping the meter and the delivery service
- Definitely not the preferred method for some kinds of services
- MPMS 4.3 covers tank prover design and use.
Typical Fixed Location Tank Prover

- Sealing wire and seal
- Gauge glass and scale
- Overlapping gauge glasses
- Sealing wire and seal
- Temperature sensor
- Splash dome (optional)
- 0.5 percent of prover volume
- Calibrated volume
- 0.5 percent of prover volume
- Cone bottom, dish bottom (optional)
- Alternate gauge-glass zero design for bottom of tank
- Gauge glass
- Location of starting level (optional)
- 0.5 percent of prover volume
- Drain for calibration purposes and for zeroing liquid level
- Inlet or discharge
- Bottom valve must be in vertical line
- Check drain
- Discharge
- Bottom inlet (optional)
Displacement Provers

- The known volume is contained in a specific length of pipe between two detector switches
- Number of meter pulses (or volume) counted between a displacer tripping first one switch then the second switch
- Displacers can be a ball, cylinder, or piston
- Considered by many to be an excellent proving method
- Allows proving during continuing delivery operations, faster, consistent
- Standards no longer make a distinction between types of displacement provers, only in their size relative to the meter the prove
- API MPMS 4.2 covers displacement provers
Typical Bidirectional Ball Prover
Master Meters

- Master meters are high grade meters that have been carefully proved using displacement or tank provers.
- By running the master meter in series with the meter being proved, a comparison can be made.
- Very practical in some services for the small space and rapid proving allowed.
- Often used in truck racks to allow proving during the actual loading of trucks.
- Does require that the master meter be proved on a fluid that gives a representative meter performance.
Pulse Interpolation

- As everything becomes smaller how does one ensure that precision is not compromised
- API discrimination criteria for proving has traditionally been 1 part in 10,000
  - Required a prover that was large enough that the meter generated at least 10k pulses for each pass
  - Technology improvements made the 10k limit obsolete
  - High speed clocking allows the initial and final partial pulses to be “split” or interpolated, to a much higher precision than 1:10k making small provers practical
- The practical limit on smaller provers is reached by process stability not the ability to discriminate pulses
- API MPMS 4.6
Field Standard Test Measures

- How is the prover volume determined reliably?
  - Individual small measures are calibrated by national labs and then used to calibrate the provers
  - Range in size from very small up to about 2000 L
  - Always calibrated with water
Operation of Proving Systems

- The procedure is to run the meter while in series with the prover (for any type) counting the pulses between the prover switches.
- Both the prover and the meter are adjusted to standard conditions.
- The prover volume divided by the meter indication gives a “meter factor”.
- API standards give various criteria for acceptance of proving runs but they are generally set around meeting mutually agreed uncertainties.
- Repeatability is an often quoted term in meter proving, defined as the range of the pulses divided by the lowest number of pulses, this is a traditionally used measure of the scatter in the results.
- Some newer types of meters actually prove more reliably with a greater number of runs with wider repeatability tolerances.
- API MPMS 4.8
Calibration of Provers

- General procedure for tank and displacement provers is to be calibrated on a 3 to 5 year cycle
- Master meters require more frequent calibration
- Historically most provers have been calibrated using water to about 0.02% repeatability, but newer calibration methods using the service fluid is becoming much more popular
- Actual calculation of the volumes is covered by the calculation chapter of MPMS, API 12.2
Waterdraw Prover Calibration

- To calibrate the prover, water is pumped through the prover and into field standard test (FSTM) measures.
  - Prover needs to be cleaned of all hydrocarbons first and then piped to the water draw trailer
  - The water is circulated in a loop through the prover to stabilize the temperatures, then as the first detector switch is tripped the water from the prover is routed to the largest of the FSTM.
  - As each measure is filled, the flow is sequentially routed to the next and smaller measure, until the last smallest measure (often a graduated cylinder) until the second switch is tripped.
  - Measurements of the water temperature allow the liquid and FSTM volumes to be adjusted to standard temperature.
- API MPMS 4.9.1, 4.9.2,
Displacement Prover Calibration by Master Meter

- The newest prover calibration method involves determining the prover volume with the actual service liquid in the prover.
  - No (or less) cleaning required
  - Much shorter downtime
- A very precisely calibrated Master Prover and Master Meter are used.
- The service fluid is passed through the master meter and the master prover and the prover at the same time.
- The master meter is used to “transfer” the calibration from the master prover to the prover being tested.
- A master meter is never used by itself to calibrate the prover.
- API MPMS 4.9.3
Gravimetric Prover Calibration

- Gravimetric proving is much less common for meters except for field standard test measures
- It is starting to be used more frequently for coriolis meters
  - Often factory calibrated using water
  - Has been used for propane and asphalt truck loading meters
- API MPMS 4.9.4
## Manual of Petroleum Measurement Standards Chapter 4

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