Materials used for industrial pipe work

The material polyvinyl chloride unplasticized (PVC-U)

PVC-U properties (reference values)

Characteristics	Value *)	Units	Test Standard
Density	1.38	g/cm³	EN ISO 1183-1
Yield stress at 23 °C	≥ 52	N/mm²	EN ISO 527-1
Tensile e-modulus at 23 °C	≥ 2500	N/mm²	EN ISO 527-1
Charpy notched impact strength at 23 °C	≥ 6	kJ/m²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C	≥ 3	kJ/m²	EN ISO 179-1/1eA
Ball indentation hardness (358N)	≥ 105	MP	EN ISO 2039-1
Heat distortion temperature HDT A 1.80 MPa	66	°C	EN ISO 75-2
Vicat heat distortion temperature B/50N	≥ 76	°C	ISO 306
Heat conductivity at 23 °C	0.15	W/m K	EN 12664
Water absorption at 23 °C	≤ 0.1	%	EN ISO 62
Colour	7011	-	RAL
Limiting oxygen index (LOI)	42	%	ISO 4589-1

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

General

Polyvinylchloride, widely known by its abbreviation PVC, is one of the most important and oldest mass-produced polymers. World-wide consumption of PVC is only exceeded by PE and PP, PVC was first produced in the middle of the nineteenth century. An industrial production process was, however, first patented in 1913. Nowadays, many industrial applications couldn't be realised without PVC. But also in the use of daily products, PVC has become irreplaceable.

PVC is a polymer having approximately 56 % by weight of chlorine. Only by using additives does it become a processable and usable material. The additives allow a wide variation of its characteristics and allows it to be adjusted to the planned application. There are two classes of PVC materials. Soft PVC (PVC-P), produced by adding plasticizers (such as, e. g. phthalate), is not used by GF. Hard PVC, the so-called unplasticized PVC (PVC-U) is used for pipeline engineering.

PVC-U is an amorphous thermoplastic. The characteristics of PVC-U moulded parts are strongly dependent on the composition of the formula, but also on the processing. Because of our 40-year experience in PVC processing and the continuous advancement of our own formula, GF has become a benchmark in the field of PVC-U piping.

GF's PVC-U is characterised by the following characteristics:

- universal use
- very good chemical and corrosion resistance
- proven physiological harmlessness and therefore suitable for contact with food
- no influence on drinking water quality
- biologically inert; no support of microbial growth
- high mechanical tensile strength with good impact strength
- self-extinguishing
- secure solvent cementing using Tangit© and Dytex©
- adhesive development designed for GF PVC-U
- use of tin stabilisers for fittings and valves
- low friction loss owing to smooth surfaces
- recyclable

Mechanical properties

PVC-U from GF reflects a balanced picture regarding the mechanical short-term properties. Because of the strong interaction between the chlorine atoms in the polymer chain, PVC-U shows a high tensile strength and stiffness. At the same time, the elasticity of the GF structural parts is good, a characteristic guaranteed by regular quality control testing.

The long-term behaviour for internal pressure resistance is provided by the hydrostatic strength curve based on the EN ISO 15493 or DIN 8061 standards (also see the Calculation and Long-Term Behaviour of PVC-U section). The application limits for pipes and fittings, as shown in the PVC-U pressure-temperature diagram, can be derived from these curves.

Behaviour during dynamic loading corresponds to the highest quality requirements and is tested regularly.

Chemical and weathering resistance

The outstanding chemical resistance of PVC-U extends to high concentrations. Resistance against the influence of most mineral acids, bases and salt solutions and also sodium hypochlorite solutions is very good. Resistance to aliphatic hydrocarbons and elemental chlorine is also good. PVC-U, in general, shows weakness against aromatic or chlorinated solvents, esters and ketones. Use with gases is also not recommended. If the use of oils, varnish or fats is being considered, a prior investigation is advisable.

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

These specifications are also valid - with exceptions - for adhesive joints, which normally are implemented by applying strongly dissolving gap-filling solvent cement to the PVC-U.

PVC-U is very resistant to weathering. Long-term influence of direct sunlight as well as the effect of wind and rain damage the material only superficially. Despite its very good weathering resistance regarding ultraviolet radiation, PVC-U loses some of its impact strength. In extreme applications it can be advantageous to protect the material from direct sunlight exposure.

Thermal properties

PVC-U shows very good characteristics in the temperature range from 0 to 60 ºC. At lower temperatures, the impact strength drops considerably. Tensile strength and stiffness drop with increased temperatures. Please consult the pressure-temperature diagram especially for your maximum working temperature. Because the softening-point temperature of the fitting and valve materials lies above 76 ºC, applications must remain limited to temperatures below 60 ºC.

The thermal expansion coefficient of PVC-U at 0.07 to 0.08 mm/m K lies clearly above that of metals. Of all the materials for industrial piping installations, available from GF, PVC-U shows one of the lowest expansion coefficients. Nevertheless, the thermal expansion has to be taken into account during the planning of the installation.

Similar to all polymers, PVC-U is a good thermal insulator. At 0.15 W/m K, the heat conductivity of PVC-U is very low. The value for steel, on the other hand, is 250 W/m K.

Combustion behaviour

The high chlorine content of PVC-U causes an advantageous combustion behaviour. Self-ignition resulting from temperature influences occurs only at 450 °C. PVC-U burns when exposed to an open flame, but extinguishes immediately after removing the flame.

The oxygen index amounts to 42 %. (Materials that burn with less than 21 % of oxygen in the air are considered to be flammable).

PVC-U thus falls in the best flammability class V0 according to UL94, and in the B1 (difficult to ignite) building material class with wall thicknesses $\leq$ 3.2 mm respective B2 (normally flammable) with wall thicknesses >3.2 mm according to DIN 4102-1. According to the French test method NF P 92-501, GF PVC-U is tested as M2.

Because the combustion of PVC produces hydrogen chloride, which forms a corrosive acid in connection with water, immediate cleaning of areas susceptible to corrosion is necessary after a fire. Danger to personnel from HCl is minimal because its pungent odour allows early escape from toxic combustion gases, mainly from the odourless carbon monoxide.

There are no restrictions concerning the choice of fire-fighting agents.

Electrical properties

PVC-U is, as all unmodified thermoplastics, non-conductive. This means that no electrochemical corrosion takes place in PVC-U systems. On the other hand, these non-conductive characteristics have to be taken into account because an electrostatic charge can develop in the piping. It is especially important to take this condition into account in areas where explosive gases can appear. There are various methods available to avoid the occurrence of electrostatic charges on polymer piping systems. Please contact your GF representative for more information regarding these methods.

The specific volume resistance is $>10^{15}\,\Omega$cm.

Physiological properties

The PVC-U formulas were developed by GF for use with drinking water and food. PVC-U's physiological harmlessness regarding neutral, acidic and alcoholic foods and the non-influence on drinking water in respect to odour, taste or microbiological effects is regularly checked and monitored by neutral institutions in various countries.

GF offers PVC-U systems free from lead and cadmium for your applications in the fields of drinking water or food. The residual monomer content of vinyl chloride lies below the detection limit of modern analytical methods.