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Specialist Water Supply Systems

PP-R pipe system

Specification manual

2017


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Fairmont hotel Palm Jumeirah
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Wefatherm specialist water supply systems

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Wefatherm disclaimer

Validity
This Specification Manual is dated June 2017 and replaces older versions. The current technical documentation can be downloaded at www.wefatherm.de.

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This information contained in this technical manual is based on current information and product design at the time of publication and is subject to change without notification.

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Important information and pictograms
This manual contains pictograms to emphasize important or beneficial information.

- Important information and safety alerts to take into account
- Update actual version
- Conditions
- Consult the Wefathem Export Sales Office
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Validity of technical information
Please check for your safety and for the proper application of our products at regular intervals if your present Specification Manual has been replaced by a new version. The issue date is always mentioned on the cover. The valid technical information can be obtained at your Wefatherm wholesaler, the Wefatherm Export Sales Office and be downloaded at www.wefatherm.de.

Safety and operating instructions
- Read the safety and operating instructions for your own safety and the safety of others carefully and completely before starting the installation.
- Store the operating instructions and keep them available.
- If the safety instructions or installation instructions are unclear, please contact the Wefatherm Export Sales Office.
- Ignoring safety instructions can cause property damage or personal injury.

Disclaimer
Follow all applicable national and international assembly, installation, accident prevention, safety regulations and the information in this Specification Manual during the installation of piping systems.

Also follow the applicable laws, standards, guidelines, regulations and instructions for environmental protection, professional associations and the local utility companies.

Intended use
The system components and the jointing techniques may only be designed, engineered, installed and operated as described in this Specification Manual. Any other use is improper and therefore inadmissible.

The planning and installation instructions are directly related to the respective Wefatherm product. The reference to standards or regulations is on a general level. Be aware of the current status of guidelines, standards and regulations. Other standards, regulations and guidelines regarding the planning, installation and operation of drinking water or building systems need to be taken into account also and are not part of this Specification Manual.

Personnel requirements
- Allow installation only to be performed by authorized and trained people
- Allow work on electrical installations or parts only to be performed by specially trained and authorized personnel

General precautions
- Keep your work area clean and free of obstructing objects
- Provide adequate lighting of your work area
- Keep unauthorized persons away of tools and the work area, especially at renovations in inhabited areas
- Use only Wefatherm system components. The use of non-system components can lead to accidents or other hazards

Disclaimer

Workwear

Wear suitable work clothing

Wear a safety helmet

Wear safety shoes

Wear safety glasses

Wear hearing protection

Improper use can cause severe cuts, bruising or dismemberment

During assembly

- Always read and follow the operating instructions of the respective used tool.
- Improper use of tools can cause severe cuts, cause bruising or dismemberment.
- Improper use of tools can damage components and cause leaks.
- Pipe cutters have a sharp blade. Store and handle without risk of injury.
- Note the safety distance between holding hand and cutting tool when cutting the pipes.
- Never grip the cutting zone of the tool or moving parts during the cutting process.
- Pull out the AC power plug for maintenance or relocation activities and protect it against unintentional switching on.

Operating parameters

When the operating parameters are exceeded, pipes, fittings and joints will be overloaded. Exceeding the operating parameters is therefore not permitted. Ensure compliance with the operating parameters with safety and control facilities (such as pressure reducing valves or safety valves).

Applications not covered in this Specification Manual (special applications) require consultation with our technical department. For specific advice consult the Wefatherm Export Sales Office.

1 Water supply systems

1.1 Domestic systems

The Wefatherm system can be applied for typical domestic water supply systems such as:
- Drinking water; Drinking water is considered fresh water up to a temperature of 25°C for drinking and preparing food.
- Hot tap water; Hot tap water is heated drinking water up to a temperature of 60°C.
- Sanitary applications; Sanitary applications are applications for which the drinking water quality is not required, such as flush systems, washing and irrigation.

Typical hot and cold water applications classified as class 1 and class 2 in standard ISO 15874 'Plastic piping systems for hot and cold water installations - Polypropylene PP'.

Hot water applications with temperatures above 70°C are considered as heating applications. Heating applications classified as class 5 in standard ISO 15874 are not covered in this specification manual.

Similar, but not identical, classifications are used in standards;
- DIN8077 - Pipes of Polypropylene (PP)
- ASTM F2389-15 Pressure rated Polypropylene (PP) piping systems

Pipe work is usually conceiled in the wall/floor in order to not disturb the visual appearance of the sanitary room. In non sanitary lounge rooms the pipe work is usually surface mounted, because the visual aspect is less important.

Illustration 1.1

1.2 Supply systems

A domestic water supply system finds its application in family houses and residential buildings with apartments/condominiums. When more than 2 houses are combined in one system it is considered a large plant which consist of:
- Floor distribution
- Rising mains
- Transport to rising mains

Illustration 1.2

Illustration 1.3

Water supply systems

1.3 Hot tap water installations

Hot tap water installations are technical sophisticated installations which need to consider requirements on water quality, hygiene, comfort and economy. A judgement of sometimes contradicting requirements leads to a responsible hot water supply.

Hot water installations can be divided in:

- *Centralized installations*
  All tapping points in one (or more) building(s) are supplied by one utility net and heated by one (or more) water heater(s).
- *Decentralized installations*
  Groups of close by tapping points with larger distances between these groups and heated by multiple water heaters to the multiple groups. Or a single tap point is supplied by a single water heater.

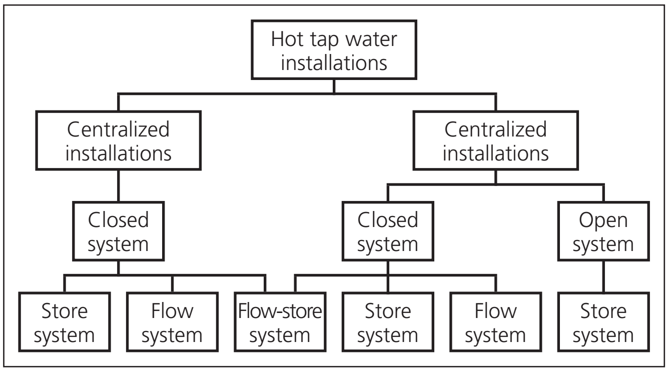

Illustration 1.4

Hot tap water installations can be realized as flow, store and combined flow-store systems:

- *Flow systems*
  The drinking water is heated while flowing through the heater. Direct heating is applied in gas and electrical heaters, indirect heating is applied in heat distribution systems.
- *Store systems*
  The drinking water is heated directly or indirectly and stored before it will be tapped on demand. This can be done in open and closed systems. An open system is a non-pressurised system, in general for one tapping point, connected with specialized valves. In closed systems multiple tapping points can be connected, executed with proper cleaning and maintenance facilities.Distinction is made between small scale and large scale installations. For large scale installations following considerations need to be taken in account:
- *Operating temperature*
  Hot water installations should not consume more energy as necessary for its application. To prevent corrosion and calcification, limits are set for the operating temperature. From a hygienic view (legionella prevention) the installation should operate so that the temperature of the water in any point of the circulation system should not drop under 55°C for long term operation (see DVGW work sheet W551 and W552).
- *Operating pressure*
  Hot water installations are designed for a nominal pressure of 10 bar. Water heaters for nominal pressure of 6 bar are applicable when a suitable pressure reducing valve is applied.
- *Technical safety measures*
  Every closed system requires a pressure relief valve in the cold water supply line and the relieved water needs to be drained into the drain system (see DIN 1988).

In general the smallest pipe diameter and shortest route to the tapping points is preferred. The pipe system must be insulated. The circulating volume flow needs to be adjusted permanently. The non-operational pipe segment has to be disconnected.

Hot tap water installations need to be maintained by annual inspection.

2 Requirements on water supply systems

Drinking water is one of our most important elements and is accordingly subjected to very strict regulations. It is obliged to follow national guidelines on drinking water. The guidelines mentioned in this Specification Manual are based on the regulation in Germany and the European Union.

Directives on the quality of water intended for human consumption:
- Germany: Trinkwasserverordnung TrinkwV2001
- European Union: Drinking Water Directive 98/83/EC

Drinking water
High quality, safe and sufficient drinking water is essential for our daily life, for drinking and food preparation. We also use it for many other purposes, such as washing, cleaning, hygiene or watering our plants. The European Union has a history of over 30 years of drinking water policy. This policy ensures that water intended for human consumption can be consumed safely on a life-long basis, and this represents a high level of health protection. The main pillars of the policy are to:
- ensure that drinking water quality is controlled through standards based on the latest scientific evidence
- secure an efficient and effective monitoring, assessment and enforcement of drinking water quality

The Directive overview
The Drinking Water Directive concerns the quality of water intended for human consumption. Its objective is to protect human health from adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean.

The Directive laid down the essential quality standards at EU level. A total of 48 microbiological, chemical and indicator parameters must be monitored and tested regularly. In general, World Health Organization's guidelines for drinking water and the opinion of the Commission's Scientific Advisory Committee are used as the scientific basis for the quality standards in the drinking water.

National Legislation
When translating the Drinking Water Directive into their own national legislation, Member States of the European Union can include additional requirements e.g. regulate additional substances that are relevant within their territory or set higher standards. Member States are not allowed, nevertheless, to set lower standards as the level of protection of human health should be the same within the whole European Union.

Source: European Union

In Germany the relevant requirements on drinking water and technical requirements on drinking water systems are based on long term practical experience and are laid down in codes of practice. These general accepted codes of practice are a combination of laws, standards and guidelines to ensure:
- Hygienic reliable drinking water
- Long term undisrupted system use
- Avoid nuisance like noise
- Prevention from the loss of waste and energy

Substance	CAS Nr.	EINECS Nr.	Application	Requirement	Allowable addition	Max. concentration after treatment	To be observed reaction product	Remarks
Calciumhypochlorit	778-54-3	321-908-7	Disinfection	DIN EN 900 Tab 1, type 1	1,2 mg/l free Cl_2	max. 0,3 mg/l free Cl_2 min. 0,1 mg/l free Cl_2	Trihalogen-methane, Bromat	Additive to 6 mg/l free Cl_2 and content to 0,6 mg/l free Cl_2 after treatment beside else disinfection is not guaranteed or disinfection is reduced by Ammonium
Chlorine	7782-50-5	231-959-5	Disinfection production of Chlorin-edioxide	DIN EN 937 Tab 2, type 1	1,2 mg/l free Cl_2	max. 0,3 mg/l free Cl_2 min. 0,1 mg/l free Cl_2	Trihalogen-methane	Additive to 6 mg/l free Cl_2 and content to 0,6 mg/l free Cl_2 after treatment beside else disinfection is not guaranteed or disinfection is reduced by Ammonium
Chlorinedioxide	10049-04-4	233-162-8	Disinfection	DIN EN 12671 (EN 937, 901, 939, 899, 938, 12926)	0,4 mg/l ClO_2	max. 0,2 mg/l free Cl_2 min. 0,05 mg/l free Cl_2	Chlorite	Maximum value of Chlorite 0,2 mg/l ClO_2 after treat-ment must be maintained. Note possible formation of Chlorate
Natriumhypochlorite	7681-52-9	231-668-3	Disinfection	DIN EN 901 Table 1, type 1 Limit for impurities with Chlorate ($NaClO_3$): <5,4% (m/m) of active chlorine	1,2 mg/l free Cl_2	max. 0,3 mg/l free Cl_2 min. 0,1 mg/l free Cl_2	Trihalogen-methane, Bromat	Additive to 6 mg/l free Cl2 and content to 0,6 mg/l free Cl_2 after treatment beside else disinfection is not guaranteed or disinfection is reduced by Ammonium
Ozon	10028-15-6	Not applicable	Disinfection, oxidation	DIN EN 1278 Attachment A.3.2	10 mg/l O_3	0,05 mg/l O_3	Trihalogen-methane, Bromat	

CAS: Chemical Abstracts Service Registry Number
EINECS: European Inventory of Existing Commercial Chemical Substances

Table 2.1 Water treatment substances for disinfection in drinking water, according to Trinkwasserverordung Trinkw V2001

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Requirements on water supply systems

Substances list
For preparation of water for human consumption only substances may be applied which are recognized by the German ministry of health. With the goal to:
a. Remove undesired substances from the water
b. Make the water suitable for human consumption
c. Kill or inactivate disease exiters at:
- preparation of the water in the water treatment plant (primary disinfection)
- distribution of the water in pipe systems (secondary disinfection)
- storage of water in tanks (secondary disinfection)

Water treatment substances consumed in certain levels may harm public health. To prevent an excessive consumption of these substances the maximum allowed concentration of applied water treatment substances in the drinking water is specified in table 2.1.

> The reference to standards or regulations is on a general level. Follow all applicable national and international laws, standards, guidelines, regulations and instructions for environmental protection, from professional associations and the local utility companies.

2.1 Hygienic reliabilility

Protection against contamination of hygienic quality by:

- *Increase of microbiological growth*
  Water contains a certain low amount of patogenic germs which can lead to illnesses when the bacteria start to grow and increase in the water, like legionella and dysentery. These organisms generally develop at temperature between 20°C and 55°C. So the water in the system needs to avoid this temperature range or water needs to be exposed to this temperature for a limited time.

- *Contamination applied materials*
  The drinking water makes contact to the materials applied in the water distribution system. Elements applied in the materials for pipe work can migrate into the drinking water. Some elements have a negative effect on human beings when a certain value is exceeded. So it needs to be avoided that materials applied contain elements which can wash out and accumulate in the drinking water to an unaccepted level. A knowable example is the application of lead pipes in drinking water distribution. But also weak makers and colour dies applied in plastics are potential contaminators.

- *Back flow of 'used water' into the system*
  When water flushes from the tap point, like in a bath, it makes contact with soap or oils and is no longer fit for human consumption. Flush systems have the likely chance of not being operated every day and the flush water is exposed to elevated temperature with the result that it might contain an increased amount of bacteria. So no fixed connections between bath tub, flush cistern, heating system or cooling system is allowed.

2.2 Long term undisrupted use

For long term undisrupted use the system should be protected:
- against fire
- against freezing
- against excessive heating
- against condensation
- against corrosion
- against mechanical damage

Standard	Title
DIN 1988	Technical rules for drinking water installations - Technical rules from DVGW
DIN 4708	Central heat water installations
EN 806	Specifications for installations inside buildings conveying water for human consumption

Table 2.2 Specification for drinking water installations

Standard	Title
W551	Technical measures to reduce legionella increase
W552	Reduction of legionella - remediation and operation
W553	Dimensioning hot water circulation systems
W554	Operated valves in circulation systems
VDI 6023	Guideline on how to plan, design, engineer, operate and maintain

Table 2.3 Codes of practice: specification for large scale drinking water installations

- *Protection against fire*
  In buildings protection against fire is in principle based on zones with barriers to slow down the spread of fire, to limit the exposure and providing time to extinguish the fire. Pipe systems usually exceed these areas. Pipe and cable work may not operate as a fuse for the development of a fire. So apply fire protection sleeves when the water system crosses a fire barrier zone.

- *Protection against freezing*
  When pipe systems freeze, the flow and function of the system gets blocked. The frozen pipe system might get damaged and starts leaking as soon as the water will melt again. So apply insulation when there is a potential risk of freezing.

- *Protection against excessive heating*
  When cold and hot water systems are near each other or at crossings, the cold water might be heated up by the hot water system, with the result that the cold water is no longer fresh. Excessive heating after a heater might damage the pipe system, resulting in early failure of the material.

- *Protection against condensation*
  When moist warm air gets in contact with cool surfaces, it solves moist condensates on the cool surface in tiny water drops. When this process continues, it can cause a wet area where funguses can develop. This can be the case on cold water systems and cooling systems. So insulate cold water systems and cooling systems and the risk on condensation will be elevated.

- *Protection against corrosion*
  Corrosion is a degradation process of the pipe material. It will lead to early failure of the system. So for metal pipe systems measures like passivation or insulation are applied to reduce the risk for corrosion.

- *Protection against mechanical damage*
  Mechanical damages like scratches or notches by bad handling lead to weakening of the material. Careless clamping and insufficient expansion compensation leads to additional material stresses. Both can lead to early failure of the system.

2.3 Avoid nuisances

Avoid nuisances due to:

- *Noise*
  Hearing water flow becomes nuisance above a noise level 30 dB(a). Apply insulation to prevent noise to exceed this noise level.

- *Waiting time before availability of warm water*
  Waiting on the right temperature becomes nuisance after a certain time. Apply an application specific pipe diameters to avoid excessive waiting time.

2.4 Waste prevention

Waste prevention against excessive use of:

- *Water*
  When excessive time is necessary to wait for the required water temperature, the water gets spilled. Spilling of valuable drinking water should be avoided. Apply a specific dimension of the pipe system to avoid excessive waiting time.

- *Energy*
  Reduction of energy consumption in buildings is regarded as a substantial attribution to climate goals. Beside insulation of buildings and modern heating technology also reduction of energy for the availability of hot water is possible. In modern buildings the energy consumption is optimized in such a way that hot water preparation requires substantial lower energy.

2.5 Disinfection

Although properly treated to comply with stringent national health regulations and safe for human consumption, drinking water may contain traces of bacteria and chemicals.

Drinking water supplied according to the public water authority regulation is not perfectly sterilized. It contains (pathogenic) germs in concentrations which are not harmful for public health. In the public distribution network with temperatures below 20°C the growth of bacteria is prevented. In general the public water authorities supply a good drinking water quality.

In the building the owner has to take care that the water quality does not deteriorate before it is tapped. Drinking water installations in private and public buildings harbor a danger source for the drinking water quality. Raised temperature and retention period of the drinking water in the pipe system and cisterns lead to bacterial growth and raised quantity of bacteria in the water. This is caused by inadequate heat insulated pipes, less operated pipe segments and at low temperature (below 60°C) operated hot water storage.

Most significant for drinking water quality in buildings is legionella. It distinguishes itself from other pathogenic bacteria that it does not increase inside the human body but in biofilm, especially in the temperature range from 20°C to approximately 55°C. They are absolutely the most relevant environmental germ for which the human population needs to be protected.

Legionella can grow to questionable concentration in the temperature range from 20 to 55°C with a retention time of several hours to days. This needs to be considered when the operational temperature for hot water systems is reduced for the purpose of energy consumption reduction.

Thermal disinfection
Legionella growth is stopped at a temperature between 55-60°C. Killing legionella settlements requires a minimal temperature of 70°C for minimal 30 minutes in the total pipe system. A frequent heating above 60°C limits the lifetime of installation materials.

Chemical disinfection
Legionella bacteria on the surface of biofilms are killed by chlorine substances such as Calcium Hypochlorit, Chlorine, Chlorine Dioxide, Natrium Hypochlorite. In general the chemical resistance of polypropylene to these chlorine substances is not satisfactory. However in reality these chlorine substances are dosed in aqueous solutions at low concentrations and prepared at 20°C. This reduces the impact on installation materials.

Reduction of energy consumption by reducing boiler temperature setting may not endanger the hygienic quality of the water. It is preferably realized by:
- Insulation of pipe systems and storage tanks
- Hydraulic alignment of circulation systems
- Applying economic circulation pumps and storage tanks
- Applying water saving taps

Codes of practice for drinking water installations make a distinction between large and small scale installations. Large scale installations require a circulation system to prevent that heated water cools down in the pipe system (when it flows back from a tap branch) before it is heated again on the required temperature. Circulation systems lead to heat loss and additional energy consumption.

Requirements on water supply systems

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.)

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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' are 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	–	–
Bernzyl 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
Magnecium carbonate	Sat.sol	S	S	S
Magnecium 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	–	–
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)

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Material properties

3.1.2 Fire behavior 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 smoldering. The relative flammability depends not only on the polypropylene material itself and its burning behavior, 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 rather a 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 oxygencontaining 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 degratation protect above ground outdoor pipe systems with insulation and UV blinding.

Material properties

3.2 PP-R material

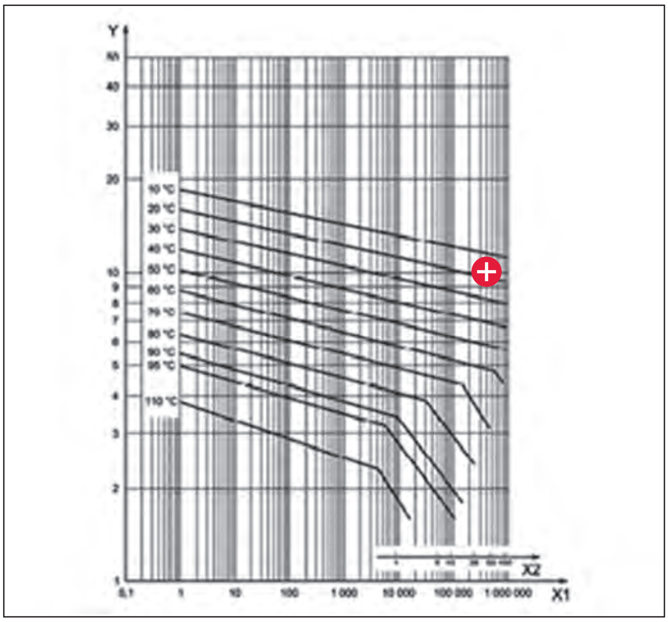
The PP-R material Borealis RA130E has become a leading PP-R grade due to its outstanding performance and quality.

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.



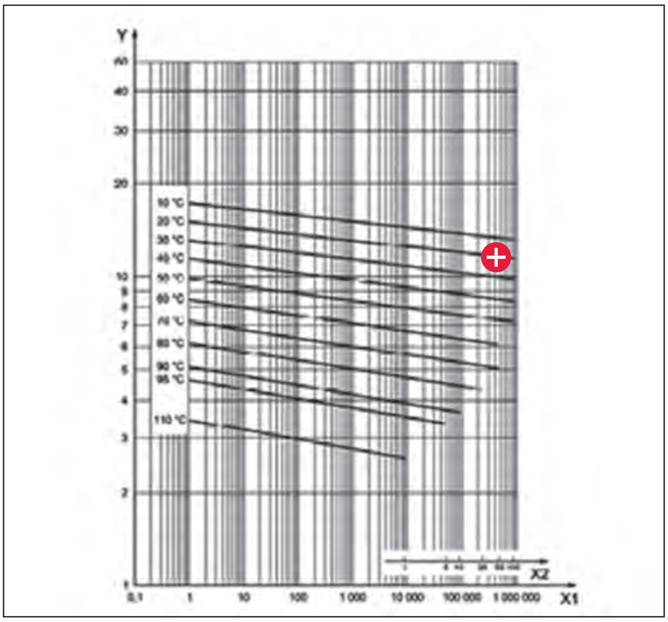
Graphic 3.1 PP-R MRS 10 MPa (20°C, 50 years)

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/m^3	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/m^2	ISO 179/1eA
Charpy impact strength, notched (0°C)	4	kJ/m^2	ISO 179/1eA
Charpy impact strength, notched (-20°C)	2	kJ/m^2	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, underpressure at temperature up to 70°C

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

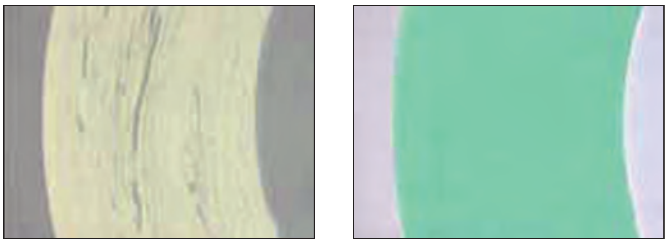


Illustration 3.4 Stereomicroscopic observation of pipe cross sections with poor dispersion and excellent dispersion of pigment and additives

The translucent area in the pipes cross section are an indication for lack of compound homogenity. The lack of compound homogenity 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.

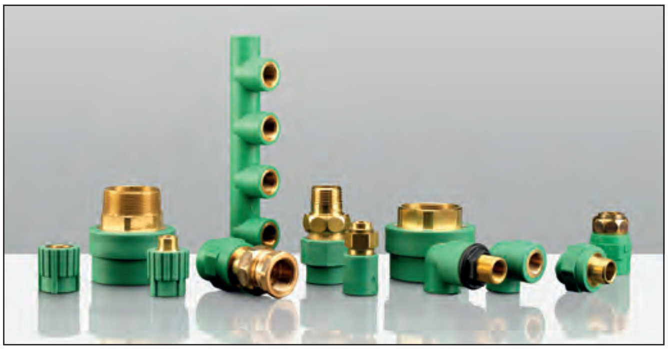


Illustration 3.5

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

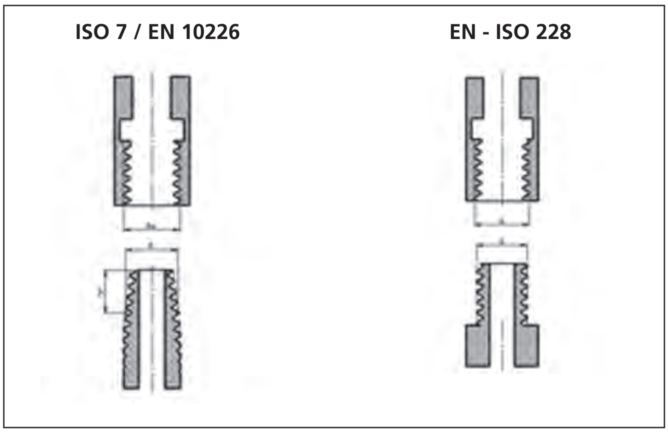


Illustration 3.6

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.

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

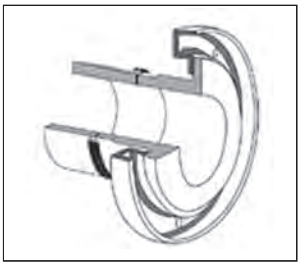


Illustration 3.9

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 molding 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-torquing 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 thermo-plastic 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 priodical and re-tighten the fasteners if necessary.

Material properties

4 Standards and guidelines

4.1 Standard ISO 15874 - Plastic piping system for hot and cold water installations

Standard ISO 15874 is the international application standard for hot and cold water installations of PP.

Standard	Title
ISO 15874	Plastic piping systems for hot and cold water installations - polypropylene (PP)
Part 1	General
Part 2	Pipes
Part 3	Fittings
Part 5	Fitness for purpose of the system
Part 7	Recommendations for the assessment of conformity

Table 4.1

Beside determination of terms, this standard specifies the subjects in following paragraphs.

4.1.1 Classification of operation

Application class	Design temperature T_D °C	Operation time at T_D Year	Tmax °C	Operation time at T_{max} Year(s)	Tmal °C	Operation time at T_{mal} h	Application
1a	60	49	80	1	95	100	Hot water supply (60°C)
2a	70	49	80	1	95	100	Hot water supply (70°C)
4b	20 followed by 40 followed by 60	2,5 20 25	70	2,5	100	100	Underfloor heating and low temperature radiator connections (70°C)
5b	20 followed by 60 followed by 80	14 25 10	90	1	100	100	High temperature radiator connections (80°C)

Note: This standard is not applicable when the values for TD, Tmax and Tmal are exceeded.

Table 4.2

Td = design temperature
Tmax = maximum design temperature
Tmal = malfunction temperature

a) According to national regulation application class 1 or class 2 can be selected.
b) When for one application class more as one operating temperature applies, the associated time of operation needs to be added. For example: the collective temperatures of the 50 years design life time of application class 5 is calculated as:
- 20°C over 14 years followed by
- 60°C over 25 years followed by
- 80°C over 10 years followed by
- 90°C over 1 year followed by
- 100°C over 100 hours

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Standards and guidelines

4.1.2 Design parameters

Based on a design life time of 50 years the maximum operating pressures are classified:

- for hot water application: 4, 6, 8 or 10 bar
- for cold water application: 10 bar

The maximum operating pressure for PP pipes:

Application class	Design pressure [bar] acc. ISO 15874 PP-R SDR11	PP-R SDR 7.4	PP-R SDR 6	PP-RCT SDR 11	PP-RCT SDR 7.4
1	6	8	10	6	10
2	4	6	8	6	10
4	6	10	10	6	10
5	-	6	6	4	8

Table 4.3

4.1.3 Materials

PP materials to be applied are:

- Polypropylen - homopolymer PP-H (formerly known as Type 1)
- Polypropylen Block Copolymer PP-B (formerly known as Type 2)
- Polypropylen Random Copolymer PP-R (formerly known as Type 3)
- Polypropylen Random Copolymer with fine structure and raised temperature resistance at elevated temperatures PP-RCT

4.1.4 Long term material strength

Creep behavior is an important factor to take in consideration for plastic pipe systems. The minimum required strength at different temperatures for PP-R and PP-RCT are mentioned in chapter 3 (material properties).

4.1.5 Geometry of pipes and fittings

Dimensions and tolerances for single wall pipes d16-125 mm. Not for fiber or stabi pipes.

Outer diameter	Average outer diameter		SDR 17 S8*	SDR 13,6 S6,3*	SDR 11 S5	SDR 9 S4*	SDR 7,4 S3,2	SDR6 S2,5	SDR 5 S2
d_n	$d_{em,min}$	$d_{em,max}$	Wall thickness						
12	**12,0**	**12,3**	**1,8**	**1,8**	1,8	1,8	1,8	2,0	2,4
16	**16,0**	**16,3**	**1,8**	**1,8**	1,8	1,8	2,2	2,7	3,3
20	**20,0**	**20,3**	**1,8**	**1,8**	1,9	2,3	2,8	3,4	4,1
25	**25,0**	**25,3**	**1,8**	**1,9**	2,3	2,8	3,5	4,2	5,1
32	**32,0**	**32,3**	**1,9**	**2,4**	2,9	3,6	4,4	5,4	6,6
40	**40,0**	**40,4**	**2,4**	**3,0**	3,7	4,5	5,5	6,7	8,1
50	**50,0**	**50,5**	**3,0**	**3,7**	4,6	5,6	6,9	8,3	10,1
63	**63,0**	**63,6**	**3,8**	**4,7**	5,8	7,1	8,6	10,5	12,7
75	**75,0**	**75,7**	**4,5**	**5,6**	6,8	8,4	10,3	12,5	15,1
90	**90,0**	**90,9**	**5,4**	**6,7**	8,2	10,1	12,3	15,0	18,1
110	**110,0**	**111,0**	**6,6**	**8,1**	10,0	12,3	15,2	18,3	22,1
125	**125,0**	**126,5**	**7,4**	**9,2**	11,4	14,0	17,1	20,8	25,1

**) only for PP-RCT*

Table 4. Geometry of pipes

Geometry of fittings

Dimensions for sockets. Distinction is made between:

- type A, for pipes which need to be scraped
- type B, for pipes which do not need to be scraped

Wefatherm socket dimension are according to type B and do not require pipe scraping before socket welding. Sockets according ISO 15494/DIN16962 for industrial purposes have shorter weld lengths.

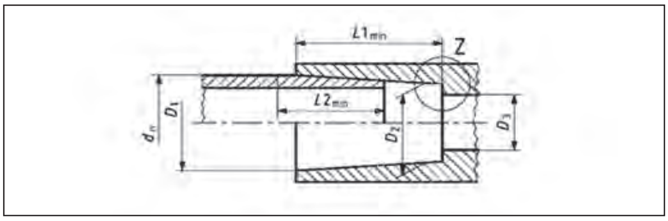


Illustration 4.1

4.1.6 Safety factor and design stress

Temperature °C	SF PP-R	PP-RCT
T_D	1,5	1,5
T_{max}	1,3	1,3
T_{mal}	1,0	1,0
T_{cold}	1,4	1,4

Table 4.5 Safety (design) factor (SF)

Application class	Design stress Mpa* PP-R	PP-RCT
1	3,02	3,64
2	2,12	3,40
4	3,29	3,67
5	1,89	2,92
20°C/50 years	6,93	8,25

**) values rounded at 0,01 Mpa*

Table 4.6 Design stress of the material

4.1.7 Tests requirements and parameters

Property	Requirement PP-RCT	Test parameters: Hydraustatic stress Mpa	Test temp. °C	Test time h	Number of tests	Test method
Resistance to internal pressure	No failure	PP-R				ISO 1167-1 and ISO 1167-2
		16,0	20,0	1	3	
		4,3	95,0	22	3	
		3,6	95,0	165	3	
		3,5	95,0	1000	3	
		PP-RCT				
		15,0	20,0	1	3	
		4,2	95,0	22	3	
		4,0	95,0	165	3	
		3,8	95,0	1000	3	

Table 4.7 Test requirements and parameters

4.1.8 Pipe and fitting marking

Requirement	Example
Number of standard	EN ISO 15874
Name producer or sign	WF Wefatherm
Nominal outer diameter x wall thickness	20 x 3,4
Tolerance class	A
Material	PP-R
Application class and maximum pressure	class 1/10 - 2/8 - 4/10 - 5/6 bar
Opacity	Opak
Information producer	Made in Germany DVGW DW-8501AT2335

Table 4.8 Pipe marking

Nominal diameter d_n	Socket length $L_{1, min}$	Insertion depth $L_{2, min}$	Socket inner diameter				Maximum ovality	Inner diameter $D_{3, min}$	Radius base R
			Socket mouth D_2		Socket base D_2				
			$D_{1, min}$	$D_{1, max}$	$D_{2, min}$	$D_{2, max}$			
			Fittings type A, for pipes which need to be scraped						
16	13,3	11,0	15,2	15,5	15,1	15,4	0,4	11,2	2,5
20	14,5	12,0	19,2	19,5	19,0	19,3	0,4	15,2	2,5
25	16,0	13,0	24,2	24,5	23,9	24,3	0,4	19,4	2,5
32	18,1	14,5	31,1	31,5	30,9	31,3	0,5	25,0	3,0
40	20,5	16,0	39,0	39,4	38,8	39,2	0,5	31,4	3,0
50	23,5	18,0	48,9	49,4	48,7	49,2	0,6	39,4	3,0
63	27,4	24,0	61,9	62,5	61,6	62,1	0,6	49,8	4,0
75	30,0	26,0	73,7	74,2	73,4	73,9	1,0	59,4	4,0
90	33,0	29,0	88,6	89,2	88,2	88,8	1,0	71,6	4,0
110	37,0	32,5	108,4	109,0	108,0	108,6	1,0	87,6	4,0
125	40,0	35,0	122,7	123,9	122,3	123,5	1,2	99,7	4,0
			Fittings type B, for pipes which not need to be scraped						
75	30,0	26,0	73,4	74,7	72,6	73,6	1,0	59,4	4,0
90	33,0	29,0	88,2	89,7	87,4	88,4	1,0	71,6	4,0
110	37,0	32,5	108,0	109,7	107,0	108,2	1,0	87,6	4,0
125	40,0	35,0	122,4	124,6	121,5	123,0	1,2	99,7	4,0

Table 4.9 Geometry of fittings

Standards and guidelines

4.2 Standard DIN 8077/8078 and DIN 16962

Standard DIN 8077 and DIN 16962 are general German standards for PP pipes and fittings. These general standards apply when the application is not covered by an application standard, such as ISO 15874 for hot and cold water application.

Standard	Title
DIN 8077	Polypropylene (PP) pipes - PP-H, PP-B, PP-R, PP-RCT - dimensions
DIN 8078	Polypropylene (PP) pipes - PP-H, PP-B, PP-R, PP-RCT - general quality requirements and testing
DIN 16962	Pipe joints and fittings for pressure systems of polypropylene (PP)
Part 1	Segment welded bends for butt-welding
Part 2	Segment welded tees for butt-welding
Part 3	Seamless formed bends for butt-welding
Part 4	Stub ends, backing rings and gaskets for butt-welding
Part 5	General quality requirements, testing
Part 6	Injection moulded elbows for socket welding
Part 7	Injection moulded tees for socket welding
Part 8	Injection moulded sockets and end caps for socket welding
Part 9	Injection moulded reducers and nipples for socket welding
Part 10	Injection moulded fittings tees for butt-welding
Part 11	Machined reducers tees for butt-welding
Part 12	Stub ends, backing rings and gaskets for socket welding

Table 4.10

The DIN standards are similar to the ISO standard. A significant difference between the general DIN standard and application ISO standard is that some subjects are described in more detail. Other significant differences are mentioned in the following paragraphs.

4.2.1 Safety (design) factor

DIN 8077 describes a lower safety (design) factor for general water application.

Material	Safety (design) factor
PP-R	1,25
PP-RCT	1,25

Table 4.11

4.2.2 Geometry of pipes and fittings

Geometry of pipes

Dimensions and tolerances for single wall pipes from 16-1600 mm. Not for fiber or stabi pipes. See appendix B.

Geometry of fittings

The difference between DIN 16962 and ISO 15874 is that the DIN standard describes the shape of fittings in detail and the ISO standard description is functional with less details.

4.2.3 Maximum Operating Pressure (MOP)

The maximum operating pressure is calculated for all PP materials and safety (design) factors, and is presented in tables. See appendix B, the tables for PP-R and PP-RCT with SF 1,5 and SF 1,25.

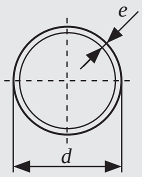
4.3 Maximum Operating Pressure

The Maximum Operating Pressure is calculated according to equation:

$$\mathbf{MOP} = \frac{\mathbf{20\ MRS}}{\mathbf{SF\ (SDR-1)}}$$

Equation 4.1

The MRS for required temperature and life cycle can be found in a regression curve. The SF is the safety (design) factor. SDR is the SDR rating of the pipe universal wall thickness according to ISO 4065.



$$\mathrm{SDR} = 2S + 1 \approx \frac{d}{e} \qquad e = \frac{d}{2S + 1}$$

Equation 4.2

4.3.1 PN rating

The historic PN rating in DIN8077:1989 was based on a safety (design) factor 2,0 for industrial applications, and the design stress was set on 5 N/mm². This resulted in the well know PN rating PN20, PN16 and PN10. The maximum operating pressures of 20 bar, 16 bar and 10 bar only applies at 50 years design life time at constant temperature of 20°C! At elevated temperatures the Maximum Operating Pressure is lower. All together a matter of definition which can lead to confusion. This is the reason why the PN rating was abandoned. This PN rating has been replaced by SDR value to established Maximum Operating Pressures for different applications.

For example: at a design life time of 50 years at constant temperature of 20°C the MRS for PP-R material is 10 N/mm² (1MPa = 10 bar = 1 N/mm²).

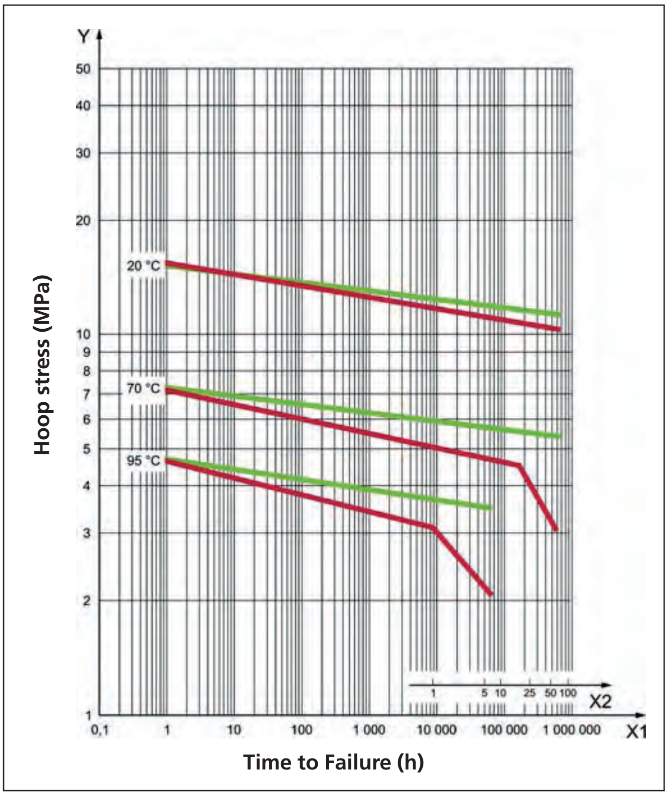
SDR value	PP-R Maximum Operating Pressure (bar)		
	DIN8077:1989 SF = 2,0	ISO 15874:2010 SF = 1,5	DIN8077:2008 SF = 1,25
SDR 6	20,0 (PN 20)	25,7	30,9
SDR 7,4	15,6 (PN 16)	20,4	24,5
SDR 11	10,0 (PN 10)	12,9	15,4

Table 4.12

4.3.2 Advantages PP-RCT over PP-R

The regression lines of PP-R and PP-RCT are shown in appendix A.

When projected upon each other, they clearly show the improved long term performance of the PP-RCT material in the temperature range 70-95°C.



Graphic 4.1

The higher CRS value of PP-RCT material allows:

- a higher operating pressure for PP-RCT at equal wall thickness

Temp (°C)	factor MOP PP-RCT
60	1,25
65	1,33
70	1,50
75	1,75
80	2,00
85	2,25
90	2,50
95	2,75

Table 4.14

- a smaller wall thickness to achieve an equal operating pressure

SDR PP-R	Calculated equivalent	Rounded SDR PP-RCT
11	12,62	13,6
7,4	8,53	9,0
6	6,95	7,4
5	5,80	6,0

Table 4.15

Advantages PP-RCT material

The improved long-term strength of the PP-RCT material leads to a more economic set of dimensions of the pipe system. It enables designers to select thinner wall pipes and in some situations also smaller diameter pipes can be used. This results in higher hydraulic pipe capacity or the possibility to apply higher pressure than with standard PP-R.

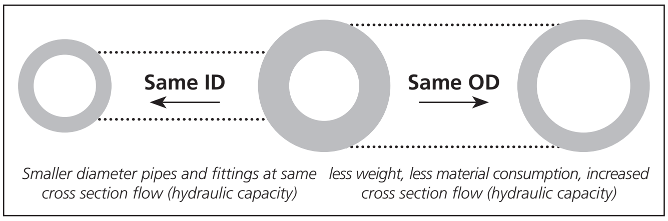


Illustration 4.2

Not least important, the substantially lower material usage provides an additional contribution to the conservation of resources supporting a sustainable environment.

Each specific application requires to be calculated in detail in the design stage of the project. The real operating temperature and pressure are determinative. If you require additional assistance contact the Wefatherm Export Sales Office.

DVGW work sheet W544 specifies to apply for cold water (max. 25°C) and hot water (max. 70°C) a pipe system which is suitable for 10 bar water pressure. According to DIN 8077 with safety (design) factor 1,25 this can be realized:

- PP-R: cold water SDR 11, hot water SDR 6
- PP-RCT: cold water SDR 17, hot water SDR 9

Standards and guidelines

4.3.3 Miners rule
Above mentioned calculations for design purposes are based on a 50 years design life time at constant temperature during this life time. In reality pipe systems do not operate at constant temperature during their life time. Deviations in temperature are compensated in the applied safety (design) factor.

Operating conditions can vary in:
- fully operational: full operating pressure and operating temperature
- low: low pressure and operating temperature
- switched off: no pressure and environment temperature

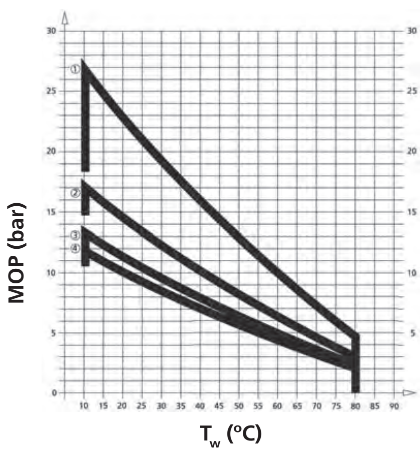
If these operating conditions vary substantial a Minimum Required Strength (MRS) of the weighted average can be applied. This calculation method is called the Miners Rule and is described in standard ISO 13760.

When the maximum operation parameters are exceeded the pipe system can be overloaded and is therefore not permitted. If you require additional information contact the Wefatherm Export Sales Office.

4.3.4 Pressure reduction factor of welded fittings
PP-R and PP-RCT can be welded without restriction. Welding PP-RCT onto PP-R components can also be performed unrestricted. The welding processes (socket welding, butt-welding and electrofusion) of polypropylene are described in The German Welders Association guideline DVS 2207-11.

For butt-welding (d ≥ 160 mm) the wall thickness of the pipe and fitting needs to be equal. Injection moulded butt-welding and electrofusion fittings are available in SDR 11. For SDR 6 - 5 - 7,4 - 9 - 13,6 welded fittings are available with spigot suitable for butt-welding and electrofusion.

In case of application of welded fittings, a reduced pressure load on the Maximum Operating Pressure for pipes has to be taken into account.



Graphic 4.2

The indicated values do not apply to pipes exposed to UV radiation.
Maximum operating pressures of <1 are not included in the table.
1 = pipe, injection fittings, seamless bends and welded bends < 30°
2 = welded bends >30°- 90°, tees 90° welded
3 = welded 60° tees
4 = welded 45° tees
SF = safety factor 1,25
tld = design life time 25 year
MOP = internal pressure
Tw (°C) = pipe wall temperature

Take notice of the pressure reduction of welded fittings. Welded bends of 30° to 90° and welded tees of 90° have a pressure (reduction) factor of 60% of the Maximum Operating Pressure. If you require additional information contact the Wefatherm Export Sales Office.

4.4 Product quality

Standards
Various standards such as DIN, DVS and SKZ guidelines, ISO or DVGW worksheets form the framework for the production monitoring of the Wefatherm system. Regular monitoring, checks and controls of the fabricated materials, production processes, storage and delivery processes assist us to maintain and guarantee our high standard of quality. The results of our tests are confirmed regularly by external checks.

