3 Material properties

3.1 Material features and advantages

For more than 30 years, polypropylene random copolymer (PP-R) has been applied successfully for hot and cold water applications in countries worldwide. The combination of properties such as resistance to internal pressure, flexibility and impact have made PP-R the material of choice for a safe and reliable long-lasting installation in domestic water management, such as hot and cold water distribution, under-floor heating, radiator connections or wall cooling and heating systems.

Illustration 3.1

Benefits of PP-R piping systems:
- Lifetime according to tests performed under ISO 15874
- No limitations to the pH value of water
- No contact corrosion when exposed to iron particles
- Taste and odour neutral
- Bacteriologically neutral
- Fast and easy installation
- Entire plastic systems available
- Good chemical resistance
- Low tendency to incrustations

3.1.1 Chemical resistance of PP

Table 3.2 summarises the data given in a number of polypropylene chemical resistance tables at present in use in various countries, derived from both practical experience and test results (source: ISO/TR 10358). The table contains an evaluation of the chemical resistance to a number of fluids judged to be either aggressive or not towards polypropylene. This evaluation is based on values obtained by immersion of polypropylene test specimens in the fluid concerned at 20, 60 and 100°C and atmospheric pressure, followed in certain cases by the determination of tensile characteristics.

Scope and filed application

This document establishes a provisional classification of the chemical resistance of polypropylene with respect to about 180 fluids. It is intended to provide general guidelines on the possible utilization of polypropylene piping for the conveyance of fluids:
- at temperatures up to 20, 60 and 100°C
- in the absence of internal pressure and external mechanical stress (for example flexural stresses, stresses due to thrust, rolling loads etc.)

Material properties

Definitions, symbols and abbreviations

The criteria of classification, definitions, symbols and abbreviations adopted in this document are as follows:

S = Satisfactory

The chemical resistance of polypropylene exposed to the action of a fluid is classified as 'satisfactory' when the results of test are acknowledged to be 'satisfactory' by the majority of the countries participating in the evaluation.

L = Limited

The chemical resistance of polypropylene exposed to the action of a fluid is classified as 'limited' when the results of tests are acknowledged to be 'limited' by the majority of the countries participating in the evaluation. Also classified as 'limited' is the resistance to the action of chemical fluids for which judgements 'S' and 'NS' or 'L' are pronounced to an equal extent.

NS = Not satisfactory

The chemical resistance of polypropylene exposed to the action of a fluid is classified as 'not satisfactory' when the results of tests are acknowledged to be 'not satisfactory' by the majority of the countries participating in the evaluation.
Also classified as 'not satisfactory' are materials for which judgements 'L' and 'NS' are pronounced to an equal extent.

Sat. sol Satured aqueous solution, prepared at 20°C
Sol Aqueous solution at a concentration higher than 10%, but not saturated
Dil.sol Dilute aqueous solution at a concentration equal to or lower than 10%
Work.sol Aqueous solution having the usual concentration for industrial use

Solution concentrations reported in the text are expressed as a percentage by mass. The aqueous solutions of sparingly soluble chemicals are considered, as far as chemical action towards polypropylene is concerned, as saturated solutions. In general, common chemical names are used in this document.

The evaluation of chemical resistance of polypropylene (table 3.2) is based on PP not subjected to mechanical stress. Polypropylene subjected to mechanical stress may behave different and show different result.

If the use of other chemicals is considered or at different concentrations or temperatures contact the Wefatherm Export Sales Office.

Chemical or product	Concentration	Temperature °C		
		20	60	100
Acetic acid	Up to 40 %	S	S	–
Acetec acid	50 %	S	S	–
Acetic acid, glacial	Greater than 96 %	S	L	NS
Acetic anhydride	100 %	S	–	–
Acetone	100 %	S	S	–
Aceptophenone	100 %	S	L	–
Acrylonitrite	100 %	S	–	–
Air		S	S	S
Almond oil		S	–	–
Alum	Sol	S	–	–
Ammonia, aqueous	Up to 30 %	S	–	–
Ammonia, dry gas	100 %	S	–	–
Ammonia, liquid	100 %	S	–	–
Ammonium acetate	Sat.sol	S	S	–
Ammonium chloride	Sat.sol	S	–	–
Ammonium fluoride	Sol	S	S	–
Ammonium hydrogen carbonate	Sat.sol	S	S	–
Ammonium hydroxide	Sat.sol	S	–	–
Ammonium metaphosphate	Sat.sol	S	S	–
Ammonium nitrate	Sat.sol	S	S	S
Ammonium phosphate	Sat.sol	S	–	–
Ammonium sulphate	Sat.sol	S	S	S
Amyl acetate	100 %	L	–	–
Amyl alcohol	100 %	S	S	S
Aniline	100 %	S	S	–
Apple juice		S	–	–
Aqua regia	$HCl/HNO_3=3/1$	NS	NS	NS
Barium carbonate	Sat.sol	S	S	S
Barium chloride	Sat.sol	S	S	S
Barium hydroxide	Sat.sol	S	S	S
Barium sulphate	Sat.sol	S	S	S
Benzene	100 %	L	NS	NS
Benzoic acid	Sat.sol	S	–	–
Bemzyl alcohol	100 %	S	L	–
Borax	Sol	S	S	–
Boric acid	Sat.sol	S	–	–
Bromine, gas		L	NS	NS
Bromine, liquid	100 %	NS	NS	NS

