Liquid Measurement Solutions
Custody Transfer & Fiscal Measurement

AGENDA

Crude Oil Value Chain
Why Measure/ Sample
Regulations, Codes & Standards
Key Functions of a Liquid Measurement System
Key Components of Systems Design
Primary Elements
Control System
Engineered Automated Measurement Systems

- Lease Automated Custody Transfer (LACT) Units
- Upstream
- Pipeline ACT Systems
- Marine Loading/Unloading Systems
- Bi-directional Meter Prover Systems
- Control Systems – Flow Computers, HMI, Supervisory
- Rail/Truck Unloading Systems
- Refinery Feed Systems
- Refined Product Pipeline Systems
Applications of Interest
Liquid Value Chain: Production, Transmission, Storage & Distribution

- Across the crude oil value chain from Production to consumer utilization
  - Onshore & Offshore Exploration & Production
  - Leased Automatic Custody Transfer (LACT) Units
    - First stage of custody transfer measurement from well pad
  - Gathering System Pipelines
  - Tank Terminals – Storage, Transmission Pipeline, Marine Transport
  - Refinery Feed Stock Measurement
  - Refined Product Measurement (Gasoline, Diesel, Aviation Fuel)
  - Industrial Consumers – Chemical plants, by-products
  - Retail Consumers (distribution)- Fuel
Why Measure & Sample?

- Low Uncertainty Measurement (quantity) and Sampling (quality) of Crude Oil
  - Field Production
  - Buyer/Seller agreement
  - Taxation & Royalties
  - Fiscal Allocation
  - Leak Detection
  - Pipeline agreements

- Key Considerations
  - Volume / Energy or Mass Measurement
  - Crude Quality, Energy content (sampling)

- Custody Transfer: Transfer of product from one party to another

- Fiscal Measurement: Measurement for Money

Quantity + Quality are Equal Components in Custody Transfer Measurement of Crude Oil & Natural Gas = MONEY
Liquid Measurement Station Functions
Measure, Prove, Sample & Control

➢ Metering – Product Quantity/Volume/Mass
  • To measure and report Volumetric or Mass Flow Rate
  • Typical System uncertainty +/- 0.25%

➢ Proving – Meter verification/calibration
  • To verify and calibrate the meter to ensure meter accuracy
  • Meter repeatability requirement is +/- 0.05% while proving

➢ Sampling – Product Quality, Energy/BTU content
  • To retrieve a representative sample from the flowing media based on volume or time.

➢ Control Panel – Flow Computers, HMI, Supervisory System
  • Graphic interface, proving valve sequencing, automated operation, reports, alarms, volume calculations, communication to DCS & company control room operators.
Industry Standards and Measurement Criteria Documents

- **American Petroleum Institute (API)**
  - Manual of Petroleum Measurement Standards (MPMS)
  - Ch. 1 Vocabulary (Definitions)
  - Ch. 4 Proving Systems
  - Ch. 5 Metering
  - Ch. 6 Metering Assemblies
  - Ch. 7 Temperature Determination
  - Ch. 8 Sampling
  - Ch. 12 Calculation of Petroleum Quantities
  - Ch. 21 Flow Measurement Using Electronic Metering Systems

- **International Standards Organization (ISO)**

- **Government Weights and Measures Requirements**

- **Company Specific Standards**
Metering Systems vs. LACT Units

- Designed to meter larger volumes of liquids
- Typically two or more operating meters; one stand-by meter
- Prover is part of the system (in-situ)
- Ability to expand or upgrade system
- Designed for accessibility for maintenance and verification
- Measurement Accuracy – Meters, Prover and Instrumentation
- API Manual of Petroleum Measurement Standards, Chapter 6, Metering Assemblies, Section 6, Pipeline Metering Systems (currently in revision as Section 2)
Liquid Metering System Applications

- Production
  - Wellhead, LACT Units
- Pipelines
  - Gathering, Transmission
- Marine Loading and Unloading
  - Oil Tankers on major waterways
- Floating Production, Storage, and Offloading vessel (FPSO)
- Refinery Feed / Output
System Design Criteria