The technical requirements for plastic pipe systems are written down in DVGW worksheets:
- W544 : Plastic pipe systems for drinking water - pipes
- W534 : Plastic pipe systems for drinking water - fittings
- W270 : Assessment of microbiological growth

These worksheets refer to the German standards for PP pipe systems:
- DIN 8077 : Pipes of polypropylene - dimensions
- DIN 8078 : Pipes of polypropylene - general quality requirements and testing
- DIN 19692 : Fittings and components for pressure systems of polypropylene (PP)

These German standard refers to ISO standard for hot and cold water applications:
- ISO 15874 : Plastic pipe systems for hot and cold water installations - Polypropylene

Internal monitoring
The Wefatherm system quality assurance starts at the gate of the factory with the receipt of raw materials. Only raw material of approved quality is processed. Processing itself is checked regularly. The modern and computer-controlled production machines and systems are checked and set by qualified and experienced personnel to ensure that they always function optimally. This gives a continuous process monitoring system of which the results are documented.

The following monitoring sequence has been laid down: checking of incoming goods, process and manufacturing checks, intermediate checks, final checks, monitoring of test devices. Permanent records document this sequence in accordance with DIN ISO 9001.

Production monitoring
The settings of machines and the dimensional correctness of test pieces are checked carefully before production is commenced and adjustments are made if necessary. The dimensional correctness of the items produced, the setting data of the extrusion and injection moulding machines and the surfaces of the products produced are checked continuously and compared with the production specifications. These measures ensure optimum series production. Similar checks are also carried out regularly in the course of production runs.

Final checks
The final products are subjected to further tests. The results of these are laid down and documented in test memoranda. Only products which have been checked and released are transferred to the warehouse. When the checks laid down in the test memoranda have been carried out and documented, the final products are released for stockholding and dispatch. Precise instructions and regular checks ensure the proper storage of the products. Packing and dispatch are regulated internally in a precise manner.

Polypropylene pipe systems for drinking water and hot tap water application are subject to following requirements and tests to prevent endangering public health:

Property	Initial type test	Internal monitoring	External monitoring	W544 paragraph	
Hygiene	X	-	1x year	4.1	W270 EN 10204-2.1
Application instructions	X	-	2x year or at technical change	4.2	German language Underground Application ban
Identification	X	Continuous	2x year	4.3	

Table 4.16 General requirements

Property	Initial type test	Internal monitoring	External monitoring	W544 paragraph	
Melt flow Index (MFR) 190/5	-	Every batch	-	6.1.1.1	ISO 1133 <0,2 g/110 min
Drying loss	-	Every batch	-	6.1.1.2	IR or HFM
Delivery	X	Every pipe	2x year	6.1.2	DIN 8078
Surface	X	Continuous	2x year	6.1.3	DIN 8078
Sizes and tolerances	X	Continuous	2x year	6.1.4	DIN 8077/8078
Change after heat treatment	X	3x week	2x year	6.1.5	DIN 8078
Melt flow index pipe	X	1x week	2x year	6.1.6	ISO 1133 <0,2 g/110 min
Impact flexural test	X	1x day and dimension	2x year	6.1.7	DIN 8078
Internal pressure test	X	1x week	2x year	6.1.8	DIN 8078
Homoge-neousness material	X	1x month	2x year	6.1.9	Microscope Max 0,02 mm

Table 4.17 General requirements

4.5 Product certification

The Wefatherm pipe system is subjected to multiple external and internal checks. National and international authorities and institutions, the neutrality of which is out of question, check our products regularly and certify their constant high level of quality. This guarantees the user a high level of safety and reliability.

External monitoring
The external monitoring is carried out by the South-German Plastics Centre (SKZ), Würzburg and TZW Karlsruhe. These are authorized as testing institutes (amongst other institutes) by the DVGW (German Association of the Gas and Water Profession). Analogous checks are carried out abroad. The results of these checks are passed on to Wefatherm and documented in test certificates.

Certification process
Complying to the requirements and tests confirms that the pipes and fittings are fit for their application. Independent institutes like DVGW confirm that the system is fit for purpose when following requirements are met:

- Confirmation of mechanical test requirements by an independent body
- Confirmation by an independent body that the production Quality Management System is ISO 9001 certified
- Confirmation of the producer that exclusively virgin material and no other material is used in the production process
- Confirmation by an independent institute that applied materials form no hygienic hazard for public health
- Third party testing and inspection by independent notified bodies is performed.

4.6 Approvals

The Wefatherm pipe system has been certified by DVGW and independent bodies and carries a number of internationally recognized approvals.

Illustration 4.3

The actual versions of these certificates can be found in the download area of www.wefatherm.de.

Due to their wall structure fiber pipes and stabi pipes are not covered by standards DIN 8077 and ISO 15874. They are external monitored by SKZ and no part of the DVGW certification.

Standards and guidelines

4.7 Manufacturers position on Legionella prevention & control and Wefatherm PP-R pipe systems

Preambule
Most considerations in this statement are not specific to plastic pipe systems. They are applicable to all types of drinking water pipe works, whatever the material (plastic, metal, etc.).

> This statement is focused on the Legionella bacteria. Other dangerous bacteria like pseudomonas may appear in drinking water networks and require different types of treatments to cure the drinking water network from their contamination, which are not covered in this statement.

> **Considerations about the Legionella bacteria and risk for human health**
> Legionella Pneumophila, the most prevalent form of legionellae by far, is particularly dangerous to humans. This bacteria is found in minimal, generally non-pathogenic quantities not only in groundwater or surface water, but also in drinking water supply systems, as well as in building plumbing drinking water networks.
>
> The bacteria present a pathological effect particularly in the warm vaporized water such as in showers. There are virtually no problems with Legionella bacteria under 18°C. The situation is quite different with water temperatures between 25°C and 50°C: At these temperatures the micro-organisms replicate quickly and do not die until temperatures exceed 60°C.
>
> The need to control the Legionella risk is particularly high in buildings where weakened residents may particularly suffer from bacterial exposure (hospitals, retirement homes, schools), in large complex water systems of buildings like hotels, fitness centers and to a great extent in other large commercial buildings.
>
> In these buildings specific measures are usually recommended and systematically implemented to prevent the occurrence of Legionella growth and to treat the installation, whenever the level of Legionella has exceeded the regulatory thresholds.

Considerations about the biofilm
The biofilm is offering a favourable substrate for Legionella growth.

> Microbial growth is difficult to predict, influenced by multiple factors

Key factors are such as pipe work design, nature and quality of the water, disinfection chemicals applied to the water in the public network, local conditions e.g. temperature, operation and maintenance conditions, interface between water and pipe surface, in particular presence of scale and surface alterations due to corrosion of the pipe surface etc., making it difficult to develop any predictive model.

> Biofilm develops in all water-conveying systems, irrespective of the pipe work material

A biofilm is a symbiosis of a variety of microorganisms and comes into being when bacteria attach to surfaces. Even perfectly hygienic potable water contains bacteria and the nutrients fuelling their growth. Bacteria attach to any kind of surface, which is why biofilms develop in all water-conveying systems, irrespective of the material used.

Field study shows that in practical life the pipe material doesn't demonstrably influence the biofilm development, nor the incidence of Legionella

A field survey carried out by Öfi (The Austrian Research Institute for Chemistry and Technology) between 2004 and 2006 assessed pipe systems in Austrian public buildings e.g. hospitals, retirement homes and schools, for the incidence of Legionella. For the first time, such a study included not only analysis of potable water, but also biofilm formation in the pipes. This study showed that plastics and non-plastics piping systems have in practice a similar behavior regarding biofilm development.

Regarding Legionella development Öfi made the following conclusions:
"The study made one thing obvious: the development of legionella does not depend on the material used for the pipes. This means that in practice the pipe material does not demonstrably influence the incidence of Legionella."

Standards and guidelines

European and National standards/guidelines dealing with water safety and disinfection processes

The following European standards, applicable to all types of pipe works whatever the material (plastic, metal, etc.), are giving indications to prevent the contamination of the pipe work by e.g. Legionella, through the proper design and operation of the drinking water installation without the use of disinfectants and describe the measures to be taken in case of problems with microbial contamination :

- EN 805 "Water supply - Requirements for systems and components outside buildings"
- EN 806-series "Specifications for installations inside buildings conveying water for human consumption".

Regulations regarding water safety and disinfection processes are not unified among EU states. They are covered at national level through national standards, regulations and guidelines, which may significantly vary from one European country to the other, in particular as regard to water temperature, allowable chemicals and concentrations.

For example whereas in Germany the concentration's maximal value for a preventive continuous disinfection with chlorine dioxide is 0.4 mg/l, in France, Great Britain and Italy, the national regulations specify 1.0 mg/l.

National regulations shall be followed. Each country is a special case

> Applicable national regulation in the relevant country should therefore be checked and acceptable exposure times clarified with the pipe work's manufacturer. Consult the Wefatherm Export Office.

Presence of disinfectant in public fresh water network to be taken into consideration

If a continuous preventive chemical disinfection is carried out in the public fresh water supply network, the nature of the disinfection chemical, its concentration and potential impact on the pipe work should be assessed and taken into consideration to determine the choice of the disinfectant and allowable exposure time of the pipe work to the disinfection procedures to be carried out inside the building.

Important general recommendations

> Disinfection chemicals are strong oxidizing substances, chlorine dioxide being the most oxidizing and active one. For certain materials they may significantly reduce the lifetime of the piping system. It may happen in unfavourable circumstances that the pipe work's materials (plastic, metal and elastomer) are damaged after even one single exposure.

The impact of a disinfection procedure on the piping components depends among others upon the following factors:

- The type of material of the various components of the pipe system (pipes, fittings, seal joints and equipments such as valves etc.),
- The presence of disinfectant in the fresh water supplied to the building network,
- The disinfection concept itself (type of chemical, concentration, temperature, duration, etc.),
- The way this disinfection procedure is carried out, in particular as regard to respecting the specified concentrations, temperatures and durations at any point in the pipe work.

All these aspects of disinfection procedures must be considered and professionally addressed to minimize the risk of damages to the pipe work.

Any disinfection procedure shall be carried out only by qualified personnel.

During any disinfection procedure the pertinent data such as type of chemical used, concentration, duration, temperature, dosing equipment, should be professionally monitored and officially documented, securing the availability of a reliable and full history of the exposure of the pipe work to disinfection processes from the installation and along its whole service life, in compliance with the relevant standards/guidelines. Failure to comply with the specified conditions and recommendations, may lead to damages to the piping system (pipes, valves, devices, seals, O-rings, etc.) and lifetime performance cannot therefore be guaranteed.

Manufacturer strongly recommends that, prior to apply to the building drinking water network a chemical disinfection (shock or continuous), relevant information such as applicable regulations and characteristics of the fresh water delivered into the building should be collected and then advice should be sought from the manufacturers of the pipe system, of the disinfection chemical and of the disinfection dosing equipment, in order to assess the compatibility of the pipe work with the contemplated disinfection procedure, the level of potential damage it might cause to the piping system (pipes, valves, devices, seals, O-rings, etc.) and the subsequent reduction of its service life.

> In case of specific questions concerning mechanical performances, chemical resistance, design, installation, commissioning, operation and maintenance, please contact the Wefatherm Export Sales Office.

wefatherm

Standards and guidelines

4.7.1 Manufacturers position on Legionella prevention & control and Wefatherm PP-R pipe systems Germany

National regulation/guidelines
Legionella prevention and control is covered by following guidelines:
- DVGW worksheet W557 "Cleaning and Disinfection of Drinking Water Supply System".
- DVGW worksheet W556 "Hygienic-Microbial abnormities in drinking water installations - method and measures for their remedies
- DVGW publication TWIN Nr5 (2009) "Disinfection of drinking water installations to eliminate microbial contamination"

Measures to restrict the growth of Legionella bacteria
Above mentioned worksheets recommend the key following measures to restrict the growth of Legionella bacteria :

Measures to control the water temperature:
These measures are linked to the design and operation of the installation:
- The water temperature shall be in a range that the bacteria will not grow or have minimum growth, wherever possible.
- The cold water temperature in the installation should be kept below 25°C.
- The hot water installation should allow keeping the water temperature at a minimum of 55°C or 60°C at any point of the plumbing network during normal use.
- Hot water systems shall be designed and built to enable the temperature at any point of the system to be raised to 70°C for disinfection purposes.
- The drinking water installation should be designed and installed in a way that stagnation of the water under normal use is avoided.

Measures to minimize the formation of biofilm:
Measures should be taken to minimize the formation of biofilm in drinking water installations. In particular:
- Attention should be paid to cleanliness during installation and commissioning,
- Scaling and corrosion should be kept as low as possible by appropriate design and maintenance procedures, adapted to the water quality and the characteristics of the pipe work.

It is reminded that plastic pipes offer the benefits of being hardly subject to scaling and not being corroded by water.

Good practices in design, installation, commissioning, operation and maintenance as described above and in accordance with recognized technical regulations, generally ensure a microbiologically safe drinking water quality at the draw-off point, without requiring further disinfection treatments.

However a faulty design or maintenance practice or the evolution of other factors in the plumbing network may create favourable conditions for bacterial growth.

Disinfection treatments may then become necessary in order to prevent bacterial growth and keep the drinking water quality at a safe and healthy level (within regulatory thresholds).

Disinfection treatment methods, Germany
In case a microbial contamination occurs, it has to be removed to safeguard health protection. If flushing or cleaning of the installation has not allowed to eliminate the contamination, then a disinfection procedure becomes necessary. Cleaning and disinfection will provide a sustainable result only if the real causes of the contamination have been removed. A cleaning and disinfection process does not replace a sustainable renovation of the installation.

Elements in this section are based upon DVGW Worksheets W557 and DVGW W556 and publication TWIN Nr5 (2009). These regulations/guidelines define three types of disinfection treatments:
- Thermal
- Chemical shock
- Chemical continuous

Thermal disinfection
Pipes, fittings and piping accessories of a drinking water network may, whatever the material, be damaged by chemical disinfection procedures, with as a consequence a possible and sometimes severe reduction of the service life of the piping network. Therefore the thermal disinfection should always be preferred to a chemical one.

In this type of disinfection, the water is heated to 70°C and each tap (including showers) or sampling point is opened for at least 3 minutes (after the discharge water temperature reached 70°C at the outlet). Germs and bacteria present in the water are killed at this temperature. It should also be noted that the risk of scalding of people is to be avoided by appropriate safety measures.

Chemical disinfection - "Shock Disinfection"
The chemical "shock disinfection" is described as follows: the disinfectant is injected into the cold or hot water circuit. If feeding disinfectant into the hot water system, the temperature must be lowered to a maximum of 25°C. The implementation of "shock disinfection" at higher temperatures is not allowed since damage of pipe, fittings, seals, valves and devices may occur. During the disinfection and the subsequent rinsing with fresh cold water, the system must not be used to provide drinking water.

The concentrations and exposures of chemicals in accordance with DVGW Worksheet W557 "Shock disinfection"

Disinfectant	Chemical Formula	Operation concentration max. value	Operation time max. duration	Operation tempe-rature
Chlorine dioxide	ClO_2	5-10 mg/l as Cl_2	12 hours	<25°C
Hypochlorite	ClO^-	50 mg/l as $Cl_{2\,(Chlorine)}$	12 hours	<25°C
Permanganate	MnO_4^-	15 mg/l	24 hours	<25°C
Hydrogen peroxide	H_2O_2	150 mg/l	24 hours	<25°C

Table 4.18

Manufacturers recommendation on concentrations and exposures to chemicals for "Shock disinfection" in the Wefatherm PP-R pipe system

Disinfectant	Chemical Formula	Operation concentration max. value	Operation time max. duration	Operation tempe-rature
Chlorine dioxide	ClO_2	6 mg/l as Cl_2	12 hours	<25°C
Hypochlorite	ClO^-	50 mg/l as Cl_2 (Chlorine)	12 hours	<25°C
Permanganate	MnO_4^-	unknown	unknown	<25°C
Hydrogen peroxide	H_2O_2	unknown	unknown	<25°C

Table 4.19

The number of disinfection cycles should not exceed a cumulated time of 120 hours in the lifetime of the piping system.

The concentration of the disinfectant and application temperature must not be exceeded in any part of the piping system during the disinfection process, otherwise damage to the piping system (pipes, valves, devices, seals, O-rings, etc.) may result. This applies to all common materials (plastics, metals, elastomers, etc.) used in modern installation systems.

Chemical disinfection - "Time limited continuous disinfection"
The continuous addition of chemicals is only permitted if repeated cleaning, thermal or chemical disinfection was not effective and if the existing biofilm in the systems is low.

It should be noted that continuous dosing of chemicals does not in any case replace the necessary structural re-design of the installation system, and acts only as a supportive and temporary measure until a proper system refurbishment is undertaken. The continuous dosing is not a measure for Legionella prevention.

The table below gives for three most commonly used disinfectants the regulatory maximal concentrations and operation temperatures and indicates the estimated maximum exposure duration of the pipe work to remain on the safe side.

The concentrations and exposures of chemicals in accordance with DVGW worksheet W557 "Time limited continuous disinfection"

Disinfectant	Chemical Formula	Operation concentration max. value	Operation tempe-rature	Operation time (*) maximum duration
Chlorine dioxide**	ClO_2	0.4 mg/l as ClO_2	60°C	6 months
Hypochlorite	ClO^-	0.3 mg/l as Cl_2 (Chlorine)	60°C	6 months
Chlorine	Cl_2	0.3 mg/l as Cl_2 (Chlorine)	60°C	6 months
Chlorine dioxide**	ClO_2	0.4 mg/l as ClO_2	< 25°C	18 months
Hypochlorite	ClO^-	0.3 mg/l as Cl_2 (Chlorine)	< 25°C	18 months
Chlorine	Cl_2	0.3 mg/l as Cl_2 (Chlorine)	< 25°C	18 months

Table 4.20

(*) The maximum operation time means the total exposure time during the planned lifetime of the piping system.

The above regulatory recommendations regarding concentration and temperature are specified from a hygienic and toxicological point of view and do not take into consideration the chemical resistance of the piping components.

Manufacturers recommendation on concentrations and exposures to chemicals for "Time limited continuous disinfection" in a Wefatherm PP-R pipe system:

Disinfectant	Chemical Formula	Operation concentration max. value	Operation tempe-rature	Operation time (*) maximum duration
Chlorine dioxide**	ClO_2	Not recommended		
Hypochlorite	ClO^-	0.3 mg/l as Cl_2 (Chlorine)	60°C	6 months
Chlorine	Cl_2	0.3 mg/l as Cl_2 (Chlorine)	60°C	6 months
Chlorine dioxide**	ClO_2	Not recommended		
Hypochlorite	ClO^-	0.3 mg/l as Cl_2 (Chlorine)	< 25°C	18 months
Chlorine	Cl2	0.3 mg/l as Cl_2 (Chlorine)	< 25°C	18 months

Table 4.21

(*) The maximum operation time means the total exposure time during the planned lifetime of the piping system.

If the concentrations and the maximum water temperatures are exceeded, damage to the piping system (pipes, valves, devices, seals, O-rings, etc.) may result, depending upon the pipe work's material.

The above is only applicable in Germany. Other national papers may specify different. Check relevant applicable national regulations and with the pipe manufacturer the compatibility of the pipe work. Consult the Wefatherm Export Sales Office.

Disclaimer:
This information has been gathered to the best of our knowledge. It is customer's responsibility to verify the application conditions and to verify this information. The system components and jointing techniques may only be designed, engineered, installed and operated as described in the Wefatherm Specification Manual. Any other use is improper and therefore inadmissible.

Standards and guidelines

5 Planning and design

5.1 Installation

Prerequisites for a professionally designed pipe system are in principle good technical knowledge in combination with many years of experience in application and production techniques. Customers nowadays expect that both the engineering (planning) firm and construction company has the appropriate theoretical basis and the correspondingly qualified professional personnel. In addition, they must be able to offer an environmentally friendly, low-maintenance, economical and long-lasting pipe system, properties that a plastic system can provide in.

The references to corresponding chapters of the Specification Manual indicated in the figures will serve as guide to passages in which the relevant subjects are discussed in detail and should facilitate the use of this Specification Manual in specific applications.

5.1.1 Classification criteria

In the project planning and installation of thermoplastic pipe systems, consideration must always be given to material specific properties. The applicability of general principles to specific applications is only possible when material variables and behaviours display similarities (to the requirements of the given situation). In the age of the PC, computer programs are used to design reliable pipe systems, and graphical planning occurs with the support of modern CAD applications. But these are not sufficient to guarantee the operational reliability of pipes, which still depends on the professional processing and use of plastic.

The following instructions should be used, especially in planning, as a guide for the design and construction of water supply systems. A general distinction in the classification of drinking water installations is based on the method of installation. In general, there are 4 main groups, see illustration 5.1.

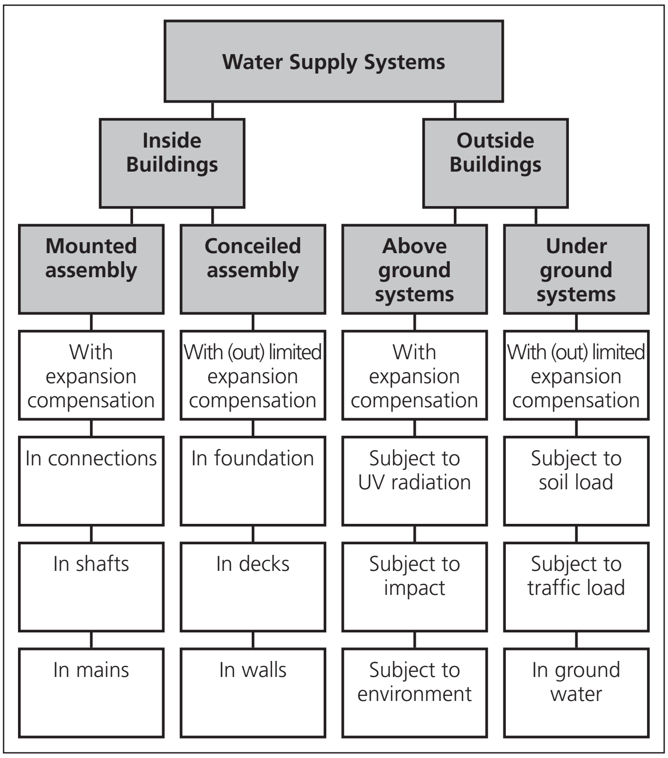


Illustration 5.1

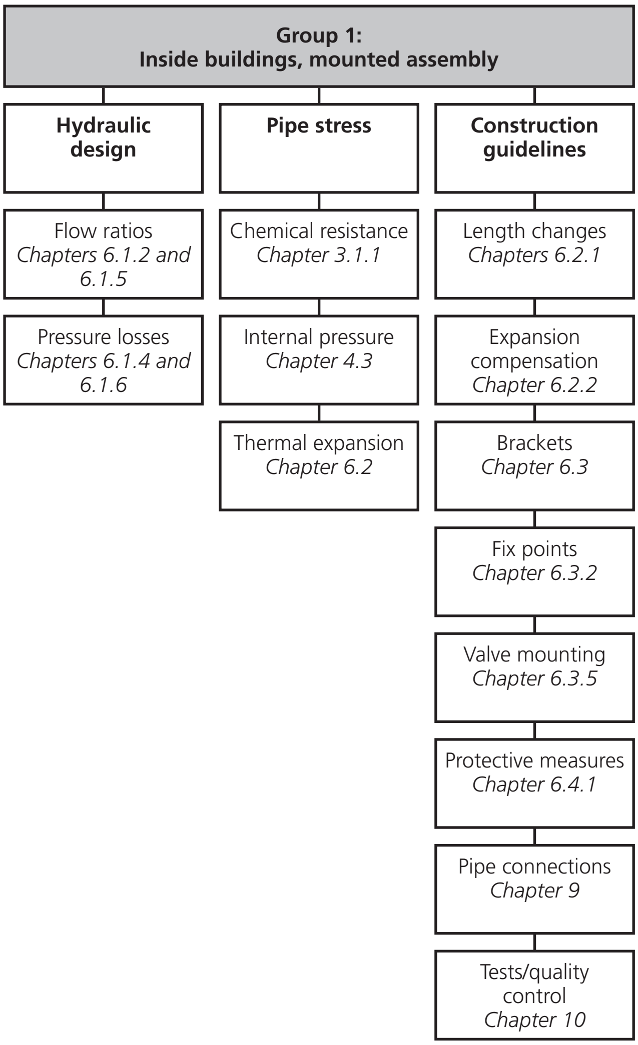
Group 1: Inside buildings mounted systems with expansion compensation
These systems require an expansion compensation construction with brackets and are predominantly found in mains, shafts and hot water circulation systems. They generally require the largest project outlays. Planning aids and influential factors for these pipe systems can be seen in illustration 5.2.

Group 2: Inside buildings conceiled systems without (or limited) expansion compensation
Longitudinal expansion does not necessarily have to be taken into account with conceiled laying. In an insulated system the insulation will absorb the longitudinal expansion without any problem. Problems resulting from longitudinal expansion generally do not arise. Pipes can be laid in floor topping or concrete, or buried beneath plaster when clamped appropriately. Conceiled systems' accessibility for maintenance is limited. Planning aids and influential factors for these pipe systems can be seen in figure 5.3.

Group 3: Outside buildings above ground systems with expansion compensation
Fundamentally it will always be possible to lay a pipe network in an open and visible manner with high requirements on the optical aspects in general. As a result of its high dimensional stability and reduced longitudinal expansion Wefatherm stabi pipework is specially suitable for exposed systems. Optically acceptable pipework requires expansion compensation construction with brackets. Planning aids and influential factors for these pipe systems can be seen in illustration 5.4.

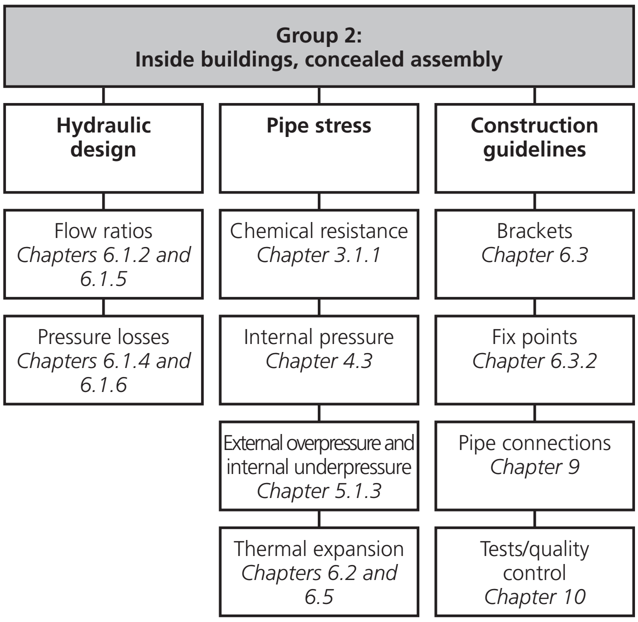
Group 4: Outside buildings under ground systems
Fundamentally it will always be possible to lay an underground polypropylene network. Longitudinal expansion does not necessarily have to be taken into account because problems resulting from longitudinal expansion generally do not arise. For hot water systems the material strength decreases in the course of time and the load of soil and traffic become more evident for the life cycle of the system. Buried systems' accessibility for maintenance is limited. Planning aids and influential factors for these pipe systems can be seen in illustration 5.5.

Standards



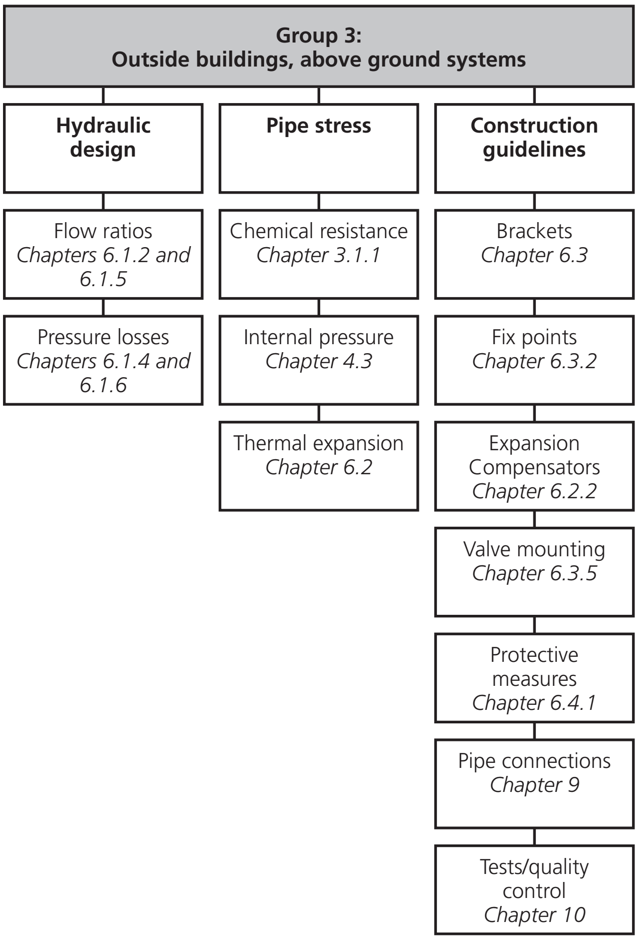
Pipe systems are usually installed so that the pipelines can elongate under the effects of heat. The latitude of movement can be provided by the installations own compensation elements (e.g. expansion bends and compensators) and by properly positioned sliding and guiding brackets. Special consideration needs to be given to ensure adherence to the acceptable support distances and the limiting of flexural loads in pipe bends and branches.

Illustration 5.2 Inside buildings, mounted assembly



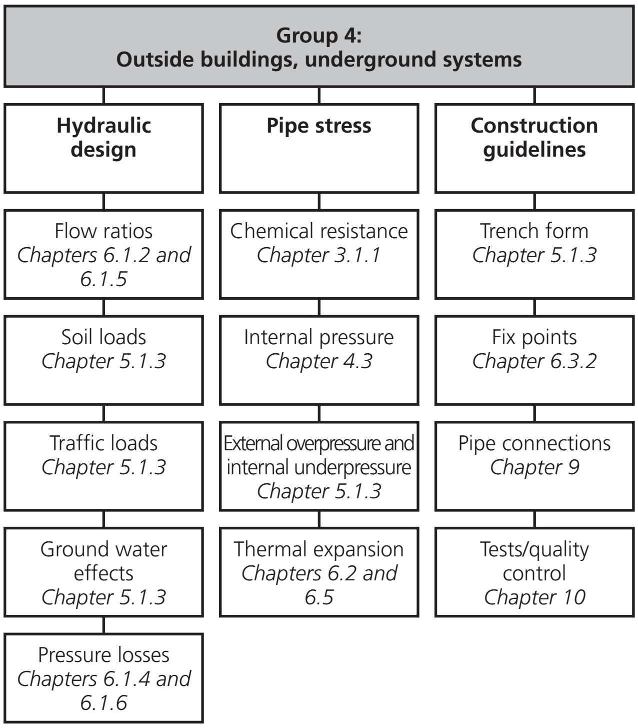
Pipe systems can also be installed so that an encasement in concrete walls, decks, foundations, etc. is possible after completion of the installation. The concrete surrounding the pipe impedes length changes resulting from temperature fluctuations (e.g. due to the temperature of the flow medium or the effects of external temperature). Since no friction-type connection exists between the plastic pipe and the concrete, measures must be taken to protect individual pipe elements.

Illustration 5.3 Inside buildings, concealed assembly



Pipe systems can also be installed without special thermal linear compensation. Pipe systems in which linear movement is impeded must pay special attention to the tensile and compressive stresses that occur, as well as to forces at fixed points. Exposed plastic pipes that are rigidly or firmly clamped (e.g. on a pipe bridge) can be exposed to large temperature variations. For this reason, calculations can be used in individual cases to test the expected stresses in order to determine if linear compensation can be excluded.

Illustration 5.4 Outside buildings, above ground systems



Buried pipe systems are subject to other load characteristics than above ground pipe systems. In designing pipelines, emphasis is placed on determining the largest possible load capacity of the pipe under the effects of external forces and the testing of stability.

Illustration 5.5 Outside buildings, underground systems

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Standards

5.1.2 Influence of operating conditions
The influence of pressure and temperature fluctuations depends on the individual system. Since the possibility of thermal linear compensation is not always available, this limitation must be taken into account when calculating load effects. Stress due to internal pressure, bending, external loads, etc. can collectively occur and make it necessary for the individual pipe system to be sized in a system-dependent manner.

5.1.3 Structural analysis
Depending on the nature of the load, various tests can be run on buried pipe systems. In one design, it is the stress and deformation calculation that is important. In another, it is a stability test. The principles underlying the calculations for buried plastic pipe installations are provided in ATVA 127. If you require additional assistance contact the Wefatherm Export Sales Office.

The stress and deformation calculation
Soil loads and traffic loads give rise to pipe cross-section tensile and compressive stresses. The extent of the stress is influenced by the elasticity of the pipe. In general, increasing the elasticity of the pipe will reduce tension. The testing for stress is therefore to be conducted while considering all inner and outer influential factors (e.g. soil stress, traffic load, water, ground water, chemical resistance and internal over- or under pressure). The manner of embedding in the ground is particularly responsible for degrees of pipe deformation. The higher the compression ratio of the surrounding ground, the smaller the deformation. The requirement of locating the pipe zone in compactable soil is derived from this observation. The acceptable vertical deformation of a PP pipe is currently 6% and is based on the average pipe diameter. Stress and deformation calculations are always performed in parallel.

Stability test
In a PP pipe susceptible to deformation, exceeding a critical load will cause the pipe cross section to buckle. This occurs as a result of increased external (external overpressure due to the effects of groundwater, depth of the covering soil, etc.) or internal (under pressure) stresses. The stability test is used to document the safety clearance between the critical and actually occurring load. Details and instructions for the calculation and the installation of the pipe systems are provided in the following chapter.

5.2 Maintenance

Legionella contamination can have severe and even deadly consequences. Reducing the risk of contamination for the installation, owners care obligation is based on risk analysis and a maintenance plan.

Risk analyses
Collective drinking water installations in mentioned buildings are submitted to a risk analyses and maintenance plan:
- Medical care facilities
- Rehabilitation and recover centers
- Care and shelter centers
- Hotels
- Swimming pools and wellness centers
- Buildings which have a logies function and/or shower facilities

Maintenance plan
The maintenance plan describes, as most important part, how risks for periodic management actions are limited and how the water quality is monitored. Also is written down how to act when requirements are not met.
Taking samples and analyzing water samples is first done for the risk anaysis and then every half year. Also the number of samples, related to the number of tap points, is specified.

Management measures
Management measures are:
- Flushing of less operated tap points
- Measuring temperatures
- Check clapet valves
- Taking water samples
- Flushing boilers and storage tanks

> Follow the applicable laws, standards, guidelines, regulations and instructions for environmental protection, professional associations and the local utility companies.

5.3 Pipe selection

5.3.1 Pipe wall configurations
Wefatherm pipes are available in three different wall configurations.

Standard pipe
This is the traditional mono layer pipe as described in the standards ISO 15874 and DIN8077/8078. The international product certification applies on this pipe wall type.
- PP-R available in SDR 6 - 7,4 - 11
- PP-RCT available in SDR 7,4 - 11
- Thermal expansion factor 0,150 mm/m.K

Properties:
- Marking = green color for hot and cold water
  purple color for reused water
- Mono layer = PP-R/PP-RCT

The international product certification applies on this pipe wall type.

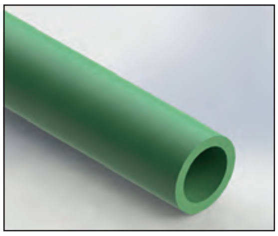


Illustration 5.6

Fiber pipe
This is a three-layer pipe of which the middle layer is enforced with glass fiber. The production of these pipes is externally monitored by the South-German Plastics Centre (SKZ), Wurzburg.
- PP-R available in SDR 7,4
- PP-RCT available in SDR 11 - 7,4
- Thermal expansion factor 0,035 mm/m.K
- Less bracketing
- Higher thermal stability

Properties:
- Marking = 4 red stripes
- External layer = PP-R/PP-RCT
- Middle layer = glass fibre compound
- Inner layer = PP-R/PP-RCT

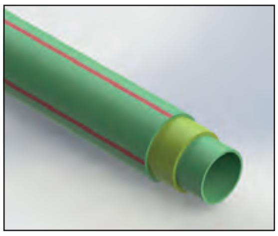


Illustration 5.7

Stabi pipe
This is a traditional mono layer pipe with an additional encapsulated perforated aluminium layer. The function of the perforated aluminium layer is to limit the thermal expansion of the pipe. It is no oxygen barrier. The fully encapsulated aluminium layer is additional to the traditional standard pipe. Before welding the additional aluminium layer needs to be removed. For above ground outdoor application we provide the stabi UV pipe with outer layer of UV resistant black PE.
- PP-R available in SDR 7,4
- Thermal expansion factor 0,030 mm/m.K
- Less bracketing
- Suitable for hot water lines and mains
- Black UV resistant pipe for outdoor application

Properties:
- Marking = many shallow dimpels
- External layer = encapsulated aluminium
- Standard pipe = PP-R

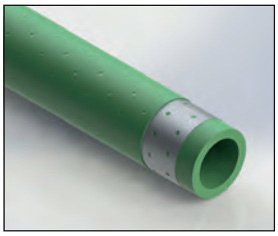


Illustration 5.8

Standards

5.3.2 Pipe wall selection

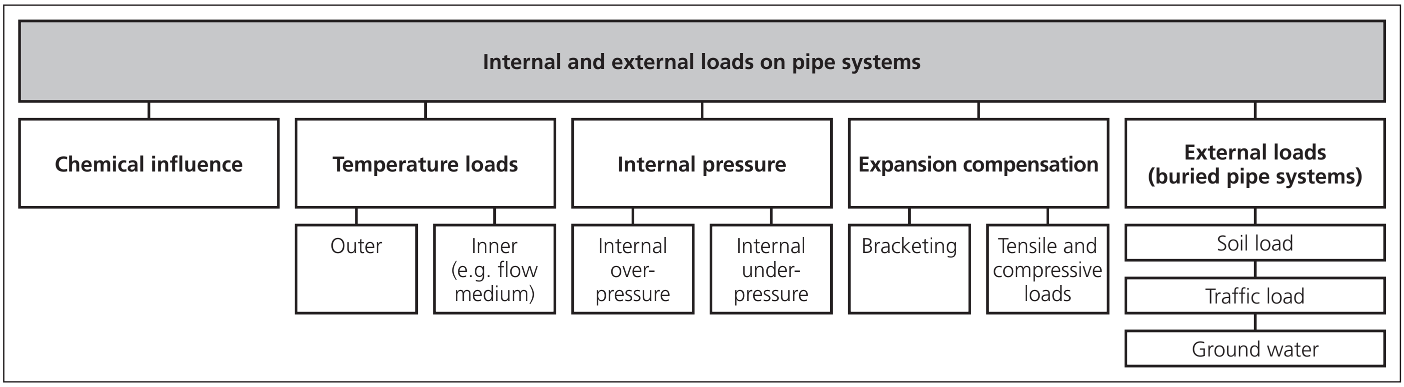


Illustration 5.9

Chemical influence
The first step in material selection for plastic pipe systems is to check the plastics material resistance against the chemical influence of the medium flowing through the pipe. The chemical resistance of polypropylene against a number of fluids is given in chapter 3.

In general, drinking water for human consumption can be conveyed without restriction by a polypropylene pipe system. The potentially dissolved amount of chlorine is of such a low value that it has no chemical influence on the polypropylene material at consumption temperature (max. 25°C).

> ! In hot tap water systems the potentially dissolved amount of chlorine can be increased due to secondary (preventive and corrective) disinfection water treatment. Especially in recirculating hot water systems with water temperatures above 70°C limitations have to be respected. See limitation mixed copper/PP-R hot water recirculation systems and manufacturers position on Legionella prevention & control and Wefaterm PP-R pipe systems.

The pipe wall selection is based on the required wall thickness (indicated by the SDR value), preferred expansion behavior of the pipe system and the jointing technique. The required SDR value is determined by the temperature load and internal pressure.

The pipe wall selection is based on the required wall thickness (indicated by the SDR value), preferred expansion behavior of the pipe system and the jointing technique.

The required SDR value is determined by the temperature load and internal pressure.

Temperature load and internal overpressure
An overload of pressure in a pipe system due to internal overpressure results, especially in association with additional heat effects, in a continuous expansion of the pipe until it breaks. The danger of an expansion arises as a result of too small wall thicknesses, in which an indiscriminate wall thickness increase is not justifiable. In the presence of heat expansion, a wall thickness enlargement also increases the reactive forces on the pipe fixed points. The engineer must ensure that the wall thickness is designed to meet the requirements while the pipe remains elastic in response to any length changes that might arise. A sudden change in structural operating conditions due to internal pressure leads to pressure surges. The distinctive elasticity of the plastic pipe has the advantage that the extreme values of pressure waves are significantly lower than in steel pipes. Despite this fact, pipe systems operated by pumps or containing rapidly closing shut-off valves must be tested for any foreseeable effects of pressure surges.

For hot and cold water installations the German DVGW work sheet W 534 prescribes a nominal pressure of 10 bar for hot and cold water systems.

Standard ISO 15874 defines 4 operating classes:

Class	Temperature maximum in °C	Application
1	60	hot water supply
2	70	hot water supply
3	70	low temperature heating
4	80	high temperature heating

Table 5.1

Standard DIN 8077 calculations for PP-R and PP-RCT materials, at several temperatures, safety (design) factors and SDR values, these tables are given in appendix B. The steps in the pipe selection process are described in following example.

Example for the selection of pipe

Basic parameters: Cold water
Maximum Operating Pressure 10 bar
Medium temperature 20-25°C

Selection process steps
Step 1: Select medium temperature => 20°C
Step 2: Select required design life cycle => 50 years
Step 3: Read Maximum Operating Pressures => MOP 15,4 bar > OP 10 bar
Step 4: Read SDR value => SDR 11

Basic parameters: Hot water
Maximum Operating Pressure 10 bar
Medium temperature 70°C

Selection process steps
Step 1: Select medium temperature => 70°C
Step 2: Select required design life cycle => 50 years
Step 3: Read Maximum Operating Pressures => MOP 12,9 bar > OP 10 bar
Step 4: Read SDR value=> SDR 7,4

Temperature °C	Operating years	Maximum Operating Pressure			
		SDR 11	SDR 7,4	SDR 6	SDR 5
10	1	21,1	33,4	42,1	53,0
	5	19,8	31,5	39,7	49,9
	10	19,3	30,7	38,6	48,7
	25	18,7	29,7	37,4	47,0
	50	18,2	28,9	36,4	45,9
	100	17,8	28,2	35,5	44,7
20	1	18,0	28,5	35,9	45,2
	5	16,9	26,8	33,7	42,5
	10	16,4	26,1	32,8	41,4
	25	15,9	25,2	31,7	39,9
	50	15,4	24,5	30,9	38,9
	100	15,0	23,9	30,2	37,8
30	1	15,3	24,2	30,5	38,5
	5	14,3	22,7	28,6	36,0
	10	13,9	22,1	27,8	35,0
	25	13,4	21,3	26,8	33,8
	50	13,0	20,7	26,1	32,9
	100	12,7	20,1	25,4	31,9

Table 5.2 Maximum Operating Pressure (MOP) for PP-R for water safety factor (SF) = 1,25 DIN 8077

Temperature °C	Operating years	Maximum Operating Pressure	
		SDR 11	SDR 7,4
50	1	12,6	20,1
	5	12,2	19,3
	10	12,0	19,0
	25	11,7	18,6
	50	11,5	18,3
	100	11,3	18,0
60	1	10,7	17,0
	5	10,3	16,3
	10	10,1	16,0
	25	9,9	15,7
	50	9,7	15,4
70	1	9,0	14,3
	5	8,6	13,7
	10	8,5	13,5
	25	8,3	13,1
	50	8,1	12,9
80	1	7,5	11,9
	5	7,2	11,4
	10	7,0	11,2
	25	6,9	10,9

Table 5.3

Standards

5.3.3 Pipe diameter selection

In order to select the pipe diameters correctly, the following must be determined:

- Number and size of the removal points connected
- Peak flow at each removal point
- Flow speeds
- Pressure losses

A considerable amount of data is necessary in order to calculate the correct diameters for a pipe network. The following data is required:

- Geodetic height difference
- Minimum supply overpressure and/or pressure on the output side of a pressure reducing or pressure increasing device
- Pressure losses at items of equipment such as water gauges, filters, water treatment units etc.
- Minimum flow pressures of the removal point fittings employed
- Pipe friction pressure gradient of the pipe material employed
- Coefficients of resistance of the fittings and connection units employed

Planning aid

You can find the tables providing the relevant information (pipe friction resistances, loss coefficients for fittings and connection units etc.) in appendix B.

The use of modern software systems make the repeating calculations efficient. Different software systems are available. Ensure that the underlying calculations are based on the national requirements.

If you require assistance for the design and calculation of water supply systems contact the Wefatherm Export Sales Office.

6 Engineering

6.1 Hydraulic parameters

6.1.1 Delivery capacity

The delivery capacity is determined by the number and size of the delivery and tapping points. Values minimum flow pressure and flow rates according the German standard DIN 1988 and EN 805 are given in tables 6.1 and 6.2. Ensure to apply the values according the national standards.

