Forestall Fugitive Emissions – Consider two crucial design elements before selecting a valve

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Limiting leakage of harmful volatile organic compounds (VOCs) from valves is a business imperative for chemical manufacturers. Process plants must curb such emissions to comply with increasingly stringent regulations, and to protect workers, communities and the environment as well as the company's bottom line and reputation.

A recent report [1] by the United Nations notes that, by the year 2020, the acceptable level of emissions of VOCs will have been reduced by 95% since 1990 — and that more than 60% of fugitive emissions worldwide emanate from valves.

The task of complying with applicable standards can prove challenging. However, several steps can ensure the highest degree of protection from fugitive emissions: evaluating external leak paths such as the valve stem and body joints, and implementing onsite compliance measures. This article will explore these considerations and how they affect valve selection.

The First Line Of Defense

For controlling fugitive emissions, perhaps the most crucial consideration in valve selection is the stem seal design. Although traditional packing options such as chevron (v-ring) or cup-and-cone styles can successfully combat most fluid leakage, those options alone won't suffice in guarding against fugitive emissions of highly hazardous chemicals in volatile applications with extreme fluctuations in temperature and pressure. Therefore, processors needing valves for such services should carefully assess stem seal design and materials.

While both rising-stem and quarter-turn valves can be susceptible to leaks, valve stem movement through the packing in rising-stem valves makes them a more precarious choice than their quarter-turn counterparts.

To mitigate the leak potential with rising-stem valves, a bellows-sealed design has proven highly effective compared to alternatives. In selecting a bellows-sealed valve, users should look for the following design features pertaining to fugitive emissions control:

- Two-part rising stem. This isolates the rotational movement of the stem and shields inner components from the effects of torque.
- Full-size safety gland packing made of graphite or polytetrafluoroethylene (PTFE). A safety backup enables continued valve function, eliminating the need to shut down the plant in case of emergency or failure.
- Bonnet gasket with tongue-and-groove bonnet flanges. A valve that utilizes a tongue-and-groove design focuses the force of the nuts and bolts on a smaller area. Therefore, the gasket doesn't wear out or become dislodged due to temperature swings, helping achieve leak tightness in volatile applications.

Despite the benefits of a bellows-sealed design for rising-stem valves, processors often opt instead for quarter-turn valves for fugitive emissions control to avoid potential leak paths created by the vertical movement of a stem through packing. In this case, valves with redundant seals and side-load protection offer the best defense against external leakage. Valve design, materials and function can vary greatly among different valve types; therefore, we'll focus only on considerations for process ball valves.

End users should consider the following when selecting a quarter-turn ball valve:

- Side-load protection. A common fugitive emissions concern with traditional valve designs is stem seal leakage caused by side loads due to actuator misalignment, improper manual operation or abusive contact. A pressure-assisted stem seal can provide a high degree of protection against fugitive emissions while supplying superior side-load resistance. Alternative designs rely on bearings located above or below the packing to combat side loads on the stem.
- Live-loading protection. Live loading maintains a consistent force on valve packing during pressure and thermal cycles and reduces the potential for cold flow of packing, which can compromise its sealing capabilities. Live loading usually is more effective on PTFE than on graphite packing.
- Packing types. Packing generally is used in valves because it allows for adjustments that can help stop a leak once detected. Traditional PTFE packings such as chevron v-ring or cup-and-cone styles are effective in most chemical applications, and suit temperatures up to 600°F. Graphite packing, which can handle temperatures in excess of 1,000°F, is more common in higher-temperature applications or where fire safety is a concern. While graphite is less susceptible to temperature fluctuations, it isn't as effective when used with gases such as helium and methane. Other specialty materials are available from various manufacturers for niche applications.

- Multiple stem seals. These address specific sealing concerns to provide the highest degree of protection against fugitive emissions. A traditional, single stem seal with standard v-ring packing can be adjusted to prevent leakage in standard applications but eventually will leak in challenging environments. Dual seals build upon the single seal and use multiple materials to deliver added protection and extend the life of the seals. Finally, a triple stem seal combines these advantages with added side-load protection, fire safety, a chemically inert seal and pressure assist. Processors increasingly are favoring double and triple stem seals because of the enhanced protection they provide.

The Second Safeguard

A valve's body joint can pose a second major point of susceptibility to fugitive emissions, particularly when the valve must handle dynamic temperature conditions.

Thermal cycling in chemical processes can create a leak path at the body joint in severe service conditions characterized by extreme pressure and temperature fluctuations. Not all valve manufacturers will present test data that reflect multiple thermal cycles; it's therefore important to ask whether the vendor has gathered this information.

To mitigate the leak risks associated with thermal cycling and body joint susceptibility, processors should consider the following during product selection:

- PTFE-type body gaskets. These work well with stable temperatures but thermal cycles can cause the PTFE to cold flow and reduce compression, allowing a leak.
- Graphite-type body gaskets. Rope packing/die-formed rings work well at most temperatures, can cope with many thermal cycles, and usually are required to achieve a fire safe rating on a valve. However, media compatibility can limit their applicability.
- Dual-material body gasket. Such a gasket combines the benefits of PTFE and graphite to provide a chemically inert seal that will both protect against fugitive emissions and ensure fire-safe operation.
- Spiral-wound body gasket. This industry-proven design provides structural support and live loading via metal spiral v-shaped rings. Most spiral-wound gaskets use either a PTFE or graphite seal material. As already noted, each material has limitations. However, when combined, they achieve the best of both designs. These v-rings protect the PTFE and graphite seals from extrusion and cold flow during thermal cycles. A dual-material gasket in the spiral-wound configuration is chemically resistant and able to recover during thermal cycling, operate uncompromised in all temperatures, and meet fire-safe performance requirements.
- Self-relieving seats. By design, ball valves contain a cavity in which the medium becomes trapped when the valve is in the fully closed position. Under certain conditions, the medium may expand, resulting in high pressures that exceed the valve's maximum capacity and creating the potential for leaks and other catastrophes. Self-relieving seats enable pressure relief and mitigate the potential for disaster.

The Need For Ongoing Vigilance

A robust leak detection and repair (LDAR) program is essential for safe and efficient plant operation. However, the emissions reduction potential of LDAR varies markedly and depends upon several factors. You must consider the frequency of monitoring, the source of a leak, and the threshold definition of a leak when determining the effectiveness of the program. Furthermore, characteristics of individual sources can affect the emissions reduction achieved by LDAR. Important factors include leak occurrence and recurrence rate, accessibility of leaking equipment, and repair effectiveness [2].

Select Wisely

Chemical processors aiming to avoid fugitive emissions from valves should pay attention to the design features of valve stem seals and body joints, and talk to vendors about innovations to combat fugitive emissions.

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