CONVENTIONAL LIQUID METER PROVERS – DESIGN AND CONSTRUCTION

I. Meter Prover Definition

Liquid Flow Provers are defined as a "Known Traceable Volume" which is used to verify and establish a meter factor during actual flowing and operating conditions. (Traceable to NIST)

II. Types of Conventional Meter Provers

A) Bidirectional Prover (pipe prover): A positive displacement type prover with flow and displacer traveling in both directions by means of a 4-way diverter valve.

B) Unidirectional Prover (pipe prover): A positive displacement type prover with flow and displacer traveling always in one direction, by means of a transfer chamber, or interchange.

C) Volumetric Tank Prover: As the name implies, this prover is a calibrated tank or vessel with a sight gauge and scale to read a metered volume. The flow must be stopped to determine the volume.

III. Principle of Operation of a Positive Displacement Meter Prover

We will use bidirectional provers as the example for most items. (Please see the drawing attached)

A) To prove a meter, flow is established though the meter then to the prover via the prover manifold valves.

B) Flow goes into the 4-way diverter valve and forces a sphere displacer into the pipe section, which seals against the pipe walls.

C) The displacer passes between two detector switches. The volume between switches is known as the "calibrated volume." This volume is compared to the volume indicated by the meter, to determine a meter factor.

$$\text{Meter Factor} = \frac{\text{Actual Volume (Prover)}}{\text{Metered Volume (Meter)}}$$

IV. Design of Meter Provers

A) Parameters Required for Prover Design
   1) Service
      a) Products
      b) Pressure and temperature
      c) Gravity
      d) Viscosity
      e) Maximum & Minimum Flow Rate

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2) Meter(s) to be proved
   a) Minimum pulses per unit volume, or "K" factor (e.g., 1000 pulses per BBL).

3) Design Specifications and Codes
   a) ASME/ANSI B31.4 Pipeline (mechanical design)
   b) ASME/ANSI B31.3 Refinery (mechanical design)
   c) Material Specifications
   d) Electrical Classification
   e) ANSI Pressure Rating
   f) Space Limitations
   g) Automation
   h) Prover configuration, (e.g., aboveground, portable, etc.)

API Chapter 4 Proving Systems, Section 2 – Conventional Displacement Type Pipe Provers, is the industry standard for prover design, calibration, and recommended practices.

B) <u>Sizing and Volume Requirements</u>

1) Prover <u>sizing</u> is determined by Maximum and Minimum Sphere Velocities

Maximum: Unidirectional - 10 ft/sec.
Bidirectional - 5 ft/sec. or higher. (see API 4.2)

Minimum: depends on lubricating properties of the product
--low velocities may cause sphere to jerk or surge
Recommend 1.0 ft/sec. min.

See API Chapter 4, Paragraph 4.3.4

2) Prover <u>volume</u> is determined by:
   a) API specifies "the accumulation of 10,000 unaltered meter pulses between detector switches." (see e. below)
   b) Meter "K" Factor (or pulses per unit volume).
   c) Repeatability of the detector switches and system.
   d) Prover counter resolution
   e) Use of Double Chromometry to allow use of Reduced Volume Provers

A prover must be capable of repeating the volume between detector switches by 0.02 percent. (By Water-Draw Calibration)

Prover sizing and Volume must be considered with other factors to have a "Realistic Prover Design", e.g.:

Space Available
Costs
Meter Selection and Pulses Transmitted
Product service
Etc.

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C) Pre-Run Length

A prover must have a sufficient pre-run length from the launch chamber to the first detector switch to allow the 4-way diverter valve to cycle completely and seal properly before the displacer triggers the first detector switch. Also allowing the displacer to reach uniform velocity.

V. Prover Construction and Components

A) Pipe: Pipe should be free of defects, dents, scratches or rust pits. Pipe should be hand-picked for uniformity and roundness.

B) Flange Seats: Flanges in the calibrated section are match-bored, machined with O-Ring grooves for sealing, and dowel-pinned.

C) Launch Chambers: The pipe section prior to the pre-run and calibrated section is used to launch and receive the sphere. Launch chambers should be two pipe sizes larger to allow flow by-pass around the sphere and allow the sphere to decelerate. Also allowing easy sphere removal with the use of quick opening closures. Launch chambers can be horizontal, vertical, or inclined.

