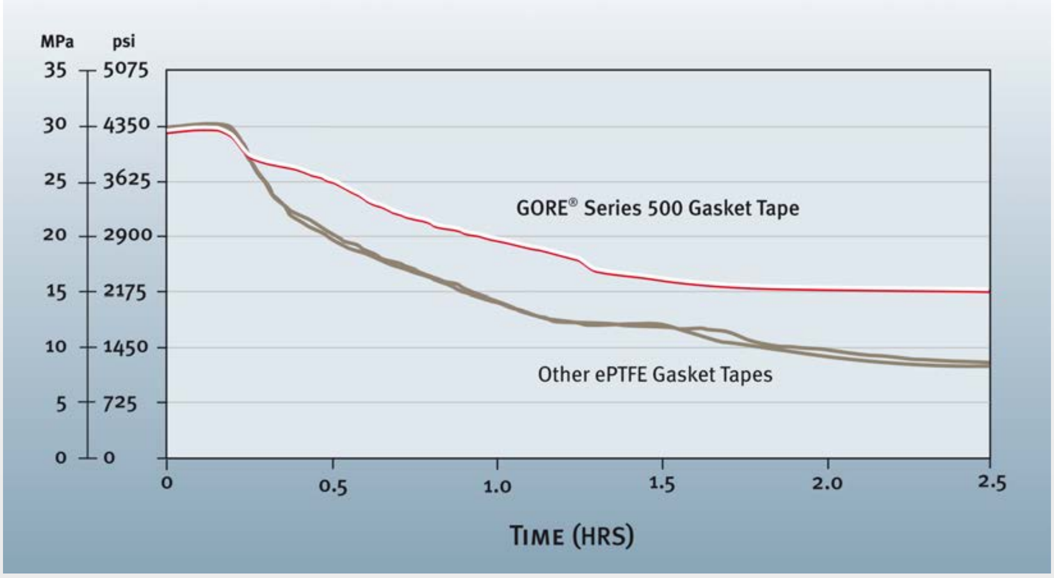


Progression of the sealing surface pressure over time. Based on EN13555, PQR, using 15mm x 3mm bands laid to form a closed ring (Ø150mm). The values were determined at 30 MPa and 150 °C (302 °F).

RELIABLE SEALING
OF HEAT EXCHANGERS

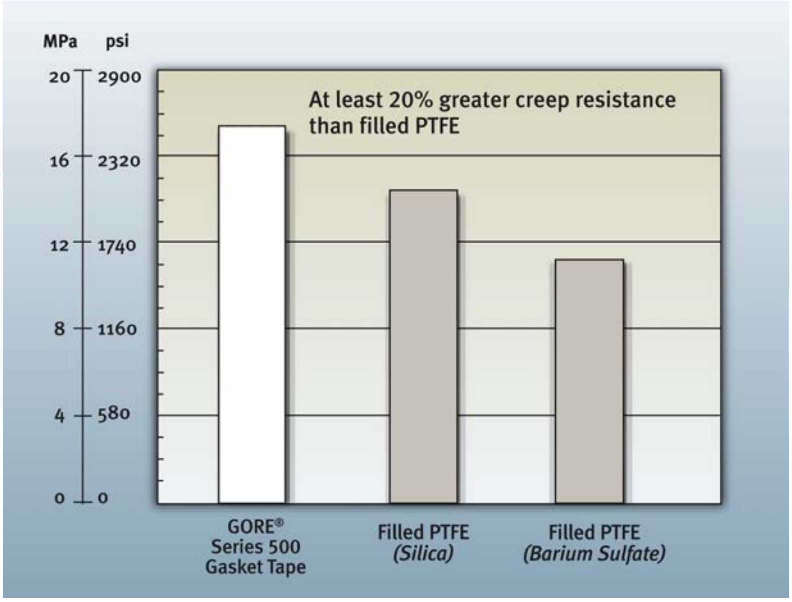
ePTFE gasket tapes for high chemical resistance — The connections to shell and tube heat exchangers pose immense challenges for the seals that are used because of both the chemically aggressive media and the frequent temperature load changes. Despite its excellent chemical resistance, polytetrafluoroethylene (PTFE) is not typically suitable as a sealing material in this case because the creep tendency of this material jeopardizes a reliable seal.