Minimum flow pressures and calculation flow rates for commonly available fittings and items of apparatus (guideline values)

Minimum flow pressure P min Fl bar	Extract DIN 1988 E Type of drinking water removal point			Calculation flow rate with the removal of: Mixed water QR cold l/s	 QR hot l/s	 Only cold or only hot water QR l/s
0,5	Outlet valves without aeration	....	DN 15	-	-	0,30
0,5		....	DN 20	-	-	0,50
0,5		....	DN 25	-	-	1,00
1,0	Outlet valves with aeration	....	DN 10	-	-	0,15
1,0		....	DN 15	-	-	0,15
1,0	Showerheads for cleaning showers	....	DN 15	-	-	0,20
1,2	Flushing valves to DIN 3265 Part 1	....	DN 15	-	-	0,70
1,2	Flushing valves to DIN 3265 Part 1	....	DN 20	-	-	1,00
0,4	Flushing valves to DIN 3265 Part 1	....	DN 25	-	-	1,00
1,0	Flushing valves to urinal basins	....	DN 15	-	-	0,30
0,5	Corner valves for urinal basins	....	DN 15	-	-	0,30
1,0	Domestic dishwashing machine	....	DN 15	-	-	0,15
1,0	Domestic washing machine	....	DN 15	-	-	0,25
	Mixing battery for					
1,0	shower tubs	....	DN 15	0,15	0,15	-
1,0	bath tubs	....	DN 15	0,15	0,15	-
1,0	kitchen sinks	....	DN 15	0,07	0,07	-
1,0	wash stands	....	DN 15	0,07	0,07	-
1,0	bidets	....	DN 15	0,07	0,07	-
1,0	Mixing battery	....	DN 20	0,30	0,30	-
0,5	Flushing boxes to DIN 19542	....	DN 15	-	-	0,13
	Drinking water heaters for supplying a tap (incl. mixed removal fitting)					
1,0	Electric water boiling device	....	DN 15	-	-	0,10 *)
	Electric hot-water tank and boiler					
1,1 **)	with nominal volume 5 bis 15 l	....	DN 15	-	-	0,10
1,2 **)	with nominal volume 30 bis 150 l	....	DN 15	-	-	0,20
	Electric continuous-flow water heater, hydraulically controlled, without flow limiter					
1,5	Rated power	....	12 kW	-	-	0,06
1,9		....	18 kW	-	-	0,08
2,1		....	21 kW	-	-	0,09
2,4		....	24 kW	-	-	0,10
1,0	Gas continuous-flow water heater	....	12 kW	-	-	0,10

**) With trottle screw, fully opened*

***) Values with unfavourable conditions (shower)*

Note: Water removal points not listed in the table as well as items of apparatus as listed in the table, but with greather flow rates, are to be taken into account in accordance with the manufacturer's statements when calculating pipe diameters

Table 6.1 Values according DIN 1988

Engineering

6.1.2 Flow speed

Flow speeds must be selected in such a way that flow noise and water hammer are avoided as far as possible. When the pipe diameters are selected correctly, the flow speeds given in table 6.2 will not be exceeded.

Pipework section	Max. computed flow speed at flow duration of	
	≤ 15 min.	>15 min.
	m/s	m/s
Connection lines	2	2
Consumer lines, part sections for low pressure loss fitting pressure (<2,5) *)	5	2
Part sections with through fittings	2,5	2
Recirculating hot water systems	0,9	0,9

**) e.g. ball valve, valve DIN 3500/3502*

***) e.g. straight seat valve DIN 3512*

Table 6.2 Flow speeds

6.1.3 Resistance coefficients

Resistance coefficients of the individual components of the Wefatherm system are given in table 6.4.

6.1.4 Pressure losses from individual resistance

Pressure losses from individual resistances Z as a function of the flow speed.

Computed flow speed v m/s	Pressure loss Z for ζ = 1 mbar	Computed flow speed v m/s	Pressure loss Z for ζ = 1 mbar
0,1	0,1	**2,6**	33,8
0,2	0,2	**2,7**	36,5
0,3	0,5	**2,8**	39,2
0,4	0,8	**2,9**	42,1
0,5	1,3	**3,0**	45
0,6	1,8	**3,1**	48
0,7	2,5	**3,2**	51
0,8	3,2	**3,3**	55
0,9	4,1	**3,4**	58
1,0	5,0	**3,5**	61
1,1	6,1	**3,6**	65
1,2	7,2	**3,7**	68
1,3	8,5	**3,8**	72
1,4	9,8	**3,9**	76
1,5	11,3	**4,0**	80
1,6	12,8	**4,1**	84
1,7	14,5	**4,2**	88
1,8	16,2	**4,3**	92
1,9	18,1	**4,4**	97
2,0	20,0	**4,5**	101
2,1	22,1	**4,6**	106
2,2	24,2	**4,7**	110
2,3	26,5	**4,8**	115
2,4	28,8	**4,9**	120
2,5	31,3	**5,0**	125

Table 6.3 Pressure loss from individual resistance for resistance coefficient ζ =1 (at ϑ = 10°C and Q = 999,7 kg/m³) and flow speed (z = 5v ² . Σ ζ)

The total pressure loss of the line is the sum of the pressure losses from the pipe friction and from the individual resistances: $\Delta p_{loss} = \Sigma\,(l\ .\ R + Z)$. Please see table 6.3 for the guideline values for the individual resistances.

6.1.5 Maximum flow rate

Maximum flow rates are given in appendix B.

6.1.6 Pipe friction gradients

Pipe friction gradient R and calculated flow speed in dependance of circulation are given in appendix B.

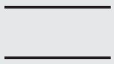
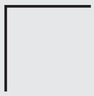
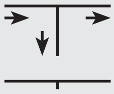
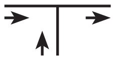
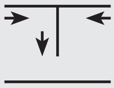
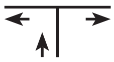
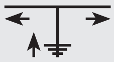
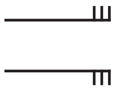
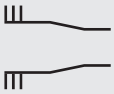
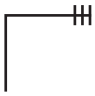
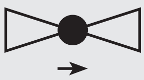
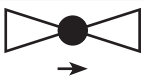
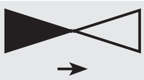
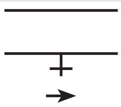
Nr.	Individual resistance		Graphical symbol	Resistance coefficient
1	Socket			0,25
2 2a	Reduction up to 2 dimensions Reduction from 3 dimensions			0,55 0,85
3 3a	Elbow 90° Elbow 90° i./a.			2,0 1,2
4 4a	Elbow 45° Elbow 45° i./a.			0,6 0,5
5 5a	Tee (separation) Tee (reduced)			1,8 3,6
6 6a	Tee (combination) Tee (reduced)			1,3 2,6
7 7a	Tee (counterflow) Tee (reduced)			4,2 9,0
8 8a	Tee (counterflow) Tee (reduced)			2,2 5,0
9	Tee with transition			0,8
10	Transition with outside thread, without counterpart			0,4
11	Transition with outside thread, reduced, without counterpart			0,85
12	Transition angle piece with outside thread, without counterpart			2,2
13	Transition angle piece with outside thread, reduced, without counterpart			3,5
14	Straight seat valve	20 mm 25 mm 32 mm 40 mm		9,5 8,5 7,6 5,7
15	Inclined seat valve	20 mm 25 mm 32 mm 40 mm		5,0 4,4 3,8 3,2
16	KFR valve	20 mm 25 mm 32 mm 40 mm		5,0 4,4 3,8 3,2
17	Drain nozzle			0,25

Table 6.4

Engineering

6.2 Mechanical parameters

6.2.1 Longitudinal expansion

Polypropylene pipe systems extend when subjected to heat in accordance with their material characteristics. The longitudinal expansion of the Wefatherm stabi pipe or Wefatherm fiber pipe is considerably less than 100% plastic pipe experiences. The method of calculating the longitudinal expansion theoretically can be found in an example. For practical use the longitudinal expansion to be expected with the three different materials is shown in tables. In these tables you will find the longitudinal expansion to be expected for a particular free length of pipe. Critical for the determination of the longitudinal expansion is the difference between the temperature at which the pipework is installed and the maximum operating temperature to be expected. After the expected longitudinal expansion has been determined, a decision can be made if any of the possible measures should be taken to compensate it.

Definition of free pipe length

The free pipe length is the length of the pipe between two points at which the pipe is secured or clamped in a fixed manner.

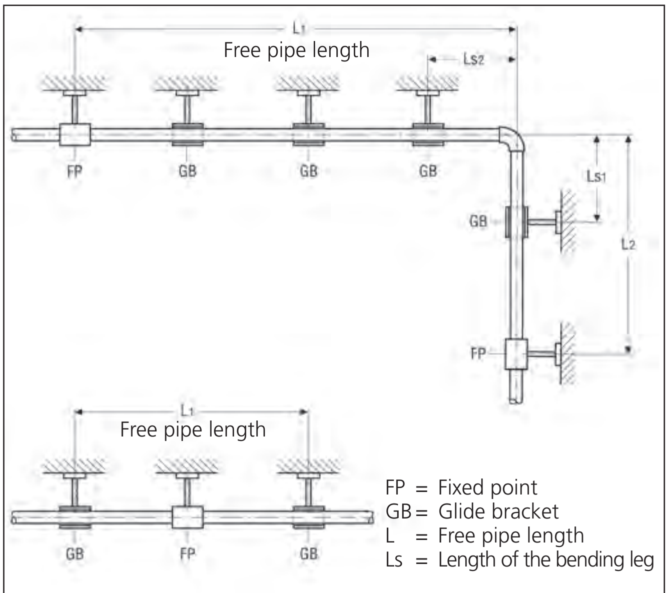


Illustration 6.1 Longitudinal expansion

Type of laying	Longitudinal expansion compensation yes/no	Comments
Laying in shafts Rising mains	no	Free length less than 3 m
Buried laying in plaster Laying in floor topping Laying in concrete	no	Expansion is absorbed by the insulation or by the pipe material
Exposed laying	yes	Take expansion compensation measure

Table 6.5

Calculation example of longitudinal expansion:

$$\Delta t = \alpha \text{ x } L \text{ x } \Delta t$$

Δt = Longitudinal expansion in mm
α = linear expansion factor
for Wefatherm standard pipe 0,150 mm/m . K
for Wefatherm stabi pipe 0,030 mm/m . K
for Wefatherm fiber pipe 0,035 mm/m . K
L = Length of pipe in m
Δt = temperature difference between assembly temperature and operation temperature

Equation 6.1

Calculation example of longitudinal expansion of Wefatherm pipe:

$$\alpha = 0{,}15 \text{ mm/m . K}$$

Equation 6.2

Pipe length (m)	Longitudinal expansion Temperature difference Δ_t (K) 10	20	30	40	50	60	70	80
0,1	0,15	0,30	0,45	0,60	0,75	0,90	1,05	1,10
0,2	0,30	0,60	0,90	1,20	1,50	1,80	2,10	2,40
0,3	0,45	0,90	1,35	1,80	2,25	2,70	3,15	3,60
0,4	0,60	1,20	1,80	2,40	3,00	3,60	4,20	4,80
0,5	0,75	1,50	2,25	3,00	3,75	4,50	5,25	6,00
0,6	0,90	1,80	2,70	3,60	4,50	5,40	6,30	7,20
0,7	1,05	2,10	3,15	4,20	5,25	6,30	7,35	8,40
0,8	1,20	2,40	3,60	4,80	6,00	7,20	8,40	9,60
0,9	1,35	2,70	4,05	5,40	6,75	8,10	9,45	10,80
1,0	1,50	3,00	4,50	6,00	7,50	9,00	10,50	12,00
2,0	3,00	6,00	9,00	12,00	15,00	18,00	21,00	24,00
3,0	4,50	9,00	13,50	18,00	22,50	27,00	31,50	36,00
4,0	6,00	12,00	18,00	24,00	30,00	36,00	42,00	48,00
5,0	7,50	15,00	22,50	30,00	37,50	45,00	52,50	60,00
6,0	9,00	18,00	27,00	36,00	45,00	54,00	63,00	72,00
7,0	10,50	21,00	31,50	42,00	52,50	63,00	73,50	84,00
8,0	12,00	24,00	36,00	48,00	60,00	72,00	84,00	96,00
9,0	13,50	27,00	40,50	54,00	67,50	81,00	94,50	108,00
10,0	15,00	30,00	45,00	60,00	75,00	90,00	105,00	120,00

Table 6.6

$$\alpha = 0{,}03 \text{ mm/m . K}$$

Equation 6.3

6.2.2 Expansion compensation constructions

Bending legs
Frequent changes in the direction of a pipe, which are in any case necessary, will enable bending legs to be planned, which can compensate for the previously determined longitudinal expansion.

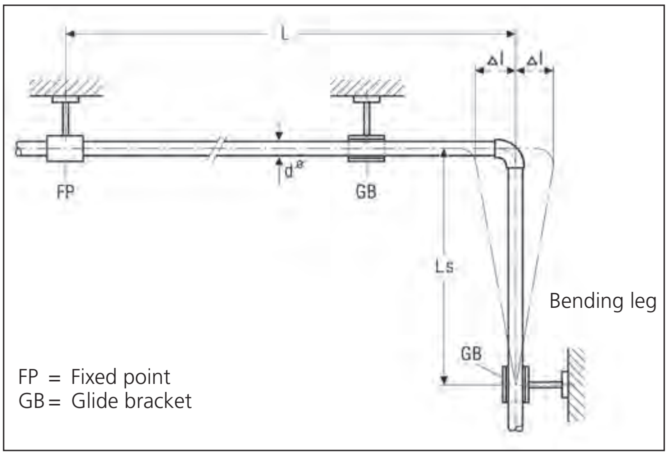


Illustration 6.2

Pipe length (m)	Longitudinal expansion Temperature difference Δ_t (K) 10	20	30	40	50	60	70	80
0,1	0,03	0,06	0,09	0,12	0,15	0,18	0,21	0,24
0,2	0,06	0,12	0,18	0,24	0,30	0,36	0,42	0,48
0,3	0,09	0,18	0,27	0,36	0,45	0,54	0,63	0,72
0,4	0,12	0,24	0,36	0,48	0,60	0,72	0,84	0,96
0,5	0,15	0,30	0,45	0,60	0,75	0,90	1,05	1,20
0,6	0,18	0,36	0,54	0,72	0,90	1,08	1,26	1,44
0,7	0,21	0,42	0,63	0,84	1,05	1,26	1,47	1,68
0,8	0,24	0,48	0,72	0,96	1,20	1,44	1,68	1,92
0,9	0,27	0,54	0,81	1,08	1,35	1,62	1,89	2,16
1,0	0,30	0,60	0,90	1,20	1,50	1,80	2,10	2,40
2,0	0,60	1,20	1,80	2,40	3,00	3,60	4,20	4,80
3,0	0,90	1,80	2,70	3,60	4,50	5,40	6,30	7,20
4,0	1,20	2,40	3,60	4,80	6,00	7,20	8,40	9,60
5,0	1,50	3,00	4,50	6,00	7,50	9,00	10,50	12,00
6,0	1,80	3,60	5,40	7,20	9,00	10,80	12,60	14,40
7,0	2,10	4,20	6,30	8,40	10,50	12,60	14,70	16,80
8,0	2,40	4,80	7,20	9,60	12,00	14,40	16,80	19,20
9,0	2,70	5,40	8,10	10,80	13,50	16,20	18,90	21,60
10,0	3,00	6,00	9,00	12,00	15,00	18,00	21,00	24,00

Table 6.7

α **= 0,035 mm/m . K**

Equation 6.3

Pipe length (m)	Longitudinal expansion Temperature difference Δ_t (K) 10	20	30	40	50	60	70	80
0,1	0,04	0,07	0,11	0,14	0,18	0,21	0,25	0,28
0,2	0,07	0,14	0,21	0,28	0,35	0,42	0,49	0,56
0,3	0,11	0,21	0,32	0,42	0,53	0,63	0,74	0,84
0,4	0,14	0,28	0,42	0,56	0,70	0,84	0,98	1,12
0,5	0,18	0,35	0,53	0,70	0,88	1,05	1,23	1,40
0,6	0,21	0,42	0,63	0,84	1,05	1,26	1,47	1,68
0,7	0,25	0,49	0,74	0,98	1,23	1,47	1,72	1,96
0,8	0,28	0,56	0,84	1,12	1,40	1,68	1,96	2,24
0,9	0,32	0,63	0,95	1,26	1,58	1,89	2,21	2,52
1,0	0,35	0,70	1,05	1,40	1,75	2,10	2,45	2,80
2,0	0,70	1,40	2,10	2,80	3,50	4,20	4,90	5,60
3,0	1,05	2,10	3,15	4,20	5,25	6,30	7,35	8,40
4,0	1,40	2,80	4,20	5,60	7,00	8,40	9,80	11,20
5,0	1,75	3,50	5,25	7,00	8,75	10,50	12,25	14,00
6,0	2,10	4,20	6,30	8,40	10,50	12,60	14,70	16,80
7,0	2,45	4,90	7,35	9,80	12,25	14,70	17,15	19,60
8,0	2,80	5,60	8,40	11,20	14,00	16,80	19,60	22,40
9,0	3,15	6,30	9,45	12,60	15,75	18,90	22,05	25,20
10,0	3,50	7,00	10,50	14,00	17,50	21,00	24,50	28,00

Table 6.8

Calculation example of the minimum length L_s of the bending leg:
The minimum length L_s of the bending leg can be calculated with the following formula:

$$L_s = K \times \sqrt{d \cdot \frac{\Delta l}{2}}$$

1. Calculation of the longitudinal expansion Δl
   For a temperature difference of Δt 40 K between the hot water temperature and the ambient temperature.
   α = 0,15 mm/m . K
   L = 10,0 m
   Δt = 40 K (°C)

   To be calculated: Δl
   $\alpha \times L \times \Delta t = \Delta l$
   0,15 x 10,0 x 40 = 60 mm

2. Calculation of the minimum length of L_s of the bending leg
   d = 40 mm
   Δl = 60 mm
   K = 15 mm

   To be calculated: L_s

   $$K \times \sqrt{d \times \Delta l}$$

   $$15 \times \sqrt{40 \times 60}$$

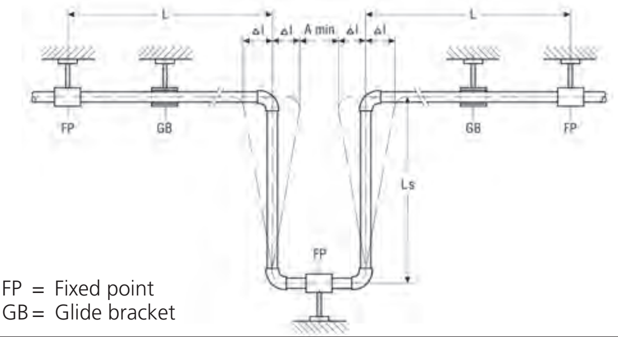
Equation 6.5

L_s = length of the bending leg in mm
d = external diameter Wefatherm pipe in mm
Δl = longitudinal expansion in mm
K = constant for the material, for Wefatherm pipes = 15

Engineering

Expansion bow

If the installation requires a 'U-shape', this can be used to provide compensation for longitudinal expansion. Here the width of the pipe bow A_{min} and the lengths of the two bending legs must be calculated.



FP = Fixed point
GB = Glide bracket

Illustration 6.3

Calculation example of expansion bow width Amin:
The width of the expansion bow A_{min} is calculated with the following formula:

$$2 \times \Delta l + SA = A_{min}$$
$$2 \times 60{,}0 \text{ mm} + 150 \text{ mm} = 270 \text{ mm}$$

Equation 6.6

Designation	Significance	Value	Unit
A_{min}	Width of expansion bow	?	mm
Δl	Longitudinal expansion	60,0	mm
SA	Safety distance	150,0	mm

Table 6.9 Given values and values to be calculated

Prestressing

By prestressing of a bending leg the length of the leg might be shortened with narrow space. When exactly planned and carried out, preload assemblies offer an optically perfect image as expansion movement is not visible. The calculated Δl is negatively prestressed when being installed. After initial operation of a pipe system a correct 90° angle will arise.

Calculation example of length of bending legs with prestressing:
The length of the bending leg with prestressing is calculated in accordance with the following formula (U-shape):

$$K \times \sqrt{d \cdot \frac{\Delta l}{2}} = L_s$$
$$15 \times \sqrt{40 \text{ mm} \cdot \frac{60 \text{ mm}}{2}} = 520 \text{ mm}$$

Equation 6.7

Designation	Significance	Value	Unit
L_{SV}	Length of the bending leg with prestressing	?	mm
K	Material-specific constant for Wefatherm pipes	15	
d	External diameter Wefatherm pipes	40,0	mm
Δl	Longitudinal expansion	60,0	mm

Table 6.9 Given values and values to be calculated

In accordance with the above stated starting values the length of bending leg is 520 mm.

6.3 Mounting and bracketing

6.3.1 Techniques for mounting pipework

When considering the techniques for mounting pipe work, one must differentiate fundamentally between fixed point mountings (hereafter fixed points) and loose or sliding point mountings (hereafter sliding points). By definition the fixed point or fixed clamp holds the pipe in a fixed manner, in which in contrast a sliding point will permit the pipe to move in the axial direction of the pipe. An optimally satisfactory installation can be ensured by appropriate selection of these two different methods of mounting. Rubber clamp inserts for plastic pipe prevent the pipe surface from being damaged at the clamp and ensure the required guiding and holding of the pipe.

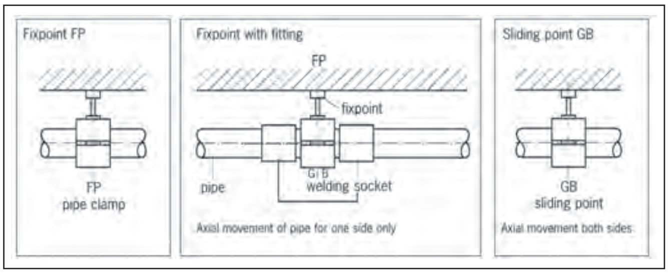


Illustration 6.4

6.3.2 Fix points

Fix points (fixed point mountings) divide a pipe network into sections. The free lengths from a fixed point must be measured and the possible longitudinal expansion that can take place in this free length must be calculated. Fixed point mountings with a long distance between the part of the clamp, holding the pipe and the ceiling or wall to which the clamp is mounted, should be avoided, since in these cases the clamps can act in a self-aligning manner and will not provide a fixed point. Sliding point clamps positioned on each side of the fittings, will act as fixed points! Vertical distribution lines (shaft mounting) and pipework laid beneath plaster or in concrete or floor topping, can also be laid in a rigid manner. Branch points, where the pipe branching off passes through a wall, must be mounted in a fixed manner since otherwise the pipe branching off could be cut off.

6.3.3 Loose or sliding mounting points

Axial movement of a pipe produced by longitudinal expansion should not be influenced by loose or sliding point mountings. The clamps should have suitable inserts (e.g. rubber) to prevent the pipe surface from being damaged and allow movement. Fittings must be at a sufficient distance from the sliding point clamps since otherwise these will act as fixed points.

6.3.4 Principles for the layout and construction of fixed points

- Fixed points are to be arranged so that direction changes in the pipe route can be used to absorb length changes.
- They are also to be designed in considering all the loads that might arise. In addition to reaction forces from friction at bracket contact points and deformation of bends, large forces are produced by fixed restraints of pipe lengths.
- The pipe must have the appropriate retainer rings to transfer the forces to the construction of the fixed point. Insufficient consideration of the restraint of the pipe in the bracket alone will, in many cases, cause deformation of the pipe cross section or damage to the pipe surface.
- Fixing pipe systems at fixed points should, if possible, be done at low ambient temperatures, giving rise to predominantly compressive stresses when heated (operating state).
- If flange connections occur in pipe lengths between fixed points, tensile stresses can cause the joint pre-tension forces to decrease, resulting in leakage at the flange connections.
- In inclining pipe segments, fixed points are employed to absorb dead weight and dynamic loads. The design has to ensure that vertical length changes do not produce any unacceptable tensile loads on the horizontal connections.

6.3.5 Valve mounting

Locations in which valves or other heavy equipment encumber the pipe system have to be provided with an additional support structure. Supporting valves not only serves to bear weight but also prevents the transfer of large actuating forces to the pipe system.

The design features must be arranged to enable replacement of the valves without simultaneous disassembly of the entire fixing. If the valve mount corresponds to a fixed point, consideration must be given to the consequences of the restricted length change.

6.3.6 Recommended spans LA at pipe wall temperature T_R

Wefatherm PP-R pipe

Pipe wall temp.	Pipe diameter (mm)										
TR (°C)	16	20	25	32	40	50	63	75	90	110	125
	Recommended spans L_A (cm) (Montage distance)										
0	70	85	105	125	140	165	190	205	220	250	250
20	50	60	75	90	100	120	140	150	160	180	190
30	50	60	75	90	100	120	140	150	160	180	190
40	50	60	70	80	90	110	130	140	150	170	180
50	50	60	70	80	90	110	130	140	150	170	180
60	50	55	65	75	85	100	115	125	140	160	170
70	50	50	60	70	80	95	105	105	125	140	150

Table 6.11

Wefatherm stabi pipes

Pipe wall temp.	Pipe diameter (mm)										
TR (°C)	16	20	25	32	40	50	63	75	90	110	125
	Recommended spans L_A (cm) (Montage distance)										
0	130	155	170	195	220	245	270	285	300	325	340
20	100	120	130	150	170	190	210	220	230	250	265
30	100	120	130	150	170	190	210	220	230	240	255
40	100	110	120	140	160	180	200	210	220	230	245
50	100	110	120	140	160	180	200	210	220	210	225
60	80	100	110	130	150	170	190	200	210	200	210
70	70	90	100	120	140	160	180	190	200	200	210

Table 6.12

Wefatherm stabi pipes

Pipe wall temp.	Pipe diameter (mm)										
TR (°C)	16	20	25	32	40	50	63	75	90	110	125
	Recommended spans L_A (cm) (Montage distance)										
0	120	140	160	180	205	230	245	260	290	320	340
20	90	105	120	135	155	175	185	195	215	240	265
30	90	105	120	135	155	175	185	195	210	230	255
40	85	95	110	125	145	165	175	185	200	220	245
50	85	95	110	125	145	165	175	185	190	205	225
60	80	90	105	120	135	155	165	175	180	190	210
70	70	80	95	110	130	145	155	165	170	180	210

Table 6.13

For vertical pipelines increase the relevant distances by 20% (factor 1.2).

6.4 Insulation

6.4.1 Protective measures

Protective measures for above ground pipe systems outside buildings (e.g. on pipe bridges) include insulation against loss of heat or cooling, concomitant heating and UV light blinding. Protected pipes are no longer exposed to extreme ambient temperatures that can result in such effects as a reduction in length change. In establishing the bracket distances it should be noted that the dead weight of the insulation will cause increased deflection. Protective measures can also be used to limit maximum pipe wall temperatures and therefore broaden the range of internal pressure loads for which the pipes are suitable.

Energy-saving is environmental protection. The legal regulation of the specific countries have to be taken into consideration.

6.4.2 Insulation warm water lines

In spite of the high level of insulation of PP-R pipe systems, warm and hot water lines must be insulated. Insulation protects against physical contact with the hot surface, it reduces noise nuisance and reduces the heat loss of the water. In hot water circulation systems the temperature loss needs to be reduced to assure conditions which are unfavourable for legionella. The return flow temperature needs to maintain a minimum temperature of 60°C. To compensate the heat loss the boiler temperature is raised. A raised boiler temperature requires additional energy and is often an additional attack on the applied (plastic) pipe work. At water temperatures above 70°C reduction of the life time expectancy of PP needs to be considered. Depending the operating conditions the life time can be reduced significantly. With proper insulation the boiler temperature setting can be limited and the PP-R's material properties exploited fully.

Mounting situation	Insulating layer thickness at λ = 0,040 W (mK)
Pipework laid exposed in unheated room (e.g. basement)	4 mm
Pipework laid exposed in heated room	9 mm
Pipework laid in channel with additional heated pipe lines	4 mm
Pipework laid in channel next to heated pipe lines	13 mm
Pipework laid in masony slit rising main	
Pipework laid in wall recess next to heated pipe lines	13 mm
Pipework laid on cement floor 4 mm	4 mm

Table 6.14 Guideline values for minimum thicknesses of insulation for insulating drinking water systems (cold)

Engineering

6.4.3 Insulation cold water lines

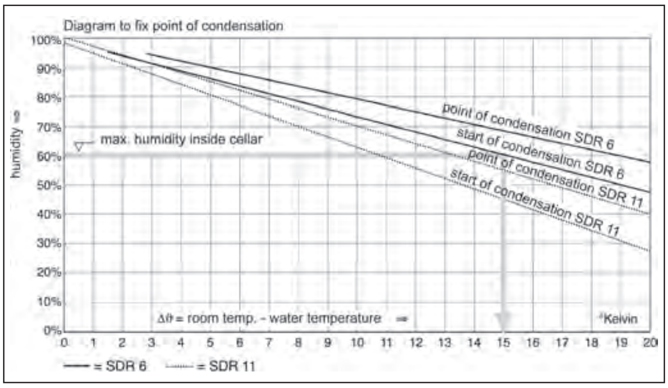
Condensation is the precipitation of water vapour on a surface that is cooler than its environment. Condensation arises when the humidity in the air is higher than the maximum quantity water vapour that the air can contain at that temperature. If water valour condenses to water depends on the insulation and humidity.

Illustration 6.5 Condensation on cold water lines

6.4.4 Condensation point

- The normal case is a cellar submerged to two thirds of the wall height in the earth, that has no continuously opened doors and windows.
- Such a 'normal case' stays even in summer after strong rain below a room temperature of 25°C and 60% moisture.
- With 25°C and 60% moisture and 10°C water temperature the pipe begins to sweat.
- For southern regions is important that these temperatures are some times exceeded and the water temperature is often higher than 10°C.
- With all rooms not according to a standard cellar, it has to be determined from case to case, whether the maximum room temperature may be 15°C higher than the water temperature.
- For pipes SDR 11 the permissible temperature difference is at 11°C.

Result: Cold water systems consisting of pipe SDR 6 normally do not show condensation water.



Graphic 6.1 Condensation on cold water lines

6.5 Construction of concealed pipe systems

Plastic pipes encased in concrete after installation represent a special case. Their handling in connection with the technical application guidelines for pressure pipes in this manual is therefore limited to important or critical details. The instructions may be applied to other similar circumstances.

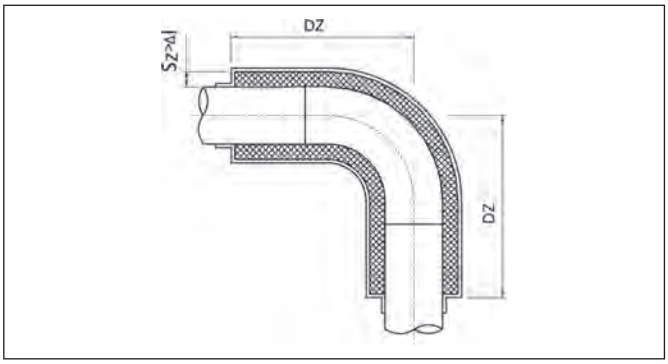


Illustration 6.6 Expansion zones in pipe bends

6.5.1 Behaviour of pipe systems under temperature loads

Once a pipe system is encased in concrete, no movement can any longer occur. A pipe system without linear compensation is created, meaning that increased heat stresses have to be taken into account. Since no friction-lock connection is formed between the straight pipe and surrounding concrete, the fittings constitute fixed points and are correspondingly subjected to stress. In installing pipe systems, measures need to be taken to limit the load on the fittings. Examples of such practices are described below.

6.5.2 Load on a pipe bend

If extreme temperature differences can arise, pipe bends have to be protected against overstress. For this purpose, an expansion zone using deformable material is incorporated. The chosen thickness of the expansion cushions must be at least as large as Δl.

6.5.3 Load on a tee

Due to varying temperatures, fittings are subject to surface pressure. This adverse load concentrates on tee sections, as additional shear forces are created at outgoing connections. If a load limiting element is placed directly beside the fitting, an electrofusion coupler is the most suitable connection piece. The longitudinal force (force on a fixed point) remains equally large, but the deformation due to the significantly smaller Δl is clearly less. Another option for protection against overload is the incorporation of an expansion zone (expansion cushion).

6.5.4 Fixing pipe systems

In comparison with brackets, the installation of a concrete-encased pipe system does not require any special measures. The fixing during installation only serves as float protection and is to be regarded as provisional attachment prior to encasement with concrete.

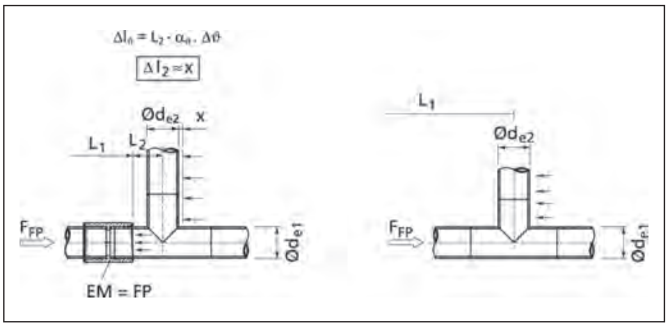


Illustration 6.7 Shear and fixed point forces on tees and 45° branches

6.6 Putting in use

6.6.1 Pressure test

After a drinking water system has been installed but before it is commissioned, it must be tested for tightness. This should be done while the system is still visible. Polypropylene expands under the influence of heat and pressure. For this reason it is necessary that the test medium (as a rule water) and the pipe work material are at the same temperature. Attention should therefore be paid to the fact that the test medium has a temperature that is as constant as possible. The pressure test is divided into three parts, namely the initial, the main and the final test.

Initial test

The highest possible operating pressure is increased by a factor of 1,5. This test pressure must be restored twice at intervals of in each case 10 minutes within a period of 30 minutes. After the pressure has been restored again a second time, the test pressure may not fall by more than 0,6 bar within the next 30 minutes. In addition no leakage may occur.

Main test

The main test commences immediately after the completion of the initial test and lasts two hours. During this period the pressure may not fall by more than 0,2 bar relative to the pressure at the end of the initial test.

Final test

Test pressures of 10 bar and 1 bar are applied alternately at intervals of at least 5 minutes. After each application of pressure, the pipe network is to be depressurized. Leakage may not occur at any point in the network being tested.

Measuring devices

The pressure measuring device used, must permit accurate readings to the nearest 0,1 bar. Where possible, the pressure is to be determined at the lowest point of the network.

Test memorandum

The test as carried out is to be documented in a memorandum which must be signed by the client and contractor with statement of the place and date of signing. See illustration 6.8 on the next page for a test memorandum form.

6.6.2 Flushing out of pipe work systems

The purpose of flushing out pipe work systems is ensuring the quality of drinking water, avoidance of corrosion damage, avoidance of damage to fittings and equipment and cleaning of the inner surface of the pipes. Regardless of the material of the pipes, all pipe work systems carrying drinking water are to be flushed out.

Suitable processes are:

1. Flushing out with water
2. Flushing out with a mixture of air and water

Flushing out process 1, namely flushing out with water, is sufficient in the case of drinking water systems which are composed exclusively of Wefatherm pipes and fittings. The appropriate flushing out process should be selected on the basis of the experience of the installing firm and of the client.

6.6.3 Balancing

After the flushing procedure has been performed, the flow in the pipe system segments are balanced by setting and adjusting valves.

Engineering

Name of project:

Client represented by:

Contractor/responsible expert

represented by:

☐ Filling water was filtered and the pipeline system was fully vented.

Permissible operating pressure totals P_{perm} = 10 bar/ _____ bar (if greater)

Water temperature ϑw = ______________ °C

Ambient temperature ϑu = ______________ °C

$\Delta\vartheta = \vartheta u - \vartheta w$ = ______________ K

Minimum duration for testing is 30min.
Minimum pressure for testing is 11bar.
Temperature differences of more than 10K might cause pressure changes.
A waiting time of minimum 30min has to be respected.

Description of the installation:

The WEFATHERM installation system was integrated in the above-mentioned construction project.

☐ Wefatherm ☐ Wefaklim

Pressure test/Date:

Pressure test/Start: Pressure (min. 11 bar): **bar**

Pressure test/End:

Pressure drop: ☐ Yes ☐ No

☐ ***The pipelines are tight.***

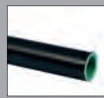
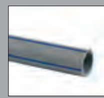
Place/Date: **Place/Date:**

(Client representative) ***(Contractor representative)***

Illustration 6.8 Test memorandum form

PP-R pipe system d20-315 mm

7 Product range

Material	PP-RCT	PP-R	PP-R	PP-R	PP-RCT	PP-R	PP-RCT	PP-R	PP-R	PP-RCT
Type	Standard	Standard	Standard	Standard	Standard	Fiber	Fiber	Stabi	Stabi-UV	Fiber
Colour	Green	Green	Green	Green	Green	Green	Green	Green	Black	Gray
										
SDR	**7,4**	**6**	**7,4**	**11**	**11**	**7,4**	**11**	**7,4**	**7,4**	**11**
20	●	●	●	●		●		●	●	●
25	●	●	●	●		●		●	●	●
32	●	●	●	●		●		●	●	●
40	●	●	●	●		●		●	●	●
50	●	●	●	●		●		●	●	●
63	●	●	●	●		●		●	●	●
75	●	●	●	●		●		●	●	●
90	●	●	●	●		●		●		●
110	●	●	●	●		●		●		●
125	●	●	●	●		●				●
160					●		●			●
200					●		●			
250					●		●			
315					●					

ISO 15874, Maximum Operating Pressure MOP										
Class 1	10	10	8	6	6	8	6	8	8	6
Class 2	10	8	6	4	6	6	6	6	6	6
Class 4	10	10	10	6	6	10	6	10	10	6
Class 5	8	6	6		4	6	4	6	6	4

Class 1 hot water supply 60°C - class 2 hot water supply 70°C - class 4 low temperature heating 60°C - class 5 high temperature heating 80°C.

DIN 8077, Maximum Operating Pressure MOP										
SF 1,50-20°C	24,3	25,7	20,4	12,9	15,3	20,4	15,3	20,4	20,4	15,3
SF 1,50-70°C	10,7	8,5	6,7	4,2	6,8	6,7	6,8	6,7	6,7	6,8
SF 1,25-20°C	29,2	30,9	24,5	15,4	18,4	24,5	18,4	24,5	24,5	18,4
SF 1,25-70°C	12,9	10,2	8,1	5,1	8,1	8,1	8,1	8,1	8,1	8,1
PN 1)		20	16	10		16		16	16	

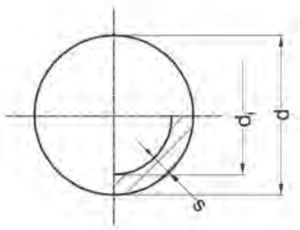
SF = Safety (Design) Factor - permanent temperature over 50 years Design Lifetime
1) PN = Pressure Nominal based on DIN8077:1989 - 50yrs - 20°C - SF2,0 - water

Pipe SDR 7,4 PP-RCT

PP-RCT
SDR 7,4
green

length of pipes = 4 m

dxs	Code	d_i	l/m	DN	kg
20x 2,8	**5152 25201**	14,4	0,163	15	0,624
25x 3,5	**5152 25202**	18,0	0,254	20	0,968
32x 4,4	**5152 25203**	23,2	0,415	25	1,564
40x 5,5	**5152 25204**	29,0	0,615	32	2,432
50x 6,9	**5152 25205**	36,2	1,029	40	3,760
63x 8,6	**5152 25206**	45,8	1,633	50	5,936
75x10,3	**5152 25207**	54,4	2,307	-	8,444
90x12,3	**5152 25209**	65,4	3,318	65	12,124
110x15,1	**5152 25211**	79,8	5,001	80	18,072
125x17,1	**5152 25212**	90,8	6,470	100	23,212



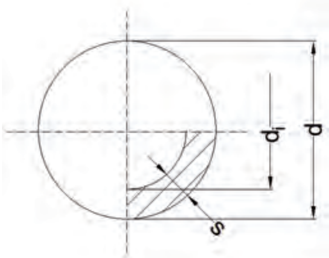
Suitable for hot and cold water, central heating and air conditioning.
ISO 15874 class 1/10bar, 2/10 bar, 4/10 bar, 5/8bar.
DIN 8077-8078 class 20°C/20bar, 70°C/10 bar.

Pipe SDR 6 PP-R

PP-R
SDR 6
green

length of pipes = 4 m

dxs	Code	d_i	l/m	DN	kg
20x 3,4	**5155 20002**	13,2	0,137	12	0,724
25x 4,2	**5155 20003**	16,6	0,216	15	1,116
32x 5,4	**5155 20004**	21,2	0,353	20	1,824
40x 6,7	**5155 20005**	26,6	0,556	25	2,820
50x 8,3	**5155 20006**	33,2	0,866	32	4,388
63x10,5	**5155 20007**	42,0	1,385	40	6,660
75x12,5	**5155 20008**	50,0	1,963	50	9,816
90x15,0	**5155 20009**	60,0	2,827	-	14,104
110x18,3	**5155 20010**	73,2	4,208	65	21,068
125x20,8	**5155 20011**	83,4	5,460	80	27,140



Suitable for hot and cold water, central heating and air conditioning.
ISO 15874 class 1/10, 2/8, 4/10, 5/6 bar.
DIN 8077/8078 20°C/20 bar, 70°C/10 bar.

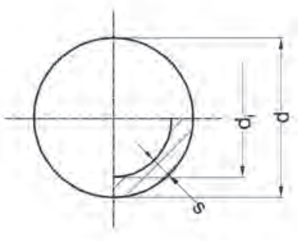
PP-R pipe system d20-315 mm

Pipe SDR 7,4 PP-R

PP-R
SDR 7,4
green

length of pipes = 4 m

dxs	Code	d_i	l/m	DN	kg
20x 2,8	**5155 20101**	14,4	0,163	15	0,624
25x 3,5	**5155 20102**	18,0	0,254	20	0,968
32x 4,4	**5155 20103**	23,2	0,415	25	1,564
40x 5,5	**5155 20104**	29,0	0,615	32	2,432
50x 6,9	**5155 20105**	36,2	1,029	40	3,760
63x 8,6	**5155 20106**	45,8	1,633	50	5,936
75x10,3	**5155 20107**	54,4	2,307	-	8,444
90x12,3	**5155 20108**	65,4	3,318	65	12,124
110x15,1	**5155 20109**	79,8	5,001	80	18,072
125x17,1	**5155 20110**	90,8	6,470	100	23,212

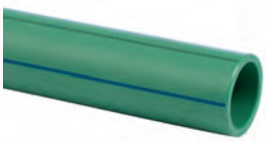


Suitable for hot and cold water, central heating and air conditioning.
ISO 15874 class 1/8, 2/6, 4/10, 5/6 bar.
DIN 8077/8078 20°C/16 bar, 70°C/8 bar.

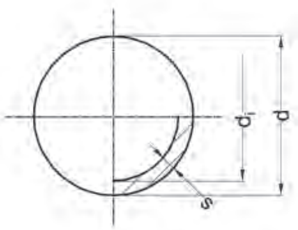
Pipe SDR 11 PP-R

PP-R
SDR 11
green

length of pipes = 4 m



dxs	Code	d_i	l/m	DN	kg
20x 1,9	**5155 20050**	16,2	0,205	15	0,452
25x 2,3	**5155 20051**	20,4	0,328	20	0,688
32x 2,9	**5155 20052**	26,2	0,531	25	1,120
40x 3,7	**5155 20053**	32,6	0,834	32	1,728
50x 4,6	**5155 20054**	40,8	1,307	40	2,676
63x 5,8	**5155 20055**	51,4	2,075	50	4,224
75x 6,8	**5155 20056**	61,4	2,941	-	5,964
90x 8,2	**5155 20057**	73,6	4,254	65	8,528
110x10,0	**5155 20058**	90,0	6,362	80	12,680
125x11,4	**5155 20059**	102,2	8,199	100	16,384



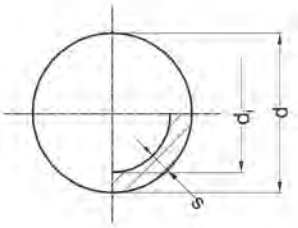
Recognizable by four blue stripes.
Suitable for cold water and air conditioning.
ISO 15874 class 1/6, 2/4, 4/6 bar.
DIN 8077/8078 20°C/10 bar.

PP-R pipe system d20-315 mm

Pipe SDR 11 PP-RCT

length of pipes = 4 m

PP-RCT
SDR 11
green



dxs	Code		d_i	l/m	DN	kg
160x14,6	**5152 25016**		130,8	13,4	125	25,320
200x18,2	**5152 25020**		163,6	21,0	150	39,232
250x22,7	**5152 25025**	1)	204,6	32,9	200	61,156
315x28,6	**5152 25031**	1)	257,8	52,2	250	69,156

1) L = 5,8 m.

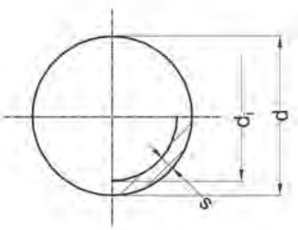
For hot & cold water and sanitary installations.

DIN 8077/8078 20°C/16 bar, 60°C/8 bar.

Pipe SDR 11 - lilac PP-R

length of pipes = 4 m

PP-R
SDR 11
lilac



dxs	Code	d_i	l/m	DN	kg
20x 1,9	**5159 20050**	16,2	0,205	15	0,452
25x 2,3	**5159 20051**	20,4	0,328	20	0,688
32x 2,9	**5159 20052**	26,2	0,531	25	1,120
40x 3,7	**5159 20053**	32,6	0,834	32	1,728
50x 4,6	**5159 20054**	40,8	1,307	40	2,676
63x 5,8	**5159 20055**	51,4	2,075	50	4,224
75x 6,8	**5159 20056**	61,4	2,941	-	5,964
90x 8,2	**5159 20057**	73,6	4,254	65	8,528
110x10,0	**5159 20058**	90,0	6,362	80	12,680
125x11,4	**5159 20059**	102,2	8,199	100	16,384

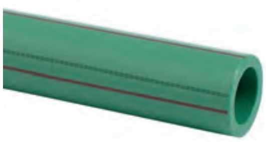
Suitable for rainwater.

