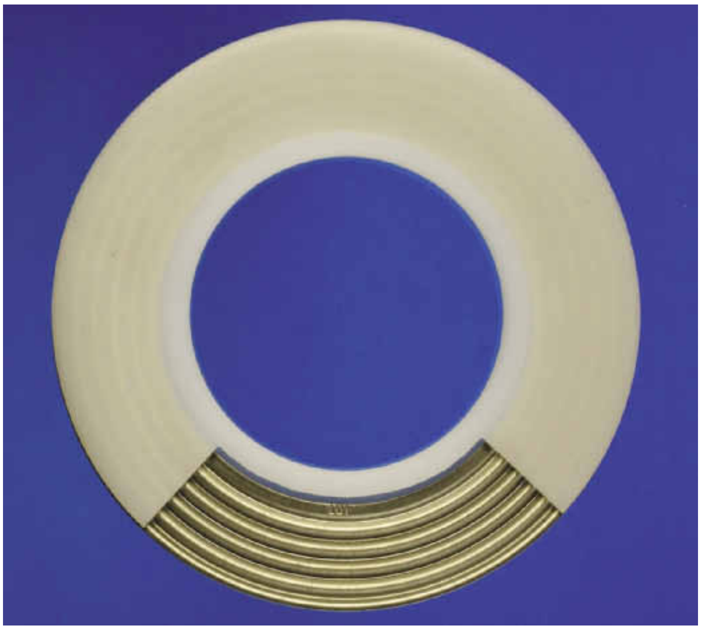
Envelope based on modified PTFE with stainless steel corrugated ring

One sealing solution for almost all cases

The PW-I gasket, a composite solution using modified PTFE and a corrugated stainless steel ring insert, provides a L0.01 seal tightness. It combines low leakage rates with blow-out resistance and suitability for almost any application. Since its excellent sealing function is independent of the surface pressure in the installed state, it compensates tolerances of the metal structure efficiently and improves handling safety.



The PW-I gasket consists of a Dyneon TFM 1600 shell with an inner diffusion barrier and a stainless steel corrugated ring insert

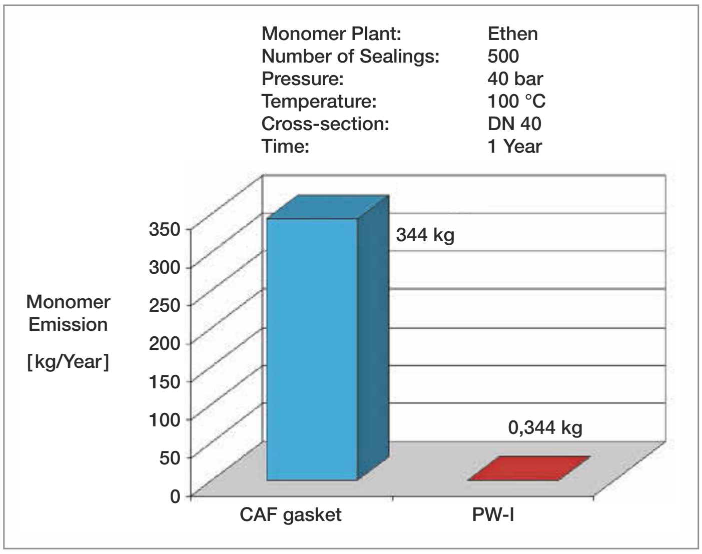
Polytetrafluoroethylene, more commonly known as PTFE, has established itself as the material of choice for sealing applications due to its almost universal chemical resistance, wide service temperature range and excellent ability to withstand ageing or embrittlement. However, its tendency to deform under load, so-called "cold flow", means it is limited in terms of the permissible pressure and temperature. In the following, a case study is used to demonstrate how modified PTFE, specifically 3M Dyneon TFM Modified PTFE Granules TFM 1600, in a complex gasket structure not only extends the suitability of this PTFE material group but at the same time lowers the emission levels and increases plant safety.

Emissions reduced

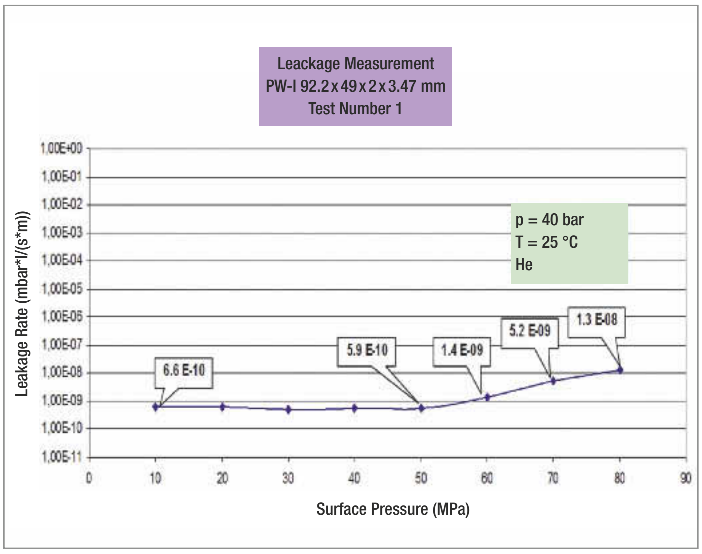
The successful deployment of the PW-I envelope gasket on the basis of Dyneon TFM 1600 is described in the following example: in an ethene monomer plant PW-I envelope gaskets (ED01 profile) are used exclusively instead of compressed aramid fibre (CAF). For the case study, it was assumed that there are 500 gaskets and the monitoring period for determining the total emissions is one year. Based on the leakage rates for the two gasket types, the calculated monomer emissions decreased from 344 kg/a for CAF gaskets to approximately 0.3 kg/a for the PW-I gasket. The reduction in ethene emissions is derived from an assumed average flange size of DN 40 at 100 °C and 40 bar pressure as representative operating conditions for the flanges. The main reason for the emissions from the CAF gaskets is the embrittlement of the elastomer component. The IDT PW-I flat gasket showed no signs of ageing and maintained its sealing properties over the entire period considered.