CHRISTIAN WIMMER*

Shell and tube bundle heat exchangers generally include not only several connection pieces but also a shell cover flange with a significantly larger nominal diameter. The shell cover flange creates the seal to the tube bundle flange, which then seals the shell flange. These connections are subjected to the full operating pressure and test pressure of dozens of bar and seal it from the environment. Oftentimes the tube bundles are arranged in several passes that are channeled by the use of partition plates. This requires a seal at the head of the heat exchanger and between the tube passes at the partition plates where the pressure difference is considerably lower. The numerous potential different arrangement of the passes requires specially adapted seal designs.

The sealing challenges that pertain to the shell cover flange position can be attributed to a combination of different conditions:

* The author works for W. L. Gore & Associates Sealant Technologies, Putzbrunn/Germany. Contact: Phone +49-89-4612-2215



- High temperatures/pressures
- Temperature load changes caused by starting up and shutting down part of the process
- Complex sealing geometries including separators, often combined with large nominal diameters
- Chemically aggressive media
- Damaged sealing surfaces, due to corrosion or warping
- The economic necessity of minimizing downtime
- The requirement to document legal compliance

"Creeping" gasket tapes made of PTFE

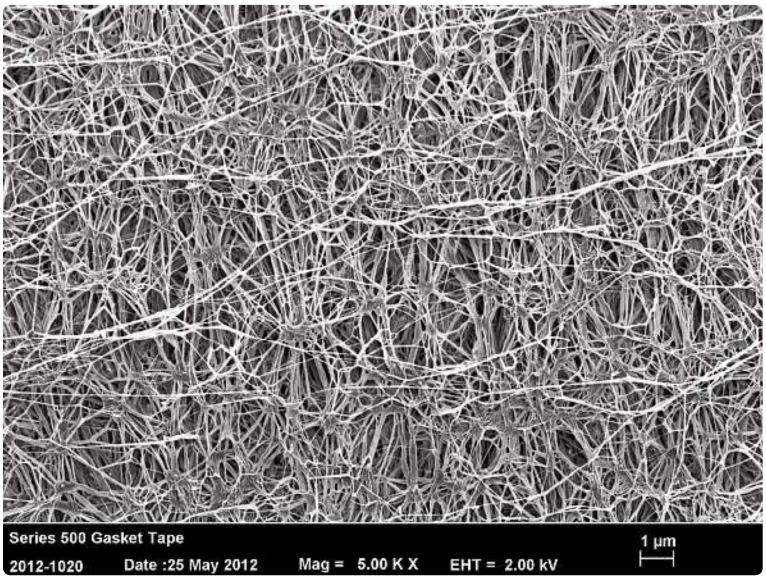
Gasket tapes are occasionally used to seal the static connections to shell and tube heat exchangers — sealing materials with a defined width and thickness, but an undefined length. They offer a way of functionally connecting the junction points and can be shaped as desired at the point of installation. Since the gasket circumference is completed at the time of installation, it is no longer necessary to completely dismantle the heat exchanger, removal of the tube bundle, for example. It is only important that the sealing surfaces be sufficiently accessible. Gasket tapes have been around in many different industrial fields for several decades. By introducing the Gore Joint Sealant, Gore launched the first gasket tape made of expanded PTFE (ePTFE) back in 1971. However, multiaxially expanded PTFE technology finally made it easier to use ePTFE with shell and tube heat exchangers across a broader range of application conditions.

The need for these material performance improvements by Gore is the low creep resistance of PTFE. In molecular terms, PTFE consists of a chain of carbon atoms that is saturated with fluorine atoms. The strong covalent carbon-fluorine bond is responsible for this polymer's nearly inert chemical reaction behavior. This explains why this material is desired as a sealing material in aggressive media. However, the lack of reactivity also means that PTFE chains cannot be molecularly linked like other materials, elastomers for example, and this results in a profound cold and warm flow behavior, also known as "creeping".

Risk of deformation of the sealing material

Creeping refers to the mechanical deformation of a component, in this case the seal, when subjected to loads and temperatures. One reason why seals in flange connections function is because the surface pressure caused by the bolts allows for irregularities in the sealing surfaces to be filled up and for blocking of leakage channels inside the seal. This reduces leakage (depending on the behavior of the sealing material) to an acceptable level. In this sense, leakage refers to the admissible substance flow, irrespective of the prevailing mechanism, in other words the sum of all mass flows from Fick's law of diffusion to gross leakage.