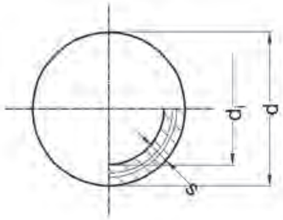
PP-R pipe system d20-315 mm

Pipe fiber SDR 7,4 PP-R

PP-R
SDR 7,4
green

length of pipes = 4 m





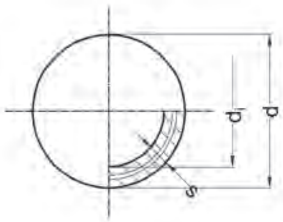
dxs	Code	d_i	l/m	DN	kg
20x 2,8	5155 20150	14,4	0,163	15	0,608
25x 3,5	5155 20151	18,0	0,254	20	0,944
32x 4,4	5155 20152	23,2	0,415	25	1,532
40x 5,5	5155 20153	29,0	0,615	32	2,376
50x 6,9	5155 20154	36,2	1,029	40	3,716
63x 8,6	5155 20155	45,8	1,633	50	5,816
75x10,3	5155 20156	54,4	2,307	-	8,284
90x12,3	5155 20157	65,4	3,318	65	11,908
110x15,1	5155 20158	79,8	5,674	80	17,816
125x17,1	5155 20159	90,8	6,472	100	23,380

Recognizable by four red stripes.
Suitable for hot and cold water and central heating.
ISO 15874 class 1/8, 2/6, 4/10, 5/6 bar.
DIN 8077/8078 20°C/16 bar, 70°C/8 bar.

Pipe fiber SDR 11 PP-RCT

PP-RCT
SDR 11
green

length of pipes = 4 m



dxs	Code		d_i	l/m	DN	kg
160x14,6	5152 27016		130,8	13,6	125	27,100
200x18,2	5152 27020	1)	163,6	21,0	150	42,560
250x22,7	5152 27025	1)	204,6	32,9	200	66,440

1) *L = 5,8 m.*

For hot & cold water and sanitary installations.

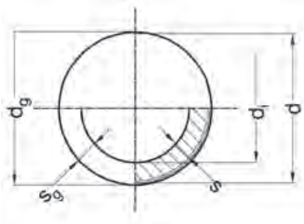
DIN 8077/8078 20°C/16 bar, 70°C/8 bar.

Striped.

Pipe stabi SDR 7,4 PP-R
with perforated aluminium layer
length of pipes = 4 m

PP-R
SDR 7,4
green

dxs	Code	d_i	d_g	s_g	l/m	DN	kg
20x 2,8	**5155 20301**	14,4	21,6	3,6	0,163	15	0,792
25x 3,5	**5155 20302**	18,0	26,8	4,4	0,254	20	1,176
32x 4,4	**5155 20303**	23,2	33,8	5,4	0,415	25	1,816
40x 5,5	**5155 20304**	29,0	42,0	6,6	0,615	32	2,736
50x 6,9	**5155 20305**	36,2	52,0	7,9	1,029	40	4,136
63x 8,6	**5155 20306**	45,8	65,0	9,7	1,633	-	6,404
75x10,3	**5155 20307**	54,4	77,0	11,4	2,307	60	8,988
90x12,3	**5155 20308**	65,4	92,0	13,5	3,318	65	12,920
110x15,1	**5155 20309**	79,8	113,0	16,7	5,674	80	19,500



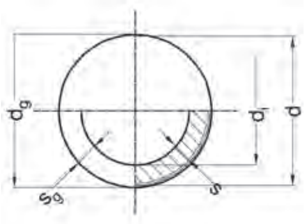
Suitable for hot and cold water and central heating.
ISO 15874 class 1/8, 2/6, 4/10, 5/6 bar.
DIN 8077/8078 20°C/16 bar, 70°C/8 bar.

Pipe stabi UV SDR 7,4 - black PP-R
UV stabilized, with perforated aluminium layer
length of pipes = 4 m

PP-R
SDR 7,4
black

dxs	Code	d_i	d_g	s_g	l/m	DN	kg
20x 2,8	**5155 20370**	14,4	21,6	3,6	0,163	15	0,792
25x 3,5	**5155 20371**	18,0	26,8	4,4	0,254	20	1,166
32x 4,4	**5155 20372**	23,2	33,8	5,4	0,415	25	1,816
40x 5,5	**5155 20373**	29,0	42,0	6,6	0,615	32	2,736
50x 6,9	**5155 20374**	36,2	52,0	7,9	1,029	40	4,136
63x 8,6	**5155 20375**	45,8	65,0	9,7	1,633	50	6,404
75x10,3	**5155 20376**	54,4	77,0	11,4	2,307	60	8,988

Suitable for hot and cold water (outside) and central heating.
ISO 15874 class 1/8, 2/6, 4/10, 5/6 bar.
DIN 8077/8078 20°C/16 bar, 70°C/8 bar.

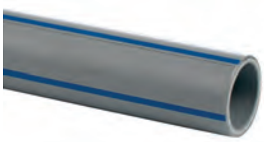


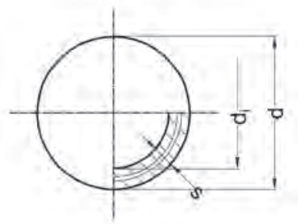
PP-R pipe system d20-315 mm

Pipe Wefaklim fiber SDR 11 - grey PP-RCT

length of pipes = 4 m

PP-RCT
SDR 11
grey





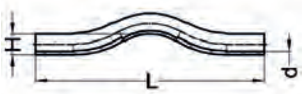
dxs	Code		d_i	l/m	DN	kg
20x 2,8	**5150 20130**	1)	14,4	0,148	15	0,608
25x 3,5	**5150 20131**	1)	18,0	0,230	20	0,944
32x 2,9	**5150 20132**		26,2	0,539	25	1,544
40x 3,7	**5150 20133**		32,6	0,835	32	2,440
50x 4,6	**5150 20134**		40,8	1,307	40	3,696
63x 5,8	**5150 20135**		51,4	2,075	50	4,224
75x 6,8	**5150 20136**		61,4	2,961	60	8,404
90x 8,2	**5150 20137**		73,6	4,254	65	8,268
110x10,0	**5150 20138**		90,0	6,362	80	12,744
125x11,4	**5150 20139**		102,2	8,203	100	16,396
160x14,6	**5150 20140**		130,8	13,400	125	26,100

1) *without blue stripes*

Recognizable by four blue stripes (d20 and d25 without stripes).
Suitable for central heating, air conditioning and climate control.
ISO 15874 class 1/6, 2/6, 4/6, 5/4 bar.
DIN 8077/8078 20°C/16 bar, 70°C/8 bar.

Bridge m/m

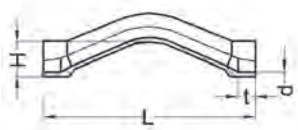
PP-R
SDR 6
green



d	Code	L	H	kg
20	**5155 20501**	350	24	0,063
25	**5155 20502**	350	27	0,092
32	**5155 20503**	350	32	0,151

Bridge s/s

PP-R
SDR 6
green

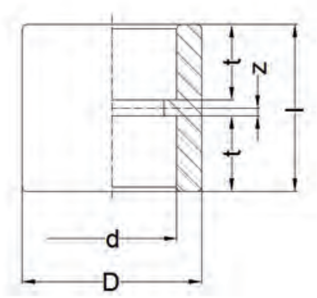


d	Code	L	t	H	kg
20	**5155 70201**	160	16	27	0,041
25	**5155 70202**	200	18	32	0,077

PP-R pipe system d20-315 mm

Socket

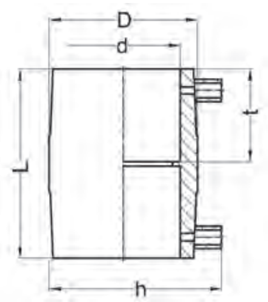
PP-R
SDR 6
green



d	Code	D	l	z	t	kg
20	**5155 27002**	29,5	32	1,5	14	0,011
25	**5155 27003**	34,0	35	1,5	15	0,014
32	**5155 27004**	43,0	40	1,9	17	0,026
40	**5155 27005**	53,5	44	1,5	18	0,042
50	**5155 27006**	68,5	50	1,5	20	0,083
63	**5155 27007**	88,0	59	2,1	26	0,159
75	**5155 27008**	105,0	67	2,5	29	0,239
90	**5155 27009**	125,0	71	2,5	32	0,376
110	**5155 27010**	146,5	80	2,5	35	0,568
125	**5155 27011**	163,5	91	5,5	41	0,756

Electrofusion coupler

PP-R
SDR 11
green



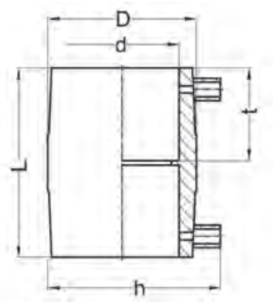
d	Code		D	L	t	h	kg
20	**5155 50101**	1)	33	70	34	52	0,031
25	**5155 50102**	1)	38	70	34	58	0,038
32	**5155 50103**	1)	45	70	34	65	0,045
40	**5155 50104**	1)	55	85	41	75	0,062
50	**5155 50105**	1)	68	88	42	87	0,076
63	**5155 50106**	1)	82	100	48	100	0,121
75	**5155 50107**		98	125	61	114	0,158
90	**5155 50108**		113	146	72	130	0,210
110	**5155 50109**		136	155	77	144	0,364
125	**5155 50110**		156	166	82	167	1,760

1) *SDR 7,4*

Safety voltage 40V.

Electrofusion coupler 160-315 mm

PP-RCT
SDR 11
green

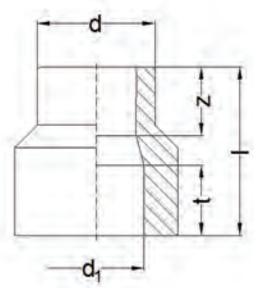


d	Code	D	L	t	h	kg
160	**5152 50116**	190	202	100	245	1,760
200	**5152 50120**	230	202	100	245	1,900
250	**5152 50125**	290	220	110	315	4,500
315	**5152 50131**	400	280	140	415	10,800

Safety voltage 40V.

Reducer PP-R

PP-R
SDR 6
green

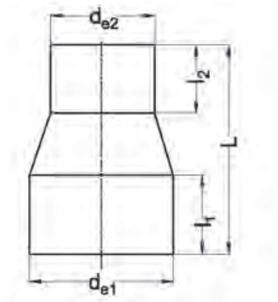


dxd_1	Code	t	l	z	kg
25x20	**5155 26003**	14	42,0	27,5	0,014
32x20	**5155 26004**	14	47,5	33,0	0,029
32x25	**5155 26005**	15	47,6	31,6	0,022
40x20	**5155 26006**	14	40,7	26,2	0,025
40x25	**5155 26007**	15	41,0	25,0	0,023
40x32	**5155 26008**	17	53,5	35,4	0,033
50x20	**5155 26009**	14	55,0	40,5	0,046
50x25	**5155 26010**	15	55,0	39,0	0,047
50x32	**5155 26011**	17	57,0	38,9	0,057
50x40	**5155 26012**	18	59,5	39,0	0,058
63x25	**5155 26014**	15	65,0	43,0	0,080
63x32	**5155 26015**	17	65,0	38,5	0,089
63x40	**5155 26013**	18	64,5	44,0	0,095
63x50	**5155 26016**	20	68,5	44,5	0,128
75x50	**5155 26017**	20	68,0	68,0	0,143
75x63	**5155 26018**	26	74,0	46,6	0,203
90x63	**5155 26019**	26	77,0	49,6	0,171
90x75	**5155 26020**	29	80,0	49,0	0,228
110x90	**5155 26025**	32	93,0	57,5	0,450
125x110	**5155 26026**	35	84,0	48,0	0,447

PP-R pipe system d20-315 mm

Reducer PP-RCT — PP-RCT, **SDR 11**, green

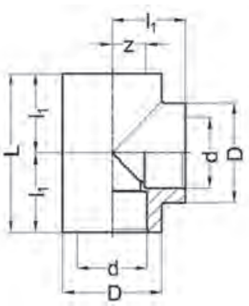
for butt-welding and electrofusion



d_{e1}xd_{e2}	Code		L	l_1	l_2	kg
160x110	**5152 41830**		255	110	93	1,534
160x125	**5152 41831**		260	113	95	1,605
200x160	**5152 41934**	1)	151	50	40	1,330
200x160	**5152 41834**		303	142	117	2,600
250x160	**5152 41936**	1)	194	60	40	2,370
250x160	**5152 41836**		339	138	111	3,900
250x200	**5152 41937**	1)	182	60	50	1,110
250x200	**5152 41837**		337	137	127	4,500
315x250	**5152 41840**		380	157	138	8,000

1) *short version suitable for butt-welding*

Tee 90° PP-R — PP-R, SDR 6, green



d	Code	D	L	l_1	z	kg
20	**5155 24002**	29,5	50,6	25,3	10,8	0,023
25	**5155 24003**	34,0	60,0	30,0	14,0	0,033
32	**5155 24004**	44,0	69,0	34,5	16,4	0,062
40	**5155 24005**	53,5	85,6	42,8	22,3	0,105
50	**5155 24006**	68,0	120,0	60,0	36,5	0,188
63	**5155 24007**	85,0	118,0	59,0	31,6	0,372
75	**5155 24008**	99,5	140,6	70,3	39,3	0,557
90	**5155 24009**	119,0	160,0	80,0	44,5	0,956
110	**5155 24010**	144,5	197,6	98,8	57,3	1,745
125	**5155 24011**	164,5	245,6	122,8	82,8	2,780

Tee 90° PP-RCT

PP-RCT
SDR 11
green

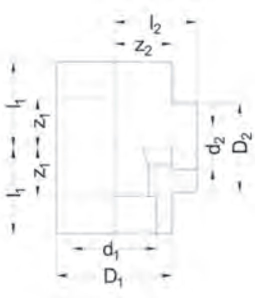
for butt-welding and electrofusion

d_e	Code		L	Z	l	kg
160	**5152 41616**	1)	320	160	40	2,920
160	**5152 41516**		502	251	127	4,300
200	**5152 41620**	1)	430	215	64	6,470
200	**5152 41520**		502	251	127	7,400
250	**5152 41625**	1)	550	275	86	12,650
250	**5152 41525**		618	309	140	9,800
315	**5152 41631**	1)	700	350	111	25,700
315	**5152 41531**		775	387	175	26,200

1) *short version suitable for butt-welding*

Tee reduced 90°

PP-R
SDR 6
green



d	Code		d_1	D_1	l_1	z_1	d_2	D_2	l_2	z_2	kg
20x 25x 25	**5155 25025**		24,2	34,0	31,3	15,3	24,2	30,0	30,0	14,0	0,039
25x 20x 20	**5155 25024**		24,2	34,0	31,3	15,3	19,2	30,0	30,0	15,5	0,037
25x 20x 25	**5155 25003**		24,2	34,0	31,3	15,3	19,2	30,0	30,0	15,5	0,032
32x 20x 25	**5155 25026**		31,1	44,0	35,5	17,4	19,2	44,0	34,5	20,0	0,075
32x 20x 32	**5155 25004**		31,1	44,0	35,8	17,7	19,2	44,0	34,5	20,0	0,070
32x 25x 25	**5155 25028**		31,1	44,0	35,5	17,4	24,2	44,0	34,5	18,5	0,071
32x 25x 32	**5155 25005**		31,1	44,0	35,8	17,7	24,2	44,0	34,5	18,5	0,066
32x 32x 25	**5155 25023**		31,1	43,5	35,5	17,4	31,1	43,5	34,8	16,7	0,066
40x 20x 40	**5155 25006**		39,0	52,0	24,0	21,5	19,2	36,0	41,5	27,0	0,089
40x 25x 40	**5155 25007**		39,0	52,4	44,0	23,5	24,2	34,9	38,8	22,8	0,085
40x 32x 40	**5155 25008**		39,0	53,5	44,0	23,5	31,1	53,5	42,3	24,2	0,116
50x 20x 50	**5155 25029**		48,9	68,0	50,0	26,5	19,2	43,0	44,1	29,6	0,180
50x 25x 50	**5155 25009**		48,9	65,4	52,0	28,5	24,2	34,5	47,3	31,3	0,175
50x 32x 50	**5155 25010**		48,9	65,4	52,0	28,5	31,1	43,0	47,3	29,2	0,169
50x 40x 50	**5155 25011**		48,9	68,0	52,0	28,5	39,0	68,0	50,0	29,5	0,207
63x 20x 63	**5155 25012**		61,9	85,0	63,0	35,6	19,2	46,5	60,5	46,0	0,375
63x 25x 63	**5155 25013**		61,9	85,0	63,0	35,6	24,2	46,5	60,5	44,5	0,368
63x 32x 63	**5155 25014**		61,9	85,0	63,0	35,6	31,1	65,0	60,5	42,4	0,404
63x 40x 63	**5155 25015**		61,9	85,0	63,0	35,6	39,0	65,0	60,5	40,0	0,392
63x 50x 63	**5155 25016**		61,9	85,0	63,0	35,6	48,9	85,0	60,5	37,0	0,417
75x 20x 75	**5155 25017**	1)	74,3	98,5	70,0	39,0	19,2	43,0	68,8	54,3	0,512
75x 25x 75	**5155 25018**	1)	74,3	98,5	70,5	39,5	24,2	34,9	73,3	57,3	0,512
75x 32x 75	**5155 25019**	1)	74,3	98,5	70,0	39,0	31,1	43,0	69,8	51,7	0,514
75x 40x 75	**5155 25020**	1)	74,3	98,5	70,0	39,0	39,0	65,0	68,8	48,3	0,529

1) *PP-RCT*

-- to be continued --

PP-R pipe system d20-315 mm

Tee reduced 90° - continuation -

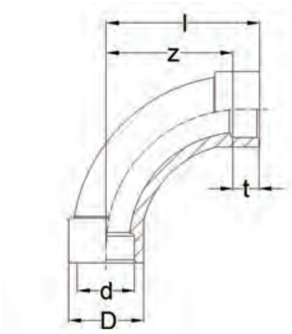
d	Code		d_1	D_1	l_1	z_1	d_2	D_2	l_2	z_2	kg
75x 50x 75	**5155 25021**	1)	74,3	99,0	70,5	39,5	48,9	65,0	70,5	39,5	0,506
75x 63x 75	**5155 25022**	1)	74,3	99,0	70,0	39,0	61,9	99,0	68,5	41,1	0,600
90x 63x 90	**5155 25032**		89,3	119,0	81,8	196,3	61,9	85,0	80,5	53,1	0,917
90x 75x 90	**5155 25033**		89,3	119,0	81,8	46,3	74,3	99,5	80,0	49,1	0,916
110x 63x110	**5155 25034**		109,4	146,0	98,5	57,0	61,9	85,0	99,0	71,6	1,674
110x 75x110	**5155 25035**		109,4	146,0	100,0	58,5	74,3	100,0	99,0	68,0	1,717
110x 90x110	**5155 25036**		109,4	146,0	98,5	57,0	89,3	119,0	97,0	61,5	1,770
125x 75x125	**5155 25037**		124,4	165,0	123,0	83,0	74,3	112,0	104,0	73,0	2,630
125x 90x125	**5155 25038**		124,4	165,0	122,5	82,5	89,3	120,0	104,5	69,0	2,610
125x110x125	**5155 25039**		124,4	165,0	122,5	82,5	109,4	148,0	109,5	68,0	2,540

1) *PP-RCT*

PP-R pipe system d20-315 mm

Bend 90°

PP-R
SDR 6
green

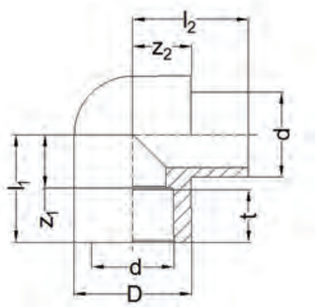


d	Code	D	l	z	t	kg
20	**5155 21101**	28	56	42	14	0,030
25	**5155 21102**	34	69	53	15	0,052
32	**5155 21103**	42	86	68	17	0,088
40	**5155 21104**	52	106	86	18	0,164

R ≈ 2 x d.

Elbow 90° s/m

PP-R
SDR 6
green

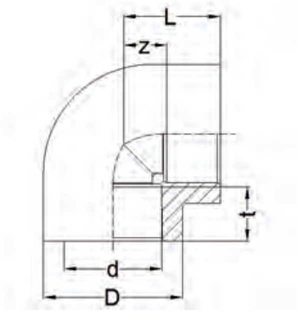


d	Code	D	l_1	z_1	l_2	z_2	t	kg
20	**5155 22001**	30,0	24,5	10,0	29,5	15,0	14	0,016
25	**5155 22002**	34,8	31,8	15,8	34,2	17,3	15	0,029
32	**5155 22003**	44,0	34,3	16,2	39,6	22,0	17	0,049

PP-R pipe system d20-315 mm

Elbow 90°

PP-R
SDR 6
green

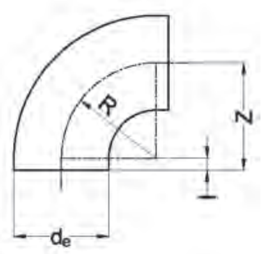


d	Code	D	L	z	t	kg
20	**5155 21002**	29,5	25,8	11,3	14	0,018
25	**5155 21003**	34,2	29,9	13,9	15	0,024
32	**5155 21004**	44,0	34,0	15,9	17	0,048
40	**5155 21005**	53,0	43,5	23,0	18	0,081
50	**5155 21006**	70,0	49,0	25,5	20	0,167
63	**5155 21007**	86,5	60,8	33,4	26	0,275
75	**5155 21008**	102,5	67,3	36,3	29	0,472
90	**5155 21009**	120,5	78,3	42,8	32	0,748
110	**5155 21010**	148,0	99,0	62,0	35	1,437
125	**5155 21011**	165,0	124,0	84,0	41	2,340

Bend 90° short

for butt-welding

PP-RCT
SDR 11
green



d_e	Code	Z	l	R	kg
160	**5152 41116**	175	15	160	1,870
200	**5152 41120**	215	15	200	3,605
250	**5152 41125**	275	25	250	7,210
315	**5152 41131**	350	35	315	13,970

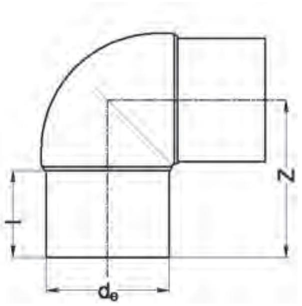
$R \approx 1 \times d_e$.

Elbow 90° long PP-RCT

SDR 11

for butt-welding and electrofusion green

d_e	Code	Z	l	kg
160	**5152 41016**	250	128	3,100
200	**5152 41020**	250	128	5,500
250	**5152 41025**	309	140	13,200
315	**5152 41031**	370	167	18,600

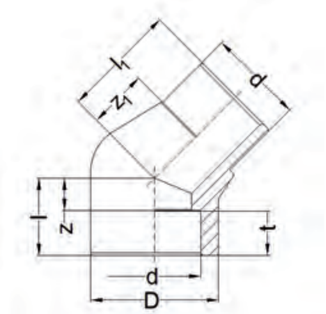


Elbow 45° s/m PP-R

SDR 6

green

d	Code	D	l	z	l_1	z_1	t	kg
20	**5155 22100**	29,0	20	5	28	13,0	14	0,013
25	**5155 22101**	34,0	22	6	34	17,0	15	0,022
32	**5155 22102**	43,0	26	8	39	20,0	17	0,040



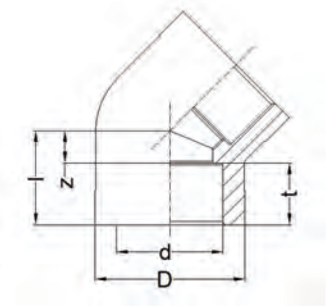
wefatherm

PP-R pipe system d20-315 mm

Elbow 45°

PP-R
SDR 6
green

d	Code	D	l	z	t	kg
20	**5155 23002**	30,0	21,6	7,1	14	0,016
25	**5155 23003**	34,5	24,8	8,8	15	0,021
32	**5155 23004**	44,0	27,6	9,5	17	0,039
40	**5155 23005**	52,0	32,0	11,0	18	0,060
50	**5155 23006**	65,0	37,0	13,0	20	0,095
63	**5155 23007**	82,0	44,0	16,0	26	0,210
75	**5155 23008**	100,0	50,0	20,0	29	0,336
90	**5155 23009**	120,0	58,0	25,0	32	0,582
110	**5155 23010**	148,0	69,0	32,0	35	1,064
125	**5155 23011**	165,0	77,0	37,0	41	1,520

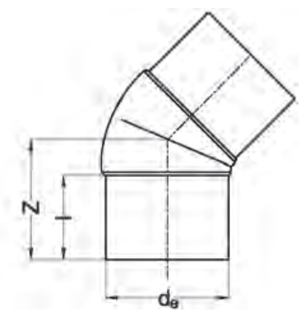


Elbow 45° long

for butt-welding and electrofusion

PP-RCT
SDR 11
green

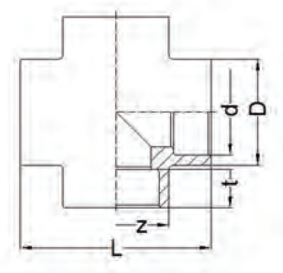
d_e	Code	Z	l	kg
160	**5152 41316**	201	127	4,400
200	**5152 41320**	201	127	4,400
250	**5152 41325**	130	140	7,700
315	**5152 41331**	320	210	18,000



PP-R pipe system d20-315 mm

Cross

PP-R
SDR 6
green

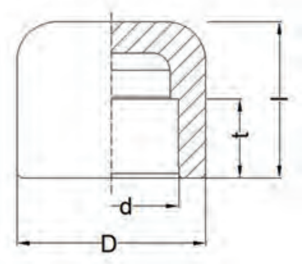


d	Code		D	L	z	t	kg
32	**5155 25101**	1)	40,0	77	34	17	0,058
40	**5155 25102**		51,0	93	42	18	0,111
50	**5155 25103**		63,0	112	66	20	0,212
63	**5155 25104**		76,0	137	84	26	0,355

1) *SDR 7,4*

End cap

PP-R
SDR 6
green



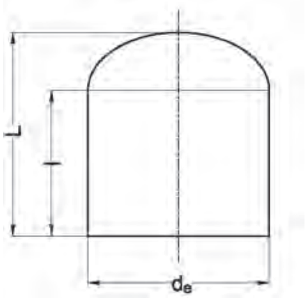
d	Code	D	l	t	kg
20	**5155 28002**	29,5	28,8	14	0,011
25	**5155 28003**	34,5	30,0	15	0,015
32	**5155 28004**	43,5	35,7	17	0,028
40	**5155 28005**	52,5	40,0	18	0,040
50	**5155 28006**	64,0	45,0	20	0,061
63	**5155 28007**	85,5	54,0	26	0,136
75	**5155 28008**	101,0	65,0	29	0,235
90	**5155 28009**	119,0	76,0	32	0,332
110	**5155 28010**	148,0	79,0	35	0,616
125	**5155 28011**	165,0	87,0	41	0,780

PP-R pipe system d20-315 mm

End cap long

for butt-welding and electrofusion

PP-RCT
SDR 11
green

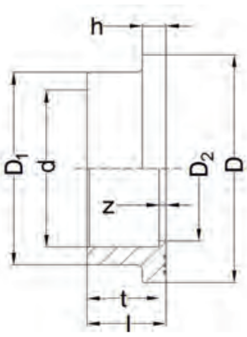


d_e	Code	L	l	kg
160	5152 42216	184	140	1,100
200	5152 42220	184	140	3,000
250	5152 42225	185	135	5,000
315	5152 42231	301	176	7,700

Flange sleeve

with EPDM gasket

PP-R
SDR 6
green

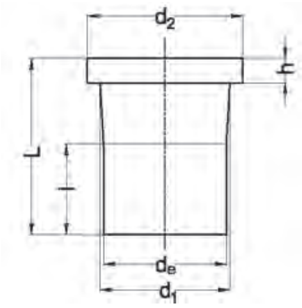


d	Code	D	D_1	D_2	h	l	z	t	kg
32	5155 28020	50	41	28,0	7	21,0	4	17	0,017
40	5155 28021	61	50	36,5	8	23,5	4	18	0,027
50	5155 28022	74	61	44,5	8	27,0	4	20	0,040
63	5155 28023	90	76	57,0	9	30,0	4	26	0,065
75	5155 28024	106	90	69,5	10	33,0	5	29	0,095
90	5155 28025	138	109	84,0	13	40,0	8	32	0,198
110	5155 28026	158	131	112,0	14	42,0	8	35	0,251
125	5155 28027	162	147	100,0	25	55,0	15	41	0,390

Stub end

PP-RCT
SDR 11
green

for butt-welding and electrofusion



d_e	Code		h	l	d_1	d_2	L	kg
160	**5152 42116**	1)	25	34	175	212	80	0,875
160	**5152 42016**		32	127	232	268	205	2,600
200	**5152 42120**	1)	32	36	232	268	100	1,875
200	**5152 42020**		32	127	232	268	205	3,000
250	**5152 42125**	1)	35	35	285	320	100	2,825
250	**5152 42025**		35	146	285	320	235	5,000
315	**5152 42131**	1)	35	35	335	370	100	3,475
315	**5152 42031**		35	165	335	370	260	7,700

1) *short version suitable for butt-welding*

With grooved sealing surface.

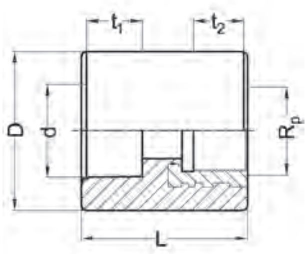
PP-R pipe system d20-315 mm

Transition round female

PP-R/brass
SDR 6
green

dxR_p	Code	L	t_1	t_2	D	kg
20x½"	**5155 28101**	42	15	17	41	0,072
20x¾"	**5155 28102**	44	15	17	47	0,100
25x½"	**5155 28103**	44	16	17	41	0,076
25x¾"	**5155 28104**	44	16	17	47	0,095
32x¾"	**5155 28105**	44	18	17	43	0,105

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

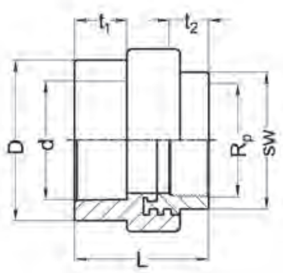


Transition hexagon female

PP-R/brass
SDR 6
green

dxR_p	Code	L	t_1	t_2	D	SW	kg
32x 1"	**5155 28204**	60	18	22	61	39	0,240
40x1¼"	**5155 28205**	63	21	22	72	47	0,347
50x1½"	**5155 28206**	85	24	20	79	52	0,396
63x 2"	**5155 28207**	75	28	25	95	66	0,612
75x 2"	**5155 28208**	83	31	25	100	66	0,668
125x 5"	**5155 28213**	124	40	44	208	149	0,383

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

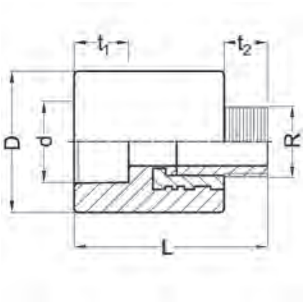


Transition round male

PP-R/brass
SDR 6
green

dxR	Code	L	t_1	t_2	D	kg
20x½"	**5155 29101**	56	15	13	41	0,098
20x¾"	**5155 29102**	61	15	17	47	0,164
25x½"	**5155 29103**	56	16	13	41	0,101
25x¾"	**5155 29104**	61	16	17	47	0,161

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

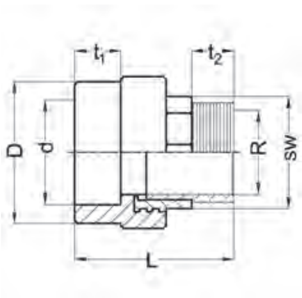


Transition hexagon male

PP-R/brass
SDR 6
green

dxR	Code		L	t_1	t_2	D	SW	kg
32x 1"	**5155 29204**		79	18	20	53	32	0,240
40x1¼"	**5155 29205**		80	20	21	67	44	0,438
50x1½"	**5155 29206**		85	24	21	74	48	0,498
63x 2"	**5155 29207**		95	28	24	90	60	0,711
75x2½"	**5155 29208**		110	31	24	98	65	1,033
90x 3"	**5155 29209**		128	36	29	120	86	1,437
110x 3"	**5155 29210**		128	42	29	147	86	1,643
110x 4"	**5155 29211**		140	42	30	148	105	2,770
125x 5"	**5155 29213**	1)	170	40	42	208	149	5,250

1) PP-RCT



Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

wefatherm

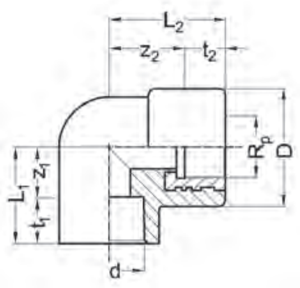
PP-R pipe system d20-315 mm

Transition elbow 90° female

PP-R/brass
SDR 6
green

dxR_p	Code	D	L_1	t_1	z_1	t_2	Z_2	L_2	kg
20x½"	**5155 28301**	40	33	15	18	17	22	39	0,084
20x¾"	**5155 28302**	44	33	15	18	17	22	39	0,110
25x½"	**5155 28303**	40	33	16	17	17	22	39	0,088
25x¾"	**5155 28304**	44	33	16	17	17	22	59	0,107
32x¾"	**5155 28305**	44	31	18	13	17	33	50	0,118
32x 1"	**5155 28306**	60	31	18	13	22	42	64	0,266

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

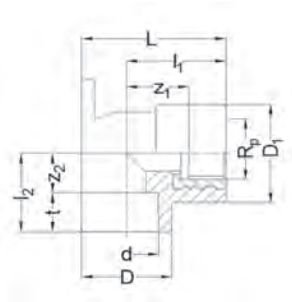


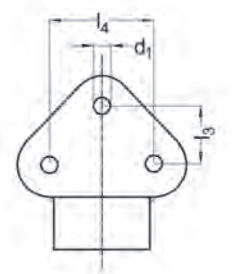
Back plate elbow female

PP-R/brass
SDR 6
green

dxR_p	Code	D	D_1	d_1	L	l_1	l_2	l_3	l_4	z_1	z_2	t	kg
20x½"	**5155 29002**	30,0	39	5,5	53,0	38,0	32	19,5	40	24,0	17,5	14	0,090
20x¾"	**5155 29003**	34,0	44	5,5	57,5	40,5	32	19,5	40	26,5	17,5	14	0,116
25x½"	**5155 29004**	34,0	40	5,5	54,5	37,5	32	19,5	40	23,5	16,0	15	0,095
25x¾"	**5155 29005**	34,5	44	5,5	57,5	40,3	32	19,5	40	26,5	16,0	15	0,013

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.





wefatherm

PP-R pipe system d20-315 mm

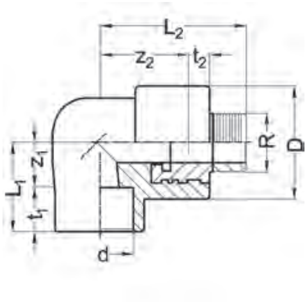
Transition elbow 90° male

PP-R/brass
SDR 6
green

dxR	Code	D	L_1	t_1	z_1	t_2	Z_2	L_2	kg
20x½"	**5155 28401**	40	32	15	17	12	41	53	0,117
20x¾"	**5155 28402**	44	32	15	17	15	43	58	0,175
25x½"	**5155 28403**	40	32	16	16	12	41	53	0,114
25x¾"	**5155 28404**	44	32	16	16	15	43	58	0,173
32x¾"	**5155 28405**	44	30	18	12	15	52	67	0,179
32x 1"	**5155 28406** [1]	54	32	18	14	20	64	84	0,400

[1] *with hexagon for wrench*

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.



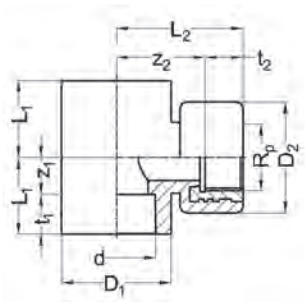
Transition tee female

PP-R/brass
SDR 6
green

dxR_p	Code	L_1	t_1	z_1	L_2	t_2	Z_2	D_1	D_2	kg
20x½"	**5155 29301**	64	15	17	37	15	22	30	38	0,087
20x¾"	**5155 29302**	79	15	24	37	15	22	34	46	0,129
25x½"	**5155 29303**	65	16	16	38	15	23	34	38	0,098
25x¾"	**5155 29304**	79	16	24	37	15	22	34	46	0,120
32x¾"	**5155 29305**	60	18	12	50	15	35	44	44	0,127
32x 1"	**5155 29306** [1]	62	18	13	65	22	43	44	60	0,278

[1] *with hexagon for wrench*

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

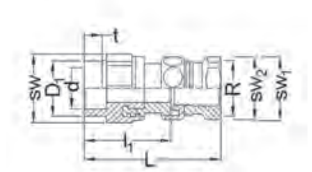


Pipe union brass female

PP-R/brass
SDR 6
green

dxR	Code		G	D_1	L	l_1	SW	SW_1	SW_2	t	kg
20x ½"	**5155 29601**		¾	29	85	56	36	30	27	14	0,179
20x ¾"	**5155 29602**		1	29	93	62	44	37	34	14	0,289
25x ½"	**5155 29603**		¾	34	87	57	36	30	27	15	0,202
25x ¾"	**5155 29604**		1	34	95	62	44	37	34	15	0,306
32x 1"	**5155 29605**		1¼	43	103	67	51	46	44	17	0,469
32x ¾"	**5155 29606**		1	43	97	62	44	37	34	17	0,298
40x1¼"	**5155 29607**		1½	52	115	77	63	52	50	18	0,647
50x1½"	**5155 29608**		1¾	64	126	85	70	59	55	20	0,774
63x 2"	**5155 29609**		$2\frac{3}{8}$	79	142	91	85	74	70	26	1,298
75x2½"	**5155 29610**	1)	2¾	99	169	112	113	90	90	29	2,400

1) PP-RCT



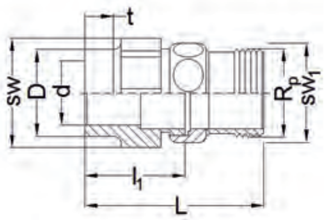
Thread according to EN 10226 (ISO 7).
Flat sealed. Connection for metal thread.

Pipe union brass male

PP-R/brass
SDR 6
green

dxR_p	Code		G	D	L	l_1	SW	SW_1	t	kg
20x ½"	**5155 29701**		¾	29	79	65	36	30	14	0,164
20x ¾"	**5155 29702**		¾	29	86	72	44	37	14	0,273
25x ½"	**5155 29703**		1	34	81	65	36	30	15	0,156
25x ¾"	**5155 29704**		¾	34	83	72	44	37	15	0,278
32x 1"	**5155 29705**		1	43	98	80	51	46	17	0,417
32x ¾"	**5155 29706**		1	43	81	63	44	37	17	0,262
40x1¼"	**5155 29707**		1½	52	113	92	63	52	18	0,584
50x1½"	**5155 29708**		1¾	64	119	96	70	59	20	0,727
63x 2"	**5155 29709**		$2\frac{3}{8}$	79	137	109	85	74	26	1,275
75x2½"	**5155 29710**	1)	2¾	99	175	145	113	90	29	2,290

1) PP-RCT



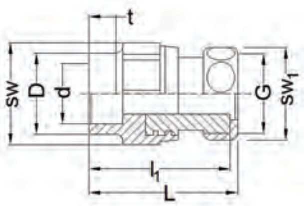
Thread according to EN 10226 (ISO 7).
Flat sealed. Connection for metal thread.
For sealing we recommend PTFE tape.

PP-R pipe system d20-315 mm

Pipe connection brass nut female

PP-R/brass
SDR 6
green

dxG	Code	D	L	l_1	SW	SW_1	t	kg
20x ¾"	**5155 29801**	29	66	44	36	30	14	0,130
20x 1"	**5155 29802**	29	68	44	44	37	14	0,234
25x ¾"	**5155 29803**	34	67	44	36	30	15	0,128
25x 1"	**5155 29804**	34	72	47	44	37	15	0,218
32x 1"	**5155 29805**	43	80	53	44	37	17	0,191
32x1¼"	**5155 29806**	43	80	53	51	46	17	0,398
40x1½"	**5155 29807**	52	90	58	63	52	18	0,477
50x1¾"	**5155 29808**	64	98	61	70	59	20	0,558
63x2$^3/_8$"	**5155 29809**	79	114	71	85	74	26	0,926
75x2$^3/_8$"	**5155 29810**	99	131	86	113	90	29	1,954

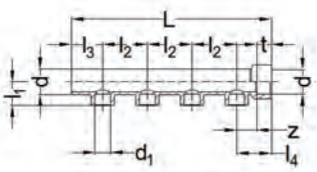


For the connection to ancillary equipment such as water meters.
Thread according to ISO 228-1.