D) Sphere and Accessories: Inflatable sphere displacers are the most common used. The sphere is normally inflated from 2% to 4% larger than the prover pipe inside diameter. The sphere is filled with 50/50 mix of glycol and water. Proper inflation and roundness are vital for sealing and repeatability.

Sphere Materials Available:
1) Neoprene
2) Nitile
3) Urethane (most commonly used and can be purchased in various durometers)

Sphere Removal Tools
Pumps & Inflating Kits
Sizing Rings

E) Detector Switches: Detector Switches are used to gate the pulse counter. Detector switch repeatability is crucial in determining the prover volume and in turn proving a meter.

The most common switch is a Mechanical Actuated Electrical type, such as our Mag-Tek M-6, which has a plunger inserted into the pipe. The sphere passes under the plunger to raise and make the switch or contact. These switches are all pressure balanced so pressure forces are not a factor.

F) Diverter Valve: Bidirectional provers utilize a 4-way diverter valve. This valve is ported to allow flow to enter one launch chamber and exit the opposite, and by cycling the valve the flow direction is reversed. All 4-way valves are designed for speed and seat seal integrity. Valves should be equipped with a means of checking the seal for leakage (e.g., Block and Bleed Port, DP Gauge or Switch).

G) Diverter Valve Operator: Most diverter valves are equipped with actuators to automate the prover operation. These can be electrical, hydraulic, or pneumatic. Electric operators are the most commonly used. Manual handwheels, with latching mechanisms, are used on smaller systems.

H) Internal Coatings: Internal coatings are applied to the prover for two main purposes:

1) Protect the pipe from corrosion and pitting which can cause repeatability problems.

2) Provide a smooth uniform surface for the sphere to travel in, and ensure a good seal with stable movement without surges or jerks.

Common Types of Coating:
1) Air-Dried Epoxy
2) Baked-On Phenolic
3) None – Bare (crude service)

VI. Prover Accessories and Trim:

1) External Paint and Insulation
2) Drain Valves, Block & Bleed Type or Arrangement
3) Pressure Gauges
4) Thermometers
5) Pressure Relief Valve
6) Pressure and Temperature Transmitters
7) Field Calibration Connections
8) Sphere by-pass for Vertical Launch Chambers
9) Skid Mounted
10) Vent Valves

WeamcoMetric always specifies and uses good quality Accessories and Trim equipment.

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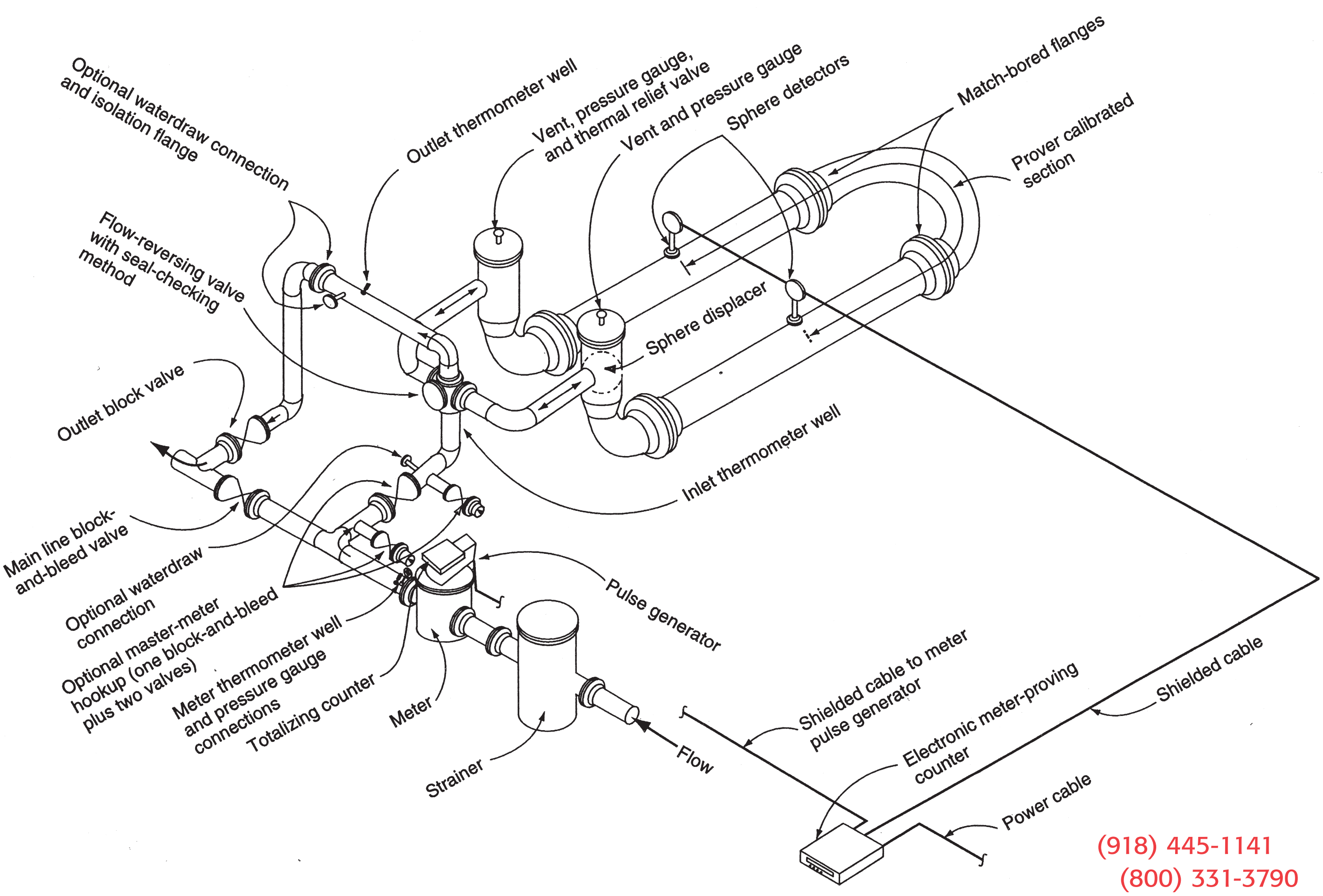
VII. Calibration

