WHITEPAPER

OPTIMISING GLOBAL VALVE PERFORMANCE: TACKLING PACKING FRICTION FOR OPERATIONAL EXCELLENCE

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CONTENTS

ABSTRACT

Valve control is crucial for controlling flow and ensuring seamless plant operation throughout industrial processes. This whitepaper explores the impact of packing friction on control valves and its critical role in industrial safety and efficiency.

While industries in emissions sealing have made much progress over the past few decades to lower valve leakage from 10,000 PPM to 100 PPM, it's now time to focus on the next challenge. How to reduce packing friction while maintaining current sealing standards.

This paper underscores the potential transformative impact of a global breakthrough in packing materials, manufacturing, and testing methodologies. Such a breakthrough could help us strike the right balance between packing seating stress and stem friction.

Figure 1. Emission packing training critical for meeting Low-E requirements.

1.0 INTRODUCTION

Many mechanical industrial systems rely on valves to control flow. Whether the transported material is gas, liquid or sediment, ensuring the integrity of each valve is vital to regulate pressure.

Controlling the friction within the stuffing box packing is a crucial element of this. A failure to control this can have consequences that not only reduce efficiency but also have the potential to impact safety and lead to a catastrophe.

One fatal example is from California in 2010, where a natural gas transmission pipeline exploded in the neighbourhood of San Bruno. Uncontrolled packing friction played a direct role in causing the accident that led to eight people losing their lives, many more with injuries, and more than 100 homes damaged or destroyed.

Safety remains an issue as critical emissions leaks continue to occur worldwide. Just recently, in March 2024, a natural gas pipeline erupted near Gladstone in Queensland, Australia. While the investigation of that leak continues, many leaks involve issues with control valves and packing friction.

While much effort continues to be made to solve packing friction issues, the challenge is yet to be fully overcome.

Figure 2. Pipeline rupture in San Bruno, California, on 9 September 2010.

2.0 WHAT IS PACKING FRICTION?

In simple terms, packing friction is a by-product of compressing packing within the stuffing box to control leakage. There are two types of packing friction: static and dynamic.

While stress within the packing material is needed to prevent the medium from escaping at these natural weak points, the more pressure it undergoes, the higher the friction.

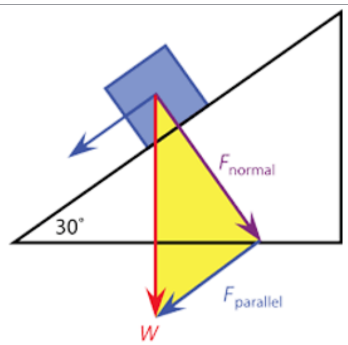

Figure 3. Standard graphic for friction demonstrating F friction force on incline plane.

Maintenance staff typically increase the gland load on the packing to reduce leaks and improve operation by applying more torque to the gland bolts.
However, doing so often results in over-tightening, overloaded tension, and a rise in packing friction.

Over-tightening causes the stem to have a jerky motion instead of operating smoothly due to excess packing friction.

This can cause system issues with inaccurate pressure settings, leading operators to loosen the gland studs to try and reduce the issue. However, this often results in further leakage and starts the whole cycle over again.

Figure 4. Correct packing sizing is essential for emissions service.

3.0 THE CONSEQUENCES OF PACKING FRICTION FAILURE

While packing friction failure doesn't always lead to a catastrophe like the San Bruno case study below, it can have various consequences that impact environmental, economic and operational elements.

3.1 Case Study - San Bruno, California, 2010
On September 9, 2010, a 30-inch diameter natural gas pipeline ruptured in the San Bruno neighbourhood of California, leading to a massive fire that killed eight people. More than 47.6 million cubic feet of natural gas were released, and more than 100 homes were damaged or destroyed.

While many small missteps occurred in the lead up to the tragic accident, one of these was the packing friction that created a problem with the control valves. The pipeline pressure oscillated wildly resulting in higher pressure levels in the pipe than could be safely contained. On the afternoon of the explosion, an employee was working on the electrical distribution system, replacing the uninterruptible power supply (UPS) that powered data acquisition equipment and the control valve electronics. The main digital control valve was plugged into the UPS, which caused it to fail in the open position. The remaining online analogue control valve then had to handle the entire load, and this caused extreme pressure cycling.

Figure 5. Natural gas pipeline ruptured, leading to a massive fire (AI).

This cycling effect is commonly seen in many control valves and is a significant problem. The main culprit behind this is high static friction, otherwise known as 'stiction'. However, this can be reduced with proper valve actuator sizing and through packing design. Whether or not it leads to a catastrophic accident, valve failure has far-reaching consequences.