The secret of success

The secret lies in the design of the gasket. The PW-I gasket is a composite structure consisting of a stainless steel corrugated ring insert with a Dyneon TFM 1600 shell. This modified PTFE offers a balanced range of properties, as required for all gaskets in plants where aggressive chemicals are handled. These include almost universal chemical resistance, low cold flow and a high barrier effect against liquid chemicals and gases. A 4 mm thick diffusion barrier on the inside diameter, on the wetted side of the gasket, protects the stainless steel corrugated ring insert from direct media contact. This barrier also ensures that media only come into contact with the Dyneon TFM 1600 material and not with the stainless steel. The stainless steel corrugated ring insert gives the gasket its good blow-out resistance, even in the event that the maximum pressure (40 bar) and temperature (200 °C) occur simultaneously. In the installed, compressed state there is hardly any space for permeation or for cold flow between the corrugated ring insert and the flange face.
A minimum TFM cross-section remains in the wave crest area of the corrugated ring insert with the installed gasket. If even the slightest amount of gas enters the gasket via the diffusion barrier, the TFM 1600 restricts the further passage of the permeate to the outer side of the flange. In the installed and compressed state, the two gasket shells are calculated with a thickness of 0.75 mm, so that they are almost entirely absorbed in the troughs of the corrugated stainless steel ring or the flange surface roughness. There is space neither for cold flow of the TFM 1600 towards the outside of the flange as a result of media pressure within the system nor for chemicals and gases to permeate the gasket.
The modified, immobilised PTFE in this gasket design guarantees not only very low permeation values but also "TÜV compliant blow out resistance" (Report AW6/0580–97). The maximum limits of use for this gasket, namely the 200 °C maximum temperature and 40 bar maximum pressure, are therefore allowed to occur simultaneously – a feature unique to PTFE gaskets.



Whilst approximately 344 kg monomer per year leaks through the flanges of an ethene monomer plant equipped with CAF gaskets, this figure is only 0.3 kg if PW-I envelope gaskets are used throughout



The leakage rate of the PW-I gasket, determined using helium, is extremely low at any surface pressure from 10 to 40 MPa

Independent of surface pressure

If the leakage rate of the gasket is determined using helium at 40 bar and 25 °C according to EN 13555, it is conspicuously low at approximately 1 x 10^{-5} mg/s m. Even more surprising is the fact that this value does not change substantially if the surface pressure is varied between 10 and 40 MPa. The principal reason for this is the design of the composite seal: the concentrically arranged wave crests and troughs in the inserted metal ring penetrate the ductile sheath material Dyneon TFM 1600 even at low torques and thus provide a complete sealing function. On the other hand, overcompression of the gasket due to the immobilisation of the TFM 1600 shell material only occurs at extremely high torques. Such gross errors in the assembly process are very unlikely.
In practice, this means that the gasket works safely even if the tightening torque is modified considerably. Neither minor, human-related installation errors nor flange irregularities or even oblique installation of the flange bed result in a rapid deterioration of the sealing function. A high level of operational reliability is thus guaranteed, even when natural tolerances are taken into account.
The PW-I sealing system has been awarded the "LE" environmental label for "low emissions". The theoretical leak detection sensitivity according to EN 1591–1 is achieved. The requirements of the Clean Air Act are complied with: the leakage rate is well below the permitted 1 x 10^{-2} mg/s m for "LE", even with 5.6 screw quality.

The molecular structure of PTFE (left) and modified PTFE (right): perfluoropropylvinyl ether (PPVE) is incorporated into the PTFE polymer chains, which simultaneously have a reduced molecular weight

Chemically modified PTFE

This second-generation PTFE is a chemically modified PTFE in which the molecular chains of the polymer are chemically altered by perfluoropropylvinylether (PPVE), a perfluorinated modifier. At the same time the molecular weight of this new PTFE generation has been significantly reduced, thereby improving the particle fusion of the press-sintered PTFE material. Channelling along the particle boundaries is systematically minimised and the permeation of chemicals drastically reduced. The modifier effectively disturbs the higher crystallisation tendency of the shorter-chain, modified PTFEs and ensures good mechanical properties – notably lower cold flow values through the dispersion of the small crystallites in the amorphous matrix. In the end it is the optimal mix of modifier content and reduced molecular weight that makes the difference.
While resistance lists are normally used in connection with aggressive chemicals or solvents, this is not common with PTFE or modified PTFE (Dyneon TFM 1600). Almost universal chemical resistance can be attributed to these materials. The possibility of chemical reactions or a change in the material properties is only relevant in the event of contact with alkali metals such as sodium, particularly in dissolved form, with fluorinated hydrocarbons in combination with elemental fluorine or chlorine trifluoride or with monomers as well as in the presence of high-energy radiation. In these cases, the suitability of the material should be first ascertained with the help of special tests. Since Dyneon TFM 1600 resists virtually all media and is extremely pure, an extensive catalogue of approvals has been obtained, providing valuable security for users confronted with increasingly complex national and international regulations. What's more, it features in the list of non-metallic materials compatible with oxygen which is published by the Federal Institute for Materials Research and Testing (BAM).
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