Prior to placing a prover into service, a Base Prover Volume must be determined. This is done by a water-draw calibration as outlined in API Chapter 4, as previously mentioned, and API Chapter 12, Section 2, Part 4. The calibration also verifies that all components are sealing properly and are in working condition.
The calibration is completed using field measures, thermometers, and gauges that are traceable to NIST, per API Chapter 4.7.

VIII. Summary

Conventional displacement type pipe provers are the most commonly used and accepted method of meter proving. Care of details in design specifications, construction, and calibration are essential to the proper functioning of a complete measurement system.

IX. Please use our "Prover Data Sheet" for your Inquiry or Purchase Order. This will allow us to propose a more detailed offering for your application.



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TYPICAL METER PROVER SPECIFICATIONS AND OPTIONS

Design and Construction:
API Manual of Petroleum Measurement Standards, Chapter 4.2 Proving Systems, ASME/ANSI B31.4, ASME/ANSI B31.3.

Radiography:
Spot or 100% in accordance with API 1104.

Hydrotest:
1.5 times design pressure with chart recording.

Inspection Flanges:
Match bored, dowel pinned and O-ring groove for metal to metal seat.

Materials:

Pipe - ASTM A-106/53-Gr B Seamless (to 24” size)

Flanges and threaded fittings - ASTM A-105

Weld fittings - ASTM A-234 WPB

Studs - ASTM A-193-B7

Nuts - ASTM A-194-2H

Gaskets - Spiralwound, 304SS

O-Rings - Viton

Calibration:
Water draw method, repeatability within 0.02 percent per API Chapter 4.2 and Chapter 12.2.4.

Internal Coating:
Sandblast to white metal and 5 to 7 mils air dried epoxy or baked on phenolic.

External Coating:
Sandblast to white metal and one coat zinc chromate primer.

Standard Equipment and Trim:

Four way diverter valve with viton seals and differential pressure gauge

Detector switches - Mag-Tek M-6, SS construction with viton seals

Valve actuator - Electric Class I Group D Div II or manual handwheel

Sphere - Inflatable polyurethane, nitrile, or neoprene with accessories (pump and sizing ring)

Quick opening closure, hinged or davit type

Thermometers - mercury in glass with 0.20ºF divisions and SS thermowells

Pressure gauges with isolation valves

Pressure relief valve

Vent valves

Drain valves

Semi-skid beam supports

Other materials and options available.

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