This sealing function is severely impaired by the creep tendency. Inside a flange connection, creep of a sealing material takes place in such a way that the load is reduced at a certain temperature until a balance between the internal strength of the seal and the external load is achieved. This behavior is called creep resistance. Deformation takes place when equilibrium is reached. With a seal, this is a reduction in the thickness that reduces the bolt elongation and thus the preload. This ultimately means a loss of strength or surface pressure that depends on the stiffness of the sealing system with respect to its extent. This surface pressure loss is called "creep relaxation" and can be so great that the bolts are loosened completely. Creep and the respective relaxation mainly occur during the heating up and cooling phases, in other words during thermal cycling. These effects occur to a significantly lower degree with a constant temperature. Creep relaxation is the main reason why simple PTFE (often brought into shape by sintering) can hardly be used in heat exchangers, which by their very nature are often subjected to significant temperature load changes.



Pictures: Gore

REM images of the Gore Gasket Tape Series 500

Increasing the creep resistance through expansion

There are different ways to reduce the creep resistance of PTFE. One way is to add filler materials. This technique is only appropriate for use with gasket tapes to a limited extent due to the fact that the flexibility of filled PTFE is extremely limited. Strips of simple PTFE are also not very useful for the same reason because it is difficult to form them into the required shape at the time of installation. Expanding the PTFE material offers an effective solution. This creates a microporous structure through mechanical stretching. This structure causes a significant change in properties. On the one hand, it improves the conformability due to the higher compressibility as well as creep resistance on the other hand. Here, it is important for the expansion to take place as evenly as possible. This is crucial to ensuring that the sealing properties are and remain the same at all positions of the seal. It can still have a texture, however, although it should not extend throughout the entire seal (in other words for the entire length of a band). In fact, a controlled transverse texture (with a circular transfer radially) can have a positive effect on deployability and bending stiffness. While such a structure changes the sealing properties (the transverse strength, for example), this can be taken into consideration structurally. Expansion allows for tapes to be produced that are flexible enough to be laid in even narrow radii.

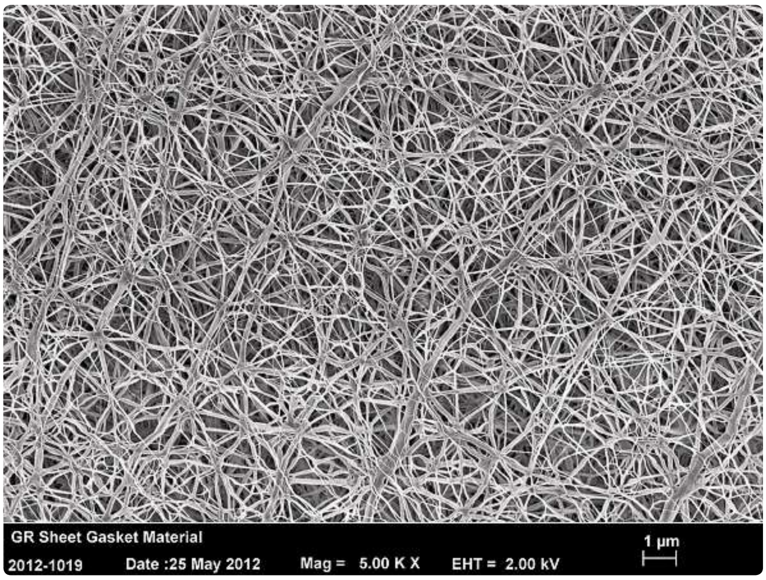
The following properties are characteristic of gasket tapes made of ePTFE:

- Easy and fast adaptation to suit even complex flange geometries
- Design flexibility because of the various widths, which then allow for higher surface pressures (higher tightness classes)
- High creep resistance compared to other PTFE-based materials

