Enhance Casing Collapse Ratings through Testing and Dimensional Measurements

Prepared for: AADE Houston Chapter Deepwater and Emerging Technologies Group

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Taking on your toughest technical challenges.
What kind of collapse are we talking about?
Why does collapse happen?

- Anytime the external pressure minus the internal pressure exceeds the collapse resistance of the pipe.
  - **Subsea Pipelines**
    - Potential Loss of Miles of Pipeline
    - Loss of Production
  - **Downhole Tubing and Casing**
    - Potential Loss of Entire Well
    - Loss of Production
Why Collapse Test?

- Why Test?
  - To confirm the collapse values for actual pipe meet specifications.
  - API 5C3, API 1111, and BS 8010 contain collapse prediction equations.
Factors that Affect the Collapse Pressure

Collapse is an instability event affected by:

- Ovality / Eccentricity
- Residual Stress
- Axial Tension/Compression (must be zero for API-compliant testing)
- Internal Pressure
- Yield Strength/Modulus of Elasticity

- It’s difficult to calculate the collapse pressure of pipe because the initiation of collapse is looking for “the weak link.”
Weak Links – Eccentricity and Ovality

**Eccentricity** – how centered is the bore?

**Ovality** – how round is the pipe?
Weak Link – Residual Stress

• The pipe is under stress prior to testing from the straightening processes used in the mills or welding of the seam.
• 2D length tested at ambient temperature in accordance with ASTM E1928.
Weak Link – Axial Load

For Testing:

- The sample must be free to collapse anywhere along the sample length
- Axial load will affect the collapse rating of a sample:
  - Compression will increase the collapse value
  - Tension will decrease the collapse value
SES’s testing is fully compliant with API 5C3, Annex I:

- **Collapse sample length of:**
  - 8D for 9-5/8” OD and less
  - 7D for larger than 9-5/8” OD

- **Test apparatus:**
  - 4.5” to 20” OD up to 25,000 psi
  - Test pressure applied to full sample length
  - NO radial or axial restraints, either mechanically or hydraulically
  - NO pressure applied to the inside surface of the specimen.
Dimensional Mapping – API 5C3, Annex I

- Measurements performed **prior** to collapse testing.
- Used to calculate ovality and eccentricity of each sample.
- Outer diameter and wall thickness measurements are recommended at five equally-spaced cross-sectional locations.
Outer Diameter

- API 5C3 specified that the diameter should be measured with a pi tape at each ring and averaged.
- SES collects OD measurements at eight equally-spaced positions (45° intervals) using a wireless Mitutoyo digital micrometer.
Wall Thickness

- SES uses a digital UT meter.
- Wall thicknesses are measured at eight equally-spaced positions (45° intervals) and averaged.
Example Data Sheet

Eccentricity: \( 100 \frac{t_{\text{max}} - t_{\text{min}}}{t_{\text{avg}}} \) 

Ovality: \( 100 \frac{D_{\text{max}} - D_{\text{min}}}{D_{\text{avg}}} \)

<table>
<thead>
<tr>
<th>Client ID #</th>
<th>Nominal OD (in)</th>
<th>Nominal Wall (in)</th>
<th>Heat</th>
<th>Grade</th>
<th>Collapse Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SES-01</td>
<td>9.625&quot;</td>
<td>0.595&quot;</td>
<td>Q123</td>
<td>HC P110</td>
<td>10,000</td>
</tr>
</tbody>
</table>

% Eccentricity: 3.98
% Ovality: 0.16

### WALL THICKNESS [in]

<table>
<thead>
<tr>
<th>Position</th>
<th>&quot;1&quot;</th>
<th>&quot;2&quot;</th>
<th>&quot;3&quot;</th>
<th>&quot;4&quot;</th>
<th>&quot;5&quot;</th>
<th>MAX</th>
<th>MIN</th>
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</thead>
<tbody>
<tr>
<td>0°</td>
<td>0.604</td>
<td>0.608</td>
<td>0.609</td>
<td>0.599</td>
<td>0.592</td>
<td>0.615</td>
<td>0.591</td>
</tr>
<tr>
<td>45°</td>
<td>0.611</td>
<td>0.606</td>
<td>0.608</td>
<td>0.602</td>
<td>0.599</td>
<td></td>
<td></td>
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<tr>
<td>90°</td>
<td>0.607</td>
<td>0.599</td>
<td>0.600</td>
<td>0.596</td>
<td>0.605</td>
<td></td>
<td></td>
</tr>
<tr>
<td>135°</td>
<td>0.598</td>
<td>0.594</td>
<td>0.591</td>
<td>0.608</td>
<td>0.602</td>
<td></td>
<td></td>
</tr>
<tr>
<td>180°</td>
<td>0.598</td>
<td>0.601</td>
<td>0.596</td>
<td>0.601</td>
<td>0.610</td>
<td></td>
<td></td>
</tr>
<tr>
<td>225°</td>
<td>0.599</td>
<td>0.607</td>
<td>0.601</td>
<td>0.595</td>
<td>0.605</td>
<td></td>
<td></td>
</tr>
<tr>
<td>270°</td>
<td>0.597</td>
<td>0.609</td>
<td>0.606</td>
<td>0.603</td>
<td>0.611</td>
<td></td>
<td></td>
</tr>
<tr>
<td>315°</td>
<td>0.607</td>
<td>0.614</td>
<td>0.615</td>
<td>0.605</td>
<td>0.600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.603</td>
<td>0.605</td>
<td>0.603</td>
<td>0.601</td>
<td>0.603</td>
<td>0.603</td>
<td></td>
</tr>
</tbody>
</table>

### OUTER DIAMETER (OD) [in]

<table>
<thead>
<tr>
<th>Position</th>
<th>0°-180°</th>
<th>45°-225°</th>
<th>90°-270°</th>
<th>135°-315°</th>
<th>OD avg.</th>
<th>MAX</th>
<th>MIN</th>
</tr>
</thead>
</table>

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Thank You!

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