

Materials used for industrial pipe work

The material polypropylene (PP)

PP properties (reference values)

Characteristics	PP-R Value *)	β PP-H Value *)	Units	Test Standard
Density	0.90-0.91	0.90-0.91	g/cm ³	EN ISO 1183-1
Yield stress at 23 °C	25	31	N/mm ²	EN ISO 527-1
Tensile e-modulus at 23 °C	900	1300	N/mm ²	EN ISO 527-1
Charpy notched impact strength at 23 °C	30.9	85	kJ/ m ²	EN ISO 179-1/1eA
Charpy notched impact strength at 0 °C	3.4	4.8	kJ/ m ²	EN ISO 179-1/1eA
Ball indentation hardness (132N)	49	58	MPa	EN ISO 2039-1
Heat distortion temperature HDT B 0.45 MPa	75	95	°C	EN ISO 75-2
Crystallite melting point	145-150	150-167	°C	DIN 51007
Heat conductivity at 23 °C	0.23		W/m K	EN 12664
Water absorption at 23 °C	0.1	0.1	%	EN ISO 62
Colour	neutral	7032	-	RAL
Limiting oxygen index (LOI)	19		%	ISO 4589-1

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

General

Polypropylene is a thermoplastic belonging to the polyolefin group. It is a semi-crystalline material. Its density is lower than that of other well-known thermoplastics. Its mechanical characteristics, its chemical resistance and especially its relatively high heat deflection temperature have made polypropylene one of the most important materials used in piping installations today.

PP is formed by the polymerisation of propylene (C₃H₆) using Ziegler-Natta catalysts.

There are three different types which are conventionally supplied for piping installations:

- Isotactic PP Homopolymeride (PP-H)
- PP block co-polymeride (PP-B)
- PP random co-polymeride (PP-R).

Because of its high internal pressure resistance, PP-H is preferred for industrial applications. On the other hand, PP-R is used predominantly in sanitary applications because of its low e-modulus (flexible piping) and its high internal pressure resistance at high temperatures. PP-B is mainly used for sewage piping systems because of its high impact strength especially at low temperatures and its low thermal endurance.

PROGEF = Polypropylene Georg Fischer

PROGEF is the subbrand for piping systems in polypropylene:

Subbrand: Pipes, fittings, valves	Material	Dimension	Nominal Pressure, SDR
PROGEF Standard	β-PP-H and PP-R	d16 - d500	SDR11 / PN10 and SDR17 resp. SDR17.6 / PN6
PROGEF Plus: Silicone- and oil-free	β-PP-H and PP-R	d20 - d315	SDR11 / PN10
PROGEF Natural	PP-R unpigmented	d20 - d63	SDR11 / PN10

Beta (β)-PP-H

Most of the grades are offered with nucleating agents (crystallisation seeds), because PP crystallises at least 10 times slower than PE. This way, we achieve lower internal stress and a finer structure. We differentiate between α and β nucleation.

Nucleation is realised by merely adding ppm (parts per million) of nucleating agents.

PP is one of the non-polar materials whose surface hardly swells or dissolves. Cementing is not possible without special surface treatment. On the other hand, PP welds very well. Pressure piping systems can use heating element socket welding, heating element butt welding or the no-contact infrared (IR-Plus) fusion technology developed by GF.

The internal pressure resistance is ensured through long-term testing in accordance with EN ISO 9080 and certified with the value of MRS 10 (minimum required strength).

The Beta (β)-PP used by GF for industrial pipeline engineering is characterised by

- good chemical resistance
- high internal pressure resistance
- high impact strength
- high thermal ageing and thermal forming resistance
- high stress fracture resistance
- outstanding weldability
- homogeneous, fine structure

PROGEF Natural (PP-R, unpigmented)

Specially for applications related to the BCF Plus (bead and crevice-free) welding technology, such as the life science/pharmaceutical industry, GF offers the PROGEF Natural system in addition to our PROGEF Standard.

For such requirements, the welding technology plays a decisive role. In using the BCF Plus welding technology, beads and dead zones are avoided. This prevents micro-organisms from accumulating, thus improving the water quality.

For all other industrial applications, especially those involving aggressive media, high impact and temperature stress, GF recommends PROGEF Standard, which has an optimal characteristics profile.

