Clamp-on Gas Flowmeter Flow Loop and Field Trials

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Outline

- Introduction
- Flowmeter Operation
- Flow Loop Testing
- Field Trials
- Challenges/Positives
- Conclusions and Future Plans
Introduction

• Does your asset have gas lift (GL) gas metering?
  – Can you measure injection for individual wells?
  – Are the meters calibrated on schedule and correctly?
  – Do you trust your metering system?

• What could you do if you were able to reliably meter GL injection rates on each well?
  – Individual well injection optimization
  – Field-wide injection gas allocation & optimization
  – Troubleshooting
Introduction

- EM piloted an ultrasonic (UT), clamp-on gas flow meter for measurement of injection gas
- This meter type has several advantages for field use
  - Non-invasive – does not need to contact the flow path; production can continue as normal while in use
  - Portable – meter and associated equipment can be hand-carried and transported by personal vehicle or helicopter
  - Battery-powered – onsite power not required; battery is rated for 8 hours of continuous operation
  - Accurate – rated to ± 2-5% flow accuracy for 6-in. (DIN 150) and smaller pipes; standard accuracy for GL applications
Acoustic signal is transmitted against the flow to the **upstream** transducer.

The process is repeated in the **downstream** direction.

The time it takes for the signal to travel between transducers is the transit time, $T$.

The difference, Delta-$T$, between $T_{\text{up}}$ & $T_{\text{down}}$ is proportional to flow velocity.
UT Short Circuit

- **Short Circuit Noise (SCN)**
  - Sound waves tend to “short circuit” around the pipe rather than travel through the gas inside
  - Larger pipes have less SCN in the signal window due to greater separation between the SCN and gas signal arrival times
  - Heavy wall pipes have more SCN due to slow dissipation of the noise. Signal and noise could overlap due to the increased SC arrival time (longer path in orange) and amplitude
Flowmeter Application Limits

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Steel</th>
<th>Pipe Wall mm</th>
<th>Max. Velocity m/s</th>
<th>Gas Lift Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI (DIN)</td>
<td>Schedule</td>
<td></td>
<td></td>
<td>Steel</td>
</tr>
<tr>
<td>3/4 (20)</td>
<td>5S</td>
<td>≤1.8</td>
<td>15.1</td>
<td>80S</td>
</tr>
<tr>
<td>1 (25)</td>
<td>40</td>
<td>≤3.6</td>
<td>15.1</td>
<td>80</td>
</tr>
<tr>
<td>1-1/2 (40)</td>
<td>40</td>
<td>≤3.8</td>
<td>26.8</td>
<td>160</td>
</tr>
<tr>
<td>2 (50)</td>
<td>40</td>
<td>≤4.1</td>
<td>20.5</td>
<td>160</td>
</tr>
<tr>
<td>3 (75)</td>
<td>40</td>
<td>≤5.6</td>
<td>22.0</td>
<td>160</td>
</tr>
</tbody>
</table>

Note: Min. gas pressure required for standard app. is 14 bar. Max. velocity assumes triple traverse.

- The flowmeter standard application limits are for thinner-wall pipes than those generally used for gas-lifting.
- EM proposed tests on the following pipe sizes to determine whether the flowmeter could be extended to GL injection applications:
  - 2" (50) sch. 80 & 160, 1½" (40) sch. 160, & ¾" (20) sch. 80S
Flow Loop Testing Facility

- Testing was performed at the Southwest Research Institute Metering Research Facility (MRF) High Pressure Loop (HPL)
  - The HPL is a closed, recirculating flow loop; discrete gas rates are provided by a combination of critical flow nozzles and pressure is changed by adding/removing gas from the flow loop
  - Meters being tested are benchmarked against calibrated critical flow nozzles; test data is recorded and can be analyzed on-line
  - Sales-quality natural gas was used for the tests
- Flowmeter test was a low-rate, high-pressure HPL application

