FLOW MANAGEMENT DEVICES

Fundamentals of Meter Provers and Proving Methods

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Flow Management Devices

SERVICE, EXPERIENCE, INNOVATION & EXCELLENCE

FLOW MANAGEMENT DEVICES

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Presentation Content

- **Fundamentals of meter proving**
  - **Definitions**
  - **What is Meter Proving?**
  - **Why Do We Prove?**
- **Meter proving techniques and characteristics**
  - **Tank Provers**
  - **Weigh Scale (Used for Meter Calibration)**
  - **Master Meter**
  - **Displacement Ball Provers**
  - **Uni-Directional Captive Displacement or Small Volume Provers**

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API Definitions

- **Calibration:** The procedure used to determine the volume of a prover.
- **Meter proof:** The multiple passes or round trips of the displacer in a prover for purposes of determining a meter factor.
- **Meter prover:** An open or closed vessel of known volume that is used as a volumetric reference standard for the calibration of meters in liquid petroleum service. Such provers are designed, fabricated, and operated within the recommendations of **API Chapter 4 MPMS's**.
- **Meter pulse:** A single electrical pulse generated by flow induced effects in the meter. The flow induced effects are normally caused by movement of physical elements within the meter's primary flow element but may be caused by other flow induced effects that are proportional to flow rate. The pulses produced by the meter shall not be multiplied to increase the number of pulses to conform to the requirements of Chapter 4.
- **Prover pass:** One movement of the displacer between the detectors in a prover.
- **Prover round trip:** The forward and reverse passes in a bi-directional prover.
- **Proving:** The procedure used to determine a meter factor.
- **Standard conditions:** ***60°F and atmospheric pressure***.

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What is Meter Proving

API Definition from MPMS 4.1.5

The purpose of proving a meter is to determine its meter factor, which is the number obtained by dividing the registered volume of the meter by the actual volume of liquid passed through a prover.

$$\frac{\text{Volume Register by Meter}}{\text{Actual Volume Passed thru Prover}} = \text{New Meter Factor}$$

The purpose of a meter factor is to correct a meter's indicated volume. Obtaining a meter factor is an essential step in calculating the standard net volume of a receipt or delivery of petroleum liquids.

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Why do we Prove?

Why do companies perform flow meter proving ?

Flow measurement systems are the **"cash registers"** for all petroleum operations.

What does it all mean ?

Simply stated.

Errors in meter factors can and will **generate enormous financial errors** in a company's invoicing in a very short period of time!

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Reasons for Meter Proving

A Prover is used for flow meter calibration to establish :

The meter's **meter factor** (Actual volume divided by indicated volume)

The meter's **Linearity** (Accuracy over the calibrated flow range)

The meter's **Repeatability** (Repeatable information under same conditions)

The meter's **K - Factor** (Pulses per unit volume)(Sometimes established by Mfg)

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General Considerations

API Definition from MPMS 4.1.5

All meters should be proved with the liquid to be measured and at operating flow(s) rate, pressure, and temperature.

This means the preferred way of proving a flow meter is installed and under actual operational conditions.