- **Manifold Sizing**
  - Max Fluid Velocity 15 fps

- **Meter Run Sizing**
  - Max Fluid Velocity 30 – 40 fps

- **Valve Sizing**
  - Velocity typically limited to 20-22 fps

- **Piping Design Standard**
  - B31.3

- **Pressure Loss**
  - Sizing and types of valves, design of strainer, design of manifolds, consideration of product and meter technology

- **Access & Maintenance**
  - Ladders, platforms, handrails, spacing
# Measurement Station Checklist

**ENGINEERED MEASUREMENT STATION CHECKLIST**

## Process Conditions

Flowing Media to be measured: (Crude, LPG, Other - Please Specify):

<table>
<thead>
<tr>
<th>SG or Density:</th>
<th>Viscosity:</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>Flow Rate:</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Normal</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Operating Temperature:</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Normal</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Operating Pressure:</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Normal</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>ANSI Rating:</th>
<th>150</th>
<th>300</th>
<th>600</th>
<th>900</th>
<th>1500</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Flange Face:</th>
<th>RF</th>
<th>RTJ</th>
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Inlet/Outlet Manifold Piping Size:

<table>
<thead>
<tr>
<th>Valve Operators:</th>
<th>Manual</th>
<th>Electric</th>
<th>Hydraulic</th>
<th>Pneumatic</th>
</tr>
</thead>
</table>

TECHNOLOGY RELIABILITY EFFICIENCY INTEGRATION
## Measurement Station Checklist

<table>
<thead>
<tr>
<th>Electrical:</th>
<th>Class</th>
<th>Group(s):</th>
<th>Division</th>
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<tbody>
<tr>
<td>Power Available:</td>
<td>Voltage</td>
<td>Phase</td>
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<tr>
<td>Site Location:</td>
<td>Onshore:</td>
<td>Offshore:</td>
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</tbody>
</table>

### Inspection/Coating

**X-Ray:** 100% per API 1104:

**Hydrostatic:** Duration:

**Paint Specifications:**

### General

**Strainer Size:** Special Mesh Size: DP Gauge: DP Transmitter:

### Meter Type

**PD Meter:** Turbine: Coriolis: Ultrasonic:

**Preferred Meter Size:** Number of Meter Runs:

**Local Indication on Meters or Flow Computer Output:**

### Drain/Vent Piping Required:

**Drip Pans:** Grating:
# Measurement Station Checklist

## Meter Prover

<table>
<thead>
<tr>
<th>Portable Prover:</th>
<th>Bi-Directional Prover:</th>
<th>Small Volume Prover:</th>
</tr>
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</table>

## Samplers - Densitometers

<table>
<thead>
<tr>
<th>Air or Electric Sampler:</th>
<th>Size of Sample Container:</th>
<th>Brand of Sampler Required:</th>
<th>Densitometer Required:</th>
<th>Static Mixer:</th>
<th>Density Range:</th>
<th>Insertion or Line Mount:</th>
</tr>
</thead>
</table>

## Flow Computer/Instrument Panel

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## PLC (if required):  Allen-Bradley:  GE Fanuc:

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**Meter System Major Components**

- **Inlet Header** –
  - Distributes flowing product to multiple metering streams

- **Inlet Block Valves** –
  - Isolation of meter run from flow
  - Normally open; closed for meter run servicing
  - Typically gate valve or ball valve

- **Strainer** –
  - Filter debris
  - Protects meter, valves, prover
  - Sized for minimum pressure drop while
  - DP gauge or DP transmitter for pressure
Meter System Major Components
Primary Measurement Devices

- **Meter** – Primary measurement device, selected per application conditions
- **Ultrasonic Meters**
  - Latest technology, no pressure drop, no maintenance, very accurate, multi-viscosity meter, no moving parts, advanced diagnostics
- **Coriolis Meters**
  - No wearing parts, potential high pressure drop, wide turn-down, accurate
- **PD Meters**
  - Proven technology, very durable, very accurate, many moving parts, maintenance intensive
- **Turbine Meters**
  - Requires flow conditioning, sensitive to density and viscosity changes, very accurate
**Meter System Major Components**