Characteristics of Gasket Tapes Made of ePTFE

8 GOOD REASONS FOR USAGE

- Easy and fast adaptation to suit even complex flange geometries
- Design flexibility because of the various widths, which then allow for higher surface pressures (higher tightness classes)
- High creep resistance compared to other PTFE-based materials
- Excellent adaptability to flange irregularities
- Not reusable (due to the high compression and hardly any spring back)
- Non-biodegradable, do not age, UV-resistant
- Resistant to all types of media (pH 0 to 14)
- Storable for a long time, limited only in terms of the declining bonding strength of the mounting aid adhesive tape



REM images of the Gore ePTFE

- Excellent adaptability to flange irregularities
- Not reusable (due to the high compression and low spring back)
- Non-biodegradable, do not age, UV-resistant
- Resistant to all types of media (pH 0 to 14)
- Long shelf life, limited only by the declining bonding strength of the mounting aid adhesive tape.

Mounting of ePTFE gasket tapes

ePTFE gasket tapes are mounted on one of the flat sides of the tape using adhesive tape. The adhesive only serves as a mounting aid and has little or no impact on the sealing effect. The adhesive is also considerably less temperature- and chemical-resistant than ePTFE. This means it usually decomposes during operation. This makes it easier to remove later on. When closing the seal made of an ePTFE gasket tape, one must make sure that the ends overlap and the right method is used. Basically, there are two different types of ePTFE gasket tape materials that require different overlapping methods: monoaxially and multiaxially ePTFE.

Monoaxial expansion is the older technique used to produce ePTFE gasket tapes. With this method, the PTFE is stretched to the tape only longitudinally. The texture that this creates is responsible for the weaker transverse strength. This results in greater broadening during initial compression, an aspect that must be taken into consideration in the design. Broadening of 20 % and more is quite common. The advantage that monoaxially expanded gasket tapes offer is that they can be compressed to be very thin during installation. This means they are able to adjust to micro unevenness very easily. Macro unevenness on the other hand is quite difficult to compensate for with this type of gasket tapes. Furthermore, unlike with multiaxial expansion, the ends can be overlapped. Nevertheless, monoaxially expanded gasket tapes are used only very rarely in heat exchanger applications because the lack of transverse strength results in a higher creep tendency. Although the small installation thickness compensates for this to some degree, the performance gap to multiaxially expanded PTFE gasket tapes increases as temperatures rise.

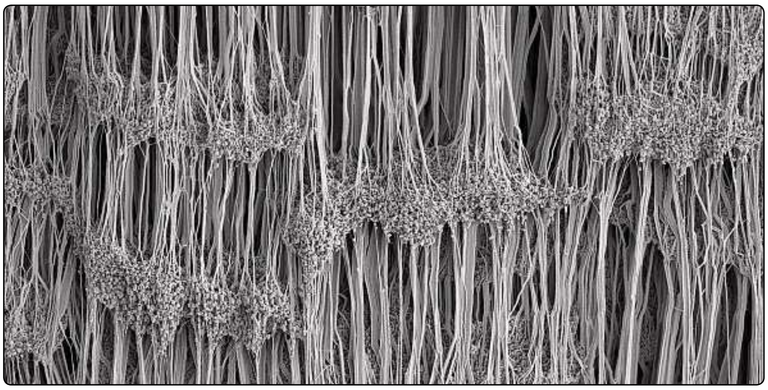
The multiaxial expansion of the material takes place in the direction of two vectors that stand at right angles to each other. This results in a multiaxial structure, in other words an orientation of the emerging fibrils in all directions. The transverse texture can be produced by varying the intensity of the expansion. Among other things, it helps to keep the nodes small because this non-oriented material contributes to creeping. Multiaxial expansion is of particular advantage in that it offers high transverse strength and allows for gasket tapes that are particularly resistant to creep.

Multiaxially expanded PTFE gasket tapes seal reliably

The process of expansion compensates for the disadvantage of the PTFE material, its high creep tendency, and results in a chemically stable, creep-resistant sealing material. If expansion takes place multiaxially, the creep tendency of the material will be reduced to such an extent that it can then be used as a sealing material under extreme conditions of both chemically aggressive media and frequent major temperature load changes.

PROCESS-Tip

- Meet the experts from Gore at this year's **valve exhibition Diam** in Bochum/Germany, (November 4–5). There will be also a technical lecture from the company.



Nodes in expanded material contribute to creep tendency.