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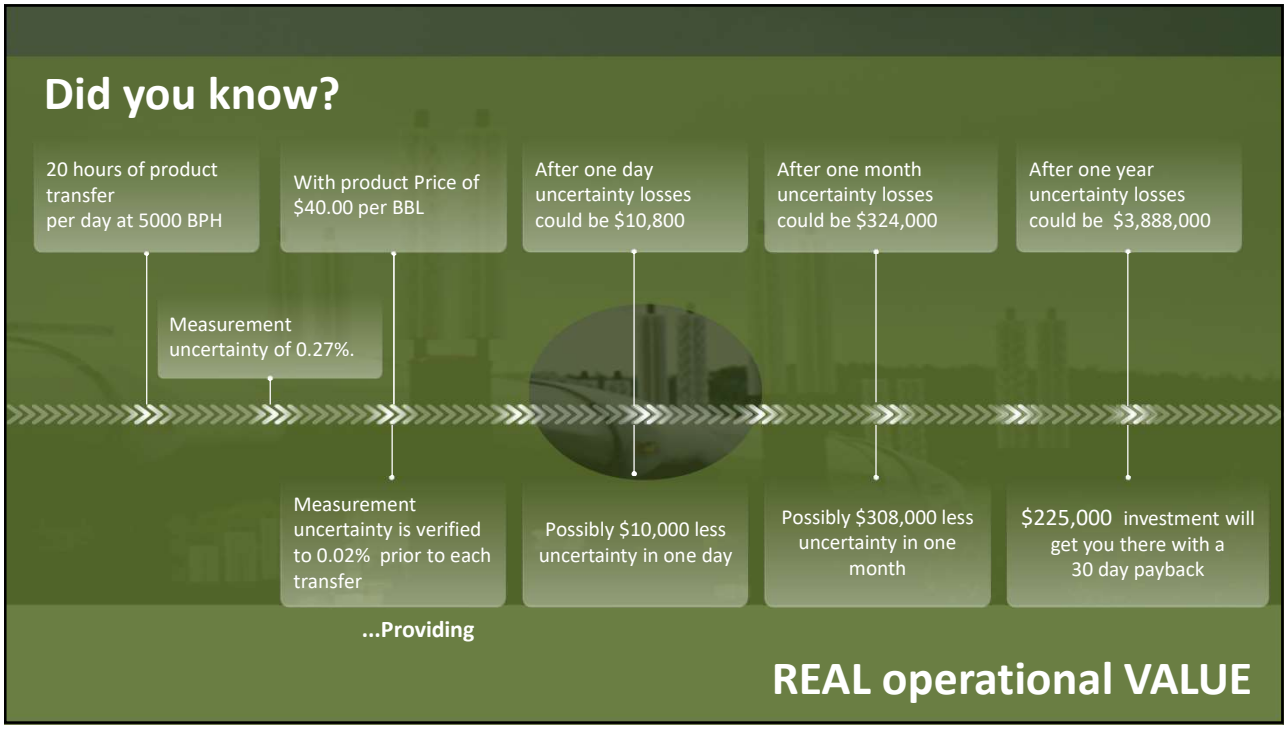

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Repeatability and Reproducibility

- Repeatability is the ability to obtain identical measurement results when a measurement is repeated under the same conditions several times in a row.

  Repeatability (%) = (Maximum – Minimum) / Maximum * 100%

- Reproducibility is the ability to obtain identical measurement results when a measurement is preformed under the same conditions at a later date, by other people or at a different location.

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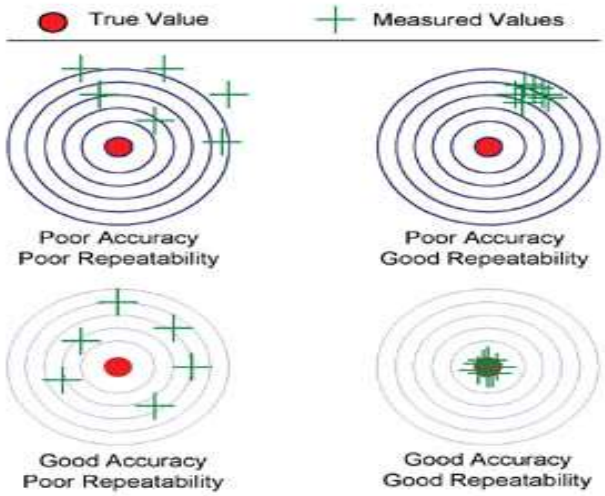
Definitions of Uncertainty



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API Chapter 4 MPMS's–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

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History of the Provers

- In 1930s
  - Volumetric tanks were used
- In the early 1950s
  - The first pipe Provers was a mile in length and linked two oil refineries
- In the late 1960s
  - A pipe Prover called a "small volume Prover" was developed that used an electronic pulse-counting technique called double chronometry
- In the late 1970s and early 1980s
  - Mechanical switches were replaced by more precision optical switches
- In 1996 changes were made to the terminology in NIST Handbook 44
  - "Liquid Measuring Device Code paragraph N.3.5. in order to allow the use of SVPs
- 1997 NIST Handbook 105-7
  - "Specifications and Tolerances for Dynamic Small Volume Provers" was published.