Chemical or product	Concentration	Temperature °C		
		20	60	100
Butane	100 %	S	–	–
Butanol	100 %	S	L	L
Butyl acetate	100 %	S	L	L
Butyl glycol	100 %	S	–	–
Butyl phenol	Cold sat.sol	S	–	–
Butyl phthalate	100 %	S	L	L
Calcium carbonate	Sat.sol	S	S	S
Calcium chloride	Sat.sol	S	S	S
Calcium hydroxide	Sat.sol	S	S	–
Calcium hypochlorite	Sol	S	–	–
Calcium nitrate	Sat.sol	S	S	–
Camphor oil		NS	NS	NS
Carbon dioxide, dry gas	100 %	S	S	–
Carbon dioxide, wet		S	S	–
Carbon disulphide	100 %	S	NS	NS
Carbon tetrachloride	100 %	NS	NS	NS
Castor oil	100 %	S	S	–
Caustic soda	Up to 50 %	S	L	L
Chlorine, aqueous	Sat.sol	S	L	–
Chlorine, dry gas	100 %	NS	NS	NS
Chlorine, liquid	100 %	NS	NS	NS
Cloroacetic acid	Sol	S	–	–
Chloroethanol	100 %	S	–	–
Chloroform	100 %	L	NS	NS
Chlorosulphonic acid	100 %	NS	NS	NS
Chrome alum	Sol	S	S	–
Chromic acid	Up to 40 %	S	L	N
Citric acid	10 %	S	S	S
Coconut oil		S	–	–
Corn oil		S	L	–
Cottonseed oil		S	S	–
Cresol	Greater than 90 %	S	–	–
Copper (II) Chloride	Sat.sol	S	S	–
Copper (II) nitrate	30 %	S	S	S
Copper (II) sulphate	Sat.sol	S	S	–
Cyclohexane	100 %	S	–	–
Cyclohexanol	100 %	S	L	–
Cyclohexanone	100 %	L	NS	NS

Chemical or product	Concentration	Temperature °C		
		20	60	100
Dekalin (decahydro-naphthalene)	100 %	NS	NS	NS
Dextrin	Sol	S	S	–
Dextrose	Sol	S	S	–
Dibutyl phthalate	100 %	S	L	NS
Dichloroacetic acid	100 %	L	–	–
Dichloroethylene (A und B)	100 %	L	–	–
Diethanolamine	100 %	S	–	–
Diethyl ether	100 %	S	L	–
Diethylone glycol	100 %	S	S	–
Diglycolic acid	Sat.sol	S	–	–
Disooctyl phthalate	100 %	S	L	–
Dimethyl amine	100 %	S	–	–
Dimethyl formamide	100 %	S	S	–
Dioctyl phthalate	100 %	L	L	–
Dioxane	100 %	L	L	–
Distilled water	100 %	S	S	S
Ethanolamine	100 %	S	–	–
Ethyl acetate	100 %	L	NS	NS
Ethyl alcohol	Up to 95 %	S	S	S
Ethyl chloride	100 %	NS	NS	NS
Ethylene chloride (mono and di)		L	L	–
Ethylene glycol	100 %	S	S	S
Formaldehyde	40 %	S	–	–
Formic acid	10 %	S	S	L
Formic acid	85 %	S	NS	NS
Formic acid, anhydrous	100 %	S	L	L
Fructose	Sol.	S	S	S
Fruit juice		S	S	S
Gasoline, petrol (aliphatic hydrocarbons)		NS	NS	NS
Gelatine		S	S	–
Glucose	20 %	S	S	S
Glycerine	100 %	S	S	S
Glycolic acid	30 %	S	–	–
Heptane	100 %	L	NS	NS
Hexane	100 %	S	L	–
Hydrobromic acid	Up to 48 %	S	–	NS
Hydrochloric acid	From 2 to 7 %	S	S	S
Hydrochloric acid	From 10 to 20 %	S	S	–
Hydrochloric acid	30 %	S	L	L
Hydrochloric acid	From 35 to 36 %	S	–	–
Hydrofluoric acid	Dil.sol	S	–	–
Hydrofluoric acid	40 %	S	–	–
Hydrogen	100 %	S	–	–
Hydrogen chloride, dry gas	100 %	S	S	–
Hydrogen peroxide	Up to 10 %	S	–	–
Hydrogen peroxide	Up to 30 %	S	L	–
Hydrogen sulphide, dry gas	100 %	S	S	–
Iodune in alcohol		S	–	–
Isopropyl alcohol	100 %	S	S	S
Isopropyl ether	100 %	L	–	–
Isoctane	100 %	L	NS	NS
Lactic acid	Up to 90 %	S	S	–
Lanoline		S	L	–
Linseed oil		S	S	S
Magnesium carbonate	Sat.sol	S	S	S
Magnesium chloride	Sat.sol	S	S	–
Magnesium sulphate	Sat.sol	S	S	–
Malic acid	Sol	S	S	–
Mercury (II) chloride	Sat.sol	S	S	–
Mercury (II) cyanide	Sat.sol	S	S	–
Mercury (I) nitrate	Sol	S	S	–
Mercury	100 %	S	S	–
Methyl acetate	100 %	S	S	–
Methyl alcohol	5 %	S	L	L
Methyl amine	Up to 32 %	S	–	–
Methyl bromide	100 %	NS	NS	NS
Methyl ether ketone	100 %	S	–	–
Methylene chloride	100 %	L	NS	NS
Milk		S	S	S
Monochloroacetic acid	Greater than 85 %	S	S	–
Naphtha		S	NS	NS
Nickel chloride	Sat.sol	S	S	–
Nickel nitrate	Sat.sol	S	S	–
Nickel sulphate	Sat.sol	S	S	–
Nitric acid	10 %	S	NS	NS
Nitric acid	30 %	S	–	–
Nitric acid	From 40 to 50 %	L	NS	NS
Nitric acid, fujming (with nitrogen dioxide)		NS	NS	NS
Nitrobenzene	100 %	S	L	–
Oleic acid	100 %	S	L	–
Oleum (sulphuric acid with 60 % of SO_3)		NS	NS	NS
Olive oil		S	S	L
Oxalic acid	Sat.sol	S	L	NS
Oxygen	100 %	S	–	–