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value(s)</th>
<th>EM Test Value(s)</th>
<th>Controllability</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Flow Rate</td>
<td>4825 Msm³/d</td>
<td>11.5 - 165 Msm³/d</td>
<td>1.0 % of rate</td>
<td>0.1 - 0.25 % of rate</td>
</tr>
<tr>
<td></td>
<td>39 Am³/m</td>
<td>0.2 - 1.7 Am³/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure Range</td>
<td>11.5 - 76 bar</td>
<td>41.5 - 69 bar</td>
<td>0.07 bar</td>
<td>0.015% of value</td>
</tr>
<tr>
<td>Pipe Diameter Range</td>
<td>2-20 in. (50-500)</td>
<td>3/4-2 in. (20-50)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Test Setup

- Two 4.6-m (15-ft) pipe spools were tested simultaneously with a pair of clamp-on flowmeters
- Pressures & flow rates were iterated
- T&P recorded near the spools
Test Setup

- Clamping Fixture
- Transducer Cable
- Preamplifier
- Portable Meter
- Dampening Material
- Transducer
Test Results – Velocity

![Graph showing test results for velocity with markers for different pipe diameters and wall thicknesses at two pressures: 68.9 bar and 41.4 bar.]

- **2" (50) sch.80**
- **2" (50) sch.160**
- **1-1/2" (40) sch.160**
- **3/4" (20) sch.80**
Test Results – Volumetric Flow

![Graph showing volumetric flow vs. average absolute % error with different data points for 2” (50) sch.80, 2” (50) sch.160, 1-1/2” (40) sch.160, and 3/4” (20) sch.80S. Pressures are 68.9 bar and 41.4 bar.]
Field Trials

- **Learnings**
  - Discovered that we had input incorrect pipe size (sch. 80), but measured velocities appeared to be correct. Found that ratio of transducer spacing error to measurement error is 10:1
  - Flow measurement can be inconsistent within similar field applications
• **Learnings**

  – Flowmeter could be applied at low velocities and on short pipe runs (less than 1.8-m)
  
  – Field’s lift gas has a significant $N_2$ content (~70%) which affects the soundspeed through the gas. The meter should be programmed differently for the next attempt
Field Trials

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Pressure (bar)</th>
<th>Velocity (m/s)</th>
<th>0.75&quot; (20) sch. 10S</th>
<th>1&quot; (25) sch. 160</th>
<th>1.5&quot; (40) sch. 80</th>
<th>2&quot; (50) sch. 80</th>
<th>2&quot; (50) sch. 160</th>
<th>3.5&quot; (90) sch. 160</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jul-11</td>
<td>Offshore California</td>
<td>86.2</td>
<td>4.3</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓ (2/3)</td>
</tr>
<tr>
<td>Jul-11</td>
<td>Southeast Texas</td>
<td>62.1</td>
<td>1.2 - 3.0</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug-11</td>
<td>Gulf of Mexico</td>
<td>11.7</td>
<td>7.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓ (2/3)</td>
</tr>
<tr>
<td>Sep-11</td>
<td>East Texas</td>
<td>57.2</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep-11</td>
<td>Offshore California</td>
<td>68.9 - 96.5</td>
<td>2.4 - 4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Jan-12</td>
<td>Gulf of Mexico</td>
<td>59.3</td>
<td>3.4</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pipe Sizes**

**Learnings**

- **Meter was applied to a test separator gas outlet line**
- **Flowmeter could be used on larger pipe at a reduced pressure**

[Image of offshore gas lift equipment]
Signal Quality Challenges

- Preparation of measurement location and installation of components are key to success
- Multiple hardware/electronic options available for finding a solution; experience will guide usage
- In some applications it can be difficult to capture a correct acoustical signal. May take 1-2 hours to get quality data stream
Data Analysis Positives

- “All-or-Nothing” Data Collection
  - If a signal with adequate quality cannot be achieved, you will not get data

- Transducer Spacing Forgiveness
  - Velocity measurements will still be accurate +/- a pipe sch. increment (at least for 2” (50) & smaller pipe)

- Logging Capability
  - If the metering has been logged, the data can be converted to spreadsheet format and edited
  - Initial input parameters can be determined and changed if necessary
Conclusions and Future Plans

- UT technology has been successfully applied to GL measurement
- **Training & experience** are key components to measurement success
- Future Plans
  - Continue & expand testing during GL optimization visits
  - Incorporate with other GL diagnostic methods
  - Develop training program for clamp-on GL metering
  - Use permanent technology to expand or retrofit GL metering in a field that does not have injection metering
Questions?
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