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Kalrez® perfluoroelastomer parts

From DuPont Performance Elastomers

Kalrez® Valve Stem Packing Technical Guidelines and Design to Improve Process Control and Minimize Fugitive Emissions

Introduction

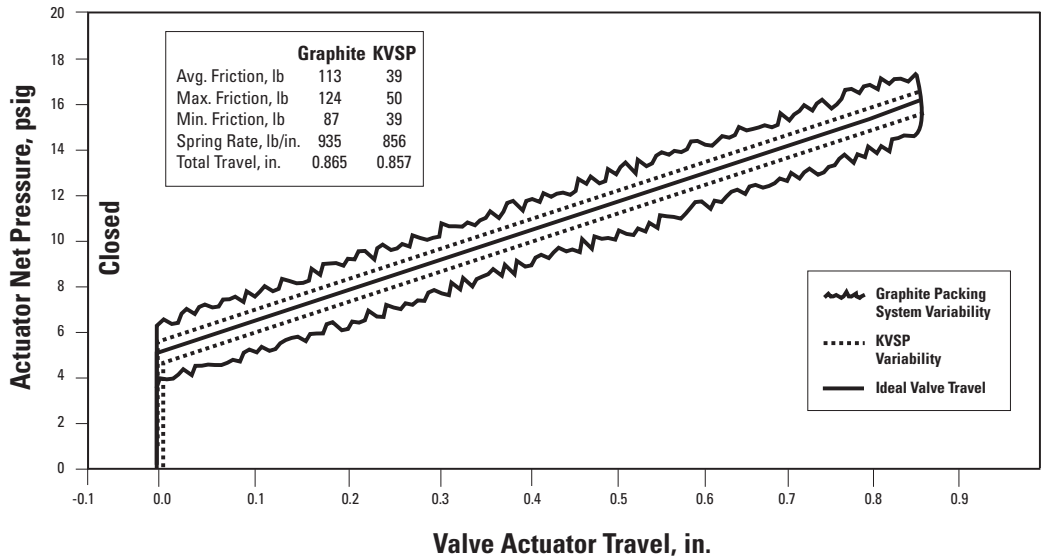
Kalrez® Valve Stem Packing (KVSP) systems can help to significantly reduce fugitive emissions and improve process control through the innovative use of Kalrez® perfluoroelastomers combined with other proven packing materials. Graphite packing systems can meet fugitive emissions requirements but restrict valve movement, leading to inconsistent process control. Polytetrafluoroethylene (PTFE) has excellent process control response characteristics but cannot contain fugitive emissions when temperature cycling is involved in conjunction with operational cycling. Kalrez® packing systems overcome these deficiencies, as well as reducing leak rates to near-bellows performance.

Kalrez® is chemically an elastomeric PTFE derived from tetrafluoroethylene (TFE), the same base monomer. It provides a unique combination of chemical resistance and inertness like PTFE, but with a higher temperature service limit and no tendency to cold flow. The chemical structure remains cross-linked and stable at high temperatures and does not move under load or deformation. Its resiliency and memory provide improved sealing for control valve stems. Using Kalrez® v-rings backed up with more rigid components of carbon fiber-reinforced PTFE (Vespel® CR-6100) has proven to be a major advancement in improving process control and reducing leakage to less than 1ppm, or below the plant's background level. Kalrez® perfluoroelastomer packing systems increase a valve's ability to react quickly and smoothly to process changes (*Figure 1*). KVSP reduces process control variability to the control system's capability, resulting in improvements to both yield and product quality on specification.

Process Optimization by Reducing Variability

The control valve is the final control element in a process. Installing a sophisticated process control

