Materials used for industrial pipe work

The material polyvinylidenefluoride (PVDF)

PVDF properties (reference values)

Characteristics	Value *)	Units	Test Standard
Density	1.78	g/cm³	EN ISO 1183-1
Yield stress at 23 °C	≥ 50	N/mm²	EN ISO 527-1
Tensile e-modulus at 23 °C	≥ 1700	N/mm²	EN ISO 527-1
Charpy notched impact strength at 23 °C	≥ 8	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C	≥ 7	kJ/m²	EN ISO 179-1/1eA
Heat distortion temperature HDT A 1.80 MPa	≥ 104	°C	EN ISO 75-2
Crystallite melting point	≥ 169	°C	DIN 51007
Heat conductivity at 23 °C	0.19	W/m K	EN 12664
Water absorption at 23 °C/24h	≤ 0.04	%	EN ISO 62
Colour	opaque	-	-
Limiting oxygen index (LOI)	≥ 43	%	ISO 4589-1

*) Typical values measured on the material. These values should not be used for design purposes.

General

Polyvinylidenfluoride (PVDF) is a semi-crystalline thermoplastic having outstanding mechanical, physical and chemical properties. These result from the chemical structure of PVDF. Polyvinylidenfluoride belongs to the class of fluorinated polymers, whose best-known representative is polytetrafluoroethylene (PTFE, trade name: Teflon). PTFE is characterised by a superb heat resistance and the best chemical resistance of all polymers; a great disadvantage is that it is not melt processable - e. g. into fittings. PVDF, on the other hand, combines various advantages of PTFE with good workability into structural parts. The fluorine content in PVDF amounts to 59 % by weight.

PVDF from GF is characterised by a very good mechanical behaviour and high temperature resistance. Because of the exceptionally wide pressure / temperature range in which PVDF can be used, it has opened, in connection with the specific characteristics of this material, completely new areas of application in plastic piping fabrication. These include applications in the semi-conductor, chemical and pharmaceutical industry, electroplating, paper and cellulose processing, the automotive industry and water treatment.

Pipes, fittings and valves of PVDF are uncoloured and opaque (milky, translucent).

By avoiding the addition of any additives, the outstanding characteristics of the material remain to the fullest extent, especially concerning the chemical resistance and physiological harmlessness.

Some of the advantages of PVDF:

- outstanding mechanical properties, even at high temperatures
- excellent chemical resistance
- no electrochemical corrosion
- long service life, even under intensely corrosive conditions
- outstanding resistance against UV and γ-radiation
- very pure material by implementing without additives
- no support of microbial growth
- physiologically harmless
- secure jointing by high-quality welding technology
- smooth inner surface
- very low heat conductivity
- excellent flame retardant properties

Mechanical properties

PVDF has a high tensile strength and stiffness. The impact strength is still good at temperatures around 0 °C. PVDF's advantages are particularly prevalent at higher temperatures. This is due to the high fluorine content which causes strong interactions between the PVDF chains. This, in turn, displaces the softening and the loss of properties to higher temperatures. This also has an effect on the long-term creep strength.

PVDF has the highest long-term creep strength of all the polymers used for GF piping systems. The long-term behaviour for internal pressure resistance is provided by the hydrostatic strength curve based on the DVS 2205-1 Guidelines, Supplement 4 (see also the Calculation and Long-Term Behaviour of PVDF section). The application limits for pipes and fittings, as shown in the pressure-temperature diagram, can be determined from these curves.

Chemical and weathering resistance

PVDF is resistant to most inorganic solvents and additionally to aliphatic and aromatic hydrocarbons, organic acids, alcohol and halogenated solvents. PVDF is also not attacked by dry and moist halogens with the exception of fluorine. PVDF is not resistant against strong basic amines, alkalis, and alkaline metals. Strong polar solvents, such as ketones and esters and organic acids can cause PVDF to swell somewhat.

For detailed information, please refer to the detailed list of chemical resistance from GF or contact your GF subsidiary.

Outstanding resistance against UV light as well as gamma radiation permits, among other applications, the use of PVDF piping outdoors. No loss of properties occurs. Abrasion resistance is considerable and approximately comparable to that of polyamide.

Thermal properties

PVDF shows its outstanding properties in a temperature range from -20 °C to +140 ºC. This allows using the material in a wide range of applications. Especially at high temperatures, PVDF provides maximum security. Its high crystalline melting point at around 173 °C speaks for itself.

Please consult the pressure-temperature diagrams for your operational temperature. For temperatures below 0 °C, the media must be prevented from freezing to avoid damaging the piping (as for other piping materials).

The thermal expansion coefficient of PVDF of 0.12 to 0.18 mm/m K lies clearly above that of metals. Because of this, its thermal expansion must be taken into account during the planning of the piping system. As for all polymers, PVDF is a good thermal insulator because its heat conductivity of 0.19 W/m K is very low. (For comparison, the value for steel is 250 W/m K).

Combustion behaviour

PVDF displays an exceptionally good combustion behaviour without the addition of fire protection additives. Material decomposition begins at 380°C.

The oxygen index amounts to 44 %. (Materials that burn with less than 21 % of oxygen in the air are considered to be flammable).

PVDF thus also falls in the best flammability class V0 according to UL94, and in the building materials class B1 (difficult to ignite) according to DIN 4102-1. Smoke development is also moderate.

GF PVDF products show such excellent fire safety behaviour that they are accepted and listed by Factory Mutual for use in clean rooms (FM 4910).

Since the combustion of PVDF produces hydrogen fluoride, which forms a corrosive acid in connection with water, immediate cleaning of areas susceptible to corrosion with water containing detergent is necessary after a fire. Additional combustion products are carbon monoxide and carbon dioxide. Concerning the choice of fire-fighting agents, sand or powder-type extinguishing agents are recommended because the use of water may result in the development of corrosive acids.

Electrical properties

PVDF is a good electrical insulator. Because of the possible electrostatic charges, caution is recommended when using PVDF in applications where combustion or explosion dangers exist.

The specific volume resistance is $>10^{14}\Omega$cm; the specific surface resistance is $10^{14}\Omega$.

Physiological properties

PVDF is physiologically non-toxic as long as it is used below the maximum temperature of 150 °C. During welding, good ventilation is required or alternately the released gases must be extracted.

PVDF can be used in the USA in accordance with the relevant regulations of the Food and Drug Administration (FDA) for food packaging and items that come into contact with food.

High purity properties

Due to the excellent stability of the PVDF molecule, it is one of the very few materials that can be processed, welded and used under severe conditions without the use of additives (no pigments, thermostabilisers, processing aids or fillers are used in the GF piping grades). This makes it the material of choice for applications that demand a very high purity of the medium and have stringent requirements stipulating that the materials which come in contact with the medium do not leach contaminants.

The PVDF raw materials used by GF fulfil the most rigid requirements of the semiconductor and pharmaceutical industry regarding high purity. In addition, products made of PVDF exhibit a very smooth surface.
Leach out tests according to SEMI57 are done regularly for quality control.

For SYGEF Plus products, only virgin raw material is used.

For details regarding the properties relevant for the market segments, Semicon and Life Science, please see our SYGEF Plus specification:
www.piping.georgfischer.com
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