Methods for Enhancing Fugitive Emissions Prevention in Chemical Process Lines

Dale A. Rice, P.E.
Fluid Sealing Specialist / Environmental Engineer
VSP Technologies
Leland, NC 28451
Agenda

• Limitations of LDAR Programs
• Connectors as a Leak Source
• Best Practices for Achieving Low Emissions
• Summary
Does LDAR Look Forward or Back?

If chemical plant performance is like a train ride, does LDAR look forward or backward?
## Potential Sources of Fugitive Emissions

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Average Number of Components at a Typical Chemical Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps</td>
<td>100</td>
</tr>
<tr>
<td>Valves</td>
<td>7,400</td>
</tr>
<tr>
<td>Connectors</td>
<td>12,000</td>
</tr>
<tr>
<td>Sampling Connections</td>
<td>560</td>
</tr>
<tr>
<td>Compressors</td>
<td>-</td>
</tr>
<tr>
<td>Pressure Relief Valves</td>
<td>90</td>
</tr>
<tr>
<td>Open-ended Lines</td>
<td>560</td>
</tr>
</tbody>
</table>

Causes of Flange Leaks

Best Practices for Proactively Reducing Fugitive Emissions: The Three “T”s
Best Practices for Proactively Reducing Fugitive Emissions: The Three “T”s

Training
Best Practices for Proactively Reducing Fugitive Emissions: Training

• ASME Qualified Bolting Specialist Training and Certification (PCC-1-2013 Guidelines)

  • Focus on best practices
  • 20 hours training (12 hours online / 8 hours hands on)
  • Flanges, fasteners, and gaskets BAT
  • Hands-on demonstration and testing

  Note: our surveys indicate that >70% mechanics have never had formal BFC assembly training!
Best Practices for Proactively Reducing Fugitive Emissions: Training

- Safety Bolting: Principles and Practices Certification (OSHA 7110)
  - Seven modules, focused on pressure vessels and piping
  - Safe / proficient use of bolting techniques and equipment
  - Completion certificate issued by OSHA and U.S. DOL
How does training reduce FE\text{s}\text{?} 

- Leads to proper flange assembly / tightness
- Improves joint reliability – not just at flange assembly but following operating conditions

Note: few guidelines exist for achieving proper torque or that consider FE leak rates!
Best Practices for Proactively Reducing Fugitive Emissions: Tactics
Best Practices for Proactively Reducing Fugitive Emissions: Tactics

- Implementation of a Comprehensive Fluid Sealing Management Program
  - Use of available gasket evaluation tools to identify lowest emission gasket choices
  - Updated, correct gasket engineering & purchasing specifications
  - Built-in controls over craftsmen gasket selection, torque or pre-load requirements identified and utilized
  - Trained and/or qualified flange assemblers
  - Written procedures in place
Best Practices for Proactively Reducing Fugitive Emissions: Tactics

- Gasket evaluation / Lowest emission gasket choices / Correct gasket engineering & purchasing specifications
  - System temperature
  - System pressure
  - Compatibility
  - Available bolt load
  - Sealability
  - Environmental
  - Cost
Best Practices for Proactively Reducing Fugitive Emissions: Tactics

• Built-in controls over trained / qualified flange assemblers for identified gasket selection, torque or pre-load requirements

Wrong size gasket or poor assembly or both!
Use Lubrication on Fasteners and Nuts

Magnitude and Location Of Nut/Bolt Friction

- Thread Friction, 40%
- Bolt Load, 10%
- Nut Bearing Friction, 50%
Flange Assembly: Use a Torque Wrench
Not an Impact Gun!
Use Proper Assembly Torque

Fugitive Emissions Comparison
by Percent of Optimized Assembly Torque (115 ft-lb)
3” NPS, Class 150 Slip On Flange with PTFE Filled Gasket @ 100 psi

Total Emissions (lb/yr)

1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00

Percent of Optimized Assembly Torque

100% 95% 90% 85% 75%

Poor / No Installation Control
Installation Control
Use Effective Bolting Patterns

**Star Pattern Tightening**
3 or More Passes at Increasing Bolt Load Levels

**Final Rotational Tightening**
Multiple Passes at Final Bolt/Torque Level Until No Further Nut Movement
Best Practices for Proactively Reducing Fugitive Emissions: Tactics

How do best practice tactics reduce FE’s?