Figure 1. KVSP Improves Process Control Performance Over Existing Materials



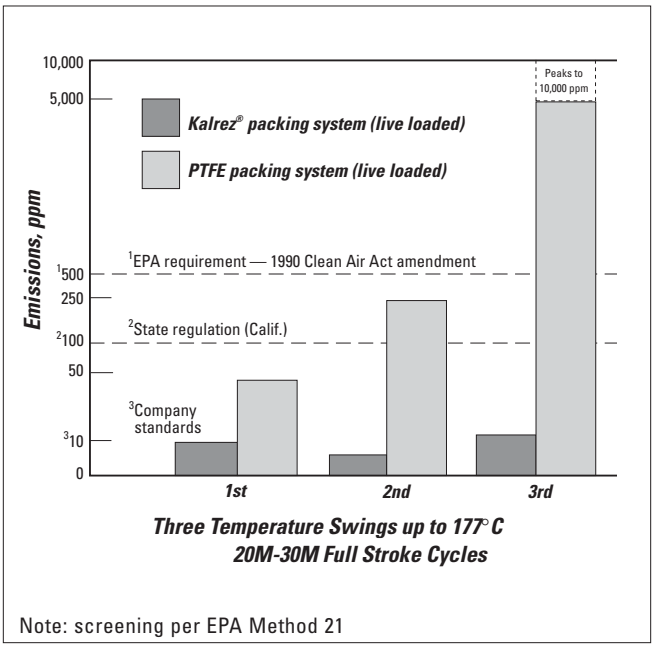
instrumentation system capable of achieving 0.5% or better variability should improve control variability, but many valves control to no better than 2–3%. KVSP systems move a control valve's performance closer to the ideal valve through low stem friction and reduced deadband. KVSP improves the control valve's response closer to the optimum performance capability of the control system.

Conventional Packings

PTFE square-braided and rope packings are the most commonly used packing elements for manual control valves (hand or automated on/off valves) in chemical plants, while automatic throttling control valves typically use more reliable and higher performance PTFE v-ring packing. PTFE packing is the standard material used in automatic control valves because of its broad chemical compatibility and excellent thermal stability. PTFE packing is used for temperatures up to, and occasionally exceeding, 204°C, making it an ideal packing material for most chemical plants and select refinery applications.

The inherent problem with a PTFE-type packing is that when temperature fluctuations occur in a chemical process, the material will creep and move because it is a plastic. Extensive testing has demonstrated that even live loading with a disc or coil spring will not keep fugitive emissions under 500 ppm (*Figure 2*). PTFE-based packing can also cause shaft fretting or scratching from particle imbedding, while perfluoroelastomer systems repel/reject particles.

Figure 2. Controlling Fugitive Emissions — Kalrez® Valve Stem Packing vs. PTFE Packing Systems



Note: screening per EPA Method 21

Graphite Packing Systems

When temperatures exceed 204°C, graphite or carbon fiber packing is commonly used. Typically with graphite, a compromise must be found between the best sealing performance and increasing the loading force. Increased stem friction affects stem movement. The higher loading forces that are needed to seal a graphite packing at less than 500 ppm cause stiction and compromise the controlling function of a valve. This problem is virtually eliminated with perfluoroelastomer packing designs.

Compression packing systems using graphite are, by definition, microvoid structures with leak paths. The choice has been to accept the cold flow and creep problems of PTFE-based systems and their affect on long-term sealing performance or to use a graphite-based system with higher stem friction and an oversized actuator and positioner. However, this still may not overcome the excessive packing stress on the stem that leads to jerky stick-slip movement and inconsistent control.

KVSP systems use resilient Kalrez® v-ring chevron seals in combination with higher modulus backup components. They use much lower loading forces to seal and are resilient and pliable enough to function effectively if misalignment occurs.

Metal Bellows or KVSP

The only option, until now, that could provide low leakage levels that approached 0 ppm has been metal bellows. Because bellows have thin metal membranes, they have pressure/temperature limitations and are subject to corrosion and cycle fatigue failures. Of course, in some extremely toxic or hazardous environments, bellows may still be the optimum choice. When combined with KVSP as the backup packing, it would offer the highest level of containment and safety.

Until now, conventional packing materials and packing systems have not been able to provide the lower leakage rates provided by the metal bellows. The Kalrez® packing systems offer a viable option in both absolute fugitive emission reduction levels and long-term performance.

The KVSP systems provide performance that approaches zero leakage. This was verified using a Foxboro flame ionization leak detection device, described by the EPA in Method 21, typically used for monitoring fugitive emission leakage of hydrocarbon-based volatile organic compounds (VOCs). The KVSP packing systems have consistently performed to the plant's background level, and approached the fugitive emission performance of metal bellows technology. In addition, the KVSP systems have been tested to over 100,000 and 250,000 cycles, and have successfully performed in the field to over 500,000 cycles.

