Materials used for industrial pipe work

The material polyethylene (PE)

PE properties (reference values)

	PE 80	PE 100		
Characteristics	**Value** *)	**Value** *)	**Units**	**Test Standard**
Density	0.93	0.95	g/cm³	EN ISO 1183-1
Yield stress at 23 °C	18	25	N/mm²	EN ISO 527-1
Tensile e-modulus at 23 °C	700	900	N/mm²	EN ISO 527-1
Charpy notched impact strength at 23 °C	110	83	kJ/ m²	EN ISO 179-1/1eA
Charpy notched impact strength at -40 °C	7	13	kJ/ m²	EN ISO 179-1/1eA
Ball indentation hardness (132N)	37		MPa	EN ISO 2039-1
Crystallite melting point	131	130	°C	DIN 51007
Heat conductivity at 23 °C	0.43	0.38	W/m K	EN 12664
Water absorption at 23 °C	0.01 - 0.04		%	EN ISO 62
Colour	9005		-	RAL
Limiting oxygen index (LOI)	17.4		%	ISO 4589-1

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

General

Polymers which consist only of carbon and hydrogen (hydrocarbons) are called polyolefins.
Polyethylene (PE) belongs to this group. It is a semi-crystalline thermoplastic. Polyethylene is the best known standard polymer.
The chemical formula is: $(CH_2\text{-}CH_2)_n$. It is an environmentally friendly hydrocarbon product.

PE and PP belong to the non-polar materials. Because of this, the material does not dissolve in common solvents and, in addition, hardly swells. As a result, PE pipes cannot be solvent cemented. The appropriate jointing method for this material is welding. For piping installations we offer three welding techniques in our product range: butt fusion, socket welding and electrofusion.

The latter jointing technique is preferred for piping systems transporting gas, water, compressed air or other less aggressive media. Butt and socket welding are preferably used on a diameter-specific basis.

High molecular PE grades of medium to high density have become state of the art for industrial piping installations. The grades are classified in accordance with their internal pressure resistance in PE80 (MRS 8 MPa) and PE100 (MRS 10 MPa).

In this context, we also talk about PE grades of the 3rd generation. PE80 grades belong, in most cases, to the 2nd generation. PE grades of the 1st generation – PE63 according to current classifications— have practically no application anymore.

In piping construction, PE is mostly used for buried gas and water lines. For this range of applications, polyethylene has become the dominant material in numerous countries. But also building technology and industrial piping installations make use of the advantages of this material.

The advantages include:

- low weight
- outstanding flexibility
- good abrasion resistance
- corrosion resistance
- high impact resistance even at very low temperatures
- good chemical resistance
- safe and easy jointing by welding
- excellent cost-performance ratio

Mechanical properties

Modern PE100 grades show a bimodal molecular weight distribution, i. e. they consist of two different kinds of molecular chains (short and long). These polyethylenes combine a high tensile strength with a high resistance against fast and slow crack propagation. In addition, the short molecular chains provide a good processability.

Similar to ABS, PE also shows a very high impact strength, even at low temperatures. For this test, a specimen is weakened with a sharp notch and then struck. In doing this the impact energy absorbed by the material is measured. This test proves that polyethylene is insensitive to surface damage with subsequent impact stress. A robust behaviour like this, combined with a high elongation to break, is of big advantage in a lot of applications, e.g. in regions that have a high risk of earthquakes.

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 abrasion resistance

Due to its non-polar nature as a hydrocarbon of high molecular weight, polyethylene shows a high resistance against chemical attack. PE is resistant to acids, alkaline solutions, solvents, alcohol and water. Fat and oil swell PE slightly. PE is not resistant against oxidising acids, ketones, aromatic hydrocarbons and chlorinated hydrocarbons.

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

If polyethylene 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. Because of this, our black polyethylene grades are effectively stabilised against UV light by adding carbon black.

As with ABS, PE also has excellent resistance against abrasion. As a result, PE piping systems are used in numerous applications for transporting solids and slurries. Experience has shown that PE as well as ABS offers considerable advantages over metal and other plastics for many such applications.

Please contact GF if you are planning such an application. We would be glad to advise you about the suitability of our PE, ABS and other materials for your media.

Thermal properties

Polyethylene pipes can be used at temperatures ranging from -50 °C to +60 °C.

At higher temperatures, the tensile strength and stiffness of the material are reduced. Therefore, please consult the pressure-temperature diagram. 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.

Like all thermoplastics, PE shows a higher thermal expansion than metal. Our PE has a coefficient of linear thermal expansion of 0.15 to 0.20 mm/m K, which is 1.5 times greater than that of e. g. PVC. 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 0.38 W/m K. Because of the resulting insulation properties, a PE piping system is notably more economical in comparison to a system made of a metal like copper.

Combustion behaviour

Polyethylene belongs to the flammable plastics. The oxygen index amounts to 17 %. (Materials that burn with less than 21 % of oxygen in the air are considered to be flammable).

PE 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 PE burns, primarily carbon dioxide, carbon monoxide and water are formed.

The following classifications in accordance with different combustion standards are used: According to UL94, PE is classified as HB (Horizontal Burning) and according to DIN 53438-1 as K2. According to DIN 4102-1 and EN 13501-1, PE is listed as B2 (normally flammable). In the French classification of building materials, polyethylene corresponds to M3 (of average flammability rating).

The self-ignition temperature is 350 °C.

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

Electrical properties

Because of the low water absorption of PE, its electrical properties are hardly affected by continuous water contact.

Since PE 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 specific volume resistance is $>10^{17}$ Ωcm; the dielectric strength is 220 kV/mm.

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

Physiological properties

The black material types from GF are authorised for use in food applications. The fittings are odourless and tasteless as well as physiologically inert. Usage in all related areas is thus possible.