Chemical or product	Concentration	Temperature °C		
		20	60	100
Paraffin oil (FL 65)		S	L	NS
Peanut oil		S	S	–
Peppermint oil		S	–	–
Perchloric acid	2 N	S	–	–
Petroleum ether (ligroine)		L	L	–
Phenol	5 %	S	S	–
Phenol	90 %	S	–	–
Phosphoric acid	25 %	S	S	S
Phosphoric acid	From 25 to 85 %	S	S	S
Phosphoric oxychloride	100 %	L	–	–
Picric acid	Sat.sol	S	–	–
Potassium bicarbonate	Sat.sol	S	S	–
Potassium borate	Sat.sol	S	S	–
Potassium bromate	Up to 10 %	S	S	–
Potassium bromide	Sat.sol	S	S	–
Potassium carbonate	Sat.sol	S	–	–
Potassium chlorate	Sat.sol	S	S	–
Potassium chloride	Sat.sol	S	–	–
Potassium chromate	Sat.sol	S	S	–
Potassium syanide	Sol	S	–	–
Potassium fluoride	Sat.sol	S	S	–
Potassium hydroxide	Up to 50 %	S	S	S
Potassium iodide	Sat.sol	S	–	–
Potassium nitrate	Sat.sol	S	S	–
Potassium perchlorate	10 %	S	S	–
Potassium permanganate	2 N	S	–	–
Potassium persulphate	Sat.sol	S	–	–
Potassium sulphate	Sat.sol	S	–	–
Propane	100 %	S	–	–
Propionic acid	Greater than 50 %	S	–	–
Pyridine	100 %	L	–	–
Sea water		S	S	S
Silicone oil		S	S	S
Silver nitrate	Sat.sol	S	S	L
Sodium acetate	Sat.sol	S	S	S
Sodium benzoate	35 %	S	–	–
Sodium carbonate	Up to 50 %	S	S	L
Sodium chlorate	Sat.sol	S	–	–
Sodium chloride	Sat.sol	S	S	S
Sodium chlorite	2 %	S	L	NS
Sodium chlorite	20 %	S	L	NS
Sodium dichromate	Sat.sol	S	S	S
Sodium hydrogen carbonate	Sat.sol	S	S	S
Sodium hydrogen sulphate	Sat.sol	S	S	–
Sodium hydrogen sulphite	Sol	S	–	–
Sodium hydroxide	1 %	S	S	S
Sodium hydroxide	From 10 to 60 %	S	S	S
Sodium hypochlorite	5 %	S	–	–
Sodium hypochlorite	10 %	S	–	–
Sodium hypochlorite	20 %	S	–	–
Sodium metaphosphate	Sol	S	–	–
Sodium nitrate	Sat.sol	S	S	–
Sodium perborate	Sat.sol	S	–	–
Sodium phosphate (neutral)	Sat.sol	S	S	S
Sodium silicate	Sol	S	S	–
Sodium sulphate	Sat.sol	S	S	–
Sodium sulphide	Sat.sol	S	–	–
Sodium sulphite	40 %	S	S	S
Sodium thiosulphate (hypo)	Sat.sol	S	–	–
Soybean oil		S	L	–
Succinic acid	Sat.sol	S	S	–
Sulphur acid	Up to 10 %	S	S	S
Sulphur dioxide, dry or wet	100 %	S	S	–
Sulphur acid	From 10 to 30 %	S	S	–
Sulphuric acid	50 %	S	L	L
Sulphuric acid	96 %	S	L	NS
Sulphuric acid	98 %	L	NS	NS
Sulphurous acid	Sol	S	–	–
Tartaric acid	10 %	S	S	–
Tetrahydrofuran	100 %	L	NS	NS
Tetralin	100 %	NS	NS	NS
Thiophene	100 %	S	L	–
Tin (IV) chloride	Sat.sol	S	S	–
Tin (II) chloride	Sat.sol	S	S	–
Toluene	100 %	L	NS	NS
Trichloroacetic acid	Up to 50 %	S	S	–
Trichloroethylene	100 %	NS	NS	NS
Triethanolamine	Sol	S	–	–
Turpentine		NS	NS	NS
Urea	Sat.sol	S	–	–
Vinegar		S	S	–
Water brackish, mineral, potable		S	S	S
Whiskey		S	–	–
Wines		S	–	–
Xylene	100 %	NS	NS	NS
Yeast	Sol	S	S	S
Zinc chloride	Sat.sol	S	S	–
Zinc sulphate	Sat.sol	S	S	–