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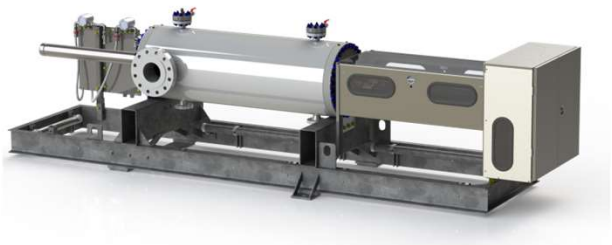
Volumetric Prover (1930 technology)

Ball Prover (1950 technology)

Unidirectional Captive Displacement Provers (Small Volume Provers)



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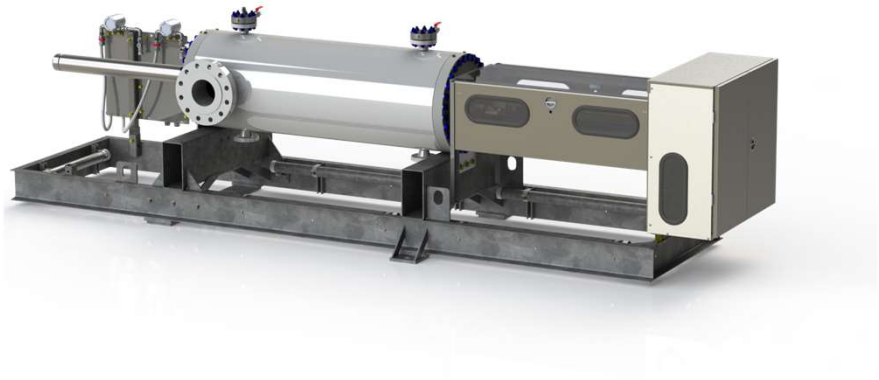
Uni-Directional Captive Displacement Prover



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Meter Proving Methods

Static Proving / Calibration

The proving is performed using a device designed to collect the discharged fluid from a flow meter in a container. The **fluid** is **measured** in a static condition.

- Calibration Can
- Weigh Scales

Dynamic Proving

The proving is performed with the fluid flowing through the flow meter and the **proving device**.

- Master Meter
- Ball Prover
- Small Volume Prover

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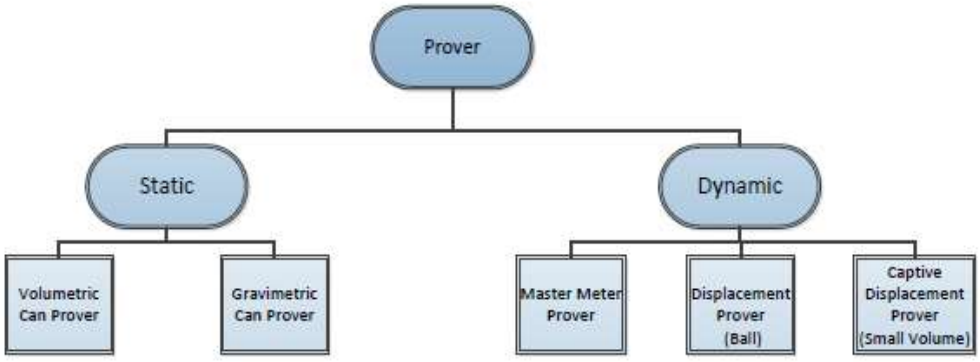
Overview Proving Methods



