Fugitive Emissions Reduction Through Valve Packing R&D

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Valves account for 60% of Fugitive Emissions in a regular plant.

Regulations becoming more strict everyday:
- Permitted levels dropping
- 5 years ago: 500 ppmv (API 622 1st Ed.)
- Today: 100 ppmv (API 622 2nd Ed., API 624)

How to comply to all these?
<table>
<thead>
<tr>
<th>Style</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Flexible Graphite Yarn reinforced with an Inconel wire mesh</td>
<td><img src="image" alt="Example A" /></td>
</tr>
<tr>
<td>B</td>
<td>Flexible Graphite Yarn reinforced with an Inconel wire mesh with PTFE Impregnation</td>
<td><img src="image" alt="Example B" /></td>
</tr>
<tr>
<td>C</td>
<td>Flexible Graphite Yarn reinforced with an Inconel wire</td>
<td><img src="image" alt="Example C" /></td>
</tr>
<tr>
<td>D</td>
<td>Carbon and Flexible Graphite yarn with Graphite Impregnation</td>
<td><img src="image" alt="Example D" /></td>
</tr>
<tr>
<td>E</td>
<td>Expanded PTFE filled with Barium Sulphate</td>
<td><img src="image" alt="Example E" /></td>
</tr>
</tbody>
</table>
Minimum Packing Seating Stress

Definition

- Minimum stress that should be exerted on the packing at the installation to assure a “leak free” environment at start
- Similar to Gaskets traditional “y” values and the recently introduced Minimum Gasket Seating Stress
Test Rig

Composed by a hydraulic press equipped with a stem/stuffing box simulation rig.

Procedure

1. Install the five rings and install the Test Rig in the Hydraulic Press;
2. Apply an initial seating stress;
3. Pressurize the Test Rig and raise the packing stress in 5 MPa increments recording the leakage rate at each step;
4. If the leakage rate is equal or less than 0.001 mbar-l/sec record the seating stress and finish the test.
Minimum Seating Stress Results

<table>
<thead>
<tr>
<th>Packing Style</th>
<th>$S_{\text{min}(0.01)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MPa</td>
</tr>
<tr>
<td>A</td>
<td>55</td>
</tr>
<tr>
<td>B</td>
<td>30</td>
</tr>
<tr>
<td>C</td>
<td>35</td>
</tr>
<tr>
<td>D</td>
<td>20</td>
</tr>
<tr>
<td>E</td>
<td>25</td>
</tr>
</tbody>
</table>
Installation Stress Tests

• Further testing was performed with different approaches:
  • Constant Packing Stress ($S_{\text{min}(0,01)}$) : Minimum seating stress is applied and kept constant as the Helium pressure is increased;
  • Constant Leakage Rate: The packing stress is increased as the Helium pressure is increased in order to keep the leakage rate constant.
  • Variable Stress: Minimum seating stress ($S_{\text{min}(0,01)}$) is applied and raised by the same value of the Test Media.
Number of Rings Influence on Torque and Sealability

1. Install the packing rings with a seating load of 1MPa (145psi);
2. Apply the load (5, 10, 20, 40, 60, 90MPa);
3. Allow the packing to relax for 10 minutes;
4. Re-apply the load;
5. Turn the stem;
6. After the two stem turns, register readings;
7. Repeat 2-7.
Number of Rings Influence on Torque and Sealability

More Rings = higher torque

Change in the packing behavior after the minimum seating stress is reached.
Packing Relaxation

- Relaxation is higher closer to the gland
- Higher Stress = Lower Relaxation
- Graphite Packings relaxed less than PTFE Packings
Number of Rings vs Sealability

- Minimum Seating Stress applied for two and seven rings
- Leakage rate equal or less than 0.001mbar-l/sec for all the styles tested – 7 bar - He
- No influence of the number of rings on the sealability results
Laboratory Valve Tests
Laboratory Valve Tests

Style B Fugitive Emissions

- API 622 2nd Ed. Simulation
  - 1510 mechanical cycles
  - 5 thermal cycles – RT to 260ºC
  - Average Leakage: 2 ppmv
  - Maximum Leakage: 11 ppmv

- API 624 1st Ed. Certification
  - 310 cycles
  - 3 thermal cycles - RT to 260ºC
  - Valves aproved – NPS ½, ¾, 4, 12, 20”
  - Maximum Leakage: 8 ppmv
Quarter Turn Valve Tests

Style D Fugitive Emissions

- API 641 Simulation
  - 5010 mechanical cycles
  - 5 thermal cycles – RT to 205ºC
  - Average Leakage: 0 ppmv
  - Maximum Leakage: 4 ppmv
- Using Spring Loads
Control Valve Tests

- Style D installed with the Sₜ
- 700 hours cycling

Result:
Retorque required to keep leakage rate in low levels
Control Valve Tests

Dynamic Load System developed to ensure the $S_S$

- Style D installed with $S_S$ and DLS
- 700 hours cycling

Style D kept the system leakage below 100ppmv for the first 600h of testing with DLS
Braskem Plant

*Initial Conditions:*

- High pressure steam and hydrocarbon lines.
- Pressures of 140bar (2030psi) under temperatures as high as 550°C (1022°F).
- Constant history of high leaks (up to 2.000 tons of steam/year).
- Several interventions to inject sealant.
- 54% of the 17,474 hydrocarbon valves presented leakage values higher than 500ppmv
Field Results

Steam Lines

- 46 valves packed with Style A
- Sizes from 1/2” to 16”
- No leaks after 36 months

Seating Stress:
- $S_s = S_{min(0,01)} + P = 69$ Mpa
- $S_{min(0,01)} = 55$ MPa (8000 psi)
- $P = 140$ bar (2000 psi)
Field Tests

- >90% of the valves with leakage levels below 250 ppmv
- Only 5% above 500 ppmv

<table>
<thead>
<tr>
<th>Type</th>
<th>Angular</th>
<th>Butterfly</th>
<th>Ball</th>
<th>Gate</th>
<th>Globe</th>
<th>Plug</th>
<th>Mach</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;250 ppmv</td>
<td>242</td>
<td>24</td>
<td>820</td>
<td>11,176</td>
<td>1,574</td>
<td>155</td>
<td>7</td>
<td>63</td>
</tr>
<tr>
<td>&gt;250 / &lt;500 ppmv</td>
<td>11</td>
<td>1</td>
<td>29</td>
<td>195</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;500 ppmv</td>
<td>54</td>
<td>5</td>
<td>181</td>
<td>527</td>
<td>104</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>
Conclusions

• The Experimental determination of minimum installation stresses is successful in granting Low Emission rates.
• Sealability can be achieved without the need of several packing rings.
• Low Emission rates can be achieved using PTFE packings and Spring Loads combined.
• Lowest emission levels can be achieved through R&D.
• Proper installation calculation and procedures can prevent leakage on the long run.
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Thank You!

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