3.2 Environmental impact

The potential for environmental disaster is significant, from gas explosions in built-up areas like the one in San Bruno to oil or chemical spills and any situation where toxic substances escape. These accidents can include massive volumes of escaped materials that lead to major environmental challenges. Often, these disastrous events can be traced back to causes that include valve failure. Catastrophic incidents aside, emissions leaking into the atmosphere are a major contributor to global air toxicity and climate change. Leaks and spills can also pollute groundwater and surface water, harming waterways and the flora and fauna that depend on them.

Figure 6. Chesterton 1622 Low Emissions Valve Packing.

Over the past few decades, U.S. state and federal agencies have significantly tightened the standards for maximum leak rates from 10,000 PPM to 100 PPM to help address this. However, the lack of a unified testing standard has made it hard to compare the effectiveness of low-emissions valve packing. The American Petrochemical Institute (API) has developed a detailed testing procedure for packing performance in methane. Importantly, the API 622 standard is not a valve test but a packing test, fast becoming the national U.S. benchmark for packing performance.

Figure 7. Emissions leaking into the atmosphere are a major contributor to global air toxicity and climate change.

3.3 Economic impact

On an economic scale, emission escape and the worst-case scenario of resulting explosions don't only cost the company involved, but also the planet. Annually, billions of dollars are pumped into reversing environmental decline. Industry is a major contributor, with harsh fines for those who fail to comply with emission regulations.

Several sources including the U.S. Environmental Protection Agency have found that around 60 percent of all fugitive emissions come from valves, particularly from within the oil, gas and coal industries. It is also estimated that these fugitive emissions make up at least 5% of all global greenhouse gas emissions.[3,4,5,6]

The economic impact trickles down the chain, ultimately to taxpayers, as the cost builds up in the fight against climate change. Aside from this, any global catastrophe involving fuels can impact the supply chain by reducing capacity and availability. This can spook the markets and result in higher prices for a sustained time.

3.4 Operational impact

While far less dramatic but important nonetheless, malfunctioning valves negatively impact industrial operations' running and maintenance costs. Only optimal output equals maximum profits. Breakdowns cause unexpected asset downtime and the associated repairs, potentially leading to a dramatically reduced bottom line.

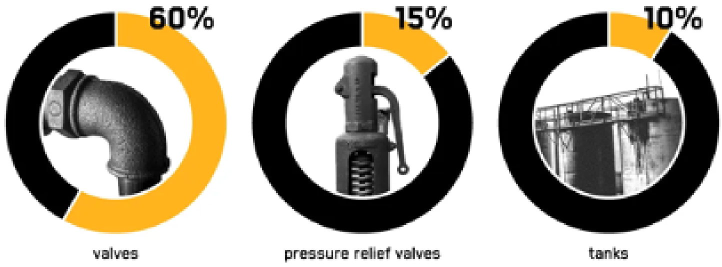

Figure 8. Valves are estimated to cause 60% of leaks (ref: persefoni.com/blog/fugitive-emissions).

4.0 CHALLENGES AND SOLUTIONS

Controlling packing friction has been and still is a constant challenge. Over the past few decades, the practice of a mechanic using their judgement to estimate the tightening needed has been superseded. Today, torque values are the preferred way to apply gland load in most industries during packing installation. Accurate loading is the most important factor for packing performance and life.

This still needs to be improved, such as the inaccuracy of lubrication and flat washer usage. Both need to be understood to get a more accurate load transfer. It is important to remember that torque is not tension. An example is how a bent thread can lead to a poor load transfer, resulting in a false positive torque application. Another example is tightening a bolt in service where the dried anti-seize gives off a different value for friction, which also results in a false positive torque-to-tension relationship.

Torque = μDF/12N

- μ = Coef. of friction between the bolts and the stud (default =.2)
- D = Stud Diameter
- F = Area x Pressure
- Packing area = (OD2 - ID2) x π/4
- P = System Pressure x Safety Factor
- N = Number of Bolts
- 12 = the conversion from inches to ft

Figure 9. Torque formula.

4.1 Next-generation solutions

Technology has already produced a better solution to improve accuracy – gland load sensor devices. These use calibrated bolts and or disc spring heights to allow operators to accurately determine tension. This latest breakthrough means that maintenance staff can now calculate and adjust gland load as needed, even while the equipment is operational.

The outer guides can act as a visual indicator of load. The outer guide's height is cut to the compressed height of the springs at the load. This visual indicator is independent of torque and can be used to give feedback on the load on the packing set at any time. This also assists during installation in ensuring the correct consolidation is applied to the packing set.