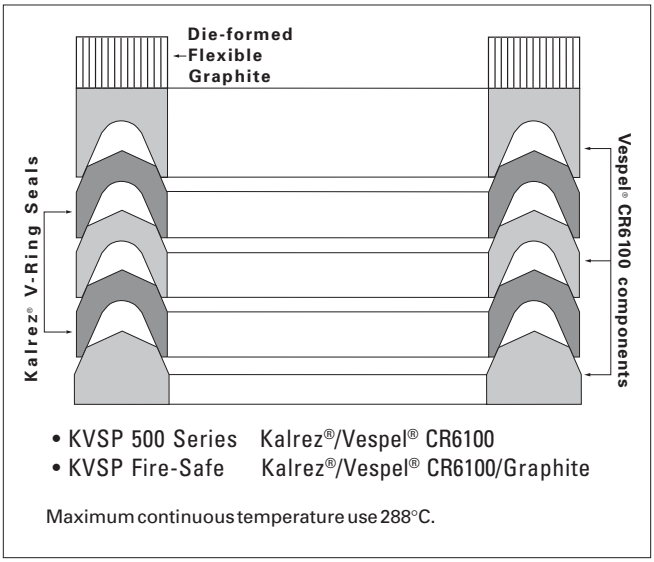
Metal fatigue and possible catastrophic failure are the realities of using metal bellows. Metal bellows made from special metal alloys can almost completely eliminate leakage, but the cost is inherently more expensive, typically 5 to 7 times more than KVSP.

Assembly and Component Material Selection

Vespel® CR-6100 is a non-creep (carbon fiber filled) PFA that provides stability and minimal creep for higher temperature applications, continuous service to 288°C. The addition of a flexible graphite ring has passed the API 607 3rd Edition Fire Test and the equivalent British Standard, BS 6755.

A five-piece assembly is suggested as the optimum design or configuration for use with Kalrez® v-ring components. The suggested assembly sequence and each component size with reference to the actual height of the packing are noted below.

Figure 3. KVSP Design Options



For those instances, where the optimum five-piece configuration cannot be used due to a space limitation, a three-piece assembly option is suggested. The sealing component (Kalrez® v-ring) should be maintained to provide a minimum of at least one-third of the total packing height. This ratio is the same used for the recommended five-piece assembly. Any differences in total height or the packing box length requirements can be accommodated by using a compatible metal or high modulus, chemical-resistant plastic spacer.

Unique V-Packing Design

The design objective for packing should be to maximize containment while improving process control. The surface and contact area for the elastomeric chevron sealing ring and design of the support elements are important. Too little elastomeric sealing surface jeopardizes the system's sealing integrity, while too much increases the system's friction and ability to react to process input changes.

A perfluoroelastomer packing increases the valve's ability to react quickly to process changes, resulting in improvements to both yield and product quality. This can be easily verified by running diagnostic tests.

Typical Control Valve Dynamics Using Kalrez® V-Rings

Conventional Controlling — Dithering/ Perturbations (small stem movements)

In most typical control valve applications, the Kalrez® v-ring seal components grip the stem and the elastomeric backbone absorbs the minute movements of the stem with little, if any, wear (*Figure 4*).

Figure 4.