Distributor manifold 4x

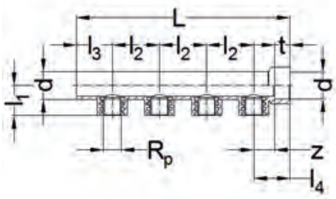
PP-R
SDR 6
green

dxd_1	Code	Z	L	l_1	l_2	l_3	l_4	t	kg
32/20	**5155 20602**	18	246	30	43	37	56	17	0,100



Distributor manifold 4x female

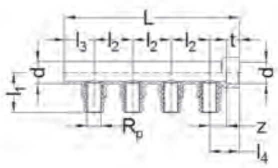
PP-R/brass
SDR 6
green



dxRp	Code	Z	L	l_1	l_2	l_3	l_4	t	kg
32/½"	**5155 20604**	18,0	250	35	43	41	56	17	0,341
40/½"	**5155 20606**	20,5	250	38	43	41	56	18	0,396

Distributor manifold 4x male

PP-R/brass
SDR 6
green

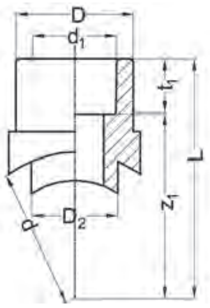


dxR	Code	Z	Z_1	L	l_1	l_2	l_3	l_4	t	kg
32/½"	**5155 20608**	18,0	15	250	50	43	41	56	17	0,413
40/½"	**5155 20610**	20,5	15	250	50	43	41	56	18	0,495

PP-R pipe system d20-315 mm

Weld-in saddle PP-R

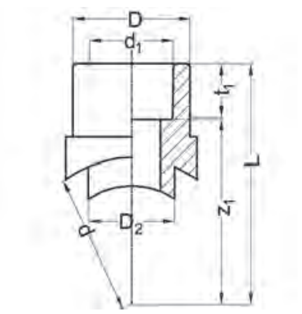
PP-R
SDR 6
green



d/d_1	Code	D	D_2	t_1	z_1	L	kg
40/20	**5155 28052**	38	25	15	32	47	0,018
40/25	**5155 28053**	38	25	16	31	47	0,019
50/20	**5155 28054**	38	25	15	37	52	0,017
50/25	**5155 28055**	36	25	16	38	54	0,020
63/20	**5155 28056**	38	25	15	44	59	0,017
63/25	**5155 28057**	38	25	16	43	59	0,018
75/20	**5155 28058**	36	25	15	51	66	0,024
75/25	**5155 28059**	36	25	16	50	66	0,021
90/20	**5155 28060**	36	25	15	58	73	0,024
90/25	**5155 28061**	36	25	16	57	73	0,021
110/20	**5155 28062**	36	25	15	68	83	0,024
110/25	**5155 28063**	36	25	16	67	83	0,021
125/20	**5155 28064**	38	25	15	75	90	0,018
125/25	**5155 28065**	38	25	16	55	71	0,019
125/32	**5155 28066**	51	32	20	9	90	0,035

Weld-in saddle PP-RCT

PP-RCT
SDR 6
green



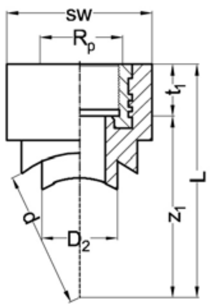
d/d_1	Code	D	D_2	t_1	z_1	L	SW	kg
40- 63/32	**5152 43007**	51	32	20	9	-	-	0,021
75-125/32	**5152 43010**	51	32	20	9	-	51	0,035
75-125/40	**5152 43011**	63	40	22	16	-	63	0,083
110-125/50	**5152 43018**	70	50	25	14	-	70	0,098
125/63	**5152 43024**	85	63	30	15	-	85	0,163
160-250/20	**5152 43026**	38	16	29	13	-	38	0,027
160-250/25	**5152 43027**	38	18	29	11	-	38	0,024
160-250/32	**5152 43028**	51	20	35	15	-	51	0,037
160-250/40	**5152 43029**	63	22	38	16	-	63	0,082
160-250/50	**5152 43030**	70	25	39	14	-	70	0,097
160-250/63	**5152 43031**	85	30	45	15	-	85	0,162
315/20	**5152 43037**	38	16	29	13	-	38	0,077
315/25	**5152 43038**	38	18	29	11	-	38	0,074
315/32	**5152 43039**	51	20	35	15	-	51	0,086
315/40	**5152 43040**	63	22	38	16	-	63	0,093
315/50	**5152 43041**	70	25	39	14	-	70	0,097
315/63	**5152 43042**	85	30	45	15	-	85	0,161

wefatherm

PP-R pipe system d20-315 mm

Weld-in saddle female PP-R

PP-R/brass
SDR 6
green

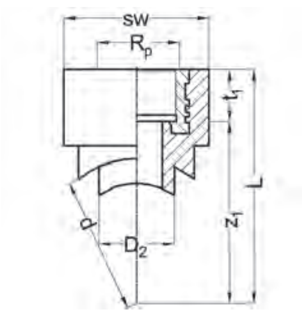


dxR$_p$	Code	D_2	t_1	z_1	L	SW	kg
40x ½"	**5155 28071**	25	15	35	50	38	0,067
50x ½"	**5155 28072**	25	15	34	49	46	0,067
63x ½"	**5155 28073**	25	15	39	54	38	0,068
75x ½"	**5155 28074**	25	15	39	54	46	0,066
90x ½"	**5155 28075**	25	15	45	60	38	0,061
110x ½"	**5155 28076**	25	15	46	61	46	0,070
125x ½"	**5155 28077**	25	15	52	67	38	0,070
40x ¾"	**5155 28171**	25	15	59	74	38	0,094
50x ¾"	**5155 28172**	25	15	59	74	46	0,096
63x ¾"	**5155 28173**	25	15	69	84	36	0,094
75x ¾"	**5155 28174**	25	15	69	84	46	0,094
90x ¾"	**5155 28175**	25	15	77	92	38	0,095
110x ¾"	**5155 28176**	25	15	77	92	46	0,095
125x ¾"	**5155 28177**	25	15	52	67	46	0,096

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

Weld-in saddle female PP-RCT

PP-RCT/brass
SDR 6
green



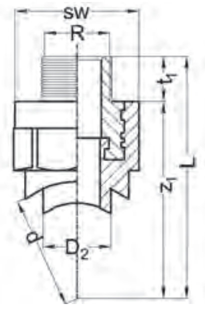
dxR_p	Code	D_2	t_1	z_1	h	L	SW	kg
75-125x 1"	**5152 43110**	40	22	16	63	-	38	0,104
75-125x1¼"	**5152 43111**	50	22	17	63	-	39	0,247
110-125x1½"	**5152 43118**	50	20	19	70	-	39	0,292
125x 2"	**5152 43124**	63	25	20	85	-	45	0,485
160-250x ½"	**5152 43126**	25	17	12	29	-	38	0,071
160-250x ¾"	**5152 43127**	32	17	12	29	-	38	0,112
160-250x 1"	**5152 43128**	40	22	16	38		63	0,197
160-250x1¼"	**5152 43129**	50	22	17	39	-	70	0,243
160-250x1½"	**5152 43130**	50	20	19	39	-	70	0,240
160-250x 2"	**5152 43131**	63	25	20	45	-	85	0,490
315x ½"	**5152 43137**	25	17	12	29	-	38	0,121
315x ¾"	**5152 43138**	32	17	12	29	-	38	0,162
315x 1"	**5152 43139**	40	22	16	38	-	63	0,240
315x1¼"	**5152 43140**	50	22	17	39	-	70	0,247
315x1½"	**5152 43141**	50	20	19	39	-	70	0,242
315x 2"	**5152 43142**	63	25	20	45	-	85	0,484

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

PP-R pipe system d20-315 mm

Weld-in saddle male PP-R

PP-R/brass
SDR 6
green

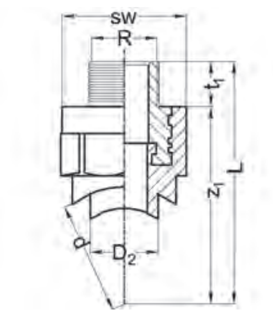


dxR	Code	D_2	t_1	z_1	L	SW	kg
40x ½"	**5155 28081**	25	13	49	62	38	0,085
50x ½"	**5155 28082**	25	17	49	66	46	0,091
63x ½"	**5155 28083**	25	13	54	67	38	0,083
75x ½"	**5155 28084**	25	17	54	71	46	0,083
90x ½"	**5155 28085**	25	13	61	74	38	0,083
110x ½"	**5155 28086**	25	17	60	77	46	0,084
125x ½"	**5155 28087**	25	13	66	79	38	0,096
40x ¾"	**5155 28181**	25	17	66	83	46	0,160
50x ¾"	**5155 28182**	25	13	74	87	36	0,158
63x ¾"	**5155 28183**	25	17	74	91	46	0,159
75x ¾"	**5155 28184**	25	13	83	96	36	0,159
90x ¾"	**5155 28185**	25	17	84	101	46	0,161
110x ¾"	**5155 28186**	25	13	92	105	38	0,158
125x ¾"	**5155 28187**	25	17	91	108	46	0,159

Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

Weld-in saddle male PP-RCT

PP-RCT/brass
SDR 6
green



dxR	Code	D_2	t_1	z_1	h	SW	kg
75-125x 1"	**5152 43210**	40	20	18	63	38	0,197
75-125x1¼"	**5152 43211**	40	21	17	63	38	0,468
110-125x1½"	**5152 43218**	50	21	18	70	39	0,553
125x 2"	**5152 43224**	63	24	21	85	45	0,919
160-250x ½"	**5152 43226**	25	13	20	43	38	0,091
160-250x ¾"	**5152 43227**	32	17	26	43	38	0,133
160-250x 1"	**5152 43228**	40	20	36	56	63	0,234
160-250x1¼"	**5152 43229**	50	21	38	59	70	0,334
160-250x1½"	**5152 43230**	50	21	38	59	70	0,353
160-250x 2"	**5152 43231**	63	24	46	70	85	0,633
315x ½"	**5152 43237**	25	13	20	43	38	0,141
315x ¾"	**5152 43238**	32	17	26	43	38	0,183
315x 1"	**5152 43239**	40	20	36	56	63	0,239
315x1¼"	**5152 43240**	50	21	38	59	70	0,342
315x1½"	**5152 43241**	50	21	38	59	70	0,353
315x 2"	**5152 43242**	63	24	46	70	85	0,648

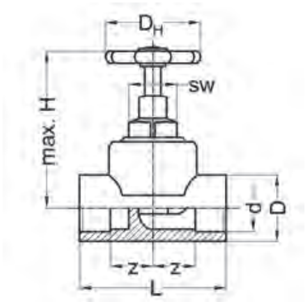
Thread according to EN 10226 (ISO 7).
For sealing we recommend PTFE tape.

PP-R pipe system d20-315 mm

Stop valve surface assembly

PP-R
SDR 6
for surface installation
green

d	Code	L	z	D	H	D_H	SW	kg
20	**5155 29500**	79	25	35	55	50	17	0,205
25	**5155 29501**	79	23	35	75	50	17	0,187
32	**5155 29502**	97	30	44	85	50	17	0,319

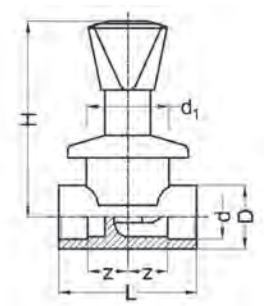


Stop valve concealed assembly

PP-R/chrome plated
SDR 6
for concealed installation
green

d	Code	L	z	D	H	d_1	kg
20	**5155 29510**	79	25	35	90	25	0,382
25	**5155 29511**	79	23	35	90	25	0,374
32	**5155 29512**	97	30	44	90	25	0,478

Color coded for hot and cold water.
Rosette d76 mm.



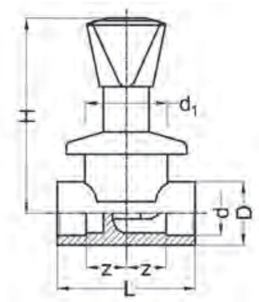
Stop valve concealed assembly - extended PP-R/chrome plated

SDR 6

for concealed installation green

d	Code	L	z	D	H	d_1	kg
20	**5155 29525**	79	25	35	100	25	0,382
25	**5155 29526**	79	23	35	100	25	0,374
32	**5155 29527**	97	30	44	100	25	0,478

Color coded for hot and cold water.
Rosette d76 mm.



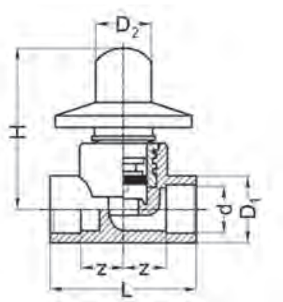
Stop valve concealed assembly (tamper resistant) PP-R/chrome plated

SDR 6

for concealed installation green

d	Code	L	z	D_1	H	D_2	kg
20	**5155 29515**	79	25	35	72	28	0,288
25	**5155 29516**	79	23	35	72	28	0,281
32	**5155 29517**	97	30	35	72	28	0,281

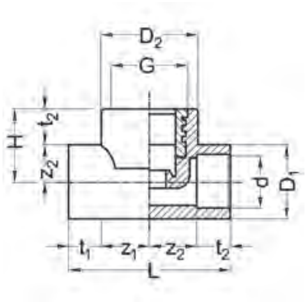
For use in public accessible areas.
Rosette 76 mm.



PP-R pipe system d20-315 mm

Stop valve body

PP-R
SDR 6
green

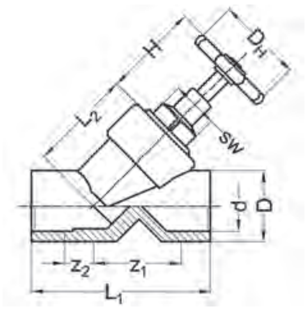


dxG	Code	D_1	D_2	L	t_1	z_1	z_2	t_2	H	kg
20x¾"	**5155 29530**	35	45	79	16	25	23	16	28	0,097
25x¾"	**5155 29531**	35	45	79	16	23	23	16	28	0,099
32x 1"	**5155 29532**	44	53	97	18	30	30	18	33	0,143

Thread according to ISO 10226.

Y-valve

PP-R
SDR 6
green



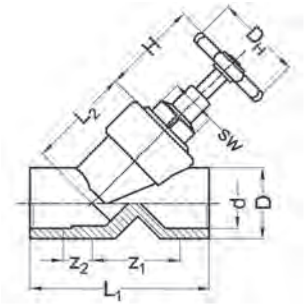
d	Code	L_1	z_1	z_2	L_2	H	SW	D_H	kg
25	**5155 29540**	85	75	28	55	55	28	60	0,268
32	**5155 29541**	94	60	34	64	55	28	60	0,540
40	**5155 29542**	113	90	40	77	55	28	60	0,773

Y-valve KFR
with integrated non return valve

PP-R
SDR 6
green

d	Code	L_1	z_1	z_2	L_2	H	SW	D_H	kg
25	**5155 29550**	85	75	28	55	55	28	60	0,264
32	**5155 29551**	94	60	34	64	55	28	60	0,526
40	**5155 29552**	113	90	40	77	55	28	60	0,746

Prevents water to flow back into the supply system.
'KFR' is the abbreviation of: Combined Free-flow valve with integrated backflow preventer.
Without outflow.

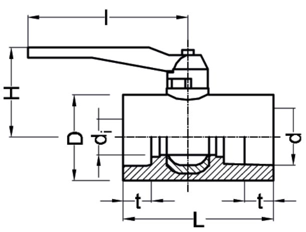


Ball valve

PP-R
SDR 6
green

d	Code	L	t	H	l	d_i	kg
20	**5155 25580**	68	15	60	102	15	0,116
25	**5155 25581**	70	16	60	102	15	0,134
32	**5155 25582**	80	18	63	102	20	0,188
40	**5155 25583**	95	21	78	120	25	0,346
50	**5155 25584**	110	24	83	120	32	0,513
63	**5155 25585**	130	28	103	145	40	0,937
75	**5155 25586**	150	31	111	145	50	1,417

Handle: glass fiber reinforced polyamide PA6.
Ball and stem: brass.
PTFE seats, NBR O-ring.
Range: >0°C - 75°C.



Complementary products

Extension 95 mm chromium plated
for concealed valves

Code	l	d	kg
5150 29520	95	24	0,139

Fits on code 5155 29510, 5155 29511, 5155 29512.

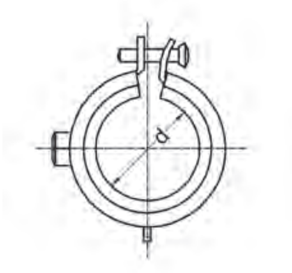
Extenstion set 30 mm brass
for concealed valves

Code		L	kg
5150 29521	1)	30	0,043
5150 29522	2)	30	0,043

1) *for tamper resistant concealed stop valve code 5155 29515 and 5155 29516*

2) *for concealed stop valves with ¾" thread, code 5155 29510, 5155 29511, 5155 29525 and 5155 29526*

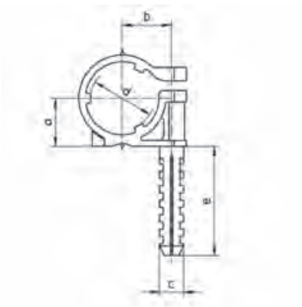
Pipe clamp
for sliding and fixed position mounting



d	Code	kg
20	**5150 34201**	0,047
25	**5150 34202**	0,051
32	**5150 34203**	0,058
40	**5150 34204**	0,068
50	**5150 34205**	0,076
63	**5150 34206**	0,091
75	**5150 34207**	0,228
90	**5150 34208**	0,281
110	**5150 34209**	0,360
125	**5150 34210**	0,413

Complementary products

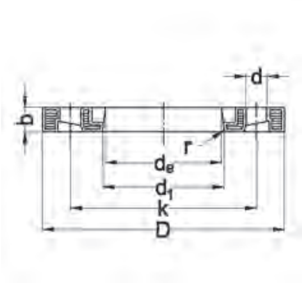
Pipe clip



d	Code	a	b	c	d	e	kg
20	**5155 34401**	16	16,3	8	21	36	0,007
25	**5155 34402**	20	20,4	10	26	45	0,014
32	**5155 34403**	25	25,5	10	33	45	0,022

Profile backing ring PP d32-125

EN 1092 - PN10 bolt hole pattern
for flange sleeve (socket-welding connection)



d_e/DN	Code		bar	d_1	D	k	b	d	n	M	r	kg
32/40	**5150 28040**		16	42	122	85	17	14	4	M12	3	0,4
40/50	**5150 28041**		16	51	142	100	17	18	4	M16	3	0,5
50/40	**5150 28042**		16	62	156	110	19	18	4	M16	3	0,7
63/50	**5150 28043**		16	78	171	125	20	18	4	M16	3	0,9
75/65	**5150 28044**		16	92	191	145	21	18	4	M16	3	1,0
90/80	**5150 28045**		16	110	206	160	21	18	8	M16	3	1,2
110/100	**5150 28046**		16	133	226	180	22	18	8	M16	3	1,5
125/100	**5150 28047**	1)	16	149	220	180	18	18	8	M16	3	1,2

1) *variant with flat design*

With ductile iron core.
n = number of bolts.
bar = maximum operating pressure.
"EN 1092 - PN10" refers to the bolt hole pattern, not to the pressure class of the backing ring.

Complementary products

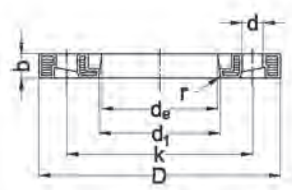
Profile backing ring PP d160-315

EN 1092 - PN10 bolt hole pattern
for stub flange (butt-welding connection)

d_e/DN	Code	bar	d_1	D	k	b	d	n	M	r	kg
160/150	**5152 52016** 1)	16	178	296	240	28	22	8	M20	3	1,800
200/200	**5152 52020**	16	235	350	295	32	22	8	M20	4	3,100
250/250	**5152 52025**	16	288	412	350	36	22	12	M20	4	4,900
315/300	**5152 52031**	16	338	462	400	42	22	12	M20	4	6,400

1) *PN16/PN10 bore*

With ductile iron core.
n = number of bolts.
bar = maximum operating pressure.
"EN 1092 - PN10" refers to the bolt hole pattern, not to the pressure class of the backing ring.

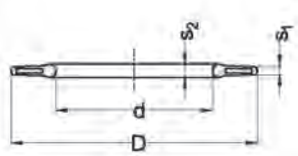


Profile gasket EPDM

with steel core
for stub flanges SDR 11

d_e/DN	Code	d	D	s_1	s_2	kg
160/150	**5152 52216**	135	218	6	8	0,150
200/200	**5152 52220**	168	273	6	8	0,200
250/250	**5152 52225**	208	328	6	8	0,250
315/300	**5152 52231**	262	378	6	8	0,300

Suitable for flange connections with maximum operating pressure water 16 bar.
With KTW-certification for potable water application.



Complementary products

Pin for pipe repair

PP-R

green

d	Code	kg
7/11	**5155 28030**	0,004

To repair point damage.

Cavity wall disk

PP-R/brass

green

d	Code	kg
½"	**5150 35000**	0,124

Mounting plate

galvanized steel

Code	kg
5150 34000	0,276

Complementary products

Plug
for pressure test
1x male

d	Code	Colour	kg
½"	**5150 36100**	red	0,016
½"	**5150 36101**	blue	0,016

Welding tool
for butt-welding

d	Code	kg
20	5150 30002	0,096
25	5150 30003	0,129
32	5150 30004	0,198
40	5150 30005	0,305
50	5150 30006	0,420
63	5150 30007	0,592
75	5150 30008	0,844
90	5150 30009	1,338
110	5150 30010	2,042
125	5150 30011	2,680

Welding tool for weld-in saddles
for weld-in saddles

d	Code	kg
40/25	5150 30051	0,182
50/25	5150 30052	0,216
63/25	5150 30053	0,237
75/25	5150 30054	0,244
90/25	5150 30055	0,246
110/25	5150 30056	0,249
125/25	5150 30057	0,251
40- 63/32	5150 30058	0,250
75-125/32	5150 30059	0,410
75-125/40	5150 30060	0,360
75-125/50	5150 30061	0,648
125/63	5150 30062	1,046
160-250/25	5150 30065	0,226
160-250/32	5150 30066	0,226
160-250/40	5150 30067	0,358
160-250/50	5150 30068	0,625
160-250/63	5150 30069	1,044
315/25	5150 30165	0,150
315/32	5150 30166	0,200
315/40	5150 30167	0,354
315/50	5150 30168	0,652
315/63	5150 30169	1,100

Complementary products

Welding tool for repair pin
for pin for pipe repair

d	Code	kg
7	**5150 30080**	0,095
11	**5150 30081**	0,098

Drill 25 mm
for weld-in saddles

d	Code	kg
25	**5150 30070**	0,119
32	**5150 30071**	0,180
40	**5150 30072**	0,280
50	**5150 30073**	0,380
63	**5150 30074**	0,535

Chamfering device
for weld-in saddles on pipe stabi

d	Code	kg
25	**5150 30075**	0,211

Peeling tool for pipe stabi - manual

d	Code	kg
20+25	5150 34101	0,388
32+40	5150 34102	0,547
50+63	5150 34103	1,345
75	5150 34104	1,051
90	5150 34105	0,930
110	5150 34106	1,699

Peeling tool for pipe stabi - mechanical

for use with drilling machine

d	Code	kg
20	5150 35101	0,187
25	5150 35102	0,222
32	5150 35103	0,295

Adjustable peeling depth for electrofusion joint.

Profi-cut pipe cutter 0-42 mm

d	Code	kg
0-42	5150 32002	0,408

Plastic pipe cutter for PP-R, PE, PB and PE-X pipes.

Complementary products

Pipe cutter 50-110 mm

d	Code	kg
50-110	**5150 32010**	1,370

Plastic pipe cutter for PP-R, PE, PB and PE-X pipes.

Manual welding device d16-25

d	Code	kg
16-25	**5150 31002**	5,800

For one tool.
With holder and case.

Manual welding device d16-63

d	Code	kg
16-63	**5150 31000**	6,540

For two tools.
With holder and case.

Complementary products

Manual welding device d16-125

d	Code	kg
16-125	**5150 31005**	12,940

For five tools.
With holder and case.

Socket welding machine d25-125

d	Code	kg
25-125	**5150 31003**	76,800

Welding jig d63-125

d	Code	kg
63-125	**5150 31006**	18,900

For the mechanical insertion of the pipe in the socket.
Battery-operated.

Complementary products

Welding jig stand
for welding jig

Code	kg
5150 31007	6,540

Butt-welding machine d160-315

d	Code	kg
160-315	**5150 31004**	76,800

Electrofusion welding machine
Universal electrofusion welding machine

Code	kg
5150 31011	11,000

- For diameter d20-d315.
- Robust plastic housing IP 54, insulation class II.
- Mains cable 5 m/4 m fusion cable with socket contacts 4,0 mm.
- Reader wand for barcode reading.
- Welding voltage up to 48 V DC.

Delivered in practical aluminum transport box.

Complementary products

Pipe scraper set

d	Code	kg
20-225	**5150 31020**	1,500

For safe removal of oxide skin on PP-R pipes.
Peeling knife made of hard metal.
Including spare peeling knife and oil maintenance spray.

Scraper - manual

Code	kg
5150 31030	0,300

For removal of oxide skin on PP-R pipes.

Spare blades

Code	For	kg
5150 35110	mechanical peeling tool pipe stabi	0,004
5150 38001	manual peeling tool pipe stabi	0,002

Complementary products

Depth gauge

Code	kg
5199 99971	0,010

8 Transport and storage

8.1 Packaging

8.1.1 Pipes

Pipes are packed in bundles, bundles are packed in foil. Pipes can be identified by the marking on the pipe.

8.1.2. Fittings

Fittings are packed in plastic bags, plastic bags are packed in carton boxes:

Carton box	Box dimensions LxBxH (cm)	Boxes/pallet
1	40x30x22	40
2	30x20x22	80

Table 8.1

Fittings can be identified by inscription on the fitting (larger items) or by the code on the plastic bag (smaller items).

Illustration 8.1

8.2 Handling

Thanks to the material properties of polypropylene, the pipes and fittings can be stored for a long time under variating temperatures. The storage of pipes and fittings must be in accordance with the following conditions:

1. The pipes should be supported along their full length.
2. Bending of the pipes is to be avoided.
3. The material becomes sensitive to impact at low temperatures and in particular at temperatures below 0°C. For this reason knocks and similar impacts are to be avoided under these conditions.
4. High-polymer materials are sensitive to UV radiation. For this reason the Wefatherm material should also be protected against the effects of UV radiation.

Suggestions for the correct treatment of pipe systems

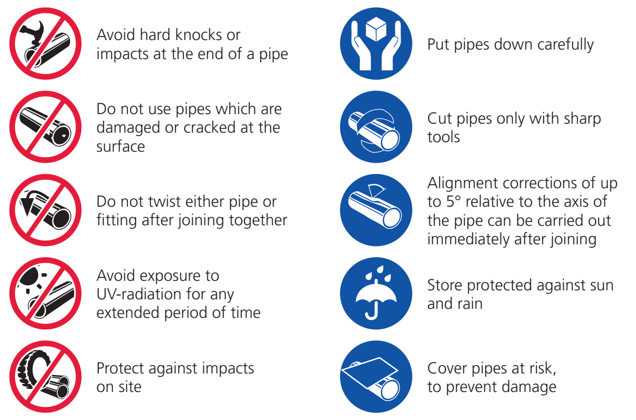


Illustration 8.3

8.3 Dispose of waste materials

Dispose waste material separated according to the regulations.
PP pipes and fittings are recyclable.

Transition fittings	Recyclable, after separation of PP and brass
Gaskets	general waste
Cardboard boxes	recyclable
Plastic bags	recyclable
Chips	general waste
Wipes general	waste

Table 8.2

International regulation on drinking water for human consumption prevents to apply recycled material in the production process for water supply systems.

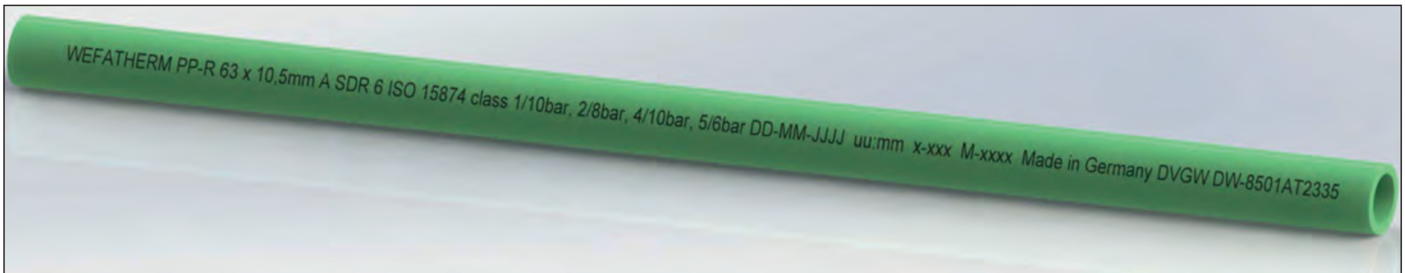


Illustration 8.2 Pipe marking example

Transport and storage

9 Jointing techniques

9.1 Health and safety regulations

> There is always a certain risk of injury when operating with plastic pipe welding machines. Observation of the following accident prevention regulations reduces this danger to a minimum. Non-observation of them can lead to accidents!

1. Dirty and untidy workplaces increase the chances of accidents.
2. Ambient surroundings: protect electrical tools from rain and drips. Do not use them in wet or moist rooms. Keep onlookers and visitors away from the places where welding is carried out (safety distance).
3. Storage: store machines and devices under dry conditions and secured against unauthorized access.
4. Working clothing: wear tightly fitting clothing and no rings or jewellery when working: loose clothing and rings or jewellery could be caught by moving parts.
5. Electrical parts: before connecting a device to the mains, check that it is switched off. Always pull out the plug before carrying repairs. Replace damaged or brittle connection cables and pull reliefs immediately. Protect cables from heat and sharp edges. Never pull plugs out of the socket by pulling on the cable. Never carry a device by the cable.
6. Workpieces: ensure that the pipe and fitting are always located firmly in the clamping devices.
7. Danger of injury: beware of squashing when closing the clamps.
8. Danger of burning: the metal parts on the heating element will have temperatures up to 300°C. Take precautions so that it is not possible to touch them. Keep inflammable materials at a safe distance away.
9. Spare parts: replace damaged parts immediately. Protect electrical parts carefully. Dirt and moisture are very good electrical conductors. Use only original spare parts. Always state the machine number and version number when ordering spare parts.

Preparations
Use only Wefatherm tools for welding of the Wefatherm pipe system. Before starting the assembly check the welding tools for impurities. If necessary clean tools with absorbent, lint-free and non-dyed paper and PP cleaner. Replace worn out and damaged parts, specially tools with damaged coating.

Safety instruction
The general industrial hygiene and accident prevention regulations of the particular country or state in which the device is to be used, are to be observed.

 Wear suitable work clothing

 Wear a safety helmet

 Wear safety shoes

 Wear safety glasses

 Wear hearing protection

 Improper use can cause severe cuts, bruising or dismemberment

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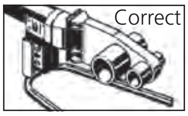
Jointing techniques

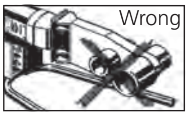
9.2 Socket welding

9.2.1 Socket welding - manual
This jointing technique is suitable for d16-63 mm.
The described process is according guideline DVS 2207 Part 11.

Welding device



1. Tighten up in cold condition the threaded inserts for holding the tools and clean with absorbent, lint-free and non-dyed paper. Screw on the tools hand tight. They may not extend beyond the edge of the tongue!



2. Switch on the device. The thermostat lamp and control lamp must light up. Set the thermostat to **260°C**. The heating-up process is completed when the thermostat lamp switches off.
3. Tighten up the tools once again with the Allen wrench. Never use pliers to avoid damage of the coating.
4. The welding tools have to be mounted according to the diameters so that the edges do not loom over the heating device. Tools from d40 mm are always to be installed at the back hole.
5. Plug in the welding device and check if the green operating lamp is switched on. The warm-up phase takes between 5 and 20 minutes, depending on the environment temperature. The welding device is operational as the orange lamp is switched on.

6. After the device has been switched off, wait until it has cooled down. Never cool down the device with water! It causes danger of injury! Electronic parts such as the thermostat could be damaged. Remove contamination with absorbent, lint-free and nondyed paper and PP cleaner.
7. The device may only be used when it is in a dry state. It must be stored in dry and dust-free conditions.
8. Proper functioning of the device can only be guaranteed when the tongue and tools are in perfect condition. Defective or contaminated parts must always be replaced.

Pipe outside diameter (mm)	Welding depth (mm)	Heating-up time (sec)	Processing time (sec)	Cooling-down time (mm)
16	13	5	4	2
20	14	5	4	2
25	15	7	4	2
32	17	8	6	4
40	18	12	6	4
50	20	18	6	4
63	26	24	8	6
75	29	30	8	8
90	32	40	8	8
110	35	50	8	8
125	41	60	10	8

Table 9.1 General guideline of socket welding DVS 2207 Part 11

If welding is to be carried out outdoors when the temperature is below + 5°C, the heating-up time in accordance with DVS 2207 Part 11 should be increased by 50%.

Socket welding - manual process

1. Prepare the welding device according to the device manual.
2. Cut the pipe square. Use the pipe shear or pipe cutter for plastic pipes.
3. Deburr the pipe and remove the cutting chips.

4. Mark the insertion depth with a gauge on the pipe.
5. Align the position of the fitting with the aid of the auxiliary marking on the fitting and the continuous line on the pipe.
6. For stabi pipes remove the aluminium cover with the peeling tool up to the insertion depth. Use only original Wefatherm peeling devices with sharp blades. Replace blunt peeling blades!

7. Insert simultaneous, without turning, the pipe end into the heating sleeve up to the marking of the insertion depth and the fitting onto the mandrel up to the stop. Observe the heating-up time mentioned in table. Timing for heating-up time starts when the full insertion depth of the pipe is reached and fitting is pushed against the stop.

8. At the end of the heating-up time, draw the pipe and fitting rapidly from the sleeve and mandrel and push them immediately together up to the point that the insertion depth marking is covered by the bead that has been formed. Do not insert the pipe too far into the fitting to prevent the internal diameter of the pipe being reduced. Do not rotate the pipe and fitting relative to each other.
9. During the processing time keep the pipe and fitting in fixed position relative to each other. The parts can still be aligned relative to each other during this phase but may not be rotated relative to each other! After completion of the cooling time the joint can be fully loaded. This welding joint is an inseparable joint, the material of the fitting and pipe have melted together.

9.2.2 Socket welding - mechanical

This jointing technique is suitable for d75-125 mm.
The described process is according guidelines DVS 2207 Part 11.

Welding device

The axial movements are brought about by a transport wheel and a toothed rod. V-shaped clamping tools of hardened steel are for holding the components independently of their external diameter. Two V-shaped clamps for pipe fixation and a single one with insert stop are for fitting fixation. The two tool carriages can be aligned axially. The insertion depth is limited by a stop. The electronically controlled heating plate can be swung into the machine.

Illustration 9.1

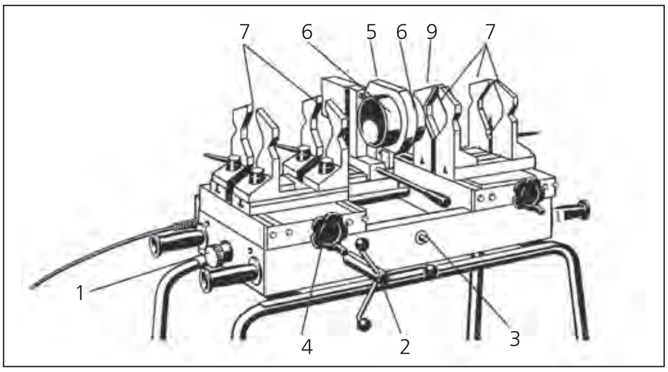


Illustration 9.2

Setting up the welding machine

1. Remove the machine and accessories from the transport case and place the machine on a suitable non-slip base. Clamp it if necessary.
2. Slide heating plate *(5)* into the guide.
3. Fold welding plate *(5)* between the clamping tools *(7)* and adjust if necessary.

Aligning the welding machine

4. Select a heating mandrel *(6)* and a heating sleeve *(6)* in accordance with the dimensions of the pipe and fitting and fit them on the plate (heating mandrel on the right, heating sleeve on the left).
5. Unscrew the clamping tools *(7)* in accordance with the diameter of the pipe and fitting.
6. Clean tools, pipe and fitting on the inside and outside with lint-free and non-dyed paper and PP cleaner.
7. Heat up the welding reflector and set the welding temperature at 260°C according the manual. The processing temperature has been reached and the device is ready for use when the control lamp switches off.

Socket welding - machined process

1. Press the fitting into the clamping tool (number 7) up to the stop *(9)* and clamp firmly.
2. Push the button *(3)*.
3. Move the carriage with hand wheel *(2)* up to the stop *(3)* and secure with the locking screw *(4)*. Position the pipe before the fitting in such a way that its face is in contact with the fitting. Clamp firmly with clamping tools *(7)*.
4. Set the diameter stop *(1)* to the diameter to be processed.
5. Check the welding plate temperature and adjust if necessary.
6. Swing the in welding plate *(5)* between the pipe and fitting.
7. Slide the pipe and fitting at the same time into the heating tools (6) up to the stops and hold in this position for the heating-up time.
8. After the heating-up time has expired, move the carriages rapidly back and swing out the plate *(5)*. Then move up the pipe and press it into the fitting up to the stop and lock it in this position.
9. Remove the welded parts from the machine and align if necessary, but do not rotate them relative to each other! After the cooling-down time has expired, the welded parts can be loaded to pressure.

For the heating-up, processing and cooling-down times see table 9.2.

Maintenance

1. The heating element is operated with 230 V/50 Hz.
2. Keep guide shafts, toothed rods and trapezoidal spindles free of dirt.
3. Clean the heating tools with absorbent, lint-free and non-dyed paper and PP cleaner.
4. Use only original spare parts for repairs.
5. Cover the machine when it is not used.

Pipe outside diameter (mm)	Welding depth (mm)	Heating-up time (sec)	Processing time (sec)	Cooling-down time (mm)
16	13	5	4	2
20	14	5	4	2
25	15	7	4	2
32	17	8	6	4
40	18	12	6	4
50	20	18	6	4
63	26	24	8	6
75	29	30	8	8
90	32	40	8	8
110	35	50	8	8
125	41	60	10	8

Table 9.2 General guideline socket welding DVS 2207 Part 11

If welding is to be carried out outdoors when the temperature is below + 5°C, the heating-up time is accordance with DVS 2207 Part 11 should be increased by 50%.

Jointing techniques

9.2.3 Weld-in saddle welding

The Wefatherm weld-in saddles weld both the pipe outer surface and the wall thickness of the pipe for a reliable joining.

Advantages
- realizing additional tees on distribution lines
- afterwards addition of sensors (thermometer, pressure gauge)
- construction of tees

Weld-in saddles can be used for PP-R and PP-R stabi pipes.

Installation

1. Drill a hole into the pipe with drill Code 5150 30070.

   Notice the depth of the drill.

2. For stabi pipes: remove the rest of the aluminium in the bore hole with chamfering tool Code 5150 30075.

3. Heat up the hole and weld-in saddle simultaneously. The heat up time is 30 sec (temperature 260°C). Heat time starts when full insertion depth of the saddle is reached and the saddle is pushed against the tool.

4. After heating up, remove the welding tool and weld the saddle immediately into the hole. The saddle should be pressed into the pipe for 15 sec. After 10 min of cooling down the weld-in saddle can be used.

9.3 Butt-welding

This jointing technique is suitable for d160-315 mm.
The described process is according guideline DVS 2207 Part11.

Butt-welding is a very economical and reliable jointing technique in which an additional tool is required to create the non-detachable joint. Butt-welding is very well-suited to the pre-fabrication of pipe elements and the construction of special fittings. In butt-welding, the welding surfaces (ends) of the components to be welded are first machined (planed). This produces coplanar ends that can later be simultaneously pressed against the heating element. The welding surfaces are then heated by the heating element (hot plate) and lined up under slight pressure (alignment pressure). Subsequently, heating proceeds under reduced pressure (heating time) and, after removing the heating element (conversion), the joint is formed under welding pressure. Table 9.3 provides a schematic representation of the butt-welding process.

Adjustable heating temperatures can be varied to match wall thickness (see illustration 9.3).

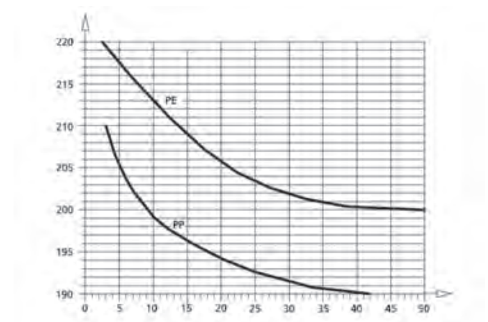
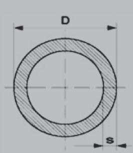


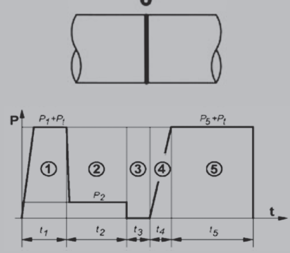
Illustration 9.3 Heating temperature as function of PP pipe wall thickness

The process parameters can be established according this guideline. The calculated pressure needs to be loaded on the butt-weld components. Each butt-welding machine has specific internal friction and machine settings need to be adapted accordingly. The values given in this Specification Manual are specific for the butt-weld machine Ritmo Delta Dragon. When another butt-weld machine (fabricator or type) is applied, the welder needs to respect the specific parameters of this fabricator/type.

Delta 250B
DVS 2207-11 (02/99)
PP



0°



					1		2	3	4	5	
D (mm)	**s (mm)**	**SDR = D/s**	**T (°C)**	***P1 (bar)**	**A**	**P_2 (bar)**	**t_2 (sec)**	**$t_{3\,max}$ (sec)**	**t_4 (sec)**	***P_5 (bar)**	**t_5 (min)**
160	14,6	11	210	7	1,0	1	277	8	13	11	24
160	17,8	9	210	13	1,0	1	315	9	16	13	28
160	21,9	7,4	210	16	1,55	2	359	10	19	16	34
160	26,6	6	210	19	2,0	2	405	11	23	19	41
200	18,4	11	210	18	1,0	2	320	9	16	18	29
200	22,3	9	210	21	1,5	2	363	10	19	21	35
200	27,4	7,4	210	25	2,0	3	411	11	23	25	42
200	33,2	6	210	30	2,0	3	456	13	29	30	50
250	22,7	11	210	28	1,5	3	367	10	20	28	35
250	27,8	9	210	33	2,0	3	414	11	24	33	42
250	34,2	7,4	210	39	2,0	4	463	13	29	39	51

Table 9.3 Add to this value the drag pressure of the welding machine

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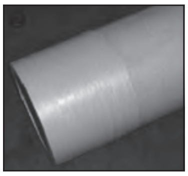
Jointing techniques

9.4 Electrofusion welding

This jointing technique is suitable for d20-315 mm. The described process is according guideline DVS 2207 Part 11.

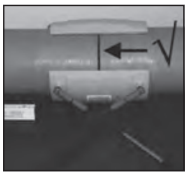
Installation

1. Cut off the end of the pipe square and deburr. Mark the welding depth of the coupler.

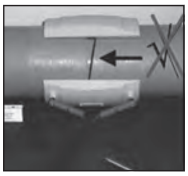


2. Prepare the pipe surface in the welding area. Remove the oxidation layer in the welding area, depth of the coupler + 0,5 cm processing surcharge. Use a rotary scraper tool. Remove the chips without touching the pipe surface.

3. Clean the pipe surface and the inside of the coupler with absorbent, lint-free and nondyed paper. Internal surface of the coupler must not be scraped. The fitting should only be taken out of the protection cover when starting the installation.



4. Slide the coupler onto the pipe, free of tension or stress up to the marking. Control by prior marking. Secure the pipe against dislocation, e.g. with a pipe clamp. Connect the two welding cables to the contact pins of the coupler and start the welding process.



5. Only start the welding process when the position of the pipes in the electrofusion coupler is even.

At the end of the welding cycle wait for the cooling time. After the cooling time you can stress the electrofusion joint to the permissible operating pressure.

d (mm)	Cooling time (min)
16 - 32	10
40 - 63	25
75 - 110	40
125	45
160 - 200	75
250 - 315	100

Table 9.4

9.5 Flange jointing

This paragraph contains a recommendation to ensure a reliable and tight flange joint according to ESA/ESF guideline publication 009/98.

Alignment

1. The sealing faces of the two stub-ends in a joint should contact each other or in case of a rubber joint with gasket, be parallel to each other all around the circumference and in full contact.
2. The flange face should be in full contact all around the circumference with the upper face of the stub-end to avoid fulcrum effect which will lead to leaking and even breaking of the flange itself while torqueing the bolts.

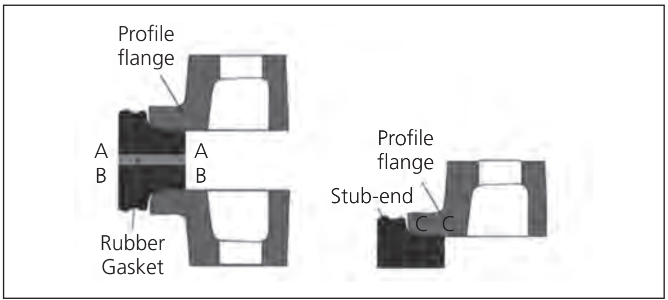


Illustration 9.4

Bolt tightening

1. Install all the bolts and nuts finger tight, ensuring at all times that the alignment is correct.
2. As the first torqueing step, tighten the bolts in a crisscross sequence as shown in illustration 9.5. Using a torque wrench with 20% of the final torque listed in table 9.5, taking care that points 1 and 2, are satisfied at all times.
3. In the four remaining steps, repeat step two four times, each time increasing the torque by 20% of the final value.
4. After reaching the final torque, use rotational tightening until all bolts are stable at the final torque value (in general two complete times around is required).

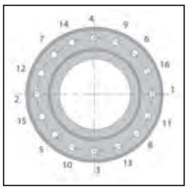


Illustration 9.5

Always use the crisscross pattern!

d_2 (mm)	DN (mm)	Bolt hole	Bolt count	Bolt size	Bolt tightening torque (Nm) Flat ring gasket (p_{acc} ≤10 bar)	Profile gasket (p_{acc} ≤16 bar)	O-ring gasket (p_{acc} ≤16 bar)
32	25	85	14	4	M12	16	15
40	32	100	18	4	M16	16	20
50	40	110	18	4	M16	16	25
63	50	125	18	4	M16	16	35
75	65	145	18	4	M16	16	40
90	80	160	18	8	M16	16	40
110	100	180	18	8	M16	16	50
125	100	180	18	8	M16	16	50
160	150	240	22	8	M20	16	60
200	200	295	22	8	M20 *)	16	75
250	250	350	22	12	M20 *)	16	95
315	300	400	22	12	M20 *)	16	100

**) Pacc ≤6 bar for elastomer sealing and accumulated friction factor μR = 0,15*

Table 9.5 Standard values for torque (DVS 2210 part 1)

Jointing techniques

10 Quality management

10.1 Quality management system

The system of monitoring the high quality of the products during the production process is given in illustration 10.1.

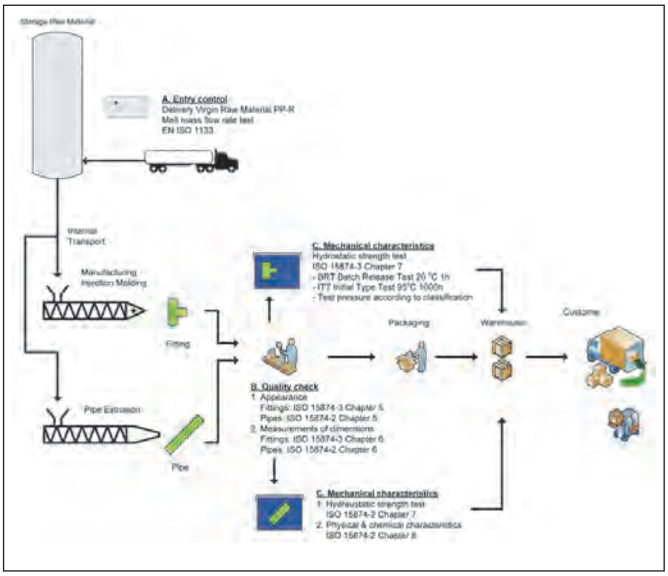


Illustration 10.1 Quality management system

10.2 Declaration of conformity

The Wefatherm pipe system is manufactured from compound polypropylene RA130E-6017 which complies with the requirements mentioned in:
- RA130E Material Data Sheet
- RA130E Safety Information Sheet
- RA130E Compliance to Drinking water
- RA130E Compliance to Food
- RA130E Statement on Chemicals

The PP-R pipe system is manufactured generally in accordance with the standards in table 10.1.

Standard	Title
ISO 15874	Plastics piping systems for hot and cold water installations - polypropylene (PP)
DIN 8077 - 8078	Pipes of polypropylene (PP)
DIN 16962	Fittings and components for pressure systems of polypropylene (PP)
ASTM F2389-S	Specification for pressure-rated polypropylene (PP) piping systems -metric series

Table 10.1

Approvals
The Wefatherm pipe system has been certified by DVGW and independent institutes and carries a number of internationally recognized approvals.

Illustration 10.2

The latest versions of these certificates can be found in the download area of www.wefatherm.de.

10.3 Quality statement

The Wefatherm pipe system is produced according to the ISO 9001 approved quality management system for the production of injection moulded and extruded products for water supply systems.

10.4 Manufacturers guarantee

When these components are correctly installed and used, the trouble free and satisfactory operation of the installed system can be expected on the long run. Should you have any question, however, our after sales service is ready to help you.