Another advance in technology includes the introduction of hand-operated valves, as opposed to wrenches. Valve wrenches or extenders are still commonly used today to adjust load and are problematic. Not only do they increase the likelihood of equipment damage, but they also present a risk of injury to the user. Technology is helping us solve these problems, and we can expect to see control valves being developed that don't require adjustment at all. Next-generation solutions such as these are already well past the blueprint stage. Development is already in progress, with prototypes and real-world testing around the corner.

4.2 New packing materials

While efforts have been focused around applying more accuracy to bolt loading, technology improvements have also been made in creating new packing materials with lower gland loads and a lower coefficient of friction.

Chesterton 1622 Low E Valve Packing

Designed to minimize VOC emissions from block (isolation) valves, exceeding the current emissions standards for the refinery, petrochemical, and chemical industries. This flexible, non-hardening packing is made from an Inconel-reinforced mesh with internal exfoliated graphite, preventing shrinkage and moisture absorption. It includes a passive corrosion inhibitor to prevent galvanic corrosion of valve parts in contact with the packing. The 1622 packing meets API and ISO qualifications, including API 622, VDI 2440 (TA-Luft), and API 624, and is fire-safe to API 607.

Figure 10. Chesterton 1622 Low E Valve Packing.

Chesterton 6800 CLLT Low E Packing Set and Kit
Developed for oil and gas processing, this control valve packing set is the latest offering, incorporating the Chesterton wedge seal design of the Chesterton 5800T with other components. The result is drastically lower packing friction and reduced control valve cycling. These require no gland adjustments to seal to ISO-15848, reducing maintenance costs and increasing critical equipment runtime. This kit has passed both the API 622 and API 607 Fire Tests.

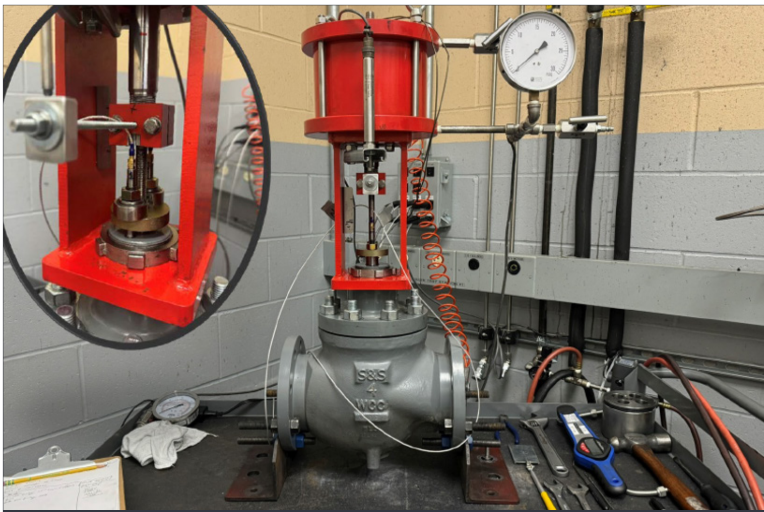

Figure 11. Chesterton test lab.

5.0 CONCLUSION

Packing friction is an ongoing issue. Outdated practices remain common, resulting in inefficient operations and associated economic and environmental impacts.

It's often a case of 'out of sight, out of mind' regarding internal valve maintenance. Packing friction is an unseen enemy that only becomes apparent when valve and system pressures move dramatically out of range. Yet addressing the issue is complex because efficient and accurate monitoring has yet to fulfil the required potential.

There are relative solutions, such as gland-load sensors, but technology isn't currently in place to easily bring a reliable and affordable solution to the mainstream. However, companies owe it to the planet, their workers and shareholders to continually push the boundaries.

Only through such advancements can issues affecting operations safety, the environment, and production efficiency be truly overcome.

Figure 12. Chesterton Low E Valve Sealing System.

ACKNOWLEDGEMENTS

A 140-year-old A.W. Chesterton Company brand, has a proven track record of enhancing critical industrial equipment and structures worldwide. Ron Frisard graduated from Northeastern University in Boston with a degree in mechanical engineering technology in 1989.

Ron has worked for the A.W. Chesterton Company for the last 33 years. He is currently focused on Global Product Line Management for both Rotating and stationary sealing for Mechanical Packing and Gasketing.

Want to know more?

Visit **Chesterton** to discover more about our valve packing solutions for the Oil and Gas Industry or send your enquiry to:
enquiries_apac@chesterton.com and speak to one of our experts to discover how we can help your business.

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FOOTNOTES/REFERENCES

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