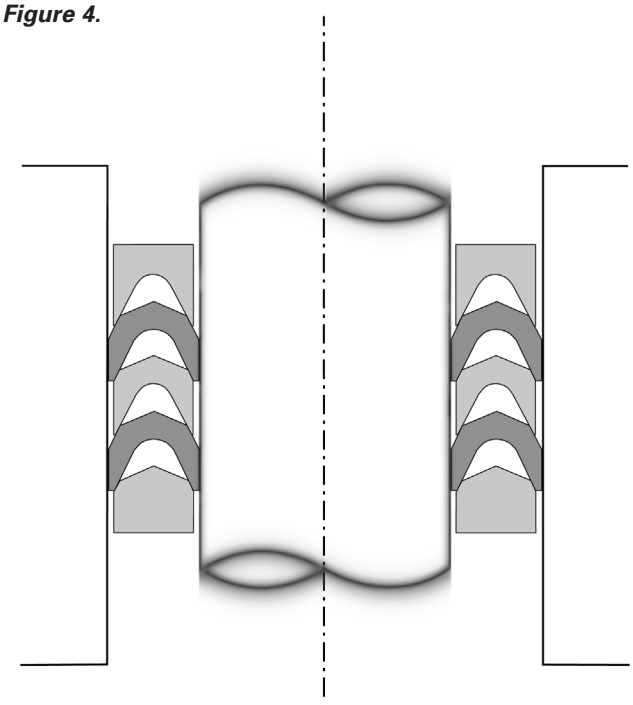
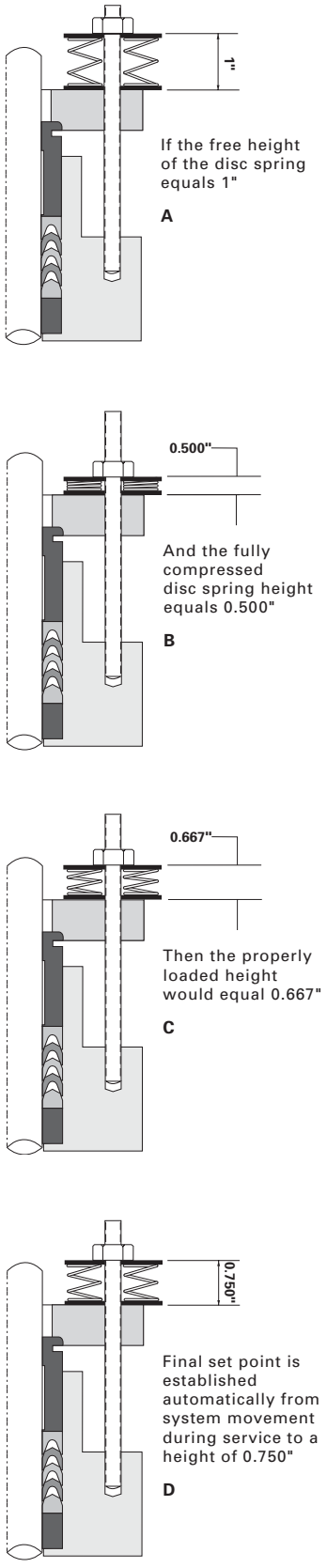


Figure 5.



For complete packing instructions, please contact DuPont Performance Elastomers.

Close/Open — Full Extension Stem Movement (large stem movements)

Full extension and movement are frequently used in applications that are either fully open or closed. Because the Kalrez® packing requires less force to seal than PTFE, the packing will release and reseal with virtually no loss of sealing and with negligible wear.

Stem and Packing Box Finishes

Stem and packing box finishes should be consistent with the original equipment manufacturer (OEM) valve specifications.

Setup Procedures

To take full advantage of the KVSP packing and its capabilities, care must be taken during the initial installation and mechanical loading. Careful installation with Krytox® lubricant is recommended for ease of assembly and to maximize service life.

A modified setup procedure is suggested for live loading the KVSP systems to ensure the correct loading force is used during the life of the packing and to avoid any over-compression of the packing. This procedure also creates open space within the spring set, allowing dynamic movement of the packing system to compensate for any volumetric changes that occur during thermal cycling. (Note: A number of control valve OEMs have successfully used KVSP by preloading the packing.)

The KVSP systems are designed so the components move together during service to eliminate free space within the packing system. This is part of the system's design and will occur automatically during service without further adjustment from normal mechanical and thermal cycling.

Experience has shown that a force between 40–80 bars (600–1,200 psi) on the packing system is required from an external disc spring when set at half of its maximum compressed load rating.

Less Wear — Lower Maintenance

KVSP systems are designed not to wear in the same way a conventional PTFE packing does. A conventional PTFE packing is, by design, forced to move and jammed-in to seal. This is how a PTFE packing functions: significant force must be applied to make it creep and move against the stem and packing box to seal. Kalrez® and the KVSP systems function and seal in an entirely different manner. They require moderate loading forces to seal. The lower loading forces required by Kalrez® translate into significantly longer service life for the KVSP systems. Packing properly installed translates into less maintenance.