Warranty
The pipes and fittings (which are parts of the Wefatherm system components) ('The Products') are warranted against manufacturing defects for a period of 10 years starting at the manufacturing date marked on The Products subject to all the following conditions:

(i) The warranty shall not apply to defects that were apparent at the products delivery
(ii) The starting date of the warranty period (10 years) shall be the manufacturing date marked on The Products
(iii) The Products must have been installed not later than 6 months after their delivery
(iv) The defects shall have been notified to Wefatherm GmbH before expiry of the warranty period and not later than 30 days of the date of occurrence of the defect
(v) The Products have been properly stored, installed, commissioned and used in accordance with the Wefatherm Specification Manual and state of the art best practices and have not been caused by any external event
(vi) The Products have not been installed in association with other products or components not supplied or recommended by Wefatherm GmbH
(vii) This warranty covers the replacement of the defective products to the exclusion of any other remedy or indemnity of whatever kind such as, but not limited to, consequential damages, indirect damages, dismantling and reinstallation costs, loss of use

10.5 Product liability insurance

For the coverage of the liability in case of personal injury or property damage we have concluded an extended product liability insurance.

For additional information contact the Wefatherm Export Sales Office.

Quality management

11 Company profile

11.1 Wefatherm GmbH

Wefatherm PP-R water supply systems have been used for many years in areas of application where the pipe system has to meet high standards of durability and reliability. 25 years of experience in water supply systems, focusing on innovation, quality and dedication: that is Wefatherm GmbH.

The Wefatherm factory is situated in Wunstorf, a town in the district of Hannover, in Lower Saxony, Germany. To the west of the city is Lake 'Steinhuder Meer', making Wunstorf and Wefatherm a perfect match: both making more of water and its quality. Wefatherm has always been focused on innovation and quality, making 'made in Germany' more than just a phrase by really living up to it. With a clear focus on meeting the demanding specifications of installers and consulting engineers, the Wefatherm team is a key element in the successful delivery of our knowledge through consultation, support processes and the application of leading technologies. Wefatherm GmbH is an Aliaxis company.

www.wefatherm.de

11.2 Akatherm BV

Akatherm BV is located Panningen, The Netherlands, and operates as Export Sales Office and contractual business partner for the Wefatherm product range. The product liability is mentioned in the terms and conditions of Akatherm BV.

Akatherm has over 40 years experience in drainage and pressure systems. Akatherm BV has always been a pioneer in PE/PP pipe systems, and has developed from prefabrication and installation through trading and subcontracted production to own manufacturing and marketing. Akatherm BV has an international distribution network and is an Aliaxis company.

www.akatherm.com

11.3 Aliaxis Group

The Aliaxis Group is a leading global manufacturer and distributor of primarily plastic fluid handling systems used in residential and commercial construction, as well as in industrial and public infrastructure applications.

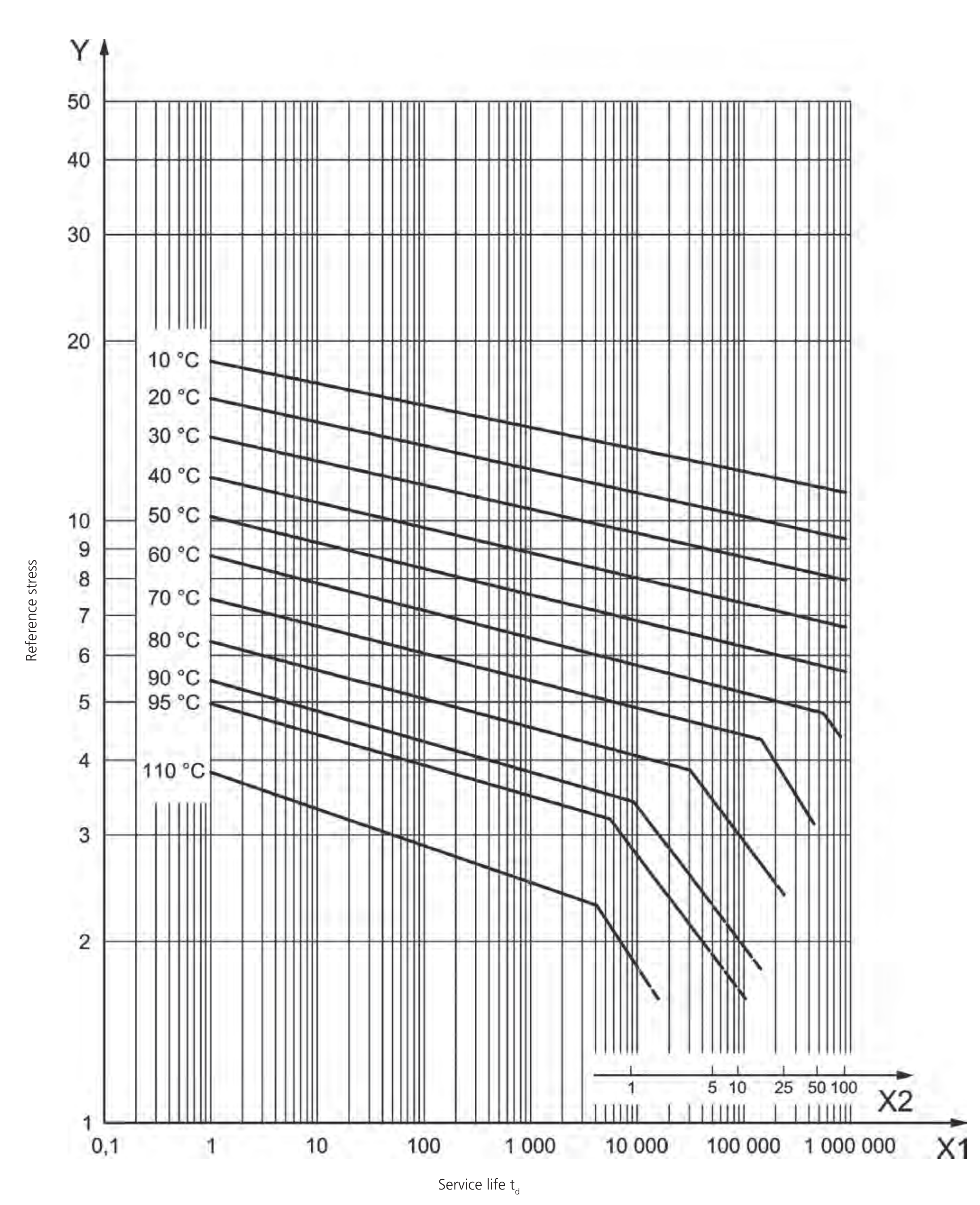
Aliaxis' brands have a strong identity and are firmly established in the markets they serve. Aliaxis is present in over 40 countries, has more than 100 manufacturing and commercial entities and employs over 14.000 people. In addition to the well-established markets of Europe and North America, Aliaxis has operations in Latin and South America, Australasia and Asia.

Aliaxis leverages their local and global knowledge of the industry, regulations and building habits to provide consistently excellent customer service through their distribution partners to building installers, infrastructure contractors and others. Thanks to the entrepreneurial spirit of its local people, balanced with the strengths, know-how and international reach of the group, Aliaxis continues to develop and improve their positions in key building applications throughout the world.

www.aliaxis.com

Company profile

Appendix A1
References for PP-R



Appendix A

Appendix A2
Polypropylene
RA130E-6017

1. Identification of the substance/mixture and of the company/ undertaking
Trade name: RA130E-6017

Material use: Raw material for plastics industry

Manufacturer: Borealis

E-mail address: product.safety@borealisgroup.com

2. Hazards identification
Health: The product is not classified as dangerous. Inhalation of dust may irritate the respiratory tract. Prolonged inhalation of high doses of decomposition products may give headache or irritation of the respiratory tract.

Fire: The product burns, but is not classified as flammable.

Environment: The product is not considered dangerous for the environment.

3. Composition/information on ingredients
The product is a polypropylene polymer. Contains no substance classified as hazardous in concentrations, which should be taken into account according to EC directives.

4. First aid measures
No specific instructions needed.

Skin contact: Cool melted product on skin with plenty of water. Do not remove solidified product.

5. Fire-fighting measures
Suitable extinguishing media: Water in spread jet, dry chemicals, foam or carbon dioxide.

Special exposure hazards: Principal toxicant in the smoke is carbon monoxide.

6. Accidental release measures
Vacuum or sweep up spill. All spill of material must be removed immediately to prevent slipping accidents.

7. Handling and storage
Handling: During processing and thermal treatment of the product, small amounts of volatile hydrocarbons may be released. Provide adequate ventilation. Local exhaust ventilation may be necessary. Avoid inhalation of dust and decomposition fumes. Dust from the product gives a potential risk for dust explosion. All equipment shall be grounded.

Storage: Safety aspects do not require any special precautions in terms of storage.

8. Exposure controls/personal protection
Provide adequate ventilation. Local exhaust ventilation may be necessary.

9. Physical and chemical properties
Appearance: solid, green

Odour: odourless

Melting point/range: 130-170°C

Density: 0,9-1,0 g/cm³

Ignition temperature: >320°C

Solubility(ies): insoluble in water

10. Stability and reactivity
The product is a stable thermoplastic, with no chemical reactivity.

11. Toxicological information
The product is not classified as hazardous according to Regulation (EC). 1272/2008 Inhalation of dust may irritate the respiratory tract. Prolonged inhalation of high doses of decomposition products may give headache or irritation of the respiratory tract.

12. Ecological information
The product is not considered dangerous for the environment.

13. Disposal considerations
Reuse or recycle if not contaminated. The product may be safely used as fuel. Proper combustion does not require any special flue gas control. Check with local regulations.

14. Transport information
The product is not regulated by ADR/RID, IMDG or IATA.

15. Regulatory information
In accordance with Regulation (EC) 1272/2008, the product does not need to be classified nor labelled.

Label:
Trade name: RA130E-6017
Manufacturer: Borealis

16. Other information
Issued in accordance with Article 32 of Regulation (EC) No 1907/2006, and its amendments.

Issuer: Borealis, Group Product Stewardship 18.05/2015 Ed. 3.

Appendix A3
Polypropylene
RA130E-6017

Statement on compliance to regulations for drinking water pipes
We confirm that this product and the monomers, additives and (if present) pigments used for its manufacturing are in compliance with the requirements of the following legislation:

Austria
Kunststoffverordnung Nr. 476/2003 und Änderungen 242/2005, 452/2006, 325/2007, 140/2009, 196/2010 und 45/2011.

Czech Republic
Vyhlaska Ministerstva zdravotnictvi c. 409/2005 Sb as amended.

EU
Regulation (EC) No 1935/2004 - so far applicable to polymer pellets. The organoleptic characteristics of food contact materials are influenced by converting conditions, time and temperature of storage and type of food, therefore compliance with article 3 must be verified and tested by the producer of the final packing material. Commission Regulation (EU) 2011/10 as amended. Commission Regulation (EC) 1895/2005 - BADGE, NOGE and BFDGE are not used for the production of this grade Commission Regulation (EC) 2023/2006. This material has been manufactured in accordance with the relevant requirements of good manufacturing practice for materials articles intended to come into contact with food, as described in more detail in the Borealis statement 'Food hygiene demands and standards'.

Finland
Maa-ja metsätalousministeriön asetus 497/2011 (referring to regulation EU2011/10).

France
Brochure No. 1227 (2002), et srrêté du 02.02.2003, tel que modificié incl. Arrêté du 09.12.13.

Germany
Bedarfgegenständeverordnung vom 23.12.1997 in der Fassung vom 24.06.2013 (referring to regulation EU 2011/10), and Empfehlung des Umweltbundesamtes: Leitlinie zur hygienischen Beurteilung von organischen Materialien in Kontakt mit Trinkwasser (KTW-Leitlinie), Tabelle 1 'Kunststoffe', Stand: 07.03.2016.

Italy
Decreto Ministeriale 06.04.2004 N. 174.

The Netherlands
Staatstoezicht op de Volksgezondheid. Publikatie 94-01, Deel B, 1.3. Polypropeen.

Norway
Sosial- og helsedepartementets forskrift 1993-12-21-1381 (referring to regulation EU 2011/10).

Spain
Real Decreto 118/2003, R.D.1262/2005, SCO/3508/2006 y ANAIP (1982), Anexo 1, Anexo 4.

Sweden
Statens Livsmedelsverks kungörelse LIVSFS 2011:7 (referring to regulation EU 2011/10).

Switzerland
Verordnung der EDI über Bedarfsgegenstände vom 23.11.2005 (817.023.21); Stand 01.04.2013, 3. Abschnitt Bedarfsgegenstände aus Kunststoff.

USA
FDA, CFR, Title 21, 177.1520 (a)(3)(i)(c)(1), (b) and (c)3.1a Olefin polymers.

National approvals
This statement is no warranty, that articles, made from this material and intended to be used in contact with drinking water, will fit the technical requirements as defined in the approval schemes of the above listed countries.

Materials and articles intended to be used in contact with drinking water in many countries have to be approved by authorised national laboratories. For that purpose Borealis is prepared to provide those laboratories detailed information on the composition of this grade on request.

Prepared by: Borealis, Group Product Stewardship 28.09.16 Ed. 16.

Appendix A

Appendix A4
Polypropylene
RA130E-6017

Statement on chemicals, regulations and standards

We certify that during manufacturing of this product we do not use or intentionally add any of the chemicals restricted by the following regulations and standards and their subsequent amendments in amounts which exceed the applicable limits.

- Annex XVII of the REACH Regulation 1907/2006/EC (superseding Directive 76/769/EEC) - Restrictions on the manufacturing, placing on the market and use of certain dangerous substances, mixtures and articles
- Directive 2000/53/EC (End of life vehicles - ELV) - Cr(VI), Hg and Pb < 0.1 wt%, Cd < 0.01 wt%)
- Directive 2011/65/EU (Restriction of the use of certain Hazardous Substances in electrical and electronic equipment - ROHS) - Cr(VI), Hg, Pb, PBB, PBDE, DEHP, BBP, DBP, DIBP < 0.1 wt%, Cd < 0.01 wt%
- Directive 2012/19/EU (Waste Electrical & Electronic Equipment - WEEE, repealing 2002/96/EC) - Annex VII - No ingredients used which require selective waste treatment (As, Hg, PCB, PCT, CFC, HCFC, HFC, brominated FR)
- Chemicals List of Proposition 65 of the State of California and subsequent amendments, as known to the State of California to cause cancer or reproductive toxicity
- Regulation 1005/2009/EC (Substances that deplete the ozone layer) - Prohibition of CFC's, HCFC's, Halons, CCl4, Trichloroethane, HBFC's
- US Clean Air Act, Title VI, Classes I and II (EPA Final Rule; Federal Register 8136, 11.2.1993) on substances that deplete the ozone layer
- Regulation 850/2004/EC on persistent organic pollutants (POPs)
- Global Automotive Declarable Substance List (GADSL) and VDA232-101 - No use of prohibited or declarable substances above threshold limits
- Swiss SR 814.018 (Verordnung über die Lenkungsabgabe auf flüchtigen organischen Verbindungen - VOCV) - VOC's according to Annexes 1 & 2 < 3 wt%
- Japanese CSCL; Class I and II Specified Chemical Substances
- Japanese PRTR law; Class I or Class II Designated Chemical Substances.

Regarding classification of the above product according to REGULATION (EC) No 1272/2008 and its subsequent amendments, reference is made in the SDS/PSIS for the above product.

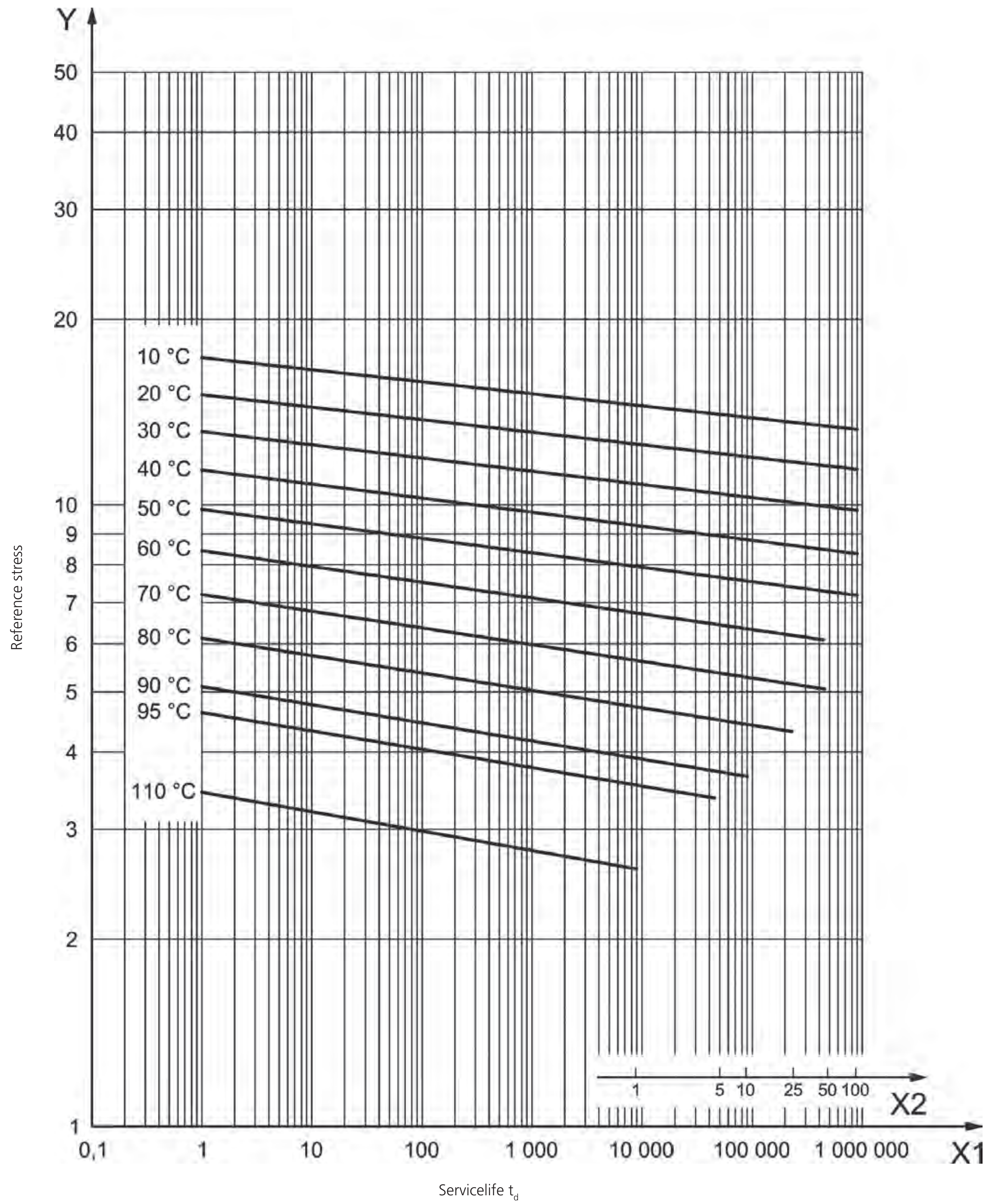
We also certify that during the manufacturing of the above product we do not use or intentionally incorporate into it any of the following materials:

Acrylamide
Aromatic Amines (restricted in Regulation 1907/2006/EC, Annex XVII)
Arsenic, Beryllium, Bismuth
Artificial Musks
Asbestos
Azocolorants (restricted in Regulation 1907/2006/EC, Annex XVII)
Azodicarbonamide, semicarbazide
Benzophenones (e.g. 4-MBP, 4-HBP, 2,2´-Dimethoxy-2-phenylacetophenone)
Biocides (Pesti-, Herbi-, Insecti-, Fungi-, Bactericides)
Brominated flame retardants (e.g. PBB, PBDE)
Cadmium, Chromium (VI), Lead, Mercury
CFC, HCFC
Colophony (rosin)
4,4'- Diaminodiphenylmethane (MDA)
Di-2-ethyl-hexyl maleate (DEHM)
Dimethylfumarate (DMF), Dibutylfumarate
1,4-Dioxane
2-Ethylhexanoic acid, Ethoxyquin, ITX, Thiurams
Formaldehyde
Fragrances
Furfural
Genetically modified materials (GMO)
Glycol ethers (EGME, EGMEA, EGEE, EGEEA)
Glyoxal
Gold, Indium, Palladium
Melamine, Cyanuric acid
Natural rubbers, Latex
Nitrosamines, Nitrates, Nitrites
Octyl- and Nonylphenols and Octyl- or Nonylphenolethoxylates; TNPP
Organotin compounds
Parabens PBT and vPvB substances according to EC Regulation No.1907/2006 (REACH)
Pentachlorophenol (PCP)
PFOA, PFOS
Plasticisers (e.g. Adipates, ESBO, Phthalates*)
Polychlorinated Bi-, Terphenyls and Naphthalenes
Polychlorinated dibenzodioxins and dibenzofurans
Polycyclic aromatic hydrocarbons (PAH)
Radioactive substances
Recycled materials
Selenium, Silver, Tellurium, Thorium
Styrene SVHC on "Candidate List of Substances of Very High Concern for Authorisation"*
Thiuram mix
Tin, Gold, Tantalum, Tungsten
UV-hardeners (e.g. ITX, Titanyl-acetylacetone)
Vinylchloride, Vinylidenechloride, PVC or PVDC

*) DEP, DEHP or DIBP may be used in the catalyst system, which may result in traces of these phthalates in the product, typically in concentrations below 1 ppm.

24.08.2016 Ed. 19

Appendix A5
References fo PP-RCT



Appendix A

Appendix A6
Polypropylene
RA7050-GN

1. Identification of the substance/mixture and of the company/ undertaking Trade name: RA7050-GN

Material use: Raw material for plastic industry

Manufacturer: Borealis

E-mail address: product.safety@borealisgroup.com

2. Hazards identification
Health: The product is not classified as dangerous preparation. Inhalation of dust may irritate the respiratory tract. Prolonged inhalation of high doses of decomposition products may give headache or irritation of the respiratory tract.

Fire: The product burns, but is not classified as flammable.

Environment: The product is not considered dangerous for the environment.

3. Composition/information on ingredients
The product is a polypropylene polymer.
Contains no substance classified as hazardous in concentrations, which should be taken into account according to EC regulations.

4. First aid measures
No specific instruction needed.

Skin contact: Cool melted product on skin with plenty of water. Do not remove solidified product.

5. Fire-fighting measures
Suitable extinguishing media: Water in spread jet, dry chemicals, foam or carbon dioxide.

Special exposure hazards: Principal toxicant in the smoke is carbon monoxide.

6. Accidental release measures
Suck or sweep up spill. All spill of material must be removed immediately to prevent slipping accidents.

7. Handling and storage
Handling: During processing and thermal treatment of the product, small amounts of volatile hydrocarbons may be released. Provide adequate ventilation. Local exhaust ventilation may be necessary. Avoid inhalation of dust and decomposition fumes. Dust from the product gives a potential risk for dust explosion. All equipment shall be grounded.

Storage: Safety aspects do not require any special precautions in terms of storage.

8. Exposure controls/personal protection
Provide adequate ventilation. Local exhaust ventilation may be necessary.

9. Physical and chemical properties
Appearance: solid, green
Odour: odourless
Melting point/range: 130–170°C
Density: 0,9-1,0 g/cm^3
Ignition temperature: >320°C
Solubility: insoluble in water

10. Stability and reactivity
The product is a stable thermoplastic, with no chemical reactivity.

11. Toxicological information
The product is not classified as hazardous according to Regulation (ED) No. 1272/2008. However, inhalation of dust may irritate the respiratory tract. Prolonged inhalation of high doses of decomposition products may give headache or irritation of the respiratory tract.

12. Ecological information
The product is not considered dangerous for the environment.

13. Disposal considerations
Reuse or recycle if not contaminated. The product may be safely used as fuel. Proper combustion does not require any special flue gas control. Check with local regulations.

14. Transport information
The product is not regulated by ADR/RID, IMDG or IATA.

15. Regulatory information
Inoccordance with Regulation (ED) No 1272/2008, the product does not need to be classified nor labelled.

Label:
Trade name: RA7050-GN
Manufacturer: Borealis

16. Other information
Issued in accordance with Article 32 of Regulation (EC) No 1907/2006, and it's amendments.

Issuer: Borealis Group Product Stewardship 14.03.2016 Ed. 14.

Appendix A7
Polypropylene
Beta-PPR RA7050-GN

General statement on compliance to food contact regulations

We confirm that this product fulfils the requirements on materials used for articles or components of articles intended to come into contact with food as described in

- Regulation (EC) No 1935/2004 - so far applicable for raw materials
- Commission Directive 2002/72/EC (as amended) and its national implementations
- FDA, CFR, Title 21 (2008) §177.1520 Olefin Polymers

The product contains substances (monomers and/or additives) with Specific Migration Limits (SML) or other restrictions.

As the information on these restricted substances is Borealis proprietary information, it only can be disclosed for the purpose of an assessment of the compliance with the relevant restrictions, after signing of a Non-disclosure.

Statement: the information will then be given in a more detailed Declaration of Compliance, which is not allowed to be forwarded to any third party.

Prepared by: Ed. 1 Borealis Group Product Stewardship 28/07/2008.

wefatherm

Appendix A

Appendix A8
Polypropylene
RA7050-GN

Statement on chemicals, regulations and standards

We certify that during manufacturing of this product we do not use or intentionally add any of the chemicals restricted by the following regulations and standards and their subsequent amendments in amounts which exceed the applicable limits.

- Annex XVII of the REACH Regulation 1907/2006/EC (superseding Directive 76/769/EEC) - Restrictions on the manufacturing, placing on the market and use of certain dangerous substances, mixtures and articles

- Directive 2000/53/EC (End of life vehicles - ELV) - Cr(VI), Hg and Pb < 0.1 wt%, Cd < 0.01 wt%)

- Directive 2011/65/EU (Restriction of the use of certain Hazardous Substances in electrical and electronic equipment - ROHS) - Cr(VI), Hg, Pb, PBB, PBDE, DEHP, BBP, DBP, DIBP < 0.1 wt%, Cd < 0.01 wt%

- Directive 2012/19/EU (Waste Electrical & Electronic Equipment - WEEE, repealing 2002/96/EC) - Annex VII - No ingredients used which require selective waste treatment (As, Hg, PCB, PCT, CFC, HCFC, HFC, brominated FR)

- Chemicals List of Proposition 65 of the State of California and subsequent amendments, as known to the State of California to cause cancer or reproductive toxicity

- Regulation 1005/2009/EC (Substances that deplete the ozone layer) - Prohibition of CFC's, HCFC's, Halons, CCl4, Trichloroethane, HBFC's

- US Clean Air Act, Title VI, Classes I and II (EPA Final Rule; Federal Register 8136, 11.2.1993) on substances that deplete the ozone layer

- Regulation 850/2004/EC on persistent organic pollutants (POPs)

- Global Automotive Declarable Substance List (GADSL) and VDA232-101 - No use of prohibited or declarable substances above threshold limits

- Swiss SR 814.018 (Verordnung über die Lenkungsabgabe auf flüchtigen organischen Verbindungen - VOCV) - VOC's according to Annexes 1 & 2 < 3 wt%

- Japanese CSCL; Class I and II Specified Chemical Substances

- Japanese PRTR law; Class I or Class II Designated Chemical Substances

Regarding classification of the above product according to REGULATION (EC) No 1272/2008 and its subsequent amendments, reference is made in the SDS/PSIS for the above product.

We also certify that during the manufacturing of the above product we do not use or intentionally incorporate into it any of the following materials:

Acrylamide
Aromatic Amines (restricted in Regulation 1907/2006/EC, Annex XVII)
Arsenic, Beryllium, Bismuth
Artificial Musks
Asbestos
Azocolorants (restricted in Regulation 1907/2006/EC, Annex XVII)
Azodicarbonamide, semicarbazide
Benzophenones (e.g. 4-MBP, 4-HBP, 2,2´-Dimethoxy-2-phenylacetophenone)
Biocides (Pesti-, Herbi-, Insecti-, Fungi-, Bactericides)
Brominated flame retardants (e.g. PBB, PBDE)
Cadmium, Chromium (VI), Lead, Mercury
CFC, HCFC
Colophony (rosin)
4,4'- Diaminodiphenylmethane (MDA)
Di-2-ethyl-hexyl maleate (DEHM)
Dimethylfumarate (DMF), Dibutylfumarate
1,4-Dioxane
2-Ethylhexanoic acid, Ethoxyquin, ITX, Thiurams
Formaldehyde
Fragrances
Furfural
Genetically modified materials (GMO)
Glycol ethers (EGME, EGMEA, EGEE, EGEEA)
Glyoxal
Gold, Indium, Palladium
Melamine, Cyanuric acid
Natural rubbers, Latex
Nitrosamines, Nitrates, Nitrites
Octyl- and Nonylphenols and Octyl- or Nonylphenolethoxylates; TNPP
Organotin compounds
Parabens PBT and vPvB substances according to EC
Regulation No.1907/2006 (REACH)
Pentachlorophenol (PCP)
PFOA, PFOS
Plasticisers (e.g. Adipates, ESBO, Phthalates*)
Polychlorinated Bi-, Terphenyls and Naphthalenes
Polychlorinated dibenzodioxins and dibenzofurans
Polycyclic aromatic hydrocarbons (PAH)
Radioactive substances
Recycled materials
Selenium, Silver, Tellurium, Thorium
Styrene SVHC on "Candidate List of Substances of Very High Concern for Authorisation"*
Thiuram mix
Tin, Gold, Tantalum, Tungsten
UV-hardeners (e.g. ITX, Titanyl-acetylacetone)
Vinylchloride, Vinylidenechloride, PVC or PVDC

*) DEP, DEHP or DIBP may be used in the catalyst system, which may result in traces of these phthalates in the product, typically in concentrations below 1 ppm.

Prepared by: Borealis Group Product Stewardship 24.08.2016 Ed. 18.

Appendix B1

Maximum Operating Pressure
Maximum operating pressure (MOP) for PP-R, for water Safety factor (SF) = 1,25 DIN 8077.

Temperature	Operating years	Maximum Operating Pressure			
°C		SDR 11	SDR 7,4	SDR 6	SDR 5
10	1	21,1	33,4	42,1	53,0
	5	19,8	31,5	39,7	49,9
	10	19,3	30,7	38,6	48,7
	25	18,7	29,7	37,4	47,0
	50	18,2	28,9	36,4	45,9
	100	17,8	28,2	35,5	44,7
20	1	18,0	28,5	35,9	45,2
	5	16,9	26,8	33,7	42,5
	10	16,4	26,1	32,8	41,4
	25	15,9	25,2	31,7	39,9
	50	15,4	24,5	30,9	38,9
	100	15,0	23,9	30,2	37,8
30	1	15,3	24,2	30,5	38,5
	5	14,3	22,7	28,6	36,0
	10	13,9	22,1	27,8	35,0
	25	13,4	21,3	26,8	33,8
	50	13,0	20,7	26,1	32,9
	100	12,7	20,1	25,4	31,9
40	1	13,0	20,6	25,9	32,6
	5	12,1	19,2	24,2	30,5
	10	11,8	18,7	23,5	29,6
	25	11,3	18,0	22,6	28,5
	50	11,0	17,4	22,0	27,7
	100	10,7	16,9	21,4	26,9
50	1	11,0	17,4	21,9	27,6
	5	10,2	16,2	20,4	25,7
	10	9,9	15,7	19,8	25,0
	25	9,5	15,1	19,0	24,0
	50	9,2	14,7	18,5	23,3
	100	9,0	14,2	17,9	22,6
60	1	9,2	14,7	18,5	23,3
	5	8,6	13,6	17,2	21,6
	10	8,3	13,2	16,6	21,0
	25	8,0	12,7	16,0	20,1
	50	7,7	12,3	15,5	19,5
70	1	7,8	12,3	15,5	19,6
	5	7,2	11,4	14,4	18,1
	10	7,0	11,1	13,9	17,5
	25	6,0	9,6	12,1	15,2
	50	5,1	8,1	10,2	12,8
80	1	6,5	10,3	13,0	16,4
	5	5,7	9,1	11,5	14,5
	10	4,8	7,7	9,7	12,2
	25	3,9	6,2	7,8	9,8
95	1	4,6	7,3	9,2	11,6
	5	3,1	4,9	6,2	7,8
	(10)	(2,6)	(4,1)	(5,2)	(6,6)

Data inside the brackets apply by verification at longer testing periods than 1 year at the 110°C-test.

Appendix B2

Maximum Operating Pressure
Maximum operating pressure (MOP) for PP-R, for water Safety factor (SF) = 1,5 DIN 8077.

Temperature	Operating years	Maximum Operating Pressure			
°C		SDR 11	SDR 7,4	SDR 6	SDR 5
10	1	17,5	27,8	35,1	44,1
	5	16,5	26,2	33,0	41,6
	10	16,1	25,6	32,2	40,5
	25	15,6	24,7	31,1	39,2
	50	15,2	24,1	30,3	38,2
	100	14,8	23,5	29,6	37,2
20	1	15,0	23,7	29,9	37,7
	5	14,1	22,3	28,1	35,4
	10	13,7	21,7	27,4	34,5
	25	13,2	21,0	26,4	33,3
	50	12,9	20,4	25,7	32,4
	100	12,5	19,9	25,0	31,5
30	1	12,7	20,2	25,4	32,0
	5	11,9	18,9	23,8	30,0
	10	11,6	18,4	23,2	29,2
	25	11,2	17,7	22,3	28,1
	50	10,9	17,2	21,7	27,4
	100	10,6	16,8	21,1	26,6
40	1	10,8	17,1	21,6	27,2
	5	10,1	16,0	20,2	25,4
	10	9,8	15,5	19,6	24,7
	25	9,4	15,0	18,8	28,5
	50	9,2	14,5	18,3	23,1
	100	8,9	14,1	17,8	22,4
50	1	9,1	14,5	18,2	23,0
	5	8,5	13,5	17,0	21,4
	10	8,2	13,1	16,5	20,8
	25	7,9	12,6	15,9	20,0
	50	7,7	12,2	15,4	19,4
	100	7,5	11,8	14,9	18,8
60	1	7,7	12,2	15,4	19,4
	5	7,1	11,3	14,3	18,0
	10	6,9	11,0	13,9	17,5
	25	6,6	10,5	13,3	16,7
	50	6,4	10,2	12,9	16,2
70	1	6,5	10,3	12,9	16,3
	5	6,0	9,5	12,0	15,1
	10	5,8	9,2	11,6	14,6
	25	5,0	8,0	10,0	12,7
	50	4,2	6,7	8,5	10,7
80	1	5,4	8,6	10,8	13,7
	5	4,8	7,6	9,6	12,1
	10	4,0	6,4	8,1	10,2
	25	3,2	5,1	6,5	8,1
95	1	3,8	6,1	7,6	9,6
	5	2,6	4,1	5,2	6,5
	(10)	(2,2)	(3,4)	(4,3)	(5,5)

Data inside the brackets apply by verification at longer testing periods than 1 year at the 110°C-test.

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Appendix B

Appendix B3

Maximum Operating Pressure
Maximum operating pressure (MOP) for PP-RCT, for water Safety factor (SF) = 1,25 DIN 8077.

Temperature	Operating years	Maximum Operating Pressure				
°C		SDR 11	SDR 9	SDR 7,4	SDR 6	SDR 5
10	1	22,8	28,8	36,2	45,6	57,4
	5	22,1	27,9	35,1	44,2	55,7
	10	21,9	27,5	34,7	42,7	55,0
	25	21,5	27,1	34,1	42,9	54,0
	50	21,2	26,7	33,6	42,3	53,3
	100	20,9	26,3	33,2	41,8	52,6
20	1	19,9	25,0	31,5	39,7	50,0
	5	19,3	24,2	30,5	38,5	48,4
	10	19,0	23,9	30,1	37,9	47,8
	25	18,6	23,5	29,6	37,2	46,9
	50	18,4	23,1	29,2	36,7	46,2
	100	18,1	22,8	28,8	36,2	45,6
30	1	17,2	21,7	27,3	34,4	43,3
	5	16,6	20,9	26,4	33,2	41,8
	10	16,4	20,6	26,0	32,7	41,2
	25	16,1	20,2	25,5	32,1	40,4
	50	15,8	19,9	25,1	31,6	39,8
	100	15,6	19,7	24,8	31,2	39,3
40	1	14,8	18,6	23,5	29,6	37,2
	5	14,3	18,0	22,6	28,5	35,9
	10	14,1	17,7	22,3	28,1	35,4
	25	13,8	17,3	21,8	27,5	34,6
	50	13,6	17,1	21,5	27,1	34,1
	100	13,3	16,8	21,2	26,7	33,6
50	1	12,6	15,9	20,1	25,3	31,8
	5	12,2	15,3	19,3	24,3	30,6
	10	12,0	15,1	19,0	23,9	30,1
	25	11,7	14,7	18,6	23,4	29,5
	50	11,5	14,5	18,3	23,0	29,0
	100	11,3	14,3	18,0	22,6	28,5
60	1	10,7	13,5	17,0	21,4	27,0
	5	10,3	13,0	16,3	20,6	25,9
	10	10,1	12,7	16,0	20,2	25,5
	25	9,9	12,4	15,7	19,8	24,9
	50	9,7	12,2	15,4	19,4	24,5
70	1	9,0	11,3	14,3	18,0	22,7
	5	8,6	10,9	13,7	17,3	21,7
	10	8,5	10,7	13,5	16,9	21,3
	25	8,3	10,4	13,1	16,5	20,8
	50	8,1	10,2	12,9	16,2	20,5
80	1	7,5	9,5	11,9	15,0	18,9
	5	7,2	9,0	11,4	14,4	18,1
	10	7,0	8,9	11,2	14,1	17,7
	25	6,9	8,6	10,9	13,7	17,3
95	1	5,6	7,1	8,9	11,2	14,2
	5	5,3	6,7	8,5	10,7	13,5
	(10)	(5,2)	(6,6)	(8,3)	(10,5)	(13,2)

Data inside the brackets apply by verification at longer testing periods than 1 year at the 110°C-test.

Appendix B4

Maximum Operating Pressure
Maximum operating pressure (MOP) for PP-RCT, for water Safety factor (SF) = 1,5 DIN 8077.

Temperature	Operating years	Maximum Operating Pressure				
°C		SDR 11	SDR 9	SDR 7,4	SDR 6	SDR 5
10	1	19,0	24,0	30,2	38,0	47,9
	5	18,4	23,2	29,3	36,9	45,4
	10	18,2	22,9	28,9	36,4	45,8
	25	17,9	22,5	28,4	35,7	45,0
	50	17,7	22,2	28,0	35,3	44,4
	100	17,4	21,9	27,6	34,8	43,8
20	1	16,6	20,9	26,3	33,1	41,7
	5	16,0	20,2	25,4	32,0	40,4
	10	15,8	19,9	25,1	31,6	39,8
	25	15,5	19,6	24,6	31,0	39,1
	50	15,3	19,3	24,3	30,6	38,5
	100	15,1	19,0	24,0	30,2	38,0
30	1	14,3	18,1	22,7	28,7	36,1
	5	13,9	17,4	22,0	27,7	34,9
	10	13,6	17,2	21,7	27,3	34,4
	25	13,4	16,9	21,2	26,8	33,7
	50	13,2	16,6	20,9	26,4	33,2
	100	13,0	16,4	20,6	26,0	32,7
40	1	12,3	15,5	19,6	24,6	31,0
	5	11,9	15,0	18,9	23,8	29,9
	10	11,7	14,7	18,6	23,4	29,5
	25	11,5	14,4	18,2	22,9	28,9
	50	11,3	14,2	17,9	22,6	28,4
	100	11,1	14,0	17,6	22,2	28,0
50	1	10,5	13,3	16,7	21,0	26,5
	5	10,1	12,8	16,1	20,3	25,5
	10	10,0	12,6	15,8	19,9	25,1
	25	9,7	12,3	15,5	19,5	24,6
	50	9,6	12,1	15,2	19,2	24,2
	100	9,4	11,9	15,0	18,9	23,8
60	1	8,9	11,2	14,2	17,8	22,5
	5	8,6	10,8	13,6	17,1	21,6
	10	8,4	10,6	13,4	16,8	21,2
	25	8,2	10,4	13,1	16,5	20,7
	50	8,1	10,2	12,8	16,2	20,4
70	1	7,5	9,4	11,9	15,0	18,9
	5	7,2	9,1	11,4	14,4	18,1
	10	7,0	8,9	11,2	14,1	17,8
	25	6,9	8,7	10,9	13,8	17,4
	50	6,8	8,5	10,7	13,5	17,0
80	1	6,2	7,9	9,9	12,5	15,8
	5	6,0	7,5	9,5	12,0	15,1
	10	5,9	7,4	9,3	11,7	14,8
	25	5,7	7,2	9,1	11,4	14,4
95	1	4,7	5,9	7,4	9,4	11,8
	5	4,4	5,6	7,1	8,9	11,2
	(10)	(4,3)	(5,5)	(6,9)	(8,7)	(11,0)

Data inside the brackets apply by verification at longer testing periods than 1 year at the 110°C-test.

Appendix B5

Maximum Operating Pressure
Maximum operating pressure (MOP) for PP-R water systems for SF = 1,25.

Heating period	Temperature	Years	Maximum Operating Pressure		
	°C		SDR 6	SDR 7,4	SDR 5
Continuous operating temperature 70°C incl. 60 days per year at...	75°C	5	14,30	11,40	15,90
		10	13,70	10,90	14,50
		25	11,80	9,30	13,70
		45	10,40	8,10	12,80
	80°C	5	12,90	10,07	15,80
		10	12,20	9,70	15,40
		25	10,70	8,60	13,20
		40	9,80	7,80	11,60
	85°C	5	12,51	9,94	15,78
		10	11,90	9,50	15,30
		25	9,70	7,80	13,20
		35	8,90	7,10	11,20
	90°C	5	11,80	9,37	14,90
		10	10,30	8,40	12,90
		25	8,40	6,60	10,48
		30	7,63	6,30	8,45
Continuous operating temperature 70°C incl. 90 days per year at...	75°C	5	14,30	11,40	15,90
		10	13,70	10,90	14,50
		25	11,80	9,30	13,70
		45	10,40	8,10	12,80
	80°C	5	12,90	10,07	15,80
		10	12,20	9,70	15,40
		25	10,70	8,60	13,20
		40	9,80	7,80	11,60
	85°C	5	12,51	9,94	15,78
		10	11,90	9,50	15,30
		25	9,70	7,80	13,20
		35	8,90	7,10	11,20
	90°C	5	11,80	9,37	14,90
		10	10,30	8,40	12,90
		10	10,30	8,40	12,90

**SDR = Standard Dimension Ratio (= diameter/wall thickness)*

Appendix B6

Maximum Operating Pressure
Maximum operating pressure (MOP) for PP-RCT hot water systems for SF = 1,25.

Heating period	Temperature	Years	Maximum Operating Pressure	
	°C		SDR 11	SDR 7,4
Continuous operating temperature 70°C incl. 30 days per year at...	75°C	5	8,45	13,2
		10	8,29	12,96
		25	8,09	12,64
		45	7,96	12,44
	80°C	5	8,45	13,2
		10	8,29	12,96
		25	8,09	12,64
		45	7,96	12,44
	85°C	5	7,09	11,07
		10	6,95	10,86
		25	6,77	10,58
		37,5	6,69	10,45
	90°C	5	6,44	10,06
		10	6,31	9,86
		25	6,14	9,60
		35	6,08	9,51
Continuous operating temperature 70°C incl. 60 days per year at...	75°C	5	8,33	13,01
		10	8,17	12,77
		25	7,97	12,46
		45	7,85	12,26
	80°C	5	7,63	11,92
		10	7,48	11,69
		25	7,30	11,40
		40	7,20	11,25
	85°C	5	6,95	10,86
		10	6,82	10,64
		25	6,64	10,37
		35	6,57	10,27
	90°C	5	6,31	8,96
		10	6,18	9,66
		25	6,02	9,41
		30	5,96	9,32
Continuous operating temperature 70°C incl. 90 days per year at...	75°C	5	8,25	12,89
		10	8,10	12,65
		25	7,90	12,34
		45	7,78	12,15
	80°C	5	7,55	11,79
		10	7,4	11,56
		25	7,22	11,28
		37,5	7,13	11,15
	85°C	5	6,87	10,73
		10	6,73	10,52
		25	6,56	10,25
		32,5	6,51	10,17
	90°C	5	6,24	9,74
		10	6,11	9,55
		25	5,95	9,30

**SDR = Standard Dimension Ratio (= diameter/wall thickness)*

Appendix B

Appendix B7-1

Maximum flow rate

Determination of the maximum flowrate $\mathbf{V_S}$ from the flow $\Sigma \mathbf{V_R}$ for buildings according to DIN 1988 Part 3 - $\mathbf{V_S} = 0{,}682.(\Sigma \mathbf{V_R})^{0{,}45} - 0{,}14$ (l/s).
This table is valid, if the calculated flow V_R of the respective water points is < 0,5 l/s.

ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S
0,03	0,00	1,02	0,55	2,02	0,80	3,02	0,98	4,02	1,14	5,10	1,28	10,10	1,79	15,10	2,17
0,04	0,02	1,04	0,55	2,04	0,80	3,04	0,98	4,04	1,14	5,20	1,29	10,20	1,80	15,20	2,18
0,06	0,05	1,06	0,56	2,06	0,80	3,06	0,99	4,06	1,14	5,30	1,30	10,30	1,81	15,30	2,19
0,07	0,07	1,08	0,57	2,08	0,81	3,08	0,99	4,08	1,14	5,40	1,32	10,40	1,82	15,40	2,19
0,08	0,08	1,10	0,57	2,10	0,81	3,10	0,99	4,10	1,15	5,50	1,33	10,50	1,82	15,50	2,20
0,09	0,09	1,12	0,58	2,12	0,82	3,12	1,00	4,12	1,15	5,60	1,34	10,60	1,83	15,60	2,21
0,10	0,10	1,14	0,58	2,14	0,82	3,14	1,00	4,14	1,15	5,70	1,35	10,70	1,84	15,70	2,21
0,13	0,13	1,16	0,59	2,16	0,82	3,16	1,00	4,16	1,16	5,80	1,36	10,80	1,85	15,80	2,22
0,15	0,15	1,18	0,59	2,18	0,83	3,18	1,01	4,18	1,16	5,90	1,38	10,90	1,86	15,90	2,23
0,20	0,19	1,20	0,60	2,20	0,83	3,20	1,01	4,20	1,16	6,00	1,39	11,00	1,87	16,00	2,23
0,22	0,21	1,22	0,61	2,22	0,84	3,22	1,01	4,22	1,16	6,10	1,40	11,10	1,87	16,10	2,24
0,24	0,22	1,24	0,61	2,24	0,84	3,24	1,02	4,24	1,17	6,20	1,41	11,20	1,88	16,20	2,25
0,26	0,23	1,26	0,62	2,26	0,84	3,26	1,02	4,26	1,17	6,30	1,42	11,30	1,89	16,30	2,25
0,28	0,24	1,28	0,62	2,28	0,85	3,28	1,02	4,28	1,17	6,40	1,43	11,40	1,90	16,40	2,26
0,30	0,26	1,30	0,63	2,30	0,85	3,30	1,03	4,30	1,17	6,50	1,44	11,50	1,91	16,50	2,27
0,32	0,27	1,32	0,63	2,32	0,86	3,32	1,03	4,32	1,18	6,60	1,45	11,60	1,91	16,60	2,27
0,34	0,28	1,34	0,64	2,34	0,86	3,34	1,03	4,34	1,18	6,70	1,47	11,70	1,92	16,70	2,28
0,36	0,29	1,36	0,64	2,36	0,86	3,36	1,04	4,36	1,18	6,80	1,48	11,80	1,93	16,80	2,29
0,38	0,30	1,38	0,65	2,38	0,87	3,38	1,04	4,38	1,19	6,90	1,49	11,90	1,94	16,90	2,29
0,40	0,31	1,40	0,65	2,40	0,87	3,40	1,04	4,40	1,19	7,00	1,50	12,00	1,95	17,00	2,30
0,42	0,32	1,42	0,66	2,42	0,88	3,42	1,05	4,42	1,19	7,10	1,51	12,10	1,95	17,10	2,31
0,44	0,33	1,44	0,66	2,44	0,88	3,44	1,05	4,44	1,19	7,20	1,52	12,20	1,96	17,20	2,31
0,46	0,34	1,46	0,67	2,46	0,88	3,46	1,05	4,46	1,20	7,30	1,53	12,30	1,97	17,30	2,32
0,48	0,35	1,48	0,67	2,48	0,89	3,48	1,06	4,48	1,20	7,40	1,54	12,40	1,98	17,40	2,33
0,50	0,36	1,50	0,68	2,50	0,89	3,50	1,06	4,50	1,20	7,50	1,55	12,50	1,99	17,50	2,33
0,52	0,37	1,52	0,68	2,52	0,89	3,52	1,06	4,52	1,20	7,60	1,56	12,60	1,99	17,60	2,34
0,54	0,38	1,54	0,69	2,54	0,90	3,54	1,06	4,54	1,21	7,70	1,57	12,70	2,00	17,70	2,35
0,56	0,39	1,56	0,69	2,56	0,90	3,56	1,07	4,56	1,21	7,80	1,58	12,80	2,01	17,80	2,35
0,58	0,39	1,58	0,70	2,58	0,90	3,58	1,07	4,58	1,21	7,90	1,59	12,90	2,02	17,90	2,36
0,60	0,40	1,60	0,70	2,60	0,91	3,60	1,07	4,60	1,22	8,00	1,60	13,00	2,02	18,00	2,36
0,62	0,41	1,62	0,71	2,62	0,91	3,62	1,08	4,62	1,22	8,10	1,61	13,10	2,03	18,10	2,37
0,64	0,42	1,64	0,71	2,64	0,92	3,64	1,08	4,64	1,22	8,20	1,62	13,20	2,04	18,20	2,38
0,66	0,43	1,66	0,72	2,66	0,92	3,66	1,08	4,66	1,22	8,30	1,63	13,30	2,05	18,30	2,38
0,68	0,43	1,68	0,72	2,68	0,92	3,68	1,09	4,68	1,23	8,40	1,64	13,40	2,05	18,40	2,39
0,70	0,44	1,70	0,73	2,70	0,93	3,70	1,09	4,70	1,23	8,50	1,65	13,50	2,06	18,50	2,40
0,72	0,45	1,72	0,73	2,72	0,93	3,72	1,09	4,72	1,23	8,60	1,66	13,60	2,07	18,60	2,40
0,74	0,46	1,74	0,74	2,74	0,93	3,74	1,09	4,74	1,23	8,70	1,67	13,70	2,07	18,70	2,41
0,76	0,46	1,76	0,74	2,76	0,94	3,76	1,10	4,76	1,24	8,80	1,67	13,80	2,08	18,80	2,41
0,78	0,47	1,78	0,74	2,78	0,94	3,78	1,10	4,78	1,24	8,90	1,68	13,90	2,09	18,90	2,42
0,80	0,48	1,80	0,75	2,80	0,94	3,80	1,10	4,80	1,24	9,00	1,69	14,00	2,10	19,00	2,43
0,82	0,48	1,82	0,75	2,82	0,95	3,82	1,11	4,82	1,24	9,10	1,70	14,10	2,10	19,10	2,43
0,84	0,49	1,84	0,76	2,84	0,95	3,84	1,11	4,84	1,25	9,20	1,71	14,20	2,11	19,20	2,44
0,86	0,50	1,86	0,76	2,86	0,95	3,86	1,11	4,86	1,25	9,30	1,72	14,30	2,12	19,30	2,44
0,88	0,50	1,88	0,77	2,88	0,96	3,88	1,12	4,88	1,25	9,40	1,73	14,40	2,12	19,40	2,45
0,90	0,51	1,90	0,77	2,90	0,96	3,90	1,12	4,90	1,25	9,50	1,74	14,50	2,13	19,50	2,46
0,92	0,52	1,92	0,77	2,92	0,96	3,92	1,12	4,92	1,26	9,60	1,75	14,60	2,14	19,60	2,46
0,94	0,52	1,94	0,78	2,94	0,97	3,94	1,12	4,94	1,26	9,70	1,76	14,70	2,15	19,70	2,47
0,96	0,53	1,96	0,78	2,96	0,97	3,96	1,13	4,96	1,26	9,80	1,76	14,80	2,15	19,80	2,47
0,98	0,54	1,98	0,79	2,98	0,97	3,98	1,13	4,98	1,26	9,90	1,77	14,90	2,16	19,90	2,48
1,00	0,54	2,00	0,79	3,00	0,98	4,00	1,13	5,00	1,27	10,00	1,78	15,00	2,17	20,00	2,49

Appendix B7-2

Maximum flow rate

Determination of the maximum flowrate $\mathbf{V_S}$ from the flow $\Sigma \mathbf{V_R}$ for buildings according to DIN 1988 Part 3 - $\mathbf{V_S} = 1{,}7.(\Sigma \mathbf{V_R})^{0{,}21} - 0{,}7$ (l/s).
This table is valid, if the calculated flow V_R of the respective water points is > 0,5 l/s.

ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S	ΣV_R	V_S
1,00	1,00	5,10	1,69	10,10	2,06	15,10	2,31	22,40	2,57	142,40	4,12	262,40	4,78	382,40	5,23
1,05	1,02	5,20	1,70	10,20	2,07	15,20	2,31	24,80	2,64	144,80	4,13	264,80	4,79	384,80	5,23
1,10	1,03	5,30	1,71	10,30	2,07	15,30	2,31	27,20	2,70	147,20	4,15	267,20	4,80	387,20	5,24
1,15	1,05	5,40	1,72	10,40	2,08	15,40	2,32	29,60	2,76	149,60	4,17	269,60	4,81	389,60	5,25
1,20	1,07	5,50	1,73	10,50	2,09	15,50	2,32	32,00	2,82	152,00	4,18	272,00	4,82	392,00	5,26
1,25	1,08	5,60	1,74	10,60	2,09	15,60	2,33	34,40	2,87	154,40	4,20	274,40	4,83	394,40	5,26
1,30	1,10	5,70	1,75	10,70	2,10	15,70	2,33	36,80	2,92	156,80	4,21	276,80	4,84	396,80	5,27
1,35	1,11	5,80	1,76	10,80	2,10	15,80	2,34	39,20	2,97	159,20	4,23	279,20	4,85	399,20	5,28
1,40	1,12	5,90	1,77	10,90	2,11	15,90	2,34	41,60	3,02	161,60	4,25	281,60	4,86	401,60	5,29
1,45	1,14	6,00	1,78	11,00	2,11	16,00	2,34	44,00	3,06	164,00	4,26	284,00	4,87	404,00	5,29
1,50	1,15	6,10	1,79	11,10	2,12	16,10	2,35	46,40	3,11	166,40	4,28	286,40	4,88	406,40	5,30
1,55	1,16	6,20	1,79	11,20	2,12	16,20	2,35	48,80	3,15	168,80	4,29	288,80	4,89	408,80	5,31
1,60	1,18	6,30	1,80	11,30	2,13	16,30	2,35	51,20	3,19	171,20	4,31	291,20	4,90	411,20	5,32
1,65	1,19	6,40	1,81	11,40	2,13	16,40	2,36	53,60	3,22	173,60	4,32	293,60	4,91	413,60	5,32
1,70	1,20	6,50	1,82	11,50	2,14	16,50	2,36	56,00	3,26	176,00	4,34	296,00	4,92	416,00	5,33
1,75	1,21	6,60	1,83	11,60	2,14	16,60	2,37	58,40	3,29	178,40	4,35	298,40	4,93	418,40	5,34
1,80	1,22	6,70	1,83	11,70	2,15	16,70	2,37	60,80	3,33	180,80	4,36	300,80	4,93	420,80	5,35
1,85	1,23	6,80	1,84	11,80	2,15	16,80	2,37	63,20	3,36	183,20	4,38	303,20	4,94	423,20	5,35
1,90	1,25	6,90	1,85	11,90	2,16	16,90	2,38	65,60	3,39	185,60	4,39	305,60	4,95	425,60	5,36
2,00	1,27	7,00	1,86	12,00	2,16	17,00	2,38	68,00	3,42	188,00	4,41	308,00	4,96	428,00	5,37
2,10	1,29	7,10	1,87	12,10	2,17	17,10	2,39	70,40	3,45	190,40	4,42	310,40	4,97	430,40	5,38
2,20	1,31	7,20	1,87	12,20	2,17	17,20	2,39	72,80	3,48	192,80	4,43	312,80	4,98	432,80	5,38
2,30	1,32	7,30	1,88	12,30	2,18	17,30	2,39	75,20	3,51	195,20	4,45	315,20	4,99	435,20	5,39
2,40	1,34	7,40	1,89	12,40	2,18	17,40	2,40	77,60	3,54	197,60	4,46	317,60	5,00	437,60	5,40
2,50	1,36	7,50	1,90	12,50	2,19	17,50	2,40	80,00	3,57	200,00	4,47	320,00	5,01	440,00	5,40
2,60	1,38	7,60	1,90	12,60	2,19	17,60	2,40	82,40	3,59	202,40	4,49	322,40	5,02	442,40	5,41
2,70	1,39	7,70	1,91	12,70	2,20	17,70	2,41	84,80	3,62	204,80	4,50	324,80	5,03	444,80	5,42
2,80	1,41	7,80	1,92	12,80	2,20	17,80	2,41	87,20	3,64	207,20	4,51	327,20	5,04	447,20	5,42
2,90	1,43	7,90	1,92	12,90	2,21	17,90	2,42	89,60	3,67	209,60	4,52	329,60	5,04	452,00	5,43
3,00	1,44	8,00	1,93	13,00	2,21	18,00	2,42	92,00	3,69	212,00	4,54	332,00	5,05	454,40	5,44
3,10	1,46	8,10	1,94	13,10	2,22	18,10	2,42	94,40	3,72	214,40	4,55	334,40	5,06	456,80	5,44
3,20	1,47	8,20	1,94	13,20	2,22	18,20	2,43	96,80	3,74	216,80	4,56	336,80	5,07	459,20	5,45
3,30	1,48	8,30	1,95	13,30	2,23	18,30	2,43	99,20	3,76	219,20	4,57	339,20	5,08	461,60	5,46
3,40	1,50	8,40	1,96	13,40	2,23	18,40	2,43	101,60	3,79	221,60	4,58	341,60	5,09	464,00	5,47
3,50	1,51	8,50	1,96	13,50	2,24	18,50	2,44	104,00	3,81	224,00	4,60	344,00	5,10	466,40	5,47
3,60	1,52	8,60	1,97	13,60	2,24	18,60	2,44	106,40	3,83	226,40	4,61	346,40	5,10	468,80	5,48
3,70	1,54	8,70	1,98	13,70	2,25	18,70	2,44	108,80	3,85	228,80	4,62	348,80	5,11	471,20	5,49
3,80	1,55	8,80	1,98	13,80	2,25	18,80	2,45	111,20	3,87	231,20	4,63	351,20	5,12	473,60	5,49
3,90	1,56	8,90	1,99	13,90	2,25	18,90	2,45	113,60	3,89	233,60	4,64	353,60	5,13	476,00	5,50
4,00	1,57	9,00	2,00	14,00	2,26	19,00	2,45	116,00	3,91	236,00	4,66	356,00	5,14	478,40	5,51
4,10	1,59	9,10	2,00	14,10	2,26	19,10	2,46	118,40	3,93	238,40	4,67	358,40	5,15	480,80	5,51
4,20	1,60	9,20	2,01	14,20	2,27	19,20	2,46	120,80	3,95	240,80	4,68	360,80	5,15	483,20	5,52
4,30	1,61	9,30	2,02	14,30	2,27	19,30	2,47	123,20	3,97	243,20	4,69	363,20	5,16	485,60	5,52
4,40	1,62	9,40	2,02	14,40	2,28	19,40	2,47	125,60	3,99	245,60	4,70	365,00	5,17	488,00	5,53
4,50	1,63	9,50	2,03	14,50	2,28	19,50	2,47	128,00	4,01	248,00	4,71	368,00	5,18	490,40	5,54
4,60	1,64	9,60	2,03	14,60	2,29	19,60	2,48	130,40	4,03	250,40	4,72	370,40	5,19	492,40	5,54
4,70	1,65	9,70	2,04	14,70	2,29	19,70	2,48	132,80	4,05	252,80	4,763	372,80	5,19	492,80	5,55
4,80	1,66	9,80	2,05	14,80	2,29	19,80	2,48	135,20	4,06	255,20	4,74	375,20	5,20	495,20	5,56
4,90	1,67	9,90	2,05	14,90	2,30	19,90	2,49	137,60	4,08	257,60	4,75	377,60	5,21	497,60	5,56
5,00	1,68	10,00	2,06	15,00	2,30	20,00	2,49	140,00	4,10	260,00	4,77	380,00	5,22	500,00	5,57

Appendix B

Appendix B8-1

Pipe friction gradient/flow speed of Wefatherm pipes SDR 6
Pipe friction gradient R and calculated flow speed in dependence of circulation $\mathring{V}$.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 20°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	$\mathring{V}$ = circulation (l/s)					R = pressure gradient (mbar/m)					v = speed	
d x s		**16 x 2,7**	**20 x 3,4**	**25 x 4,2**	**32 x 5,4**	**40 x 6,7**	**50 x 8,3**	**63 x 10,5**	**75 x 12,5**	**90 x 15,0**	**110 x 18,3**	**125 x 20,8**
$\mathring{V}$	**d_i**	**10,6 mm**	**13,2 mm**	**16,6 mm**	**21,2 mm**	**26,6 mm**	**33,4 mm**	**42 mm**	**50 mm**	**60 mm**	**73,4 mm**	**83,4 mm**
0,01	R	0,379	0,138	0,048	0,016	0,006	0,002	0,001	0,000	0,000	0,000	0,000
	v	0,113	0,073	0,046	0,028	0,018	0,011	0,007	0,005	0,004	0,002	0,002
0,02	R	1,182	0,425	0,146	0,047	0,017	0,006	0,002	0,001	0,000	0,000	0,000
	v	0,227	0,146	0,092	0,057	0,036	0,023	0,014	0,010	0,007	0,005	0,004
0,03	R	2,334	0,833	0,285	0,091	0,032	0,011	0,004	0,002	0,001	0,000	0,000
	v	0,340	0,219	0,139	0,085	0,054	0,034	0,022	0,015	0,011	0,007	0,005
0,04	R	3,806	1,352	0,461	0,147	0,051	0,018	0,006	0,003	0,001	0,000	0,000
	v	0,453	0,292	0,185	0,113	0,072	0,046	0,029	0,020	0,014	0,009	0,007
0,05	R	5,581	1,976	0,671	0,213	0,074	0,026	0,009	0,004	0,002	0,001	0,000
	v	0,567	0,365	0,231	0,142	0,090	0,057	0,036	0,025	0,018	0,012	0,009
0,06	R	7,645	2,699	0,914	0,289	0,100	0,035	0,012	0,005	0,002	0,001	0,001
	v	0,680	0,438	0,277	0,170	0,108	0,068	0,043	0,031	0,021	0,014	0,011
0,07	R	9,990	3,518	1,189	0,375	0,129	0,045	0,015	0,007	0,003	0,001	0,001
	v	0,793	0,512	0,323	0,198	0,126	0,080	0,051	0,036	0,025	0,017	0,013
0,08	R	12,609	4,431	1,494	0,471	0,162	0,056	0,019	0,008	0,004	0,001	0,001
	v	0,907	0,585	0,370	0,227	0,144	0,091	0,058	0,041	0,028	0,019	0,015
0,09	R	15,496	5,436	1,830	0,576	0,198	0,068	0,023	0,010	0,004	0,002	0,001
	v	1,020	0,658	0,416	0,255	0,162	0,103	0,065	0,046	0,032	0,021	0,016
0,10	R	18,648	6,530	2,195	0,689	0,236	0,081	0,028	0,012	0,005	0,002	0,001
	v	1,133	0,731	0,462	0,283	0,180	0,114	0,072	0,051	0,035	0,024	0,018
0,12	R	25,726	8,980	3,010	0,943	0,322	0,110	0,038	0,017	0,007	0,003	0,002
	v	1,360	0,877	0,554	0,340	0,216	0,137	0,087	0,061	0,042	0,028	0,022
0,14	R	33,819	11,774	3,936	1,230	0,420	0,143	0,049	0,022	0,009	0,004	0,002
	v	1,586	1,023	0,647	0,397	0,252	0,160	0,101	0,071	0,050	0,033	0,026
0,16	R	42,908	14,902	4,971	1,550	0,528	0,180	0,061	0,027	0,011	0,004	0,002
	v	1,813	1,169	0,739	0,453	0,288	0,183	0,115	0,081	0,057	0,038	0,029
0,18	R	52,978	18,358	6,111	1,902	0,647	0,220	0,075	0,033	0,014	0,005	0,003
	v	2,040	1,315	0,832	0,510	0,324	0,205	0,130	0,092	0,064	0,043	0,033
0,20	R	64,016	22,138	7,356	2,286	0,777	0,264	0,090	0,039	0,017	0,007	0,004
	v	2,266	1,461	0,924	0,567	0,360	0,228	0,144	0,102	0,071	0,047	0,037
0,30	R	133,423	45,764	15,094	4,658	1,574	0,533	0,180	0,079	0,033	0,013	0,007
	v	3,400	2,192	1,386	0,850	0,540	0,342	0,217	0,153	0,106	0,071	0,055
0,40	R	226,000	77,035	25,263	7,755	2,610	0,880	0,296	0,129	0,055	0,021	0,012
	v	4,533	2,923	1,848	1,133	0,720	0,457	0,289	0,204	0,141	0,095	0,073
0,50	R	341,300	115,750	37,782	11,549	3,874	1,302	0,437	0,191	0,080	0,031	0,017
	v	5,666	3,654	2,310	1,416	0,900	0,571	0,361	0,255	0,177	0,118	0,092
0,60	R	479,050	161,783	52,598	16,018	5,357	1,796	0,601	0,262	0,110	0,042	0,023
	v	6,799	4,384	2,772	1,700	1,080	0,685	0,433	0,306	0,212	0,142	0,110
0,70	R	639,073	215,047	69,672	21,150	7,056	2,360	0,788	0,343	0,144	0,055	0,030
	v	7,932	5,115	3,234	1,983	1,260	0,799	0,505	0,357	0,248	0,165	0,128
0,80	R	821,24	275,48	88,98	26,93	8,96	2,99	1,00	0,43	0,18	0,07	0,04
	v	9,07	5,85	3,70	2,27	1,44	0,91	0,58	0,41	0,28	0,19	0,15

Appendix B8-2

Pipe friction gradient/flow speed of Wefatherm pipes SDR 6

Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.

Roughness: K = 0,007 mm

sp. density: ρ = 998,00 kg/m³

Temperature: t = 20°C

kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	V̊ = circulation (l/s)				R = pressure gradient (mbar/m)					v = speed		
d x s		16 x 2,7	20 x 3,4	25 x 4,2	32 x 5,4	40 x 6,7	50 x 8,3	63 x 10,5	75 x 12,5	90 x 15,0	110 x 18,3	125 x 20,8
V̊	d_i	10,6 mm	13,2 mm	16,6 mm	21,2 mm	26,6 mm	33,4 mm	42 mm	50 mm	60 mm	73,4 mm	83,4 mm
0,90	R	1025,46	343,03	110,49	33,36	11,08	3,69	1,23	0,53	0,22	0,09	0,05
	v	10,20	6,58	4,16	2,55	1,62	1,03	0,65	0,46	0,32	0,21	0,16
1,00	R	1251,65	417,67	134,20	40,41	13,40	4,46	1,48	0,64	0,27	0,10	0,06
	v	11,33	7,31	4,62	2,83	1,80	1,14	0,72	0,51	0,35	0,24	0,18
1,20	R	1769,77	588,09	188,13	56,42	18,64	6,18	2,05	0,89	0,37	0,14	0,08
	v	13,60	8,77	5,54	3,40	2,16	1,37	0,87	0,61	0,42	0,28	0,22
1,40	R	2375,27	786,55	250,70	74,90	24,67	8,16	2,70	1,17	0,49	0,19	0,10
	v	15,86	10,23	6,47	3,97	2,52	1,60	1,01	0,71	0,50	0,33	0,26
1,60	R	3067,91	1012,94	321,83	95,84	31,48	10,39	3,43	1,48	0,62	0,24	0,13
	v	18,13	11,69	7,39	4,53	2,88	1,83	1,15	0,81	0,57	0,38	0,29
1,80	R	3847,53	1267,17	401,49	119,22	39,06	12,87	4,24	1,83	0,76	0,29	0,16
	v	20,40	13,15	8,32	5,10	3,24	2,05	1,30	0,92	0,64	0,43	0,33
2,00	R	4714,01	1549,16	489,64	145,02	47,41	15,58	5,13	2,21	0,92	0,35	0,19
	v	22,66	14,61	9,24	5,67	3,60	2,28	1,44	1,02	0,71	0,47	0,37
2,20	R	5667,26	1858,87	586,25	173,22	56,51	18,54	6,09	2,62	1,09	0,41	0,22
	v	24,93	16,08	10,17	6,23	3,96	2,51	1,59	1,12	0,78	0,52	0,40
2,40	R	6707,20	2196,26	691,30	203,82	66,37	21,74	7,13	3,07	1,27	0,48	0,26
	v	27,20	17,54	11,09	6,80	4,32	2,74	1,73	1,22	0,85	0,57	0,44
2,60	R	7833,77	2561,28	804,77	236,81	76,98	25,17	8,24	3,54	1,47	0,56	0,30
	v	29,46	19,00	12,01	7,37	4,68	2,97	1,88	1,32	0,92	0,61	0,48
2,80	R	9046,91	2953,91	926,64	272,18	88,33	28,84	9,43	4,05	1,68	0,64	0,34
	v	31,73	20,46	12,94	7,93	5,04	3,20	2,02	1,43	0,99	0,66	0,51
3,00	R	10346,59	3374,13	1056,91	309,92	100,42	32,75	10,70	4,59	1,90	0,72	0,39
	v	34,00	21,92	13,86	8,50	5,40	3,42	2,17	1,53	1,06	0,71	0,55
3,20	R	11732,76	3821,92	1195,56	350,03	113,26	36,88	12,03	5,16	2,13	0,81	0,44
	v	36,26	23,38	14,79	9,07	5,76	3,65	2,31	1,63	1,13	0,76	0,59
3,40	R	13205,40	4297,25	1342,57	392,50	126,83	41,25	13,44	5,76	2,38	0,90	0,49
	v	38,53	24,85	15,71	9,63	6,12	3,88	2,45	1,73	1,20	0,80	0,62
3,60	R	14764,48	4800,12	1497,96	437,33	141,13	45,85	14,92	6,39	2,64	1,00	0,54
	v	40,79	26,31	16,63	10,20	6,48	4,11	2,60	1,83	1,27	0,85	0,66
3,80	R	16409,98	5330,50	1661,69	484,52	156,17	50,67	16,48	7,05	2,91	1,10	0,59
	v	43,06	27,77	17,56	10,77	6,84	4,34	2,74	1,94	1,34	0,90	0,70
4,00	R	18141,87	5888,40	1833,78	534,06	171,94	55,73	18,10	7,74	3,19	1,21	0,65
	v	45,33	29,23	18,48	11,33	7,20	4,57	2,89	2,04	1,41	0,95	0,73
4,20	R	19960,13	6473,79	2014,21	585,95	188,45	61,02	19,80	8,46	3,49	1,32	0,71
	v	47,59	30,69	19,41	11,90	7,56	4,79	3,03	2,14	1,49	0,99	0,77
4,40	R	21864,75	7086,67	2202,99	640,19	205,68	66,53	21,57	9,21	3,80	1,43	0,77
	v	49,86	32,15	20,33	12,46	7,92	5,02	3,18	2,24	1,56	1,04	0,81
4,60	R	23855,72	7727,03	2400,09	696,77	223,63	72,27	23,41	9,99	4,12	1,55	0,84
	v	52,13	33,61	21,25	13,03	8,28	5,25	3,32	2,34	1,63	1,09	0,84
4,80	R	25933,02	8394,86	2605,53	755,69	242,32	78,23	25,32	10,79	4,45	1,68	0,90
	v	54,39	35,08	22,18	13,60	8,64	5,48	3,46	2,44	1,70	1,13	0,88

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Appendix B

Appendix B8-3

Pipe friction gradient/flow speed of Wefatherm pipes SDR 6
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 20°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	V̊ = circulation (l/s)				R = pressure gradient (mbar/m)					v = speed	
d x s		16 x 2,7	20 x 3,4	25 x 4,2	32 x 5,4	40 x 6,7	50 x 8,3	63 x 10,5	75 x 12,5	90 x 15,0	110 x 18,3	125 x 20,8
V̊	d_i	10,6 mm	13,2 mm	16,6 mm	21,2 mm	26,6 mm	33,4 mm	42 mm	50 mm	60 mm	73,4 mm	83,4 mm
5,00	R	28096,63	9090,16	2819,29	816,96	261,73	84,43	27,30	11,63	4,79	1,80	0,97
	v	56,66	36,54	23,10	14,16	9,00	5,71	3,61	2,55	1,77	1,18	0,92
5,20	R	30346,55	9812,92	3041,38	880,56	281,87	90,84	29,36	12,50	5,14	1,94	1,04
	v	58,93	38,00	24,03	14,73	9,36	5,93	3,75	2,65	1,84	1,23	0,95
5,40	R	32682,77	10563,14	3271,78	946,50	302,73	97,49	31,48	13,40	5,51	2,07	1,12
	v	61,19	39,46	24,95	15,30	9,72	6,16	3,90	2,75	1,91	1,28	0,99
5,60	R	35105,27	11340,80	3510,51	1014,78	324,31	104,35	33,67	14,32	5,89	2,21	1,19
	v	63,46	40,92	25,88	15,86	10,08	6,39	4,04	2,85	1,98	1,32	1,03
5,80	R	37614,05	12145,91	3757,55	1085,39	346,61	111,44	35,93	15,28	6,28	2,36	1,27
	v	65,72	42,38	26,80	16,43	10,44	6,62	4,19	2,95	2,05	1,37	1,06
6,00	R	40209,09	12978,46	4012,90	1158,33	369,64	118,76	38,26	16,26	6,68	2,51	1,35
	v	67,99	43,84	27,72	17,00	10,80	6,85	4,33	3,06	2,12	1,42	1,10
6,20	R	42890,40	13838,44	4276,56	1233,61	393,39	126,30	40,67	17,27	7,09	2,66	1,44
	v	70,26	45,31	28,65	17,56	11,16	7,08	4,48	3,16	2,19	1,47	1,13
6,40	R	45657,96	14725,85	4548,53	1311,21	417,85	134,06	43,14	18,31	7,52	2,82	1,52
	v	72,52	46,77	29,57	18,13	11,52	7,30	4,62	3,26	2,26	1,51	1,17
6,60	R	48511,77	15640,70	4828,80	1391,15	443,04	142,05	45,68	19,38	7,95	2,98	1,61
	v	74,79	48,23	30,50	18,70	11,88	7,53	4,76	3,36	2,33	1,56	1,21
6,80	R	51451,83	16582,97	5117,38	1473,41	468,95	150,26	48,29	20,48	8,40	3,15	1,70
	v	77,06	49,69	31,42	19,26	12,24	7,76	4,91	3,46	2,41	1,61	1,24
7,00	R	54478,11	17552,66	5414,27	1558,01	495,58	158,69	50,96	21,61	8,86	3,32	1,79
	v	79,32	51,15	32,34	19,83	12,60	7,99	5,05	3,57	2,48	1,65	1,28
7,50	R	62421,08	20096,83	6192,79	1779,67	565,28	180,74	57,96	24,55	10,05	3,77	2,03
	v	84,99	54,81	34,65	21,25	13,50	8,56	5,41	3,82	2,65	1,77	1,37
8,00	R	70902,90	22812,34	7023,17	2015,86	639,48	204,18	65,39	27,67	11,32	4,24	2,28
	v	90,65	58,46	36,96	22,66	14,40	9,13	5,77	4,07	2,83	1,89	1,46
9,00	R	89482,88	28757,21	8839,45	2531,81	801,30	255,21	81,52	34,44	14,06	5,25	2,82
	v	101,99	65,77	41,58	25,50	16,20	10,27	6,50	4,58	3,18	2,13	1,65
10,00	R			10862,98	3105,78	980,99	311,75	99,36	41,90	17,08	6,37	3,42
	v			46,21	28,33	17,99	11,41	7,22	5,09	3,54	2,36	1,83

Appendix B8-4

Pipe friction gradient/flow speed of Wefatherm pipes SDR 6
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 60°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	V̊ = circulation (l/s)				R = pressure gradient (mbar/m)					v = speed	
d x s		16 x 2,7	20 x 3,4	25 x 4,2	32 x 5,4	40 x 6,7	50 x 8,3	63 x 10,5	75 x 12,5	90 x 15,0	110 x 18,3	125 x 20,8
V̊	d_i	10,6 mm	13,2 mm	16,6 mm	21,2 mm	26,6 mm	33,4 mm	42 mm	50 mm	60 mm	73,4 mm	83,4 mm
0,01	R	0,283	0,102	0,035	0,011	0,004	0,001	0,000	0,000	0,000	0,000	0,000
	v	0,113	0,073	0,046	0,028	0,018	0,011	0,007	0,005	0,004	0,002	0,002
0,02	R	0,916	0,325	0,111	0,035	0,012	0,004	0,001	0,001	0,000	0,000	0,000
	v	0,227	0,146	0,092	0,057	0,036	0,023	0,014	0,010	0,007	0,005	0,004
0,03	R	1,842	0,650	0,220	0,069	0,024	0,008	0,003	0,001	0,001	0,000	0,000
	v	0,340	0,219	0,139	0,085	0,054	0,034	0,022	0,015	0,011	0,007	0,005
0,04	R	3,043	1,068	0,360	0,113	0,039	0,013	0,005	0,002	0,001	0,000	0,000
	v	0,453	0,292	0,185	0,113	0,072	0,046	0,029	0,020	0,014	0,009	0,007
0,05	R	4,504	1,575	0,529	0,166	0,057	0,019	0,007	0,003	0,001	0,000	0,000
	v	0,567	0,365	0,231	0,142	0,090	0,057	0,036	0,025	0,018	0,012	0,009
0,06	R	6,219	2,168	0,726	0,227	0,078	0,027	0,009	0,004	0,002	0,001	0,000
	v	0,680	0,438	0,277	0,170	0,108	0,068	0,043	0,031	0,021	0,014	0,011
0,07	R	8,182	2,844	0,950	0,296	0,101	0,034	0,012	0,005	0,002	0,001	0,000
	v	0,793	0,512	0,323	0,198	0,126	0,080	0,051	0,036	0,025	0,017	0,013
0,08	R	10,387	3,602	1,200	0,374	0,127	0,043	0,015	0,006	0,003	0,001	0,001
	v	0,907	0,585	0,370	0,227	0,144	0,091	0,058	0,041	0,028	0,019	0,015
0,09	R	12,832	4,440	1,476	0,459	0,156	0,053	0,018	0,008	0,003	0,001	0,001
	v	1,020	0,658	0,416	0,255	0,162	0,103	0,065	0,046	0,032	0,021	0,016
0,10	R	15,513	5,356	1,777	0,551	0,187	0,064	0,022	0,009	0,004	0,002	0,001
	v	1,133	0,731	0,462	0,283	0,180	0,114	0,072	0,051	0,035	0,024	0,018
0,12	R	21,576	7,422	2,455	0,759	0,257	0,087	0,029	0,013	0,005	0,002	0,001
	v	1,360	0,877	0,554	0,340	0,216	0,137	0,087	0,061	0,042	0,028	0,022
0,14	R	28,562	9,794	3,230	0,996	0,337	0,114	0,038	0,017	0,007	0,003	0,002
	v	1,586	1,023	0,647	0,397	0,252	0,160	0,101	0,071	0,050	0,033	0,026
0,16	R	36,458	12,466	4,100	1,262	0,426	0,144	0,048	0,021	0,009	0,003	0,002
	v	1,813	1,169	0,739	0,453	0,288	0,183	0,115	0,081	0,057	0,038	0,029
0,18	R	45,258	15,435	5,064	1,555	0,524	0,177	0,059	0,026	0,011	0,004	0,002
	v	2,040	1,315	0,832	0,510	0,324	0,205	0,130	0,092	0,064	0,043	0,033
0,20	R	54,953	18,697	6,121	1,876	0,631	0,212	0,071	0,031	0,013	0,005	0,003
	v	2,266	1,461	0,924	0,567	0,360	0,228	0,144	0,102	0,071	0,047	0,037
0,30	R	116,717	39,342	12,767	3,882	1,296	0,434	0,145	0,063	0,027	0,010	0,006
	v	3,400	2,192	1,386	0,850	0,540	0,342	0,217	0,153	0,106	0,071	0,055
0,40	R	200,365	67,082	21,626	6,534	2,172	0,724	0,241	0,105	0,044	0,017	0,009
	v	4,533	2,923	1,848	1,133	0,720	0,457	0,289	0,204	0,141	0,095	0,073
0,50	R	305,693	101,815	32,650	9,814	3,248	1,079	0,358	0,155	0,065	0,025	0,014
	v	5,666	3,654	2,310	1,416	0,900	0,571	0,361	0,255	0,177	0,118	0,092
0,60	R	432,584	143,479	45,811	13,711	4,522	1,498	0,496	0,215	0,090	0,034	0,019
	v	6,799	4,384	2,772	1,700	1,080	0,685	0,433	0,306	0,212	0,142	0,110
0,70	R	580,963	192,035	61,089	18,215	5,989	1,979	0,654	0,282	0,118	0,045	0,024
	v	7,932	5,115	3,234	1,983	1,260	0,799	0,505	0,357	0,248	0,165	0,128
0,80	R	750,78	247,45	78,47	23,32	7,65	2,52	0,83	0,36	0,15	0,06	0,03
	v	9,07	5,85	3,70	2,27	1,44	0,91	0,58	0,41	0,28	0,19	0,15

Appendix B

Appendix B8-5

Pipe friction gradient/flow speed of Wefatherm pipes SDR 6
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 60°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

V̊ = circulation (l/s)						R = pressure gradient (mbar/m)					v = speed	
d x s		16 x 2,7	20 x 3,4	25 x 4,2	32 x 5,4	40 x 6,7	50 x 8,3	63 x 10,5	75 x 12,5	90 x 15,0	110 x 18,3	125 x 20,8
V̊	d_i	10,6 mm	13,2 mm	16,6 mm	21,2 mm	26,6 mm	33,4 mm	42 mm	50 mm	60 mm	73,4 mm	83,4 mm
0,90	R	942,00	309,72	97,95	29,03	9,49	3,12	1,03	0,44	0,18	0,07	0,04
	v	10,20	6,58	4,16	2,55	1,62	1,03	0,65	0,46	0,32	0,21	0,16
1,00	R	1154,59	378,81	119,51	35,32	11,53	3,78	1,24	0,53	0,22	0,08	0,05
	v	11,33	7,31	4,62	2,83	1,80	1,14	0,72	0,51	0,35	0,24	0,18
1,20	R	1643,83	537,44	168,86	49,69	16,15	5,28	1,73	0,74	0,31	0,12	0,06
	v	13,60	8,77	5,54	3,40	2,16	1,37	0,87	0,61	0,42	0,28	0,22
1,40	R	2218,35	723,27	226,49	66,39	21,51	7,01	2,29	0,98	0,41	0,15	0,08
	v	15,86	10,23	6,47	3,97	2,52	1,60	1,01	0,71	0,50	0,33	0,26
1,60	R	2878,09	936,25	292,39	85,44	27,59	8,97	2,92	1,25	0,52	0,20	0,11
	v	18,13	11,69	7,39	4,53	2,88	1,83	1,15	0,81	0,57	0,38	0,29
1,80	R	3622,98	1176,36	366,51	106,80	34,40	11,16	3,63	1,55	0,64	0,24	0,13
	v	20,40	13,15	8,32	5,10	3,24	2,05	1,30	0,92	0,64	0,43	0,33
2,00	R	4452,97	1443,56	448,86	130,48	41,93	13,57	4,40	1,88	0,77	0,29	0,16
	v	22,66	14,61	9,24	5,67	3,60	2,28	1,44	1,02	0,71	0,47	0,37
2,20	R	5368,02	1737,83	539,42	156,47	50,18	16,20	5,24	2,24	0,92	0,35	0,19
	v	24,93	16,08	10,17	6,23	3,96	2,51	1,59	1,12	0,78	0,52	0,40
2,40	R	6368,12	2059,16	638,19	184,77	59,14	19,06	6,16	2,62	1,08	0,41	0,22
	v	27,20	17,54	11,09	6,80	4,32	2,74	1,73	1,22	0,85	0,57	0,44
2,60	R	7453,23	2407,55	745,15	215,37	68,82	22,14	7,14	3,04	1,25	0,47	0,25
	v	29,46	19,00	12,01	7,37	4,68	2,97	1,88	1,32	0,92	0,61	0,48
2,80	R	8623,34	2782,96	860,31	248,27	79,20	25,44	8,19	3,48	1,43	0,54	0,29
	v	31,73	20,46	12,94	7,93	5,04	3,20	2,02	1,43	0,99	0,66	0,51
3,00	R	9878,43	3185,41	983,65	283,46	90,30	28,96	9,32	3,95	1,62	0,61	0,33
	v	34,00	21,92	13,86	8,50	5,40	3,42	2,17	1,53	1,06	0,71	0,55
3,20	R	11218,48	3614,87	1115,17	320,95	102,11	32,70	10,50	4,45	1,83	0,68	0,37
	v	36,26	23,38	14,79	9,07	5,76	3,65	2,31	1,63	1,13	0,76	0,59
3,40	R	12643,49	4071,35	1254,87	360,73	114,62	36,66	11,76	4,98	2,04	0,76	0,41
	v	38,53	24,85	15,71	9,63	6,12	3,88	2,45	1,73	1,20	0,80	0,62
3,60	R	14153,44	4554,84	1402,75	402,81	127,84	40,84	13,09	5,54	2,27	0,85	0,46
	v	40,79	26,31	16,63	10,20	6,48	4,11	2,60	1,83	1,27	0,85	0,66
3,80	R	15748,32	5065,33	1558,80	447,17	141,77	45,24	14,48	6,12	2,50	0,94	0,50
	v	43,06	27,77	17,56	10,77	6,84	4,34	2,74	1,94	1,34	0,90	0,70
4,00	R	17428,12	5602,81	1723,02	493,82	156,40	49,85	15,94	6,74	2,75	1,03	0,55
	v	45,33	29,23	18,48	11,33	7,20	4,57	2,89	2,04	1,41	0,95	0,73
4,20	R	19192,84	6167,29	1895,41	542,76	171,74	54,68	17,46	7,38	3,01	1,12	0,60
	v	47,59	30,69	19,41	11,90	7,56	4,79	3,03	2,14	1,49	0,99	0,77
4,40	R	21042,47	6758,77	2075,96	593,99	187,78	59,73	19,06	8,04	3,28	1,23	0,66
	v	49,86	32,15	20,33	12,46	7,92	5,02	3,18	2,24	1,56	1,04	0,81
4,60	R	22977,01	7377,22	2264,68	647,50	204,53	65,00	20,72	8,74	3,56	1,33	0,71
	v	52,13	33,61	21,25	13,03	8,28	5,25	3,32	2,34	1,63	1,09	0,84
4,80	R	24996,44	8022,67	2461,56	703,30	221,98	70,48	22,44	9,46	3,85	1,44	0,77
	v	54,39	35,08	22,18	13,60	8,64	5,48	3,46	2,44	1,70	1,13	0,88

Appendix B8-6

Pipe friction gradient/flow speed of Wefatherm pipes SDR 6
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 60°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	V̊ = circulation (l/s)					R = pressure gradient (mbar/m)				v = speed	
d x s		**16 x 2,7**	**20 x 3,4**	**25 x 4,2**	**32 x 5,4**	**40 x 6,7**	**50 x 8,3**	**63 x 10,5**	**75 x 12,5**	**90 x 15,0**	**110 x 18,3**	**125 x 20,8**
V̊	**d_i**	**10,6 mm**	**13,2 mm**	**16,6 mm**	**21,2 mm**	**26,6 mm**	**33,4 mm**	**42 mm**	**50 mm**	**60 mm**	**73,4 mm**	**83,4 mm**
5,00	R	27100,76	8695,09	2666,61	761,38	240,13	76,18	24,24	10,21	4,16	1,55	0,83
	v	56,66	36,54	23,10	14,16	9,00	5,71	3,61	2,55	1,77	1,18	0,92
5,20	R	29289,97	9394,50	2879,81	821,75	258,99	82,10	26,10	10,99	4,47	1,66	0,89
	v	58,93	38,00	24,03	14,73	9,36	5,93	3,75	2,65	1,84	1,23	0,95
5,40	R	31564,07	10120,88	3101,18	884,39	278,54	88,23	28,03	11,79	4,80	1,78	0,96
	v	61,19	39,46	24,95	15,30	9,72	6,16	3,90	2,75	1,91	1,28	0,99
5,60	R	33923,04	10874,23	3330,70	949,32	298,81	94,58	30,02	12,62	5,13	1,91	1,02
	v	63,46	40,92	25,88	15,86	10,08	6,39	4,04	2,85	1,98	1,32	1,03
5,80	R	36366,89	11654,56	3568,38	1016,53	319,77	101,15	32,08	13,48	5,48	2,04	1,09
	v	65,72	42,38	26,80	16,43	10,44	6,62	4,19	2,95	2,05	1,37	1,06
6,00	R	38895,61	12461,86	3814,22	1086,03	341,43	107,93	34,21	14,37	5,83	2,17	1,16
	v	67,99	43,84	27,72	17,00	10,80	6,85	4,33	3,06	2,12	1,42	1,10
6,20	R	41509,20	13296,13	4068,21	1157,80	363,80	114,93	36,40	15,28	6,20	2,30	1,23
	v	70,26	45,31	28,65	17,56	11,16	7,08	4,48	3,16	2,19	1,47	1,13
6,40	R	44207,65	14157,37	4330,36	1231,85	386,86	122,14	38,66	16,22	6,58	2,44	1,31
	v	72,52	46,77	29,57	18,13	11,52	7,30	4,62	3,26	2,26	1,51	1,17
6,60	R	46990,97	15045,58	4600,66	1308,19	410,63	129,57	40,98	17,19	6,97	2,59	1,38
	v	74,79	48,23	30,50	18,70	11,88	7,53	4,76	3,36	2,33	1,56	1,21
6,80	R	49859,14	15960,75	4879,12	1386,80	435,10	137,21	43,37	18,18	7,37	2,73	1,46
	v	77,06	49,69	31,42	19,26	12,24	7,76	4,91	3,46	2,41	1,61	1,24
7,00	R	52812,18	16902,88	5165,73	1467,70	460,27	145,07	45,83	19,20	7,78	2,88	1,54
	v	79,32	51,15	32,34	19,83	12,60	7,99	5,05	3,57	2,48	1,65	1,28
7,50	R	60566,00	19376,18	5917,91	1679,90	526,26	165,66	52,26	21,87	8,85	3,28	1,75
	v	84,99	54,81	34,65	21,25	13,50	8,56	5,41	3,82	2,65	1,77	1,37
8,00	R	68850,13	22017,98	6721,04	1906,35	596,62	187,59	59,10	24,71	9,99	3,69	1,97
	v	90,65	58,46	36,96	22,66	14,40	9,13	5,77	4,07	2,83	1,89	1,46
9,00	R	87009,21	27807,02	8480,10	2401,94	750,46	235,48	74,02	30,89	12,46	4,60	2,45
	v	101,99	65,77	41,58	25,50	16,20	10,27	6,50	4,58	3,18	2,13	1,65
10,00	R			10442,86	2954,47	921,79	288,73	90,57	37,73	15,19	5,60	2,98
	v			46,21	28,33	17,99	11,41	7,22	5,09	3,54	2,36	1,83