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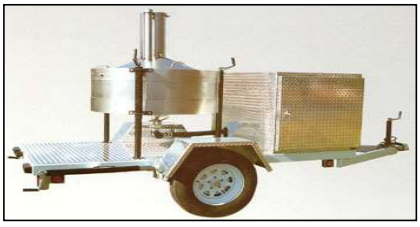
Tank Prover or Calibration Can

Prover Can



Portable Prover Can

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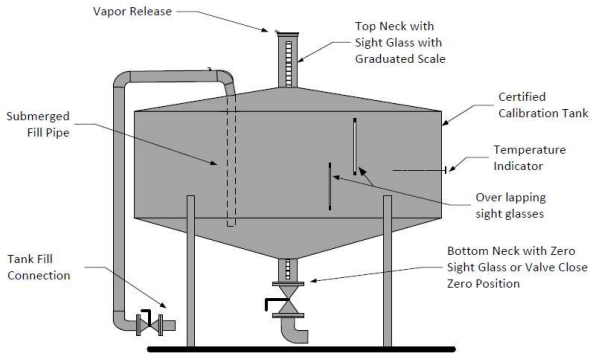
Tank Prover Components

Characteristics of Volumetric Meter Proving with Prover Can

- Size of the can determined based on the collection of **1 minute of flow**
- Prover "Can" – usually **1 to 1500 gallons** flow rate dependent.
- Relatively **Inexpensive**.
- High accuracy, **closer to national standard**.
- Used to **Volumetrically Water Draw other types of proving devices**.



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Weigh Scale

Characteristics of a Weigh Scale

- **Seldom used** (only when local regulations require it)
- **Scale installation crucial** (Placed horizontal and level)
- **External influences** to measurement (wind, temperature, location)
- Frequently **used in laboratories** to calibrate meters
- **High accuracy** closest to standards
- Used for **Gravimetric Water Draw for other types proving devices**

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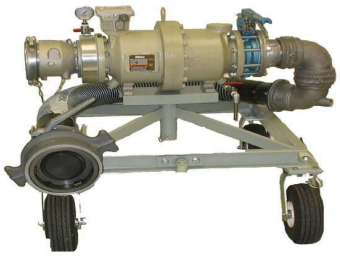
Master Meters



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Master Meters

Master Meter Characteristics

- Can be an **assigned meter** in a flow meter rack or **separate meter of a different technology.**
- Typical metering set up is using **combination of displacement prover and master meter.** Master meter is calibrated frequently and used to calibrate other flow meters.
- Typically, **PD-meters, turbine meters** and ultra sonic meters (in large sizes to prover other Ultrasonic's) are used as master meter.
- **An Indefinite volume** can be created **to gather required number of flowmeter pulses.**
- Relatively **Inexpensive.**

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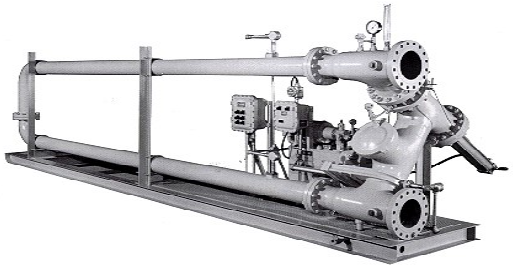
Ball Provers (Pipe Provers)