Table 3.1 Chemical resistance of polypropylene, not subjected to mechanical stress, to various fluids at 20, 60 and 100°C (source: ISO/TR 10358)

wefatherm

Material properties

3.1.2 Fire behaviour of PP

PP-R pipe systems can be classified:

Standard	Classification
EN 13501	D-s3, d2
DIN 4102	B2

Table 3.2

European standard EN 13501-1

This standard defines a class system for material behaviour at fire for building products and building constructions. The fire behaviour of the end product as applied needs to be described by its contribution to the development and spread of fire and smoke in an area or environment. All building products can be exposed to fire developing in an area that can grow (develop) and eventually flashover. This scenario contains three phases according the development of a fire:

- *Phase 1:* flammability = a fire ignited by a small flame in a small area/product.
- *Phase 2:* smoke generation = development and possible spread of fire, simulated by a test in the corner of a room.
- *Phase 3:* flaming drops/parts = after flashover when all combustible materials contribute to the fire load.

Fire classification

Phase 1: flammability

Class	Fire tests	Flashover	Contribution	Practice
F	Not tested, or does not comply to class E	Not classified	Not determined	Extremely flammable
E	EN-ISO 11925-2 (15 sec-Fs<150 mm-20 sec)	Flashover 100 kW <2 min	Very high contribution	Very flammable
D	EN 13823, Figra <750 W/s EN-ISO 11925-2 (30 sec-Fs<150 mm-60 sec)	Flashover 100 kW >2 min	High contribution	Good flammable
C	EN 13823, Figra <120 W/s + Thr <15 MJ EN-ISO 11925-2 (30 sec-Fs<150 mm-60 sec)	Flashover 100 kW >10 min	Great contribution	Flammable
B	EN 13823, Figra <120 W/s +Thr <7,5 MJ EN-ISO 11925-2 (30 sec-Fs<150 mm-60 sec)	No Flashover	Very limited contribution	Very difficult flammable
A2	EN ISO 1182 of EN-ISO 1716 plus EN 13823, Figra <120 W/s + Thr <7,5 MJ	No Flashover	Hardly contribution	Practically not flammable
A1	EN ISO 1182 = Not flammable EN-ISO 1716 = Calorific value	No Flashover	No contribution	Not flammable

Table 3.3

Phase 2: smoke generation

Class	Classification
s3	Great smoke generation
s2	Average smoke generation
s1	Little smoke generation

Table 3.4

Phase 3: flaming drops/parts

Class	Classification
d2	Parts burn longer than 10 sec
d1	Parts burn shorter than 10 sec
d0	No production of burning parts

Table 3.5

Fire safety level of buildings

The level of fire safety of a building is not equal in every European country. Each member state may determine in its regulations which products may be used and which fire class is found suitable.

German industry standard DIN 4102

In the past the official fire rating has been ruled according to DIN 4102 (still valid today).