Installation/Lubrication

The use of Krytox® lubricants optimizes packing life, therefore it is provided with new valve and retrofit kits. Krytox® GPL206 fluorinated grease is the only lubricant that provides chemical compatibility and thermal stability equivalent to the other fluorocarbon-based component materials used by KVSP systems. The use of Krytox® with the KVSP systems offers three distinct advantages:

- improves the ease of installation and decreases possible damage to the rings
- enhances the absolute fugitive emission reduction performance
- extends the life of the packing

Dimensional Retrofitting Packing Flexibility

The standard high-performance KVSP 500/Fire-Safe Series were tested to determine their adaptability and flexibility for retrofitting into bored-out stuffing boxes in the field.

Tests verify that Kalrez® can successfully seal stuffing boxes bored out up to 1.0 mm (0.040 in) over size. They help eliminate special packing sizes and the need to resleeve stuffing boxes.

The Kalrez® v-rings readjust their actual size to maintain sealing by extending to wider stuffing box dimensions while system backup elements reset in a similar manner. The KVSP systems also adjust to small incremental stem size changes from rework or refinishing.

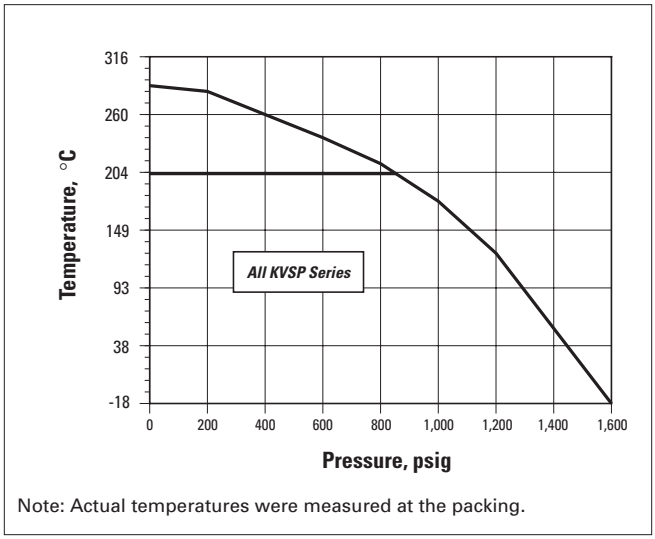
- KVSP 500/Fire-Safe Series/Vespel® Components — Maximum bored-out stuffing box dimension equals 1.0 mm (0.040 in.) diametral.

Operational Range

Kalrez® packing systems have been used and tested to various temperature/pressure combinations (*Figure 6*).

Temperature/pressure curve operational range for the KVSP systems was tested to ANSI/FCI 91-1-1994 protocol for fugitive emissions in Class 600 valves from –40 to 288°C. May also be used in higher pressure class valves. Contact DuPont Performance Elastomers for recommendations.

Figure 6. Kalrez® Valve Stem Packing Systems Five-Piece Design
Pressure/Temperature Operating Range (–40°C to 288°C)



Note: Actual temperatures were measured at the packing.