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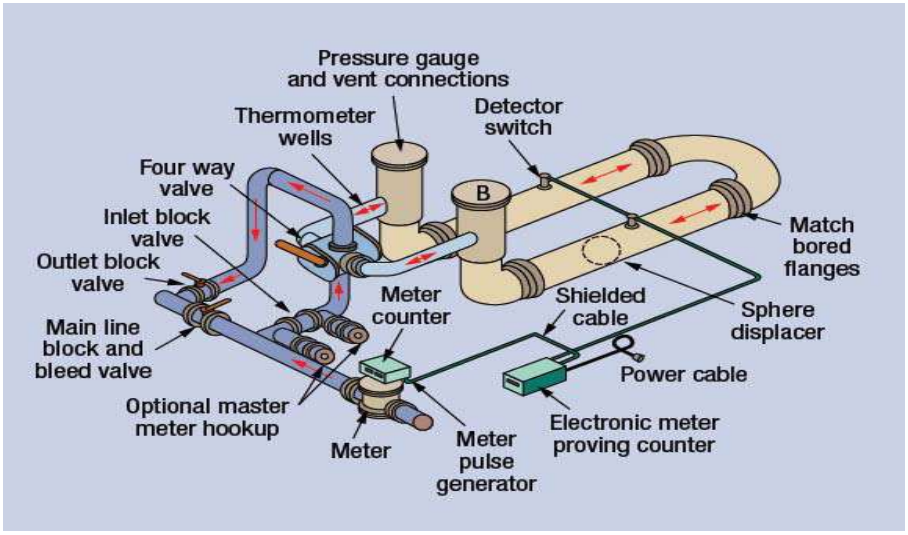
Pipe Prover Components



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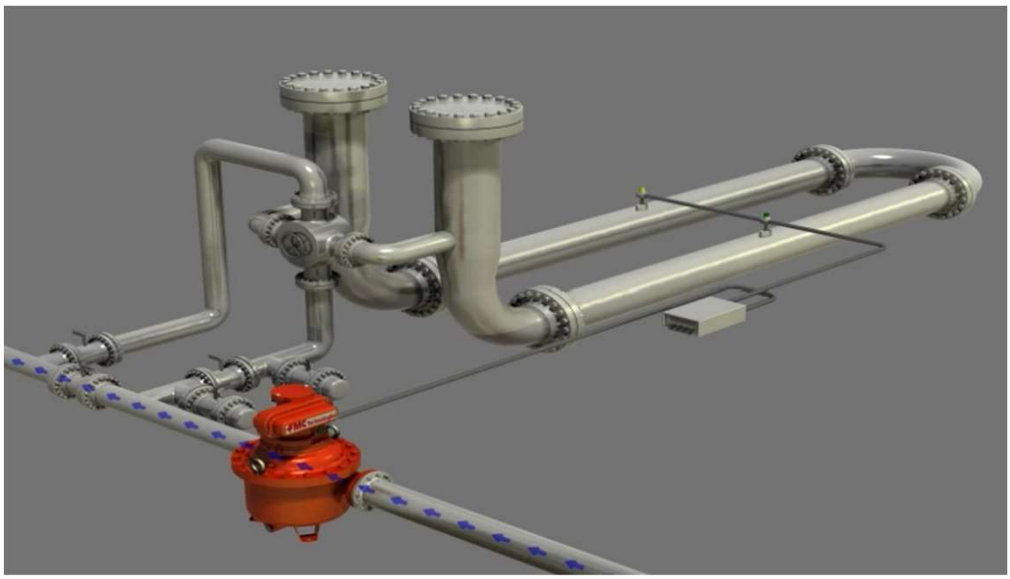

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Captive Displacement or Small Volume Provers

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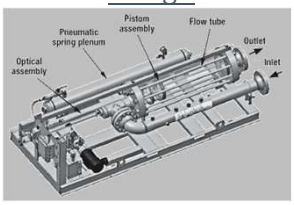
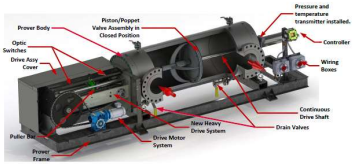
Uni-Directional Captive Displacement Prover

