Containing Fugitive Emissions

Practical ways to seal valve stems and prevent unwanted emissions

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Containing fugitive emissions of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) is a challenge to the chemical process industries (CPI). It has been estimated that these industries account for half of all fugitive emissions, and 60% of these emissions are the result of valve stem leaks. In addition to environmental benefits, effectively containing these emissions can yield significant operational and economic benefits and avoid punitive penalties for non-compliance with regulatory standards. If cap-and-trade or carbon-tax programs become law, then reducing emissions below mandated levels could yield carbon credits or reduced tax liabilities. Overall, emission reduction improves operating efficiency and creates a safer, more productive workplace.

This article describes how to effectively seal valve stems, including leak detection and repair (LDAR); various types of sealing solutions, their advantages and limitations; performance standards and testing; and proper installation.

Environmental impact

VOCs and HAPs are major contributors to ground-level ozone, a significant component in smog, which can cause respiratory illnesses. Some VOCs and HAPs are known or suspected carcinogens. The U.S. Environmental Protection Agency (EPA) prescribes proactive LDAR programs, including identifying leaking components, comparing leakage levels to compliance standards, making the necessary repairs, ongoing monitoring and measurement, recording and maintaining data, taking corrective actions, training and audits. These programs are costly and time consuming, and involve thousands of plant components, such as valve stems, flanged-joints, pump seals, pressure relief devices, end connections and others. Plant personnel devote much time and effort to gathering information, maintaining databases and generating the requisite reports, all for the ultimate objective of stopping leaks.

To avoid leaks in the first place, the EPA encourages the use of low-leak valve and packing technologies. Current consent decrees are giving attention to the most prevalent method of controlling valve stem emissions — compression packing (Figure 1).

Valve stems

Studies have indicated that leaking valve stems are by far the single largest source of fugitive emissions in processing plants. These emissions can be controlled by following simple guidelines that take into account the valve and its service conditions, the seal supplier’s recommendations, proper seal installation and ongoing performance monitoring.

Obtaining clear input on the type of valve to be sealed and its mechanical condition is the logical starting point. The most-effective sealing solution depends on whether the valve is occasionally actuated, such as a manually operated gate valve, or a continuously actuated control valve. Poorly maintained equipment can cause stem packings to fail, so it is important to inspect the physical condition of the valve for damage to the gland studs or stem, which if bent or gouged can push into or tear the packing.

Next considerations include the temperature, media and pressure to which the valve seal will be subjected, as well as the level of sealing performance required to comply with federal, state and local regulations, consent decrees and company standards. It should be noted that while federal regulations may require seal performance with a maximum leakage of 10,000 ppm, most states and consent decrees mandate 500 ppm and lower. Some local air-quality-management districts may require levels as low as 250 ppm.

Sealing types

Different types of seals have different performance attributes in terms of valve actuation force; interaction of axial compression to radial expansion of the packing; friction; emission level; and the ability to retain and adjust a seal for compliance. There are a number of viable choices for valve stem seals, notably die-formed flexible graphite, braided, flexible graphite packings deliver low leak performance for field repacks.
Two standards for valve seal performance are API 622, "Type Testing of Process Valve Packing for Fugitive Emissions" and ISO 15848, "Industrial Valves — Measurement, Test and Qualification Procedures for Fugitive Emissions — Part 1: Classification of Individual Refiners and Chemical Processing Companies." Table 2 provides the basic criteria of API 622 and ISO 15848.

**Performance standards**

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**Proper installation**

Just as important as selecting the right seal for a particular valve application is making sure it is installed properly. Correct installation insures more even compression of the packing, which results in better emissions performance.
and longer service life. Begin by referring to the manufacturer’s installation instructions. Then, remove all the old packing, inspect the stem and stuffing box for any visible defects, and replace or repair any worn or damaged components. Next, measure the stem and bore diameters and stuffing-box depth to calculate the correct packing size and number of rings. If using braid, cut the rings to size using a mandrel the same size as the stem or a packing cutter. The rings are usually installed one at a time.

Special care must be taken not to break die-formed flexible graphite rings when installing them over the gland or valve packing box bore. Installation of engineered sets is governed by manufacturers’ specific instructions. After the packing has been installed, check for proper compression and actuate the valve per the manufacturer’s instructions. Then make any necessary adjustments and monitor performance against the manufacturer’s specifications.

Most manufacturers offer performance guarantees and warranties specific to a particular type of packing. Promising a certain level of emission performance, these guarantees are subject to operating conditions and require installation to the manufacturer’s specifications. Most guarantees are dependent on the equipment’s condition. If valves are worn and require rework, the packing performance guarantee may be rendered null and void. Most valve-stem seals can wear over time, so service life limitations are typically specified in performance guarantees. It is advisable to get these programs in writing to assess their applicability to plant requirements. The latest consent decrees are requiring documentation verifying the leakage performance of low-leak packings and valves as part of enhanced LDAR programs. Most performance guarantees are also contingent upon the credentials of the installers, which are usually trained and certified by the seal manufacturer. Manufacturer site supervision and accountability may also be available, but at a price.

There are a number of basic criteria for high-performance, low-emission valve stem seals. Emissions should be less than 500 ppm using EPA measurement methods. Since the seal may be exposed to flammable media, it should be fire-safe as verified by API 607, API 589 or similar tests. The valve-stem seal should also be capable of maintaining a seal that is thermally cycled and accommodates reasonable actuation force, which is especially important in control valves.

Following this guidance on sealing selection and installation and engaging the expertise of sealing manufacturers and practicing the elements of proactive LDAR will prepare CPI plants for any type of inspection or audit. The rewards of good sealing selection and practices will manifest themselves in regulatory compliance, increased plant efficiency, improved profitability and a healthy work environment.

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**TABLE 2. A COMPARISON OF PERFORMANCE STANDARDS**

<table>
<thead>
<tr>
<th>Test Procedure</th>
<th>ISO 15848</th>
<th>API 622</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media</td>
<td>Helium or methane</td>
<td>Methane</td>
</tr>
<tr>
<td>Sensing method</td>
<td>Stem seal: Vacuum: Helium Flush: Helium or methane</td>
<td>Modified EPA Method 21 with fixed probe</td>
</tr>
<tr>
<td>Pressure</td>
<td>90 psig</td>
<td>600 psig</td>
</tr>
<tr>
<td>High temperature</td>
<td>392°F and 752°F</td>
<td>500°F</td>
</tr>
<tr>
<td>Thermal cycles</td>
<td>&lt; 2,500 cycles (on-off valves)</td>
<td>≤ 100,000 cycles (control valves)</td>
</tr>
<tr>
<td>Actuation</td>
<td>≤ 3 cycles</td>
<td>3</td>
</tr>
<tr>
<td>Pass/fail</td>
<td>Class A: ≤ 10⁻⁶ cm³/s/m of stem diameter Class B: ≤ 10⁻⁴ cm³/s/m Class C: ≤ 10⁻² cm³/s/m</td>
<td>Agreement of manufacturer and end user</td>
</tr>
<tr>
<td>Adjustments</td>
<td>Limited number and frequency</td>
<td>Limited</td>
</tr>
</tbody>
</table>

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**FIGURE 3.** Engineered sets are favored by valve builders for low emission performance.

**FIGURE 4.** Live loading: Disc spring washers on the gland bolts store energy that can prolong sealing performance.

**FIGURE 5.** This graph shows weight retained in the high-temperature oxidizing air environment as specified by API 622.

**FIGURE 6.** An emission test chart for API 622 is depicted here.

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