Kuwait 4th Flow Measurement Technology Conference

3-5 December 2019
Hilton Kuwait Resort
Laboratory and Field Experience of an Adjustable DP Cone Meter
**User’s Requirements**

- Zero Gas Releases – H₂S
- Accurate
- Zero (or Reduced) Intervention
- Low Maintenance
- Inspectable/Repairable
One Standard Cone is Equal to Approx 3-4 Orifice Plates

DP Cone Flow Range & Equivalent Orifice Plates

Flow Rate

Differential Pressure
Adjustable Cone Meter Development

- Two in One?
- Mechanism
- Seals
- Sizing Software
Adjustable Cone Patented Sliding Sleeve

ΔP

Patent GB2538805
Adjustable Cone Range is Equal to Approx 27 Orifice Plates

Adjustable Cone Flow Rate Range

- 0.75 Beta @ 1350 PSI
- 0.75 Beta at 50 PSI
- 0.5 Beta @ 1350 PSI
- 0.5 Beta @ 50 PSI

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Adjustable Cone Beta Ratios

Fig. 4 - Adjustable Cone Meter - Calculation of the Beta Ratios

\[ \beta_{low} = \sqrt{1 - \frac{d_c^2}{D_s^2}} \]  

(1)

\[ \beta_{high} = \sqrt{1 - \frac{d_c^2}{D_m^2}} \]  

(2)
4" Meter Dry & Wet Gas Calibration

- Dry Calibration in N2
- Wet Gas Calibration w/ 795 Kg/m³ Oil
- 10 & 62 bar(g)
- 0.45 & 0.7 β w/ Automatic Adjustment
4" Adjustable Cone Meter Calibration Data

4" Adjustable Cone 0.45 & 0.7 Beta Flow Computer Data

- Low Range 10 Bar N2
- Low Range 62 Bar N2
- Low Range Combined Flow Computer Data
- High Range 61 Bar N2
- High Range 10 Bar N2
- High Range Combined Flow Computer Data

Reynolds Number

Cd

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### 4” Calibrated Range

<table>
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<tr>
<th>β Ratio</th>
<th>Pressure Bar(g)</th>
<th>Min ( q_m ) (Kg/sec)</th>
<th>Max ( q_m ) (Kg/sec)</th>
<th>Turndown Ratio</th>
<th>Calibrated Turndown Ratio</th>
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<td>0.22*</td>
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<td>2.04</td>
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- **0.45 β = 0.478 % Total Uncertainty @ 95% Confidence Level (NEL)**
- **0.7 β = 0.668% Total Uncertainty @ 95% Confidence Level (NEL)**

**54.5 = 12.00 / 0.22**
4\" Meter Test Flow Regimes

Source Reader-Harris: Orifice Plates & Venturi
Wet Gas Over-Read

0.7 \beta 10 & 62 bar(g)

0.45 \beta 10 & 62 bar(g)
Example

0.12 L-M Parameter = 85 BBL/MMSCF
Field Tests in Dry Gas
Field Test Data: Well #1 Flowing to Production Line at 1000 PSIG

Approximately 2 Hours to Stabilise Flow

Adjusta-Cone & Orifice Meter Gas Rate Comparison

- Gas Orifice Rate Sm³/day
- Adjusta-Cone® Flow Rate Sm³/day

0.5% Overall Difference
0.25% Difference
0.08% Difference
Max 1.95% Liquid Effect in Orifice Impulse Lines
Field Test Data: Well #2 Flowing to Flare at 100 PSIG

- Adjusta-Cone Gas Flow Rate
- Orifice Meter Gas Flow Rate

Stable Flow
Orifice Plate reading 0.13% Under
Surging Flow
Orifice Plate reading 2.7% under.
Field Test Data: Well #2 DP Comparison

- Adjusta-Cone Differential Pressure
- Orifice Meter Differential Pressure

AGA Orifice DP Limits
Cone DP Limits
Test Conclusions

• Orifice flow meters:
  • Limited Flow Range per Plate
  • Hazardous Gas Releases
  • Hands On Device
  • Manual Operation
  • Stabilised Flow
  • Plate Selection

• Adjustable Cone Meter:
  • Flow Range = 27 Rates (250:1 turndown)
  • No Gas Releases
  • Hands Off Device
  • Automatic Operation
  • Non Stabilised Flow
  • Saves 60-90 Mins per Plate Size
Future Work

- 4” Field Trials in Oman - Complete
- Examine Wet Gas Test Results in Detail
- Run Field Trials in Wet Gas
- Compare with CFD – water, N2, Wet N2
- 3” Wet and Dry Gas Testing
THANK YOU