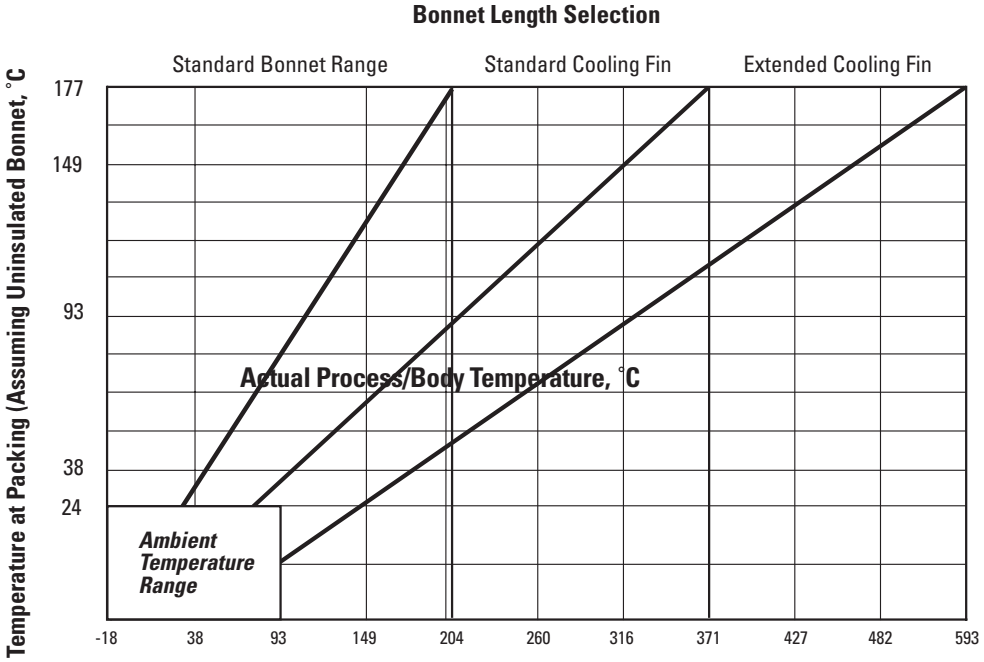
High- and Low-Temperature Services

KVSP systems are rated for actual continuous temperature service from –40 to 288°C. The actual temperature at the packing is usually lower than the process stream. A number of major OEM control valve companies have recommended Kalrez® packing systems for very high process stream temperatures, up to 427°C. KVSP systems can also be used at low temperatures for cryogenic applications with an extended bonnet. Live loading is necessary to seal to –40°C. This has been accomplished by using extended bonnets on the valves with Kalrez® v-rings and polymeric components made of Vespel® noncreep carbon fiber-filled PFA PTFE. Because the control valve acts as a large heat sink, it reduces the actual temperature the packing will see when compared with the process stream temperature. The net cooling effect on the packing can be quite significant, with temperatures at the packing reduced by as much as 93 to 149°C with an extended bonnet. Many standard bonnet designs provide a temperature differential and cooling effect, and can be considered for process stream temperatures in the 288 to 371°C range, based on the specific valve design (*Figure 7*).

Valve Design/OEM Availability

KVSP systems are available from major valve companies in three- and five-piece designs for rising stem, rotary shaft, or manual valves. They can easily be retrofitted without costly valve modifications. KVSP systems are manufactured at ISO 9001 facilities. KVSP has been fitted into thousands of control and automated valves since the early 1990s. Field service reports verify fugitive emissions still measuring to background (less than 1ppm) after five years. KVSP outperforms other packing designs in providing full containment of fugitive emissions, combined with reduced process variability, for better yields to tighter product specifications.

Figure 7. High-Temperature Applications—The Effect of Standard and Extended Stainless Steel Bonnets on the Temperature at the Packing in Control Valves



Note: This chart can be used to determine the actual temperature at the packing for standard cooling fin and extended cooling fin bonnets.

1. Locate your actual process temperature along the bottom of the chart.
2. Follow the temperature up the chart, noting the intersection point with one of the three diagonal lines.
3. Follow the intersection point to the left, noting the actual packing temperature.

This chart was provided by a major valve OEM as background information only. It illustrates the process temperature — body/packing temperature differential that can be achieved by using stainless steel construction and extended bonnets. Different OEM valve designs will have different heat dissipation characteristics than those on this chart. This chart is only applicable to stainless steel construction and is based on an average calculated value of 316 stainless steel, Hastelloy C and Monel 4000. Carbon steel does not have the same heat dissipation characteristics as stainless steel and must be plotted and considered separately.

For further information please contact one of the offices below, or visit our website at www.dupontelastomers.com/kalrez

Global Headquarters—Wilmington, DE USA
Tel. +1-800-853-5515
+1-302-792-4000
Fax +1-302-792-4450

South & Central America Headquarters—Brazil
Tel. +55-11-4166-8978
Fax +55-11-4166-8989

Japan Headquarters—Tokyo
Tel. +81-3-6402-6300
Fax +81-3-6402-6301

European Headquarters—Geneva
Tel. +41-22-717-4000
Fax +41-22-717-4001

Asia Pacific Headquarters—Singapore
Tel. +65-6275-9383
Fax +65-6275-9395

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