Materials are tested for the degree of flammability and combustibility. DIN 4102 include for testing of passive fire protection systems, as well as some of its constituent materials. The following are the categories in order of degree of combustibility as well as flammability:

Rating	Degree of flammability
A1	100% non-combustible
A2	~98% non-combustible
B1	Difficult to ignite
B2	Normal combustibility
B3	Easily ignited

Table 3.6

Roughly compared:

Classification EN13501	Classification DIN 4102
A1	A1
A2 B	A2
C	B1
D E	B2
F	B3

Table 3.7

In general F/B3 rated materials may not be used in buildings unless combined with another material which reduces the flammability of those materials.

Emissions from fire

A fire will start when an ignition source e.g. spark ignites flammable material in the presence of oxygen. A fire can also start by self-ignition at elevated temperatures. Polypropylene burns easily, because its oxygen index is low and it has a high energy content. This leads to high heat levels, combustion and a rapid spread of a fire. Polypropylene softens, melts and drips in burning droplets. This increases the burning surface and promotes the spread of fire. Polypropylene generates smoke when burning. Smoke development of polyolefins is less than other plastics, but more intense than that of wood. In oxygen rich flaming fires less smoke is generated than when the fire is smouldering. The relative flammability depends not only on the polypropylene material itself and its burning behaviour, but also on the conditions and the size and shape of the materials involved.

Since combustion tends to be incomplete in fires, a number of different combustion products, e.g. CO and soot, are formed in addition to water vapour and carbon dioxide. The major toxic component in combustion gasses in plastic fires is carbon monoxide. Small amounts of aldehydes (such as formaldehyde and acrolein), ketones, alcohols and esters are also formed.

Carbon monoxide is the most toxic degradation product in fires. CO bonds the haemoglobin of blood and blocks the ability of blood to transport oxygen around the body. This may cause intoxication and leads to unconsciousness and death. Even small amounts of CO causes dizziness, headaches and fatigue.

Emissions from processes (welding)

At elevated processing temperatures (for example during welding), thermal degradation and oxidation take place and volatile compounds (VOC) are emitted. Thermal degradation is an irreversible chemical process caused by heat. Polymer chains crack into shorter chains reducing the resins molecular weight, introducing double bonds in the polymer and producing low molecular weight volatiles. The scission of the polymer can be induced by shear or be pure thermal. Thermal degradation divides into oxidative and non-oxidative degradation. Oxidative degradation can take place during welding when the weld temperature is set too high. The higher the processing temperature, the more the polymer degrades. The bigger the air-exposed surface to volume ratio, the more oxygen containing degradation products are formed.

Emissions from processes are primarily different hydrocarbons, saturated or unsaturated, with linear, branched or cyclic structure. Some aromatic compounds are also generated when additives degrade. The number and amount of oxygenates among the degradation products are small. The most abundant oxygenates are formaldehyde, acetaldehyde, formic acid and acetone. Water vapour, carbon monoxide (CO), and carbon dioxide (CO2) are also formed. Dust and aerosols, which resembles paraffin wax fumes, are formed in significant amounts. The absolute amount of emission is small and extremely difficult to estimate since it depends on local circumstances. Reported occupational health impacts are mainly different temporary symptoms of irritation and allergy and indisposition. Despite the small amount of emissions, efficient ventilation is always needed to ensure the safety of the working environment, and to minimize the occupational risks.

3.1.5 Resistance of PP to UV- radiation

The PP materials applied for the Wefatherm water supply systems are not classified as UV resistant. Continuous exposure to sunlight ignites the process of UV degradation of the PP material. The ultra violet (UV) radiation in the sunlight affects the propylene chains to loose strength and flexibility. The rate of degradation depends on the extend and degree of exposure. This process is visible on exposed surfaces which may discolour or show a chalky appearance and become brittle. The effect is predominantly in the surface layer of the material and unlikely to extend to depths above 0.5mm. However, stress concentrations caused by the brittle nature of the PP or internal pressure may lead to failure of a pressure pipe system component.

To avoid UV degradation in plastics stabilizers, absorbers or blockers can be applied. For example carbon black at around a 2% level will block the degradation process.

To avoid material degradation, protect above ground outdoor pipe systems with insulation and UV blinding.

