Properties of PTFE

Thermal properties

Thermal stability

PTFE is one of the most thermally stable plastic materials. There are no appreciable decompositions at 260°C, so that PTFE, at this temperature, still possesses most part of its properties. Appreciable decomposition begins at over 400°C.

Transition points

The geometry of the PTFE molecules (crystalline structure) varies with the temperature. There are different transition points, with the most important ones being the following: that at 19°C corresponding to a modification of some physical properties and that at 327°C which corresponds to the disappearance of the crystalline structure: the PTFE assumes an amorphous aspect conserving its own geometric form.

Expansion

The linear thermal expansion coefficient varies with the temperature. In addition, because of the orientation caused by the working process, the PTFE pieces are generally anisotropic; in other words, the coefficient of expansion varies also in relation to direction.

Thermal conductivity

The coefficient of the thermal conductivity of PTFE does not varies with the temperature. It is relatively high, so that PTFE can be considered to be a good insulating material. The mixing of suitable fillers improves the thermal conductivity (see filled PTFE).

Specific heat

The specific heat, as well as the heat content (enthalpy) increases with the temperature.

Behaviour in presence of foreign agents

Resistance to chemical agents

PTFE is practically inert against known elements and compounds. It is attacked only by the alkaline metals in the elementary state, by Chlorine trifluoride and by elementary Fluorine at high temperatures and pressures.

Solvent resistance

PTFE is insoluble in almost all solvents at temperatures up to about 300°C. Fluorinated hydrocarbons cause a certain swelling which is however reversible; some highly fluorinated oils, at temperatures over 300°C, exercise a certain dissolving effect upon PTFE.

Resistance to atmospheric agents and light

Test pieces of PTFE, exposed for over twenty years to the most disparate climatic conditions, have not shown any alteration of their characteristic properties.

Resistance to radiations

High energy radiations tend to cause the breaking of the PTFE molecule, so that the resistance of the product to radiations is rather poor.

Gas permeability

The permeability of PTFE is similar to other plastic materials. The permeability does not depend, obviously, only on the thickness and pressure, but also on the working techniques.

Physical - mechanical properties

Tensile and compressive properties

These properties are to a large degree influenced by the working processes and the employed powder. PTFE, however, can be used continuously at temperatures up to 260°C, while possessing still a certain compressive plasticity at temperatures near to the absolute Zero.

Flexibility

PTFE is quite flexible and does not break when subjected to stresses of 0,7 N/mm2 according to ASTM D 790. Flexural modulus is about 350 to 650 N/mm2 at room temperature, about 2000 N/mm2 at -80°C, about 200 N/mm2 at 100°C and about 45 N/mm2 at 260°C.

Impact properties

PTFE possesses very high resilience characteristics also at low temperatures.

Plastic memory

If a piece of PTFE is subjected to tensile or compression stresses below the yield point, part of the resulting deformations remain (as permanent deformations) after the discontinuance of the stresses, with the result that certain strains are induced in the piece. If the piece is reheated, these strains tend to release themselves within the piece which resumes its original form. This property of the PTFE is commonly indicated as “plastic memory” and is made use of in different applications.

Also most of the semi-finished products, because of the transformation processes, possess similar strains, to a certain degree. When it is desired to obtain semi-finished parts dimensionally stable at high temperatures, it is possible to subject the parts to a temperature of 280°C for one hour every 6 mm of thickness and then cool them slowly. The parts obtained in this manner are almost completely free from internal strains and are in general known as “conditioned” or “thermo-stabilised” material.

Hardness

The hardness Shore D, measured according to the method ASTM D 2240, has values comprised between D50 and D60. According to DIN 53456 (load 13,5 Kg for 30 sec) the hardness sways between 27 and 32 N/mm2.

Friction

PTFE possesses the lowest friction coefficients of all solid materials; between 0.05 and 0.09:

- the static and dynamic friction coefficients are almost equal, so that there is no seizure or stick-slip action
- when increasing the load, the friction coefficient decreases until reaching a stable value
- the friction coefficient increases with the speed
- the friction coefficient remains constant at temperature variations.

Wear

The wear depends upon the condition of the other sliding surface and obviously depends upon the speed and loads. The wear is considerably reduced when adding suitable fillers to the PTFE (see filled PTFE).

Electrical properties

PTFE is an excellent insulator and precious dielectric as shown by the relative data reported in datasheet and maintains these characteristics throughout a large range of environmental conditions, temperatures and frequencies.

Dielectric strength

The dielectric strength of PTFE varies with the thickness and decreases with increasing frequency. It remains practically constant up to 300°C and does not vary even after a prolonged treatment at

high temperatures (6 months at 300°C). It depends also upon the transformation processes.

Dielectric constant and dissipation factor

PTFE has very low dielectric constant and dissipation factors values; these remain unvaried until 300°C, in a frequency field of up to 109 Hz even after a prolonged thermal treatment (6 months at 300°C). The dielectric constant, dissipation factor as well as the volume resistivity and surface resistivity, considered as being independent from the transformation processes.

Arc-resistance

PTFE has a good resistance to the arc. The arc resistance time according to ASTM D 495 is 700 sec..

After a prolonged action there are no signs of surface charing.

Corona effect resistance

The discharges caused by the corona effect may result in erosions of the PTFE surface which, nevertheless, is indicated as a suitable insulator in case of high potential differences.

Surface properties

The molecular configuration of PTFE brings to its surfaces a high anti-adhesiveness. For the same reason these surfaces are hardly wettable, the contact angle with water is about 110° and it is possible to affirm that, beyond a surface tension of 20 dyne/cm, the liquid no longer wets the PTFE. A special etching treatment renders the surfaces bondable and wettable.