VALVE SEALING RESEARCH AND DEVELOPMENT EQUIPMENT

Carlos D. Girão.
Teadit Packing & Gaskets Pvt. Ltd.
Vadodara, India

Luiz Paulo C. V. Romano
Teadit Industria e Comercio Ltda.
Rio de Janeiro, RJ, Brazil
AGENDA

• INTRODUCTION
• MINIMUM SEATING STRESS
• PACKING DRAG AND FORCE TRANSMISSION
• THERMAL EXPANSION / RESISTANCE
• CORROSION TEST
• FUGITIVE EMISSION TES RIGS
• OTHER RIGS - PACKING DRAG (KNIFE VALVES)
• CONCLUSIONS
INTRODUCTION

- Enhanced LDAR: 100 ppm as the target for valve stem seals.

Source: US EPA 1995
INTRODUCTION

Low-E Technology:

- A valve (including its specific packing assembly or stem sealing component) for which the manufacturer has issued a written warranty that it will not emit fugitives at greater than 100 ppm, and that, if it does so emit at any time in the first 5 years, the manufacturer will replace the valve.
MINIMUM SEATING STRESS

• Packing:
  o Style A: Flexible Graphite Yarn reinforced with an Inconel wire mesh.
  o Style D: Expanded PTFE filled with Barium Sulphate.
MINIMUM SEATING STRESS

Packing Style | $S_{\text{min}(0.01)}$
---|---
A | 55 7975
D | 25 3625
PACKING DRAG AND FORCE TRANSMISSION

1 - Stem  
2 - Gland  
3 - Bonnet  
4 - Internally Gaged Bolt  
5 - Packing  
6 - Bushing  
7 - Load Cell  
8 - Load Cell Base  
9 - Electrical Resistance
PACKING DRAG AND FORCE TRANSMISSION

Friction force difference between Graphite and PTFE packings
Ni-Cr Wire Mesh Reinforced Yarn Flexible Graphite Packing (no impregnation)

Expanded PTFE filled with Barium Sulphate Packing

Results incompatible with the traditionally used Radial Stress Distribution graph for stresses above the MSS
PTFE Packing Extrusion due to Thermal Expansion

<table>
<thead>
<tr>
<th>Material</th>
<th>$(10^{-5} \text{ K}^{-1})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>1</td>
</tr>
<tr>
<td>Barium Sulphate</td>
<td>1</td>
</tr>
<tr>
<td>Graphite</td>
<td>1</td>
</tr>
<tr>
<td>PTFE</td>
<td>12</td>
</tr>
</tbody>
</table>
THERMAL EXPANSION

<table>
<thead>
<tr>
<th>Style</th>
<th>Yarn</th>
<th>Filler</th>
<th>Comparative e-PTFE content</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>e-PTFE</td>
<td>None</td>
<td>100% e-PTFE</td>
</tr>
<tr>
<td>B</td>
<td>e-PTFE</td>
<td>Barium Sulphate</td>
<td>B% &lt; A%</td>
</tr>
<tr>
<td>C</td>
<td>e-PTFE</td>
<td>Barium Sulphate</td>
<td>C % &lt; A% &amp; B%</td>
</tr>
<tr>
<td>D</td>
<td>e-PTFE</td>
<td>Graphite</td>
<td>D% &lt; A%, B% &amp; C%</td>
</tr>
</tbody>
</table>
THERMAL EXPANSION

TOTAL LOAD LOSS AFTER 1 THERMAL CYCLE (160°C)

LOAD MAINTAINED AFTER 5 THERMAL CYCLES (160°C)

With DLS
## THERMAL RESISTANCE

### External Leakage

<table>
<thead>
<tr>
<th>Packing</th>
<th>After burn and cooldown (5min)</th>
<th>API 607 Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style E</td>
<td>0.0 mL/min</td>
<td>CERTIFIED</td>
</tr>
<tr>
<td>Style F</td>
<td>0.0 mL/min</td>
<td>CERTIFIED</td>
</tr>
<tr>
<td>Style H</td>
<td>0.2 mL/min</td>
<td>CERTIFIED</td>
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</tbody>
</table>

### Graph: Mass Loss vs Temperature

- **STYLE E**
- **Sample X**

Sealing for a Safer and Greener Tomorrow

[Image of packing and graph]
GALVANIC CELL - CORROSION

![Graph showing electrical potential difference over time for different inhibitors and the condition without an inhibitor.](image-url)
Average Mass Loss

<table>
<thead>
<tr>
<th>Inhibitor</th>
<th>1010</th>
<th>304</th>
<th>410</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhibitor 1</td>
<td>0,00%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibitor 2</td>
<td>0,50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibitor 3</td>
<td>1,00%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no Inhibitor</td>
<td>1,50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibitor 4</td>
<td>2,00%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibitor 1</td>
<td>2,50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibitor 2</td>
<td>3,00%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibitor 3</td>
<td>0,00%</td>
<td></td>
<td></td>
</tr>
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</tr>
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</table>
FUGITIVE EMISSION TEST RIGS
R&D Results

API Standard 622 2nd Ed. Simulation (4th CL300) Test Report

Static Leakage Chart
Reading

Leakage (PPM)
Cycle Number

Maximum Reading

Leakage (PPM)
Cycle Number
OTHER RIGS - PACKING DRAG (KNIFE VALVES)

1) Water Reservoir
2) Check Valve
3) Alternative Pump
4) Check Valve
5) Water/Air Pressure Vessel
6) Relief Valve
7) Pressure register
8) Water Bleed Valve
9) Needle Valve
10) Pressure Indicator
11) Tyco Valve
12) Air Bleed Valve
13) Ball Valve
14) Check Valve
15) Needle Valve
16) Pressure Register
17) Pressure Register
18) System Controller
OTHER RIGS - PACKING DRAG (KNIFE VALVES)

SYNTHETIC – $F_{\text{DRAG}}$

STUD TORQUE (lb-ft)
- 18
- 27
- 36

E-PTFE GRAPHITE – $F_{\text{DRAG}}$

SYNTHETIC – $P_{\text{H2O}}$

STUD TORQUE (lb-ft)
- 18
- 27
- 36

E-PTFE GRAPHITE – $P_{\text{H2O}}$
CONCLUSIONS

• MINIMUM SEATING STRESS RIGS
  Leak free installation and start-up
  Increase plant safety and reduce costs

• STEM TORQUE OR DRAG DETERMINATION RIGS
  Design of actuation devices

• THERMAL EXPANSION AND CONTRACTION STUDIES
  Develop lower thermal expansion packings

• CORROSION TESTS
  Increase equipment life

• FE TEST RIGS
  API 622, AP I624 (valve), ISO 15848, VDI 2440, API 641 and others

Consolidation - Development of Low Emission Packings and Technology to Enhance Packing and Valve Performance
QUESTIONS?

Carlos D. Girão, P.E. M.Sc.
cdgirao@teadit.in
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