- **Instrumentation**
  - Pressure & Temperature transmitters and/or gauges
  - Densitometer, viscometer, Reid Vapor Pressure (RVP)
  - Thermal relief and/or pressure relief valves

- **Flow Balancing or Flow Control Valves**
  - Balance flow through system’s multiple runs, especially when proving
  - Provides backpressure to prevent vapor breakout & cavitation
  - Butterfly or V-ball valves with actuation for control
  - Usually automatic control by supervisory system
**Meter System Major Components**

- Downstream Block Valves –
  - Prover manifold divert valves and outlet block valves
  - Positive shut-off, zero leakage, bubble tight, etc.
  - Double block and bleed plug valve with seal verification
  - Critical for accurate proving of meters
2. Provers (API MPMS Ch. 4)

- Bidirectional & Unidirectional Provers
- Captive Displacement Provers or Small Volume Provers
Bi-directional U-type Sphere Meter Prover
Basic Prover Design

- Pipe Schedule/Flanges
- Displacer Velocity
- Launch Chambers
- Volume Between Detector Switches
- Four Way Valve (Bi-Di)
- Valve Operator
- Pre-Run
- Detector Switches
- Sphere
- Coating
Max. $V = \frac{\text{BPH} \times 0.286}{(\text{I.D. (in)})^2}$

- $\leq 5$ fps for Bi-Di
- $\leq 10$ fps for Uni-Di

Min. Velocity $\geq 0.5$ fps

Example:

Max. Flow Rate = 2,500 BPH
Pipe Diameter = 12” (12” Sched. 40)

Max. $V = \frac{2,500 \times 0.286}{(12)^2} = 4.97$ fps
Launch Chamber

Closures:

- Blind Flange
- Quick Open Type

Launch Tube Diameter = $D + 2$ sizes

Prover Pipe Diameter ($D$)

$L = 3D$
Triple Run Liquid Metering System with Bi-Di Prover
480,000 BPD Crude Oil
3. Sampling Systems (API MPMS Ch. 8)

Jet mix sampling system
- Uncertainty +/- 0.025%
- Includes pipeline mixing with constant suction and high pressure pumping through nozzle.

Fast loop sampling system
- Uncertainty +/- 0.035%
- Requires external mixing

In-line sampling system
- Uncertainty +/- 0.118%
- Requires external mixing
Sampling cont’d
4. Control Panels

Weather Proof Panel – LACT Units

Automated Panel – Large metering stations Non-Hazardous Locations

Explosion Proof Panel
Class 1 Div 1 Applications
Fully Automated Control Panel

▪ Redundancy
▪ Flow control
▪ Automatic proving
▪ Meter linearization
▪ Customized reports
▪ Alarm systems
▪ Interface to other systems
▪ Enhanced safety and security
▪ Printers

Flow Computers
PLC
HMIs
Measurement System Testing

- Radiography
- Hydrostatic pressure test
- Point to Point Wiring
- Factory Acceptance Tests (FAT)
- Functional flow test – (metering, panel, prover)
- Water draw calibration - Prover
Chevron Agbami - Quad 12” 300# FPSO Tanker Loading Metering System
With Bi-directional Prover and Supervisory Control Panel
1,000,000 BBL/Day
Western Africa
Custody Transfer Measurement Station

Stampede – Offshore GOM
Double Deck, Triple Run FH Turbine Meter Skid with Bidi Prover, Sampling

- Clif Mock Sampling
- Deluge System
- HMI Supervisory System / Control Panel
  - Omni Flow Computers
  - AB PLC
  - Panel View HMI
Liquid Measurement Systems Design

Michael Frey
Area Flow Solutions Manager

Training Developed by [PRS and Measurement]
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