The material used for PROGEF Natural system is an unpigmented random copolymer, particularly distinguished by the following characteristics:

- excellent resistance against certain disinfectants and chemicals (mainly alkaline solutions)
- translucence
- very high surface finish quality
- good weldability (BCF Plus and IR Plus weldable)

- high temperature resistance

Mechanical properties

PP-H has the highest crystallinity and therefore the highest hardness, tensile strength and stiffness, so the pipes hardly sag and a greater distance between supports is possible. PP-R has a very good long-term creep strength at higher temperatures, such as, for example, 80 °C at continuous stress.

Unlike PE, PP is not as impact resistant below 0 °C. Because of this, GF recommends ABS or PE for low temperature applications.

The long-term behaviour for internal pressure resistance is provided by the hydrostatic strength curve based on the EN ISO 15494 standard (see the Calculation and Long-Term Behaviour section for PE). The application limits for pipes and fittings, as shown in the pressure-temperature diagram, can be derived from these curves.

Chemical, weathering and UV resistance

Due to its non-polar nature, polypropylene shows a high resistance against chemical attack.

The resistance of PP is nevertheless lower than that of PE because of its tertiary C atoms.

PP is resistant against acids, alkaline solutions, solvents, alcohol and water. Fats and oils swell PP slightly. PP is not resistant to oxidising acids, ketones, petrol, benzene, halogens, aromatic hydrocarbons, chlorinated hydrocarbons and contact with copper.

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

If polypropylene is exposed to direct sunlight over a long period of time, it will, like most natural and plastic materials, be damaged by the short-wave UV portion of sunlight together with oxygen in the air, causing photo-oxidation.

Fluorescent tubes create weakening the same effect.

PP fittings and valves are highly heat stabilised. As per approvals, polypropylene has no special additive against the effects of UV radiation. The same applies to PP piping. Piping which is exposed to UV light should therefore be protected. This is achieved by covering the pipes, e. g. with insulation or also by painting the piping system with a UV absorbing paint.

Thermal properties

In general polypropylene can be used at temperatures from 0 °C to +80 °C, β-PP-H in the range from -10 °C up to 95 °C. Below -10 °C, the outstanding impact strength of the material is reduced. On the other hand, the stiffness is even higher at low temperatures. Please consult the pressure-temperature diagram for your maximum working temperature. For temperatures below 0

°C it must be ensured, as for every other material, that the medium does not freeze, consequently damaging the piping system.

As with all thermoplastics, PP shows a higher thermal expansion (0.16 to 0.18 mm/m K) than metal. As long as this is taken into account during the planning of the installation, there should be no problems in this regard.

The thermal conductivity is 0.23 W/m K. Because of the resulting insulation properties, a PP piping system is notably more economical in comparison to a system made of a metal like copper.

Combustion behaviour

Polypropylene is a flammable plastic. The oxygen index amounts to 19%. (Materials that burn with less than 21% of oxygen in the air are considered to be flammable).

PP drips and continues to burn without soot after removing the flame. Basically, toxic substances are released by all burning processes. Carbon monoxide is generally the combustion product most dangerous to humans. When PP burns, primarily carbon dioxide, carbon monoxide and water are formed.

The following classifications in accordance with differing combustion standards are used:

According to UL94, PP is classified as HB (Horizontal Burning) and according to DIN 53438-1 as K2. According to DIN 4102-1 and EN 13501-1, PP is listed as B2 (normally flammable). In the French classification of building materials, polypropylene corresponds to M3 (of average flammable rating).

The self-ignition temperature is 360 °C.

Suitable fire-fighting agents are water, foam or carbon dioxide.

Electrical properties

Since PP is a non-polar hydrocarbon polymer, it is an outstanding insulator. These properties, however, can be worsened considerably as a result of pollution, effects of oxidising media or weathering.

The dielectric characteristics are essentially independent of temperature and frequency.

The specific volume resistance is $>10^{16}$ Ωcm; the dielectric strength is 75 kV/mm.

Because of the possible development of electrostatic charges, caution is recommended when using PP in applications where the danger of fires or explosion is given.

Physiological properties

The materials used for GF's PROGEF Standard and PROGEF Plus are in compliance with the formulation requirements of the common drinking water directives (see separate list in clause Approvals).

The polypropylene grade PROEF Natural satisfies the requirements for articles or components of articles that come into contact with food. The parts are tasteless and odourless and are physiologically inert regarding acidic, neutral and alcoholic foods as well as dairy products according to Directive 2007/19/EC.