Static Liquid Measurement Standards

Tank Gauging (Ch 3)

Christian Skaug, Emerson
• Large storage tanks (65+ ft high, 160+ ft diameter)
• Think about Oil price @ ~100 USD / bbl
• Each mm is a lot of inventory value $$$$
• API standards

  – MPMS Ch. 2       Tank Calibration
  – MPMS Ch. 3.1A    Manual Gauging
  – MPMS Ch. 3.1B    Automatic Tank Gauging (Atmospheric)
  – MPMS Ch. 3.3     Automatic Tank Gauging (Pressurized)
  – MPMS Ch. 3.4     Automatic Tank Gauging (Marine, Atmospheric)
  – MPMS Ch. 3.5     Automatic Tank Gauging (Marine, Pressurized)
  – MPMS Ch. 3.6     Hybrid Measurements
  – MPMS Ch. 7       Temperature Measurements
  – MPMS Ch. 7.3     Automatic Tank Temperature Measurements
  – MPMS Ch. 11      Physical Properties Data (VCFs)
  – MPMS Ch. 12      Calculations
  – API 2350         Overfill Protection
  – ...
The API standards typically covers:

• Equipment requirements
  – Design
  – Performance

• Installation guidelines for best measurement result in the field for different applications (best practice, considerations...)

• Procedures

• Physical Properties Data and Calculations

Best practices in tank gauging
MPMS Ch. 3.1A (Manual Gauging):

- Land and marine tanks
- Health and safety precautions
- Equipment
- Gauging procedures
- Accuracy and Traceability
MPMS Ch. 3.1A, verification of working tapes:

- Calibrated master tape
- Regular intervals
- Within +/-2 mm
MPMS Ch. 3.1B & 3.3, installation and procedures (example):

Typical guidance include:

- Stability, still pipe requirements etc...
- Considerations such as turbulence...
- Calibration/Verification procedures
### MPMS Ch. 3.1B, CT accuracy requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Custody transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory calibration</td>
<td>1 mm (1/16 in)</td>
</tr>
<tr>
<td>Effect of installation</td>
<td>3 mm (1/8 in)</td>
</tr>
<tr>
<td>Initial verification</td>
<td>4 mm (3/16 in)</td>
</tr>
<tr>
<td>Subsequent verification</td>
<td>4 mm (3/16 in)</td>
</tr>
</tbody>
</table>
# Example (verification of ATG)

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Ullage Dip 1 (mm)</th>
<th>Ullage Dip 2 (mm)</th>
<th>Ullage Dip 3 (mm)</th>
<th>Avg. Ullage Dip (mm)</th>
<th>Level Gauge Reading Ullage mm</th>
<th>Diff. Level Gauge - Dip mm</th>
<th>Remark/Tape id</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>200x-xx-xx</td>
<td>10.20</td>
<td>16144</td>
<td>16144</td>
<td>16144</td>
<td>16144</td>
<td>16144</td>
<td>0</td>
<td>TT-CS tape (calibrated)</td>
<td>TT-CS</td>
</tr>
<tr>
<td>200x-xx-xx</td>
<td>10.30</td>
<td>16149</td>
<td>16149</td>
<td>16144</td>
<td>16149</td>
<td>16144</td>
<td>-5</td>
<td>Tape No. 1 (bad)</td>
<td>Person 1</td>
</tr>
<tr>
<td>200x-xx-xx</td>
<td>10.35</td>
<td>16142</td>
<td>16142</td>
<td>16144</td>
<td>16142</td>
<td>16144</td>
<td>2</td>
<td>Tape No. 2 (OK?)</td>
<td>Person 1</td>
</tr>
<tr>
<td>200x-xx-xx</td>
<td>10.40</td>
<td>16143</td>
<td>16143</td>
<td>16142</td>
<td>16143</td>
<td>16144</td>
<td>1</td>
<td>TT-CS tape (calibrated)</td>
<td>Person 1</td>
</tr>
<tr>
<td>200x-xx-xx</td>
<td>11.00</td>
<td>16701</td>
<td>16704</td>
<td>16701</td>
<td>16701</td>
<td>16694</td>
<td>-7</td>
<td>16713 after (tank was emptying despite information that level should be stable; wouldn't be discovered if only one handdip was taken.)</td>
<td>TT-CS</td>
</tr>
<tr>
<td>200x-xx-xx</td>
<td>16.00</td>
<td>16837</td>
<td>16838</td>
<td>16838</td>
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<td>16839</td>
<td>1</td>
<td>TT-CS</td>
<td>TT-CS</td>
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</tbody>
</table>

**Good procedures are very important!**
MPMS Ch. 3.6, Hybrid Tank Measurement System:

- Four major components
  - ATG
  - ATT
  - Pressure sensors
  - Hybrid processor

- Density or Mass

- Uncertainty calculations
MPMS Ch. 3.6, Hybrid Tank Measurement System:

CT Accuracy Requirements @ 4 m level:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Custody transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>0.5%</td>
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</table>
MPMS Ch. 7.x overview

Current Ch 7 will be split up in the following chapters:

Ch. 7.1: Liquid-In-Glass Thermometers (pending)
Ch. 7.2: PETs (pending)
Ch. 7.3: Fixed Automatic Tank Temperature Systems (Oct 2011)
Ch. 7.4: Dynamic Temperature Measurement (pending)
MPMS Ch. 7.3, Equipment requirements (example):

- Temperature sensors
- Stratification
- ...
MPMS Ch. 7.3, CT system accuracy requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Custody transfer</th>
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</thead>
<tbody>
<tr>
<td>Factory calibration</td>
<td>0.25 °C (0.5 °F)</td>
</tr>
<tr>
<td>Initial Field Verification</td>
<td>0.25 °C (0.5 °F)</td>
</tr>
<tr>
<td>Subsequent Verification</td>
<td>0.5 °C (1 °F)</td>
</tr>
</tbody>
</table>
MPMS Ch. 11 (Reference Density Calculations)

- Different tables for different product types (53A, 53B, ...)

- Input:
  - Observed Density
  - Average Temperature
  - Etc...

- Output:
  - Reference Density
MPMS Ch. 11 (VFC Calculations)

• Different tables for different product types (54A, 54B, ...)

• Input:
  – Reference Density
  – Average Temperature
  – Etc...

• Output:
  – VCF
MPMS Ch. 12.1.1 (Calculations Static Petroleum Quantities)

Volume Calculation Flow Chart
## Tank gauging coverage

<table>
<thead>
<tr>
<th>Level performance</th>
<th>Temperature performance</th>
<th>Equipment Certification</th>
<th>Laboratory Environment</th>
<th>Installation guidelines</th>
<th>Procedures</th>
<th>Tank Calibration</th>
<th>Hybrid measurement</th>
<th>Physical Properties Data</th>
<th>Calculations</th>
<th>Custody Transfer</th>
<th>Inventory</th>
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</tbody>
</table>
API standards usage:

• Customers want guidelines they know will be accepted world wide (buying/selling). Much easier if possible to say in compliance with API requirements.

• Some customers more or less adopt the standards as their own and make them mandatory requirements.

• Easy to use already written procedures at situations like FAT, SAT (inspections etc)

• Up to date standards

• Aim to harmonize requirements with standards in other standardization organizations => wider acceptance
THANK YOU!