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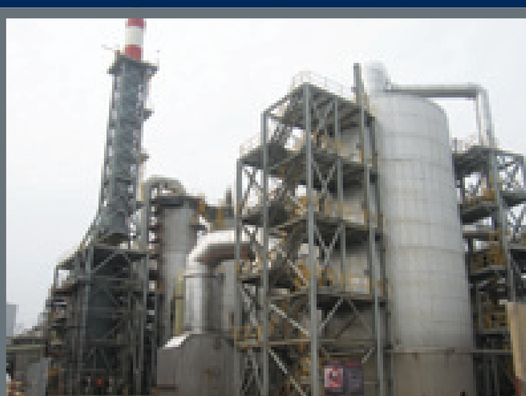

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Creating reliable, durable seals in glass-lined steel equipment

Equipment made of glass-lined steel is used when manufacturing or processing aggressive chemicals such as aniline derivatives and strong acids such as sulfuric, nitric or hydrochloric acid. The Achilles heel of such glass-lined systems is the gaskets needed to seal the joints between components. Exposure to aggressive media causes the seals to degrade over time, resulting in damage to equipment and posing a health risk to operators. Replacing the seals costs a great deal of time and effort, with a corresponding drop in production output. A newly developed gasket tape made of ePTFE (expanded polytetrafluoroethylene) is specifically designed to address the challenges of creating reliable seals in large glass-lined steel equipment.

Operators of chemical plants choose sealing materials according to a wide range of criteria such as process media, flange type, sealing performance, pressure and heat resistance, cost and longevity. Other important selection criteria include time required for installation and inventory management considerations. And of course, a plant operator's prior gasket experience weighs in as well. Gaskets for glass-lined steel equipment are safety-critical parts because their failure can endanger human lives and/or harm the environment, yet they are often managed as parts of minor significance.

Sealing challenges

Glass-lined steel presents the advantage of being highly resistant to corrosive and/or abrasive media, as well as being biologically and catalytically inert. Another characteristic feature of this material is its smooth, easy-to-clean, low adhesion surface (Fig. 1). For these reasons, the use of glass-lined steel is uniquely advantageous in some applications, despite the challenges to sealing the flanges of glass-lined vessels (Fig. 2) and piping.

Reliably sealing glass-lined steel equipment is particularly challenging relative to standard steel equipment. One contributing factor is the limited load available to seal the gasket. The glass lining is more fragile than the metal, and can therefore split or splinter if handled incorrectly. As a result, the gasket load that can be applied to the seal is lower than that for an all-steel flange. Care must be taken to limit the pressure applied when installing gaskets between interconnecting parts of the system. Another challenge is that of achieving a reliable seal when the flange's glass surface is uneven or has surface deviations. Once the glass lining has fused, its surface cannot be reworked. In addition to these sealing challenges resulting from

Fig. 1: Close-up of glass-lined steel flange.

the glass-lined surface itself, an additional challenge and limiting factor is that of choosing a suitable sealant material for glass-lined steel systems, because these involve the use of aggressive media such as aniline derivatives and strong acids under demanding conditions.

The challenges posed by these characteristics of glass-lined steel, combined with the exposure to aggressive chemicals and high temperatures, must be met by the chosen sealant. In practice, these difficult conditions often lead to premature sealing failure and a greater risk of equipment corrosion. The further consequences of sealing failure include leaks and uncontrolled emissions, damage to equipment, high replacement and repair costs, production losses, unplanned maintenance and downtime and potential risks to employees' health and safety and to the environment.

Chemically resistant sealing material

Because of its high chemical resistance, polytetrafluoroethylene (PTFE) is often used as gasket material in applications involving highly aggressive media. It resists attack by almost all media (pH range 0-14), and supports an extremely wide range of temperatures, from -269˚C to +315˚C. The non-aging material is weather and UV-resistant, has a low coefficient of friction, is physiologically harmless and is suitable for a wide range of different applications.

The molecular structure of PTFE consists of a chain or backbone of carbon atoms saturated with fluorine atoms. The strong covalent bonds between the fluorine and carbon atoms explain this polymer's quasi-inert reactivity to other chemicals. This is the reason why it is an ideally suited sealant material for aggressive chemical applications. On the other hand, its low reactivity means that, unlike certain elastomers, PTFE is unable to form molecular networks. As a result, traditional PTFE gaskets have a pronounced tendency

Fig. 2: Example of a large scale glass-lined steel vessel.

to deform, or "creep," when under stress, and particularly when exposed to thermal cycling.

Existing solutions

PTFE is widely accepted and valued for its chemical resistance. However, the PTFE polymer—without further modification—has notable shortcomings when used as a sealing material. Due to its hardness, it lacks the ability to easily conform to surface imperfections and reliably provide a tight initial seal. Additionally PTFE lacks the dimensional stability to reliably provide a long-term seal, due to its tendency to "creep" under stress and thermal cycling. Thus, commonly used sealing solutions such as envelope gaskets or filled PTFE gaskets attempt to overcome these shortcomings by incorporating a core of compressible material or a homogenous blend of PTFE and friction-creating fillers, respectively. However, each of these common sealing solutions now generates its own problems.

In the case of the PTFE envelope, a thin outer skin of PTFE allows permeation of some media, or worst case can even have or develop defects (porosity or small holes in the PTFE envelope), both resulting in degradation over time of the non-PTFE gasket interior. Additionally, high temperatures can lead to a loss in sealing effectiveness with lower grade inlays, such as compressed synthetic fiber (CSF) sheets, that can become hard and brittle. The need to shim envelope gaskets can also lead to costly delays.