Material properties

3.2 PP-R material

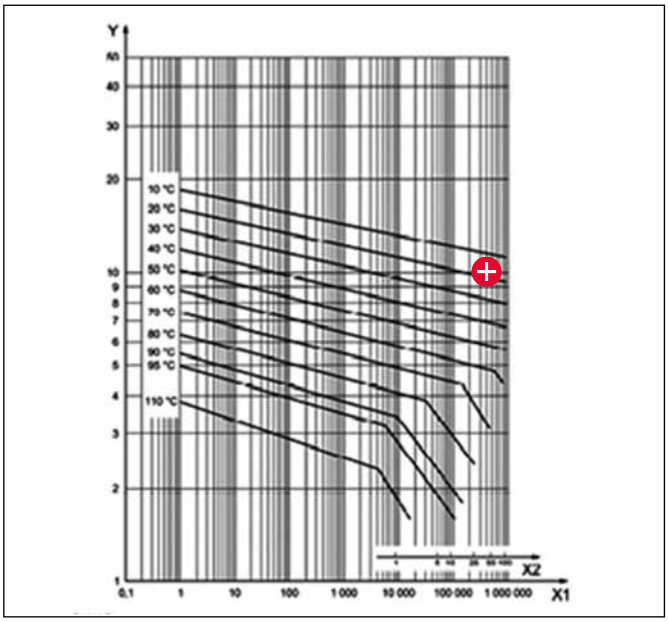
The PP-R material Borealis RA130E has become a leading PP-R grade due to its outstanding performance and quality.

Illustration 3.2

Property	Typical value	Unit	Test method
Density	905	kg/m³	ISO 1183
Melt flow rate 230°C/2.16 kg	0,30	g/10 min.	ISO 1133
Flexural modulus (2 mm/min)	800	MPa	ISO 178
Tensile modulus (1 mm/min)	900	MPa	ISO 527-2
Tensile stress at yield (50 mm/min)	25	MPa	ISO 527-2
Tensile strain at yield (50 mm/min)	13,5	%	ISO 527-2
Thermal conductivity	0,24	W/(m K)	DIN 52612
Coefficient of thermal expansion (0°C/70°C)	1,5*10E-4	1/K	DIN 53752
Charpy impact strength, notched			
(23°C)	20	kJ/m²	ISO 179/1eA
(0°C)	3,5	kJ/m²	ISO 179/1eA
(-20°C)	2	kJ/m²	ISO 179/1eA
Charpy impact strength, unnotched			
(23°C)	No break		ISO 179/1eU
(0°C)	No break		ISO 179/1eU
(-20°C)	40	kJ/m²	ISO 179/1eU
Melt temperature	210-220	°C	

Table 3.8 Physical properties PP-R material borealis RA130E

Pipes of this material possess pressure resistance, according to ISO/TR 9080 with a proven MRS class of 10 MPa and CRS class of 3,2 MPa.



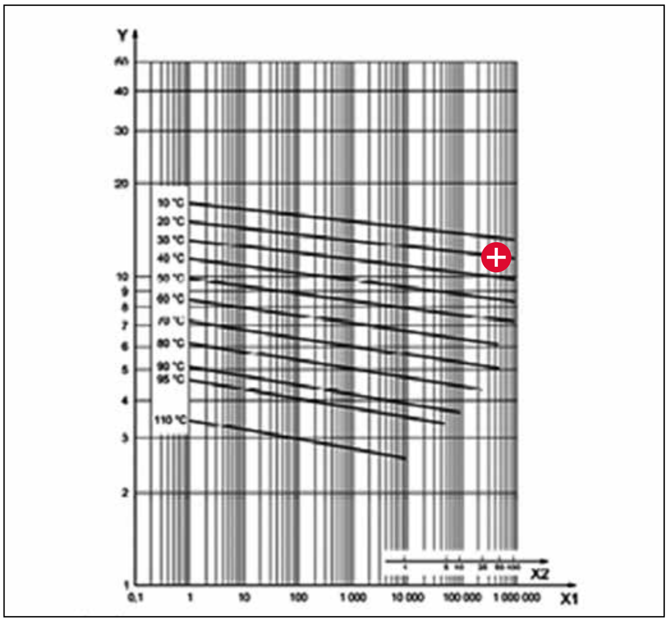
Graphic 3.1 PP-R MRS 10 MPa (20°C, 50 years)

Additional material information is given in Appendix A:
- Production safety information sheet
- Statement on compliance to regulations for drinking water pipes
- Statement on chemicals, regulations and standards

3.3 PP-RCT material

Illustration 3.3

PP-RCT (Poly Propylene-Random Crystallinity Temperature) is a material classification to describe the second generation class of PP-R materials. The Borealis RA7050 PP-RCT material has a special crystallinity which improves the mechanical characteristics of the material, especially at elevated temperatures.



Graphic 3.2 PP-RCT MRS 11,2 MPa (20°C, 50 years)

Pipes of this material possess pressure resistance according to ISO/TR 9080 with a proven MRS class of 11,5 MPa and CRS class of 5 MPa.