• Following these procedures provides the greatest likelihood of minimizing / eliminating pipeline leaks.
• Reduces time / cost needed for repairs!
Best Practices for Proactively Reducing Fugitive Emissions: **Tools**
Best Practices for Proactively Reducing Fugitive Emissions: Tools

- Torque guidance
- Assembly guidance
- Use of Available Gasket Evaluation Tools to Identify Lowest Emission Gasket Choices
Gasket Material Consolidation

Gasket consolidation / appropriate applications
Torque Guidance

Torque card establishes target torques by NPS / flange type
Assembly Reminders

Flange Assembly Procedure
1. Lubricate bolt threads and nut faces and tighten all nuts finger tight
2. Select the Target Assembly Torque for the flange type/metalurgy and operating temperature
3. Torque/tighten in a star pattern sequence as indicated below in (5) successive (increasing) increments to the Target Assembly Torque
4. After the 5th pass, continue tightening the bolts in a circular pattern at the Target Assembly Torque until no further nut movement occurs

Fastener Markings
High Strength
Intermediate Strength
Low Strength

Assembly and fastener info
Fugitive Emissions Predictions

• **Room Temperature Tightness (ROTT) Tests**
  
  • Developed by the Pressure Vessel Research Council
  • Identifies gasket sealing capabilities through increasing and decreasing stress cycles
  • Gasket constants, $G_s$, $a$, and $G_b$ determined then used to predict gasket tightness parameter, $T_p$ and empirical leak rate
Fugitive Emissions Predictions

- **Room Temperature Tightness (ROTT) Tests**
  - Third Party Testing
  - Compression / Decompression (Leakage During Stress Cycling)
  - Helium Mass Spectrometry
  - Accurate leakage measurements <10E-10 mg/sec/mm
Fugitive Emissions Predictions
Fugitive Emissions Predictions

\[ T_p = \left( \frac{S_g}{G_b} \right)^{\frac{1}{a}} \leq T_{p_{\text{max}}} \text{ (unitless)} \]  
\[ S_f = r \left( \eta S_g - P \left( A_i/A_c \right) \right) \text{ (psi)} \]  
\[ k_f = \log \left( \frac{S_g}{G_s} \right) / \log T_p \text{ (unitless)} \]  
\[ T_i = \left( \frac{S_f}{G_s} \right)^{1/k_f} < T_{p_{\text{max}}} \text{ (unitless)} \]  
\[ L_r = \left[ \left( \frac{P}{14.7}(1/T_f) \right)^2 \right] / 150 \text{ (mg/sec/mm)} \]  
\[ L_{\text{tot}} = L_r \cdot d \cdot (3600)(25.4)(1\times10^{-6}) \text{ (kg/hr)} \]

On how to use these equations, go to:

Fugitive Emissions Predictions

Fugitive Emissions Comparison By Gasket Type and NPS

Four Orders of Magnitude Difference!

TOTAL EMISSIONS (lb/yr)

NPS (IN) CLASS 150

- ePTFE w/ encapsulated corrugated metal
- 15G8 - graphite / SS foils
Summary

• Apply Best Practices for leak prevention in connectors.
• Use the Three “T”s (Training / Tactics / Tools) in your Best Practices program.
• Consider using leak rate predictions in your choice of gasket materials in flanged connections.
Contact for More Information

Dale A. Rice, P.E.
Fluid Sealing Specialist / Environmental Engineer
VSP Technologies
910-515-1942 (M)
Dale.Rice@VSPTechnologies.com