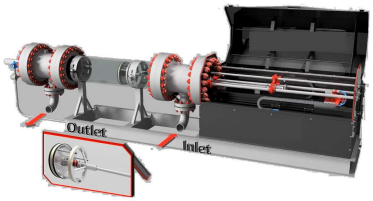
Hydraulic Drive Provers Design



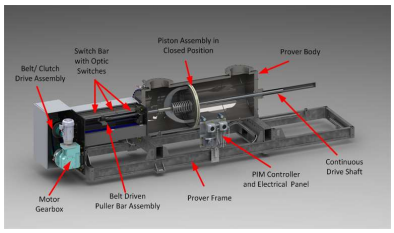
Chain Drive Provers Design



Magnetic Drive Design



Light Weight Belt/Clutch Drive



Improved Piston/Poppet Design

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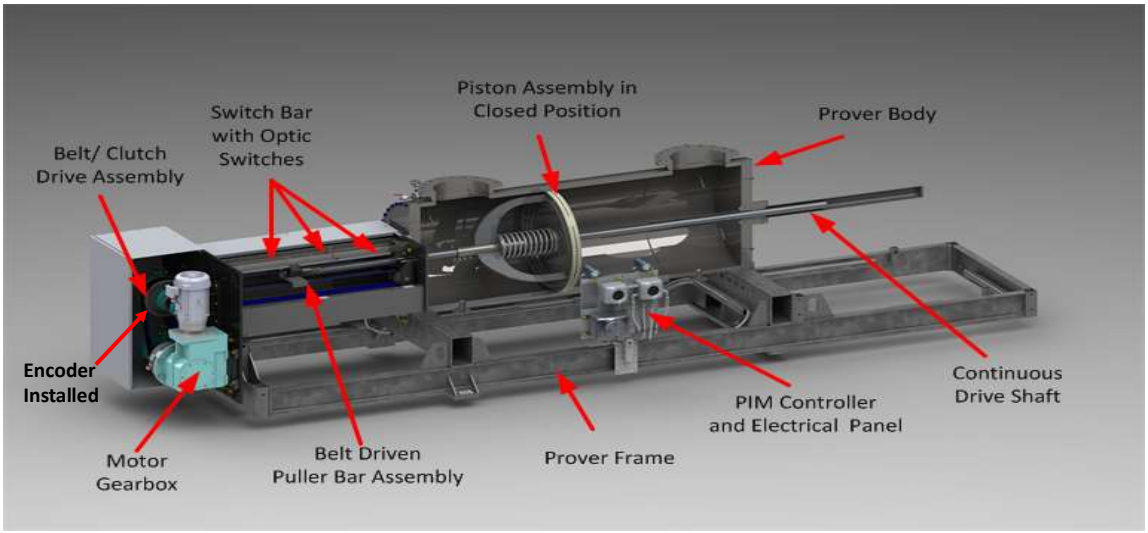
Prover Components



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Summary

Technique	Advantages	Disadvantage
Prover Can	Inexpensive Accuracy	Limited flow rate Unpractical large flow rates
Weigh Scale	Inexpensive Accuracy	External influences required enclosure if used in the field
Master Meter	Unlimited volume Inexpensive Closed system	Inaccurate Drift Range of products limited
Ball Prover	High flow rate Work on most liquids Closed system	Large footprint Maintenance sensitive Expensive
SVP	Works on all Liquids High flow rates and turndown Small Foot Print Closed system	Expensive “Thought to be Complex”

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Water draw of Provers

- To determine the **calibrated volume of a prover** a **water draw** is performed.
- Can be either **gravimetric** or **volumetric** water draw.
- Corrections are made for:
  - Corrections for liquid temperature to compensate for thermal expansion of used liquid
  - Correction for pressure of liquid to compensate for compressibility of the used liquid
  - Correction for temperature of switch bar material to compensate for thermal expansion of steel
- Uncertainty of water draw around 0.01%
- Repeatability better then 0.02%

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Volumetric Water Draw

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Gravimetric Water Draw

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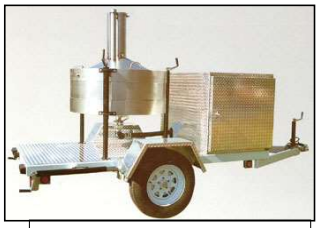
Portable Water Draw Options



Portable Volumetric

Portable Gravimetric

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Questions?

Thanks for your time!

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