Additional material information is given in Appendix A:
- Product Safety Information Sheet
- statement compliance to regulation for drinking water
- statement on chemicals regulations and standards

Property	Typical value	Unit	Test method
Density	905	kg/m³	ISO 1183
Melt flow rate 230°C/2.16 kg	0,25	g/10 min.	ISO 1133
Tensile stress at yield (50 mm/min)	25	MPa	ISO 527-2
Tensile strain at yield (50 mm/min)	10	%	ISO 527-2
Modulus of elasticity in tension (1 mm/min)	900	MPa	ISO 527
Charpy impact strength, notched (+23°C)	40	kJ/m²	ISO 179/1eA
Charpy impact strength, notched (0°C)	4	kJ/m²	ISO 179/1eA
Charpy impact strength, notched (-20°C)	2	kJ/m²	ISO 179/1eA
Mean linear thermal Coefficient of expansion from 0°C to 70°C	1,5	*10-4K-1	DIN 53752
Thermal conductivity	0,24	WK-1m-1	DIN 52612 Part 1
Melt temperature	220-230	°C	

Table 3.9 Physical properties PP-RCT material Borealis RA7050

Stabilisation package
A stabilisation package based on Borealis' long expertise in the field of polyolefins for hot water applications provides superior durability.

Stabilisation packages role is to protect the polymer against the oxidation which could occur during the:
- manufacturing step by extrusion or injection where the material is exposed at high temperature i.e. 200°C and 230°C for a short period of time
- long term exposure of the pipe system, under pressure at temperature up to 70°C

To produce a homogeneous compound, special attention is paid to ensure that the stabilizing package is finely dispersed in the PP-R resin by compounding.

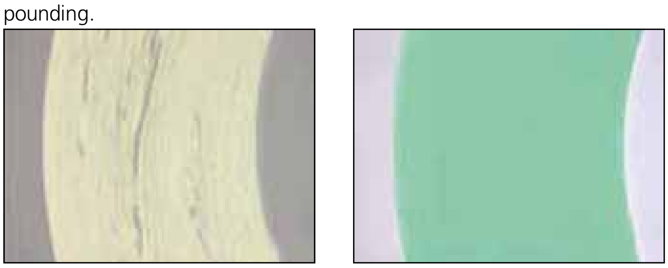


Illustration 3.4 Stereomicroscopic observation of pipe cross sections with poor dispersion and excellent dispersion of pigment and additives

The translucent area in the pipes cross section are an indication for lack of compound homogeneity. The lack of compound homogeneity might cause local points of premature aging of the material.

Material properties

3.4 Brass transitions

3.4.1 Brass

Transition fittings and unions are well known items to connect pipe systems of different materials together. Usually with male and female threaded parts according to the general accepted ISO 7/EN 10226 or ISO 228 standards.

Illustration 3.5

France, Germany, the Netherlands and the United Kingdom (4MS) work together in the framework of the 4MS Common Approach that aims to convergence the respective national approval schemes for materials and products in contact with drinking water. 4MS have adopted a common basis for accepting metallic materials in their national regulations: The 4MS common Composition List of accepted metallic materials.

Brass and Bronze components complying to the requirements as mentioned in standard DIN 50930-6 can be applied in drinking water installations.

Brass type used for inserts in WF transition fittings is classified as CW617N (CuZn40Pb2). With Cu, Ni, Pb, Zn elements level below the threshold for the migration in water.

For additional information on brass contact the Wefatherm Export Sales Office.

3.4.2 Threaded parts

The applied threaded parts are fabricated according to:

ISO 7/EN 10226 Pipe threads where pressure tight joints are made on the threads

EN-ISO 228 Pipe threads where pressure-tight joints are not made on the threads

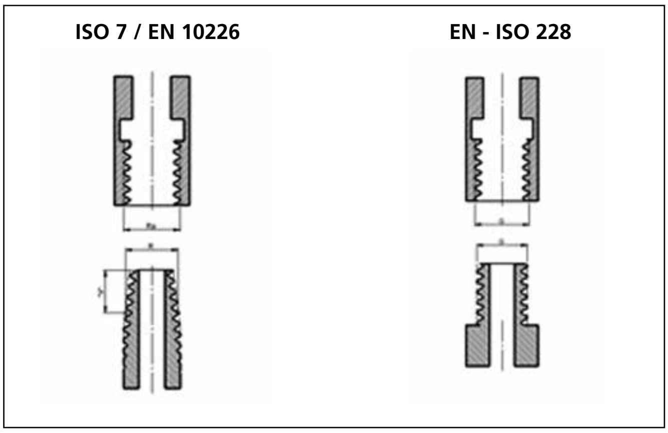


Illustration 3.6

ISO 7 / EN 10226	EN - ISO 228
Tight joints on the thread	Tight joints not on the thread
R = male threaded part conical	*G* = male threaded part cylindrical
R_p = female threaded part cylindrical	*G* = female threaded part cylindrical
R_c = female threaded part conical	
Additional seal recommended	Additional seal required
We advise to use PTFE tape for sealing	Apply additional gasket or O-ring