Filled PTFE gaskets typically contain glass spheres or fibers to provide friction within the material and improve creep resistance. This is not enough in all cases, though. High temperatures, especially cycling temperatures, combined with the low load capability of glass-lined steel lead to gasket force loss (due to creep) resulting in higher leakage.

Extra complexity is added with large flanges (> DN 600 / ASME 24") due to the need for offsite gasket fabrication. This often results in long lead times, shipping, handling and inventory challenges. Furthermore, inconsistent quality across manufacturers and product lines, as well as time consuming and complex installation, may lead to troublesome and delayed facility start-up.

Alternative solution based on expanded PTFE (ePTFE)

An alternative solution is to use expanded PTFE (ePTFE), a material that Bob Gore discovered in 1969 while experimenting with ways of heating and stretching PTFE rods. The combination of heat and rapid expansion significantly improves the material's mechanical properties while at the same time preserving the original chemical resistance properties of PTFE. The added mechanical advantages of ePTFE include:

- high resistance to creep and cold flow, resulting in longer service life
- good conformability resulting in tight seals
- outstanding blowout performance
- superior high-temperature performance

Thanks to its conformability, ePTFE is more suitable than rigid materials to sealing flange surfaces of different qualities. This is because the sealant is capable of adapting its shape to surface irregularities on the flange, further complementing the tightness of the seal. The result is a tight initial seal that reliably maintains its sealing performance.

Over the past several decades, W.L. Gore & Associates has introduced further advancements to this technology. These include extending and optimizing the expansion and resultant material properties in more than one axis, as well as significant optimization of the expanded PTFE. Each of these improvements has provided a step change in one or more of the material property advantages, and therefore the sealing performance advantage of ePTFE over non-expanded forms of PTFE, as well as the original ePTFE innovation itself.

Novel gasket tape

GORE® Gasket Tape Series 1000 (Fig. 3) was specifically designed to address the challenges of reliably sealing large glass-lined steel flanges (> DN 600 / ASME 24"). The tape uses a highly advanced version of Gore ePTFE with extraordinary resistance to the gasket creep that could take place in the service conditions of glass-lined steel vessels. Additionally, GORE® Gasket Tape Series 1000 contains a new proprietary barrier core of compressed, high-density ePTFE, which provides effective protection against leakage, optimized for the range and limitations of load available to seal glass-lined steel flanges.

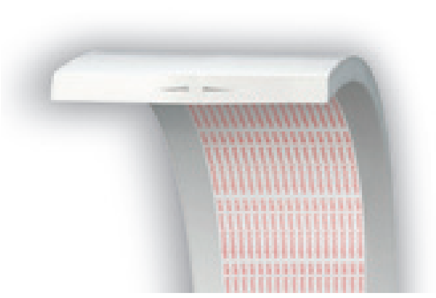

Fig. 3: Cross section of GORE® Gasket Tape Series 1000.

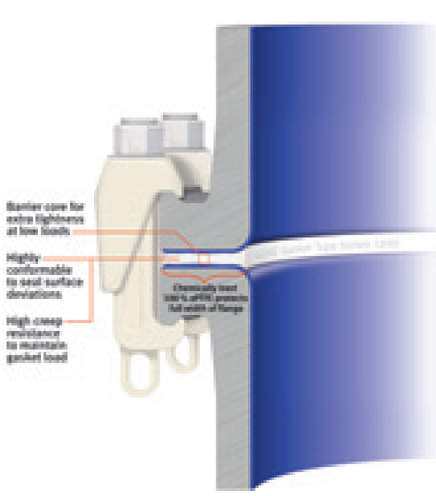

Fig. 4: Cut-away of GORE® Gasket Tape Series 1000 in use.

The barrier core enables an area of very high density ePTFE to be produced rapidly and reliably as the bolts are tightened. Thus, even when a relatively low contact pressure is applied, as is the case with glass-lined steel flanges, an optimum seal can be achieved. GORE® Gasket Tape Series 1000 prevents the diffusion of highly permeating chemicals, providing reliable protection from such emissions across the width of the flange (Fig. 4). With this technology, the resulting seal is more than ten times tighter than when using conventional ePTFE gasket tapes without the proprietary barrier core.

The tape is supplied in a convenient spool format that simplifies handling, and reduces delivery lead times by facilitating rapid shipment of a standard and compactly packaged product. This format also significantly simplifies the task of applying the sealant during flange assembly. The length of tape required is simply reeled off from the spool and fitted to the shape of the flange at the assembly location. The adhesive backing facilitates placement of the gasket tape on the flange, enabling it to be installed in one step by a single operator.

The sealing performance, along with the installation and logistical advantages of the gasket tape format, combine to make GORE® Gasket Tape Series 1000 a preferred sealing option for GLS vessels. De Dietrich Process Systems, for example, has endorsed the use of this gasket tape in its glass-lined steel reactors.

Conclusion

The new GORE® Gasket Tape Series 1000 is specifically designed to meet the challenges of sealing flanges in large glass-lined vessels. It combines an advanced generation ePTFE tape with a new proprietary barrier core of compressed ePTFE. This provides all the numerous sealing benefits relative to other PTFE-type materials, notably including extraordinary resistance to creep and cold flow. The proprietary barrier core prevents the diffusion of highly permeable media, and provides reliable protection against emission across the width of the flange even at moderate loads available in glass-lined steel flanges. The tape is entirely fabricated from chemically inert ePTFE, and does not incorporate less chemically resistant fillers or components. GORE® Gasket Tape Series 1000 is designed to provide an effective and long-term reliable seal, specifically optimized for use within the specification range of flanges for glass-lined steel equipment. This may facilitate either longer maintenance cycles or higher reliability within a fixed maintenance cycle–both of which increase operational efficiency and reduce maintenance costs as demanded by leading operators of chemical plants.

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