Table 3.10

3.4.3 Mixed copper/PP-R systems

Illustration 3.7 Damage observed with not properly stabilized PP-R under extreme conditions

Copper is a known catalyst for the oxidation process of polypropylene, more specific: the free copper ions. After ignition of the oxidation process, for example due to an elevated level of chlorine used for secondary water treatment, the copper ions have catalyst effect on the oxidation process. With the increased amount of free copper ions the effect increases also. The amount of copper ions depends on the specific pipe system, the exposed copper surface and water quality (pH value). At water temperatures above 70°C this process is accelerated. To ensure a long term undisrupted use of mixed copper/PP-R hot water circulation systems respect the limitations mentioned in the limitation for mixed copper/PP-R hot water circulation systems.

Material properties

Limitation mixed copper/PP-R
Hot water circulation systems
To avoid erosion corrosion in PP-R hot water circulation systems with up-stream copper, respect following limitations:

Water temperature	max. 70°C
Operating pressure	according Appendix B1 and B2 of Specification Manual with max. 8 bar
Medium velocity	max. 0,9 m/sec

Specific conditions, such as high concentration of chlorinated water disinfectants combined with water having low pH or high ORP, will affect the long term properties of PP-R.

For additional information contact your Wefatherm wholesaler or the Wefatherm Export Sales Office.

3.5 Rubber gaskets

For connection and transition to other materials the Wefatherm system incorporates items with gaskets.

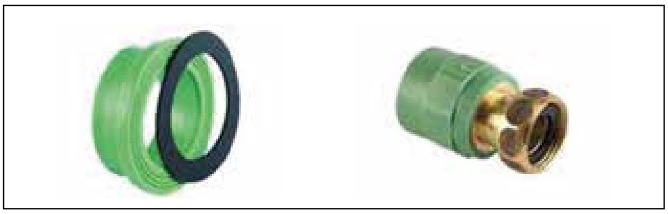


Illustration 3.8

The applied gasket material is EPDM Semperit E628 black. This EPDM material complies with KTW approval 1.3.13 D1 and D2 for cold and warm water:
- Hardness (Shore A): 70 ±5
- Density (g/cm³): 1,12
- Tensile strength (N/mm²): 11
- Elongation at break (%): 250
- Working temperature range up to 120°C
- Thickness 2,0 mm

Resistance

Medium	Class
Ozone	well
Aging	well
Oils	not
Gazolines	not
Acids	well
Basen	well
Wear	suitable

Table 3.11 Resistance

Medium	Dyn. (stat.)	Max.	Short term
Air	-40 (-50)°C	+120°C	+140°C
Water	-	+120°C	+150°C

Table 3.12 Temperature range

Conditions	Hardness	Strength	Yield
70 h/125°C	+10 shore A	+/-20%	-40%

Table 3.13 Aging DIN 53608 temperature range

Time	Temperature	DVR
70 h	100°C	30%

Table 3.14 Pressure deformation resistance DIN-ISO 815

Time	Pphm Ozone	Temperature	Crack phase
48 h	200 pphm	40°C	0

Table 3.15 Ozone resistance

For additional information on the chemical resistance of gaskets contact the Wefatherm Export Sales Office.

3.6 Backing rings

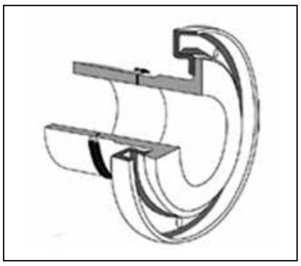


Illustration 3.9

Profiled flanges, PP encapsulated ductile iron, have a specific design and are developed for the use in thermoplastic piping systems.
Profiled PP flanges are being cast in ductile iron GGG40 (ASTM A536), then placed into an injection moulding machine and encapsulated with 30% reinforced polypropylene. This process guarantees a substantial corrosion protection barrier.

This extraordinary pipe flange concept has proven itself successful widely since 1979 in many countries in the world.

Advantages
- High corrosion resistance through the polypropylene layer over metallic insert
- Convincing weight savings
- Substantially simplified handling
- 16 bar operating pressure
- Elimination of re-torqueing after initial installation

Re-tightening
Due to the reduced weight and the profile shape of the backing ring, the need to re-tighten the fasteners is eliminated. The unique flange shape, acting like a 'Belleville washer', brings about the additional energy storage needed to overcome any thermoplastic material cold flow conditions. The design shape of the flanges is based on FEM calculations (Finite Element Method) whereby special considerations have been given to the thermoplastic stub end. For all flanges a safety factor of 2 is guaranteed on the yield strength of the material for the stated maximum operating pressures (MOP). For increased temperatures (>20°C) it remains advisable to inspect the flange joint periodical and re-tighten the fasteners if necessary.

Material properties