Appendix B

Appendix B8-7

Pipe friction gradient/flow speed of Wefatherm pipes SDR 7,4
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 20°C
kin. tenacity: ν = 1,02 x 10⁻⁶ m²/s

	V̊ = circulation (l/s)				R = pressure gradient (mbar/m)					v = speed	
d x s		16 x 2,2	20 x 2,8	25 x 3,5	32 x 4,4	40 x 5,5	50 x 6,9	63 x 8,6	75 x 10,3	90 x 12,3	110 x 15,1	125 x 17,1
V̊	d_i	11,6 mm	14,4 mm	18 mm	23,2 mm	29 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm	90,8 mm
0,01	R	0,250	0,092	0,033	0,010	0,004	0,001	0,000	0,000	0,000	0,000	0,000
	v	0,095	0,061	0,039	0,024	0,015	0,010	0,006	0,004	0,003	0,002	0,002
0,02	R	0,776	0,283	0,101	0,031	0,011	0,004	0,001	0,001	0,000	0,000	0,000
	v	0,189	0,123	0,079	0,047	0,030	0,019	0,012	0,009	0,006	0,004	0,003
0,03	R	1,528	0,554	0,195	0,060	0,021	0,008	0,003	0,001	0,001	0,000	0,000
	v	0,284	0,184	0,118	0,071	0,045	0,029	0,018	0,013	0,009	0,006	0,005
0,04	R	2,486	0,898	0,315	0,096	0,034	0,012	0,004	0,002	0,001	0,000	0,000
	v	0,378	0,246	0,157	0,095	0,061	0,039	0,024	0,017	0,012	0,008	0,006
0,05	R	3,640	1,311	0,459	0,140	0,049	0,018	0,006	0,003	0,001	0,000	0,000
	v	0,473	0,307	0,196	0,118	0,076	0,049	0,030	0,022	0,015	0,010	0,008
0,06	R	4,980	1,788	0,624	0,190	0,067	0,024	0,008	0,004	0,002	0,001	0,000
	v	0,568	0,368	0,236	0,142	0,091	0,058	0,036	0,026	0,018	0,012	0,009
0,07	R	6,502	2,329	0,811	0,246	0,086	0,031	0,010	0,005	0,002	0,001	0,000
	v	0,662	0,430	0,275	0,166	0,106	0,068	0,042	0,030	0,021	0,014	0,011
0,08	R	8,199	2,931	1,019	0,308	0,108	0,038	0,013	0,006	0,002	0,001	0,001
	v	0,757	0,491	0,314	0,189	0,121	0,078	0,049	0,034	0,024	0,016	0,012
0,09	R	10,068	3,593	1,247	0,376	0,132	0,047	0,016	0,007	0,003	0,001	0,001
	v	0,852	0,553	0,354	0,213	0,136	0,087	0,055	0,039	0,027	0,018	0,014
0,10	R	12,106	4,313	1,495	0,450	0,157	0,056	0,018	0,008	0,004	0,001	0,001
	v	0,946	0,614	0,393	0,237	0,151	0,097	0,061	0,043	0,030	0,020	0,015
0,12	R	16,679	5,926	2,048	0,615	0,215	0,076	0,025	0,011	0,005	0,002	0,001
	v	1,135	0,737	0,472	0,284	0,182	0,117	0,073	0,052	0,036	0,024	0,019
0,14	R	21,901	7,761	2,676	0,802	0,279	0,098	0,033	0,015	0,006	0,002	0,001
	v	1,325	0,860	0,550	0,331	0,212	0,136	0,085	0,060	0,042	0,028	0,022
0,16	R	27,758	9,815	3,377	1,010	0,351	0,123	0,041	0,018	0,008	0,003	0,002
	v	1,514	0,982	0,629	0,378	0,242	0,155	0,097	0,069	0,048	0,032	0,025
0,18	R	34,240	12,082	4,150	1,239	0,430	0,151	0,050	0,022	0,009	0,004	0,002
	v	1,703	1,105	0,707	0,426	0,273	0,175	0,109	0,077	0,054	0,036	0,028
0,20	R	41,339	14,559	4,992	1,488	0,516	0,181	0,060	0,026	0,011	0,004	0,002
	v	1,892	1,228	0,786	0,473	0,303	0,194	0,121	0,086	0,060	0,040	0,031
0,30	R	85,857	30,007	10,219	3,025	1,043	0,363	0,119	0,053	0,022	0,009	0,005
	v	2,839	1,842	1,179	0,710	0,454	0,291	0,182	0,129	0,089	0,060	0,046
0,40	R	145,044	50,396	17,073	5,028	1,727	0,600	0,196	0,087	0,036	0,014	0,008
	v	3,785	2,456	1,572	0,946	0,606	0,389	0,243	0,172	0,119	0,080	0,062
0,50	R	218,575	75,583	25,495	7,477	2,560	0,886	0,289	0,128	0,053	0,021	0,011
	v	4,731	3,070	1,965	1,183	0,757	0,486	0,303	0,215	0,149	0,100	0,077
0,60	R	306,251	105,476	35,447	10,358	3,537	1,222	0,398	0,175	0,073	0,029	0,015
	v	5,677	3,684	2,358	1,419	0,908	0,583	0,364	0,258	0,179	0,120	0,093
0,70	R	407,937	140,011	46,900	13,662	4,653	1,604	0,521	0,229	0,096	0,037	0,020
	v	6,624	4,298	2,751	1,656	1,060	0,680	0,425	0,301	0,208	0,140	0,108
0,80	R	523,54	179,14	59,84	17,38	5,91	2,03	0,66	0,29	0,12	0,05	0,03
	v	7,57	4,91	3,14	1,89	1,21	0,78	0,49	0,34	0,24	0,16	0,12

Appendix B8-8

Pipe friction gradient/flow speed of Wefatherm pipes SDR 7,4
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 20°C
kin. tenacity: ν = 1,02 x 10⁻⁶ m²/s

V̊ = circulation (l/s)						R = pressure gradient (mbar/m)				v = speed		
d x s		16 x 2,2	20 x 2,8	25 x 3,5	32 x 4,4	40 x 5,5	50 x 6,9	63 x 8,6	75 x 10,3	90 x 12,3	110 x 15,1	125 x 17,1
V̊	d_i	11,6 mm	14,4 mm	18 mm	23,2 mm	29 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm	90,8 mm
0,90	R	652,98	222,83	74,24	21,51	7,30	2,51	0,81	0,36	0,15	0,06	0,03
	v	8,52	5,53	3,54	2,13	1,36	0,87	0,55	0,39	0,27	0,18	0,14
1,00	R	796,21	271,05	90,09	26,04	8,82	3,02	0,98	0,43	0,18	0,07	0,04
	v	9,46	6,14	3,93	2,37	1,51	0,97	0,61	0,43	0,30	0,20	0,15
1,20	R	1123,87	381,01	126,11	36,30	12,25	4,19	1,35	0,59	0,25	0,10	0,05
	v	11,35	7,37	4,72	2,84	1,82	1,17	0,73	0,52	0,36	0,24	0,19
1,40	R	1506,26	508,88	167,84	48,13	16,20	5,53	1,78	0,78	0,32	0,12	0,07
	v	13,25	8,60	5,50	3,31	2,12	1,36	0,85	0,60	0,42	0,28	0,22
1,60	R	1943,20	654,56	215,22	61,51	20,65	7,03	2,26	0,99	0,41	0,16	0,09
	v	15,14	9,82	6,29	3,78	2,42	1,55	0,97	0,69	0,48	0,32	0,25
1,80	R	2434,57	817,98	268,23	76,44	25,60	8,70	2,79	1,22	0,50	0,19	0,10
	v	17,03	11,05	7,07	4,26	2,73	1,75	1,09	0,77	0,54	0,36	0,28
2,00	R	2980,27	999,10	326,84	92,89	31,05	10,54	3,37	1,47	0,61	0,23	0,13
	v	18,92	12,28	7,86	4,73	3,03	1,94	1,21	0,86	0,60	0,40	0,31
2,20	R	3580,22	1197,86	391,02	110,87	36,99	12,53	4,00	1,75	0,72	0,28	0,15
	v	20,82	13,51	8,65	5,20	3,33	2,14	1,34	0,95	0,65	0,44	0,34
2,40	R	4234,36	1414,24	460,76	130,35	43,41	14,68	4,69	2,04	0,84	0,32	0,17
	v	22,71	14,74	9,43	5,68	3,63	2,33	1,46	1,03	0,71	0,48	0,37
2,60	R	4942,65	1648,21	536,03	151,34	50,31	16,99	5,42	2,36	0,97	0,37	0,20
	v	24,60	15,96	10,22	6,15	3,94	2,53	1,58	1,12	0,77	0,52	0,40
2,80	R	5705,05	1899,75	616,84	173,83	57,70	19,46	6,19	2,69	1,11	0,43	0,23
	v	26,49	17,19	11,00	6,62	4,24	2,72	1,70	1,20	0,83	0,56	0,43
3,00	R	6521,51	2168,84	703,17	197,81	65,56	22,08	7,02	3,05	1,25	0,48	0,26
	v	28,39	18,42	11,79	7,10	4,54	2,91	1,82	1,29	0,89	0,60	0,46
3,20	R	7392,02	2455,45	795,01	223,28	73,90	24,86	7,89	3,43	1,41	0,54	0,29
	v	30,28	19,65	12,58	7,57	4,84	3,11	1,94	1,38	0,95	0,64	0,49
3,40	R	8316,55	2759,58	892,35	250,24	82,72	27,79	8,82	3,82	1,57	0,60	0,32
	v	32,17	20,88	13,36	8,04	5,15	3,30	2,06	1,46	1,01	0,68	0,53
3,60	R	9295,07	3081,22	995,19	278,68	92,01	30,88	9,78	4,24	1,74	0,67	0,36
	v	34,06	22,10	14,15	8,52	5,45	3,50	2,19	1,55	1,07	0,72	0,56
3,80	R	10327,57	3420,35	1103,52	308,61	101,77	34,11	10,80	4,68	1,92	0,74	0,40
	v	35,96	23,33	14,93	8,99	5,75	3,69	2,31	1,63	1,13	0,76	0,59
4,00	R	11414,03	3776,97	1217,33	340,00	112,00	37,50	11,86	5,14	2,10	0,81	0,43
	v	37,85	24,56	15,72	9,46	6,06	3,89	2,43	1,72	1,19	0,80	0,62
4,20	R	12554,44	4151,06	1336,63	372,88	122,69	41,05	12,97	5,61	2,30	0,88	0,47
	v	39,74	25,79	16,50	9,94	6,36	4,08	2,55	1,81	1,25	0,84	0,65
4,40	R	13748,78	4542,63	1461,40	407,23	133,86	44,74	14,12	6,11	2,50	0,96	0,51
	v	41,63	27,02	17,29	10,41	6,66	4,28	2,67	1,89	1,31	0,88	0,68
4,60	R	14997,05	4951,66	1591,65	443,05	145,50	48,58	15,32	6,62	2,71	1,04	0,56
	v	43,53	28,25	18,08	10,88	6,96	4,47	2,79	1,98	1,37	0,92	0,71
4,80	R	16299,22	5378,14	1727,36	480,34	157,60	52,58	16,57	7,16	2,93	1,12	0,60
	v	45,42	29,47	18,86	11,35	7,27	4,66	2,91	2,07	1,43	0,96	0,74

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Appendix B

Appendix B8-9

Pipe friction gradient/flow speed of Wefatherm pipes SDR 7,4
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 20°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

V̊ = circulation (l/s)						R = pressure gradient (mbar/m)				v = speed		
d x s		16 x 2,2	20 x 2,8	25 x 3,5	32 x 4,4	40 x 5,5	50 x 6,9	63 x 8,6	75 x 10,3	90 x 12,3	110 x 15,1	125 x 17,1
V̊	d_i	11,6 mm	14,4 mm	18 mm	23,2 mm	29 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm	90,8 mm
5,00	R	17655,30	5822,08	1868,55	519,10	170,16	56,72	17,86	7,71	3,15	1,20	0,65
	v	47,31	30,70	19,65	11,83	7,57	4,86	3,03	2,15	1,49	1,00	0,77
5,20	R	19065,27	6283,46	2015,20	559,32	183,19	61,02	19,20	8,28	3,39	1,29	0,69
	v	49,20	31,93	20,43	12,30	7,87	5,05	3,16	2,24	1,55	1,04	0,80
5,40	R	20529,13	6762,29	2167,30	601,01	196,69	65,46	20,58	8,88	3,63	1,38	0,74
	v	51,10	33,16	21,22	12,77	8,18	5,25	3,28	2,32	1,61	1,08	0,83
5,60	R	22046,86	7258,55	2324,87	644,17	210,65	70,05	22,01	9,49	3,87	1,48	0,79
	v	52,99	34,39	22,01	13,25	8,48	5,44	3,40	2,41	1,67	1,12	0,86
5,80	R	23618,47	7772,25	2487,90	688,79	225,07	74,79	23,48	10,12	4,13	1,57	0,84
	v	54,88	35,61	22,79	13,72	8,78	5,64	3,52	2,50	1,73	1,16	0,90
6,00	R	25243,93	8303,38	2656,38	734,87	239,95	79,68	25,00	10,77	4,39	1,67	0,90
	v	56,77	36,84	23,58	14,19	9,08	5,83	3,64	2,58	1,79	1,20	0,93
6,20	R	26923,26	8851,94	2830,32	782,41	255,30	84,72	26,56	11,44	4,66	1,78	0,95
	v	58,67	38,07	24,36	14,67	9,39	6,02	3,76	2,67	1,85	1,24	0,96
6,40	R	28656,44	9417,92	3009,70	831,42	271,11	89,90	28,17	12,12	4,94	1,88	1,01
	v	60,56	39,30	25,15	15,14	9,69	6,22	3,88	2,75	1,91	1,28	0,99
6,60	R	30443,47	10001,32	3194,54	881,88	287,37	95,24	29,82	12,83	5,23	1,99	1,07
	v	62,45	40,53	25,94	15,61	9,99	6,41	4,01	2,84	1,96	1,32	1,02
6,80	R	32284,34	10602,15	3384,83	933,81	304,10	100,72	31,52	13,55	5,52	2,10	1,12
	v	64,34	41,75	26,72	16,09	10,29	6,61	4,13	2,93	2,02	1,36	1,05
7,00	R	34179,04	11220,39	3580,56	987,19	321,29	106,35	33,26	14,29	5,82	2,21	1,19
	v	66,24	42,98	27,51	16,56	10,60	6,80	4,25	3,01	2,08	1,40	1,08
7,50	R	39151,33	12842,17	4093,72	1127,03	366,28	121,06	37,80	16,23	6,60	2,51	1,34
	v	70,97	46,05	29,47	17,74	11,35	7,29	4,55	3,23	2,23	1,50	1,16
8,00	R	44460,03	14572,77	4640,91	1275,97	414,14	136,69	42,63	18,29	7,43	2,82	1,51
	v	75,70	49,12	31,44	18,92	12,11	7,77	4,86	3,44	2,38	1,60	1,24
9,00	R	56086,44	18360,29	5837,29	1601,13	518,45	170,70	53,10	22,74	9,23	3,50	1,87
	v	85,16	55,26	35,37	21,29	13,63	8,74	5,46	3,87	2,68	1,80	1,39
10,00	R			7169,60	1962,62	634,20	208,36	64,66	27,65	11,20	4,24	2,26
	v			39,30	23,66	15,14	9,72	6,07	4,30	2,98	2,00	1,54

Appendix B8-10

Pipe friction gradient/flow speed of Wefatherm pipes SDR 7,4
Pipe friction gradient R and calculated flow speed in dependence of circulation $\mathring{V}$.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 60°C
kin. tenacity: ν = 1,02 x 10⁻⁶ m²/s

	$\mathring{V}$ = circulation (l/s)					R = pressure gradient (mbar/m)				v = speed	
d x s		16 x 2,2	20 x 2,8	25 x 3,5	32 x 4,4	40 x 5,5	50 x 6,9	63 x 8,6	75 x 10,3	90 x 12,3	110 x 15,1
$\mathring{V}$	d_i	11,6 mm	14,4 mm	18 mm	23,2 mm	29 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm
0,01	R	0,186	0,068	0,024	0,007	0,003	0,001	0,000	0,000	0,000	0,000
	v	0,095	0,061	0,039	0,024	0,015	0,010	0,006	0,004	0,003	0,002
0,02	R	0,598	0,216	0,076	0,023	0,008	0,003	0,001	0,000	0,000	0,000
	v	0,189	0,123	0,079	0,047	0,030	0,019	0,012	0,009	0,006	0,004
0,03	R	1,200	0,430	0,150	0,045	0,016	0,006	0,002	0,001	0,000	0,000
	v	0,284	0,184	0,118	0,071	0,045	0,029	0,018	0,013	0,009	0,006
0,04	R	1,977	0,706	0,245	0,074	0,026	0,009	0,003	0,001	0,001	0,000
	v	0,378	0,246	0,157	0,095	0,061	0,039	0,024	0,017	0,012	0,008
0,05	R	2,923	1,040	0,360	0,108	0,038	0,013	0,004	0,002	0,001	0,000
	v	0,473	0,307	0,196	0,118	0,076	0,049	0,030	0,022	0,015	0,010
0,06	R	4,030	1,430	0,494	0,148	0,052	0,018	0,006	0,003	0,001	0,000
	v	0,568	0,368	0,236	0,142	0,091	0,058	0,036	0,026	0,018	0,012
0,07	R	5,295	1,874	0,645	0,193	0,067	0,024	0,008	0,003	0,001	0,001
	v	0,662	0,430	0,275	0,166	0,106	0,068	0,042	0,030	0,021	0,014
0,08	R	6,715	2,371	0,815	0,243	0,085	0,030	0,010	0,004	0,002	0,001
	v	0,757	0,491	0,314	0,189	0,121	0,078	0,049	0,034	0,024	0,016
0,09	R	8,288	2,920	1,002	0,299	0,104	0,036	0,012	0,005	0,002	0,001
	v	0,852	0,553	0,354	0,213	0,136	0,087	0,055	0,039	0,027	0,018
0,10	R	10,011	3,520	1,206	0,359	0,124	0,043	0,014	0,006	0,003	0,001
	v	0,946	0,614	0,393	0,237	0,151	0,097	0,061	0,043	0,030	0,020
0,12	R	13,902	4,872	1,663	0,494	0,170	0,060	0,020	0,009	0,004	0,001
	v	1,135	0,737	0,472	0,284	0,182	0,117	0,073	0,052	0,036	0,024
0,14	R	18,377	6,421	2,186	0,647	0,223	0,078	0,025	0,011	0,005	0,002
	v	1,325	0,860	0,550	0,331	0,212	0,136	0,085	0,060	0,042	0,028
0,16	R	23,429	8,164	2,773	0,819	0,282	0,098	0,032	0,014	0,006	0,002
	v	1,514	0,982	0,629	0,378	0,242	0,155	0,097	0,069	0,048	0,032
0,18	R	29,052	10,099	3,423	1,009	0,346	0,120	0,039	0,017	0,007	0,003
	v	1,703	1,105	0,707	0,426	0,273	0,175	0,109	0,077	0,054	0,036
0,20	R	35,241	12,224	4,135	1,216	0,417	0,145	0,047	0,021	0,009	0,003
	v	1,892	1,228	0,786	0,473	0,303	0,194	0,121	0,086	0,060	0,040
0,30	R	74,556	25,631	8,599	2,509	0,855	0,295	0,096	0,042	0,018	0,007
	v	2,839	1,842	1,179	0,710	0,454	0,291	0,182	0,129	0,089	0,060
0,40	R	127,631	43,591	14,534	4,214	1,430	0,492	0,159	0,070	0,029	0,011
	v	3,785	2,456	1,572	0,946	0,606	0,389	0,243	0,172	0,119	0,080
0,50	R	194,309	66,025	21,904	6,319	2,137	0,732	0,236	0,104	0,043	0,017
	v	4,731	3,070	1,965	1,183	0,757	0,486	0,303	0,215	0,149	0,100
0,60	R	274,500	92,888	30,688	8,815	2,971	1,015	0,327	0,143	0,059	0,023
	v	5,677	3,684	2,358	1,419	0,908	0,583	0,364	0,258	0,179	0,120
0,70	R	368,147	124,150	40,870	11,696	3,931	1,340	0,431	0,188	0,078	0,030
	v	6,624	4,298	2,751	1,656	1,060	0,680	0,425	0,301	0,208	0,140
0,80	R	475,21	159,79	52,44	14,96	5,01	1,71	0,55	0,24	0,10	0,04
	v	7,57	4,91	3,14	1,89	1,21	0,78	0,49	0,34	0,24	0,16

Appendix B

Appendix B8-11

Pipe friction gradient/flow speed of Wefatherm pipes SDR 7,4
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 60°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

V̊ = circulation (l/s)						R = pressure gradient (mbar/m)					v = speed	
d x s		**16 x 2,2**	**20 x 2,8**	**25 x 3,5**	**32 x 4,4**	**40 x 5,5**	**50 x 6,9**	**63 x 8,6**	**75 x 10,3**	**90 x 12,3**	**110 x 15,1**	**125 x 17,1**
V̊	**d_i**	**11,6 mm**	**14,4 mm**	**18 mm**	**23,2 mm**	**29 mm**	**36,2 mm**	**45,8 mm**	**54,4 mm**	**65,4 mm**	**79,8 mm**	**90,8 mm**
0,90	R	595,66	199,79	65,39	18,60	6,22	2,11	0,68	0,29	0,12	0,05	0,03
	v	8,52	5,53	3,54	2,13	1,36	0,87	0,55	0,39	0,27	0,18	0,14
1,00	R	729,48	244,14	79,72	22,61	7,55	2,56	0,82	0,36	0,15	0,06	0,03
	v	9,46	6,14	3,93	2,37	1,51	0,97	0,61	0,43	0,30	0,20	0,15
1,20	R	1037,15	345,84	112,47	31,75	10,56	3,56	1,14	0,49	0,20	0,08	0,04
	v	11,35	7,37	4,72	2,84	1,82	1,17	0,73	0,52	0,36	0,24	0,19
1,40	R	1398,12	464,86	150,67	42,37	14,04	4,73	1,50	0,65	0,27	0,10	0,06
	v	13,25	8,60	5,50	3,31	2,12	1,36	0,85	0,60	0,42	0,28	0,22
1,60	R	1812,33	601,14	194,30	54,46	17,99	6,04	1,92	0,83	0,34	0,13	0,07
	v	15,14	9,82	6,29	3,78	2,42	1,55	0,97	0,69	0,48	0,32	0,25
1,80	R	2279,73	754,67	243,35	68,01	22,41	7,51	2,38	1,03	0,42	0,16	0,09
	v	17,03	11,05	7,07	4,26	2,73	1,75	1,09	0,77	0,54	0,36	0,28
2,00	R	2800,29	925,42	297,79	83,01	27,29	9,12	2,88	1,25	0,51	0,20	0,10
	v	18,92	12,28	7,86	4,73	3,03	1,94	1,21	0,86	0,60	0,40	0,31
2,20	R	3373,97	1113,37	357,63	99,46	32,64	10,89	3,43	1,48	0,61	0,23	0,12
	v	20,82	13,51	8,65	5,20	3,33	2,14	1,34	0,95	0,65	0,44	0,34
2,40	R	4000,75	1318,52	422,86	117,36	38,44	12,80	4,03	1,74	0,71	0,27	0,15
	v	22,71	14,74	9,43	5,68	3,63	2,33	1,46	1,03	0,71	0,48	0,37
2,60	R	4680,62	1540,85	493,46	136,70	44,70	14,86	4,67	2,01	0,82	0,31	0,17
	v	24,60	15,96	10,22	6,15	3,94	2,53	1,58	1,12	0,77	0,52	0,40
2,80	R	5413,56	1780,36	569,44	157,49	51,41	17,07	5,35	2,31	0,94	0,36	0,19
	v	26,49	17,19	11,00	6,62	4,24	2,72	1,70	1,20	0,83	0,56	0,43
3,00	R	6199,56	2037,04	650,80	179,71	58,58	19,42	6,08	2,62	1,07	0,41	0,22
	v	28,39	18,42	11,79	7,10	4,54	2,91	1,82	1,29	0,89	0,60	0,46
3,20	R	7038,60	2310,87	737,52	203,38	66,20	21,92	6,85	2,95	1,20	0,46	0,24
	v	30,28	19,65	12,58	7,57	4,84	3,11	1,94	1,38	0,95	0,64	0,49
3,40	R	7930,69	2601,87	829,61	228,47	74,28	24,56	7,67	3,29	1,34	0,51	0,27
	v	32,17	20,88	13,36	8,04	5,15	3,30	2,06	1,46	1,01	0,68	0,53
3,60	R	8875,80	2910,02	927,06	255,01	82,81	27,35	8,53	3,66	1,49	0,57	0,30
	v	34,06	22,10	14,15	8,52	5,45	3,50	2,19	1,55	1,07	0,72	0,56
3,80	R	9873,93	3235,31	1029,88	282,98	91,79	30,28	9,44	4,05	1,64	0,62	0,33
	v	35,96	23,33	14,93	8,99	5,75	3,69	2,31	1,63	1,13	0,76	0,59
4,00	R	10925,08	3577,75	1138,05	312,38	101,22	33,35	10,38	4,45	1,81	0,69	0,37
	v	37,85	24,56	15,72	9,46	6,06	3,89	2,43	1,72	1,19	0,80	0,62
4,20	R	12029,23	3937,34	1251,58	343,21	111,11	36,57	11,37	4,87	1,98	0,75	0,40
	v	39,74	25,79	16,50	9,94	6,36	4,08	2,55	1,81	1,25	0,84	0,65
4,40	R	13186,39	4314,06	1370,47	375,48	121,44	39,94	12,41	5,31	2,15	0,82	0,44
	v	41,63	27,02	17,29	10,41	6,66	4,28	2,67	1,89	1,31	0,88	0,68
4,60	R	14396,55	4707,92	1494,71	409,18	132,23	43,44	13,48	5,77	2,34	0,88	0,47
	v	43,53	28,25	18,08	10,88	6,96	4,47	2,79	1,98	1,37	0,92	0,71
4,80	R	15659,71	5118,91	1624,31	444,30	143,46	47,09	14,60	6,24	2,53	0,96	0,51
	v	45,42	29,47	18,86	11,35	7,27	4,66	2,91	2,07	1,43	0,96	0,74

Appendix B8-12

Pipe friction gradient/flow speed of Wefatherm pipes SDR 7,4
Pipe friction gradient R and calculated flow speed in dependence of circulation $\mathring{V}$.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 60°C
kin. tenacity: ν = 1,02 x 10⁻⁶ m²/s

	$\mathring{V}$ = circulation (l/s)				R = pressure gradient (mbar/m)					v = speed	
d x s		16 x 2,2	20 x 2,8	25 x 3,5	32 x 4,4	40 x 5,5	50 x 6,9	63 x 8,6	75 x 10,3	90 x 12,3	110 x 15,1	125 x 17,1
$\mathring{V}$	d_i	11,6 mm	14,4 mm	18 mm	23,2 mm	29 mm	36,2 mm	45,8 mm	54,4 mm	65,4 mm	79,8 mm	90,8 mm
5,00	R	16975,86	5547,04	1759,25	480,86	155,14	50,89	15,76	6,73	2,72	1,03	0,55
	v	47,31	30,70	19,65	11,83	7,57	4,86	3,03	2,15	1,49	1,00	0,77
5,20	R	18344,99	5992,30	1899,55	518,85	167,28	54,82	16,97	7,24	2,93	1,11	0,59
	v	49,20	31,93	20,43	12,30	7,87	5,05	3,16	2,24	1,55	1,04	0,80
5,40	R	19767,11	6454,68	2045,20	558,26	179,86	58,90	18,22	7,77	3,14	1,19	0,63
	v	51,10	33,16	21,22	12,77	8,18	5,25	3,28	2,32	1,61	1,08	0,83
5,60	R	21242,21	6934,20	2196,20	599,10	192,89	63,12	19,51	8,32	3,36	1,27	0,68
	v	52,99	34,39	22,01	13,25	8,48	5,44	3,40	2,41	1,67	1,12	0,86
5,80	R	22770,29	7430,84	2352,55	641,38	206,37	67,49	20,84	8,88	3,58	1,35	0,72
	v	54,88	35,61	22,79	13,72	8,78	5,64	3,52	2,50	1,73	1,16	0,90
6,00	R	24351,34	7944,60	2514,25	685,07	220,30	71,99	22,21	9,46	3,82	1,44	0,77
	v	56,77	36,84	23,58	14,19	9,08	5,83	3,64	2,58	1,79	1,20	0,93
6,20	R	25985,37	8475,49	2681,30	730,20	234,67	76,64	23,63	10,06	4,06	1,53	0,81
	v	58,67	38,07	24,36	14,67	9,39	6,02	3,76	2,67	1,85	1,24	0,96
6,40	R	27672,37	9023,49	2853,69	776,75	249,50	81,43	25,09	10,68	4,30	1,62	0,86
	v	60,56	39,30	25,15	15,14	9,69	6,22	3,88	2,75	1,91	1,28	0,99
6,60	R	29412,33	9588,62	3031,43	824,73	264,77	86,37	26,59	11,31	4,56	1,72	0,91
	v	62,45	40,53	25,94	15,61	9,99	6,41	4,01	2,84	1,96	1,32	1,02
6,80	R	31205,27	10170,87	3214,51	874,14	280,49	91,44	28,14	11,96	4,82	1,81	0,97
	v	64,34	41,75	26,72	16,09	10,29	6,61	4,13	2,93	2,02	1,36	1,05
7,00	R	33051,17	10770,24	3402,94	924,97	296,66	96,66	29,73	12,63	5,08	1,91	1,02
	v	66,24	42,98	27,51	16,56	10,60	6,80	4,25	3,01	2,08	1,40	1,08
7,50	R	37897,62	12343,55	3897,40	1058,28	339,03	110,32	33,88	14,38	5,78	2,17	1,16
	v	70,97	46,05	29,47	17,74	11,35	7,29	4,55	3,23	2,23	1,50	1,16
8,00	R	43075,07	14023,83	4425,26	1200,51	384,20	124,87	38,29	16,24	6,52	2,45	1,30
	v	75,70	49,12	31,44	18,92	12,11	7,77	4,86	3,44	2,38	1,60	1,24
9,00	R	54422,87	17705,28	5581,15	1511,67	482,91	156,63	47,91	20,28	8,13	3,05	1,62
	v	85,16	55,26	35,37	21,29	13,63	8,74	5,46	3,87	2,68	1,80	1,39
10,00	R			6870,57	1858,43	592,79	191,92	58,58	24,75	9,91	3,71	1,97
	v			39,30	23,66	15,14	9,72	6,07	4,30	2,98	2,00	1,54

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Appendix B

Appendix B8-13

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 20°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	V̊ = circulation (l/s)				R = pressure gradient (mbar/m)				v = speed	
d x s		20 x 1,9	25 x 2,3	32 x 2,9	40 x 3,7	50 x 4,6	63 x 5,8	75 x 6,8	90 x 8,2	110 x 10,0	125 x 11,4
V̊	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm
0,01	R	0,054	0,019	0,006	0,002	0,001	0,000	0,000	0,000	0,000	0,000
	v	0,049	0,031	0,019	0,012	0,008	0,005	0,003	0,002	0,002	0,001
0,02	R	0,164	0,056	0,018	0,007	0,002	0,001	0,000	0,000	0,000	0,000
	v	0,097	0,061	0,038	0,024	0,015	0,010	0,007	0,005	0,003	0,002
0,03	R	0,320	0,109	0,035	0,012	0,004	0,002	0,001	0,000	0,000	0,000
	v	0,146	0,092	0,057	0,036	0,023	0,014	0,010	0,007	0,005	0,004
0,04	R	0,517	0,176	0,057	0,020	0,007	0,002	0,001	0,000	0,000	0,000
	v	0,194	0,122	0,075	0,048	0,031	0,019	0,014	0,009	0,006	0,005
0,05	R	0,753	0,255	0,082	0,029	0,010	0,003	0,002	0,001	0,000	0,000
	v	0,243	0,153	0,094	0,060	0,038	0,024	0,017	0,012	0,008	0,006
0,06	R	1,026	0,347	0,111	0,039	0,014	0,005	0,002	0,001	0,000	0,000
	v	0,291	0,184	0,113	0,072	0,046	0,029	0,020	0,014	0,009	0,007
0,07	R	1,334	0,450	0,144	0,050	0,018	0,006	0,003	0,001	0,000	0,000
	v	0,340	0,214	0,132	0,084	0,054	0,034	0,024	0,016	0,011	0,009
0,08	R	1,677	0,565	0,180	0,062	0,022	0,007	0,003	0,001	0,001	0,000
	v	0,388	0,245	0,151	0,096	0,061	0,039	0,027	0,019	0,013	0,010
0,09	R	2,054	0,690	0,220	0,076	0,027	0,009	0,004	0,002	0,001	0,000
	v	0,437	0,275	0,170	0,108	0,069	0,043	0,031	0,021	0,014	0,011
0,10	R	2,464	0,827	0,263	0,091	0,032	0,011	0,005	0,002	0,001	0,000
	v	0,485	0,306	0,188	0,120	0,076	0,048	0,034	0,024	0,016	0,012
0,12	R	3,380	1,131	0,359	0,124	0,043	0,015	0,006	0,003	0,001	0,001
	v	0,582	0,367	0,226	0,144	0,092	0,058	0,041	0,028	0,019	0,015
0,14	R	4,421	1,476	0,468	0,161	0,056	0,019	0,008	0,004	0,001	0,001
	v	0,679	0,428	0,264	0,168	0,107	0,067	0,048	0,033	0,022	0,017
0,16	R	5,585	1,861	0,589	0,202	0,070	0,024	0,010	0,004	0,002	0,001
	v	0,776	0,490	0,301	0,192	0,122	0,077	0,054	0,038	0,025	0,020
0,18	R	6,868	2,284	0,721	0,247	0,086	0,029	0,013	0,005	0,002	0,001
	v	0,873	0,551	0,339	0,216	0,138	0,087	0,061	0,042	0,028	0,022
0,20	R	8,269	2,746	0,866	0,296	0,103	0,035	0,015	0,006	0,003	0,001
	v	0,970	0,612	0,377	0,240	0,153	0,096	0,068	0,047	0,031	0,024
0,30	R	16,979	5,601	1,755	0,598	0,206	0,069	0,030	0,013	0,005	0,003
	v	1,455	0,918	0,565	0,359	0,229	0,145	0,102	0,071	0,047	0,037
0,40	R	28,434	9,333	2,912	0,988	0,339	0,113	0,050	0,021	0,008	0,004
	v	1,941	1,224	0,753	0,479	0,306	0,193	0,136	0,094	0,063	0,049
0,50	R	42,545	13,907	4,322	1,462	0,501	0,167	0,073	0,031	0,012	0,006
	v	2,426	1,530	0,942	0,599	0,382	0,241	0,170	0,118	0,079	0,061
0,60	R	59,251	19,300	5,979	2,017	0,690	0,230	0,100	0,042	0,016	0,009
	v	2,911	1,836	1,130	0,719	0,459	0,289	0,204	0,141	0,094	0,073
0,70	R	78,512	25,494	7,876	2,651	0,905	0,301	0,131	0,055	0,021	0,012
	v	3,396	2,142	1,318	0,839	0,535	0,337	0,238	0,165	0,110	0,085
0,80	R	100,30	32,48	10,01	3,36	1,15	0,38	0,17	0,07	0,03	0,01
	v	3,88	2,45	1,51	0,96	0,61	0,39	0,27	0,19	0,13	0,10

Appendix B8-14

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11
Pipe friction gradient R and calculated flow speed in dependence of circulation $\mathring{V}$.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 20°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	$\mathring{V}$ = circulation (l/s)					R = pressure gradient (mbar/m)				v = speed	
d x s		20 x 1,9	25 x 2,3	32 x 2,9	40 x 3,7	50 x 4,6	63 x 5,8	75 x 6,8	90 x 8,2	110 x 10,0	125 x 11,4
$\mathring{V}$	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm
0,90	R	124,58	40,24	12,37	4,15	1,41	0,47	0,20	0,08	0,03	0,02
	v	4,37	2,75	1,70	1,08	0,69	0,43	0,31	0,21	0,14	0,11
1,00	R	151,35	48,77	14,97	5,01	1,70	0,56	0,24	0,10	0,04	0,02
	v	4,85	3,06	1,88	1,20	0,76	0,48	0,34	0,24	0,16	0,12
1,20	R	212,28	68,13	20,83	6,95	2,36	0,78	0,34	0,14	0,05	0,03
	v	5,82	3,67	2,26	1,44	0,92	0,58	0,41	0,28	0,19	0,15
1,40	R	282,99	90,50	27,57	9,18	3,10	1,02	0,44	0,18	0,07	0,04
	v	6,79	4,28	2,64	1,68	1,07	0,67	0,48	0,33	0,22	0,17
1,60	R	363,41	115,86	35,19	11,69	3,94	1,30	0,56	0,23	0,09	0,05
	v	7,76	4,90	3,01	1,92	1,22	0,77	0,54	0,38	0,25	0,20
1,80	R	453,49	144,19	43,68	14,48	4,88	1,60	0,69	0,29	0,11	0,06
	v	8,73	5,51	3,39	2,16	1,38	0,87	0,61	0,42	0,28	0,22
2,00	R	553,20	175,45	53,03	17,54	5,90	1,93	0,84	0,34	0,13	0,07
	v	9,70	6,12	3,77	2,40	1,53	0,96	0,68	0,47	0,31	0,24
2,20	R	662,50	209,65	63,22	20,87	7,01	2,29	0,99	0,41	0,16	0,08
	v	10,67	6,73	4,14	2,64	1,68	1,06	0,75	0,52	0,35	0,27
2,40	R	781,38	246,77	74,26	24,47	8,21	2,68	1,16	0,48	0,18	0,10
	v	11,64	7,34	4,52	2,88	1,84	1,16	0,82	0,56	0,38	0,29
2,60	R	909,82	286,80	86,14	28,34	9,49	3,10	1,34	0,55	0,21	0,11
	v	12,61	7,95	4,90	3,11	1,99	1,25	0,88	0,61	0,41	0,32
2,80	R	1047,78	329,73	98,86	32,48	10,86	3,54	1,53	0,63	0,24	0,13
	v	13,58	8,57	5,27	3,35	2,14	1,35	0,95	0,66	0,44	0,34
3,00	R	1195,27	375,55	112,42	36,88	12,32	4,01	1,73	0,71	0,27	0,15
	v	14,55	9,18	5,65	3,59	2,29	1,45	1,02	0,71	0,47	0,37
3,20	R	1352,28	424,26	126,80	41,54	13,86	4,51	1,94	0,80	0,30	0,16
	v	15,52	9,79	6,03	3,83	2,45	1,54	1,09	0,75	0,50	0,39
3,40	R	1518,78	475,85	142,01	46,47	15,48	5,03	2,16	0,89	0,34	0,18
	v	16,50	10,40	6,40	4,07	2,60	1,64	1,16	0,80	0,53	0,41
3,60	R	1694,77	530,32	158,05	51,66	17,19	5,58	2,40	0,98	0,37	0,20
	v	17,47	11,01	6,78	4,31	2,75	1,73	1,22	0,85	0,57	0,44
3,80	R	1880,25	587,66	174,92	57,10	18,99	6,16	2,64	1,09	0,41	0,22
	v	18,44	11,63	7,16	4,55	2,91	1,83	1,29	0,89	0,60	0,46
4,00	R	2075,21	647,88	192,60	62,81	20,86	6,76	2,90	1,19	0,45	0,25
	v	19,41	12,24	7,53	4,79	3,06	1,93	1,36	0,94	0,63	0,49
4,20	R	2279,64	710,95	211,11	68,77	22,82	7,39	3,17	1,30	0,49	0,27
	v	20,38	12,85	7,91	5,03	3,21	2,02	1,43	0,99	0,66	0,51
4,40	R	2493,53	776,89	230,44	74,99	24,86	8,05	3,45	1,41	0,54	0,29
	v	21,35	13,46	8,29	5,27	3,37	2,12	1,50	1,03	0,69	0,54
4,60	R	2716,89	845,70	250,59	81,47	26,99	8,73	3,74	1,53	0,58	0,32
	v	22,32	14,07	8,66	5,51	3,52	2,22	1,56	1,08	0,72	0,56
4,80	R	2949,70	917,36	271,55	88,20	29,19	9,44	4,04	1,65	0,63	0,34
	v	23,29	14,69	9,04	5,75	3,67	2,31	1,63	1,13	0,75	0,59

Appendix B

Appendix B8-15

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11
Pipe friction gradient R and calculated flow speed in dependence of circulation $\dot{V}$.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 20°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	$\dot{V}$ = circulation (l/s)					R = pressure gradient (mbar/m)				v = speed	
d x s		**20 x 1,9**	**25 x 2,3**	**32 x 2,9**	**40 x 3,7**	**50 x 4,6**	**63 x 5,8**	**75 x 6,8**	**90 x 8,2**	**110 x 10,0**	**125 x 11,4**
$\dot{V}$	**d_i**	**16,2 mm**	**20,4 mm**	**26,0 mm**	**32,6 mm**	**40,8 mm**	**51,4 mm**	**61,2 mm**	**73,6 mm**	**90,0 mm**	**102,2 mm**
5,00	R	3191,96	991,87	293,33	95,19	31,48	10,17	4,35	1,78	0,67	0,37
	v	24,26	15,30	9,42	5,99	3,82	2,41	1,70	1,18	0,79	0,61
5,20	R	3443,68	1069,25	315,92	102,44	33,85	10,92	4,67	1,91	0,72	0,39
	v	25,23	15,91	9,79	6,23	3,98	2,51	1,77	1,22	0,82	0,63
5,40	R	3704,84	1149,47	339,33	109,93	36,30	11,71	5,00	2,05	0,77	0,42
	v	26,20	16,52	10,17	6,47	4,13	2,60	1,84	1,27	0,85	0,66
5,60	R	3975,44	1232,55	363,55	117,69	38,83	12,51	5,35	2,19	0,83	0,45
	v	27,17	17,13	10,55	6,71	4,28	2,70	1,90	1,32	0,88	0,68
5,80	R	4255,48	1318,47	388,58	125,70	41,44	13,35	5,70	2,33	0,88	0,48
	v	28,14	17,75	10,92	6,95	4,44	2,80	1,97	1,36	0,91	0,71
6,00	R	4544,96	1407,24	414,43	133,96	44,14	14,21	6,06	2,48	0,94	0,51
	v	29,11	18,36	11,30	7,19	4,59	2,89	2,04	1,41	0,94	0,73
6,20	R	4843,88	1498,86	441,08	142,47	46,91	15,09	6,44	2,63	0,99	0,54
	v	30,08	18,97	11,68	7,43	4,74	2,99	2,11	1,46	0,97	0,76
6,40	R	5152,23	1593,33	468,55	151,24	49,76	16,00	6,82	2,78	1,05	0,57
	v	31,05	19,58	12,05	7,67	4,90	3,08	2,18	1,50	1,01	0,78
6,60	R	5470,01	1690,64	496,83	160,26	52,70	16,93	7,22	2,94	1,11	0,60
	v	32,02	20,19	12,43	7,91	5,05	3,18	2,24	1,55	1,04	0,80
6,80	R	5797,22	1790,79	525,91	169,54	55,71	17,89	7,63	3,11	1,17	0,64
	v	32,99	20,80	12,81	8,15	5,20	3,28	2,31	1,60	1,07	0,83
7,00	R	6133,85	1893,78	555,81	179,06	58,81	18,87	8,04	3,28	1,24	0,67
	v	33,96	21,42	13,18	8,39	5,35	3,37	2,38	1,65	1,10	0,85
7,50	R	7016,68	2163,70	634,08	203,98	66,89	21,44	9,13	3,72	1,40	0,76
	v	36,39	22,95	14,13	8,99	5,74	3,61	2,55	1,76	1,18	0,91
8,00	R	7958,39	2451,37	717,40	230,46	75,48	24,16	10,27	4,18	1,58	0,85
	v	38,81	24,48	15,07	9,58	6,12	3,86	2,72	1,88	1,26	0,98
9,00	R	10018,40	3079,89	899,16	288,14	94,13	30,06	12,76	5,19	1,95	1,05
	v	43,66	27,54	16,95	10,78	6,88	4,34	3,06	2,12	1,41	1,10
10,00	R	3779,30	1101,04	352,06	114,76	36,57	15,50	6,29	2,36	1,28	0,20
	v	30,59	18,83	11,98	7,65	4,82	3,40	2,35	1,57	1,22	0,44

Appendix B8-16

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11

Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.

Roughness: K = 0,007 mm

sp. density: ρ = 998,00 kg/m³

Temperature: t = 60°C

kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	V̊ = circulation (l/s)					R = pressure gradient (mbar/m)				v = speed	
d x s		20 x 1,9	25 x 2,3	32 x 2,9	40 x 3,7	50 x 4,6	63 x 5,8	75 x 6,8	90 x 8,2	110 x 10,0	125 x 11,4
V̊	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm
0,01	R	0,039	0,013	0,004	0,002	0,001	0,000	0,000	0,000	0,000	0,000
	v	0,049	0,031	0,019	0,012	0,008	0,005	0,003	0,002	0,002	0,001
0,02	R	0,124	0,042	0,014	0,005	0,002	0,001	0,000	0,000	0,000	0,000
	v	0,097	0,061	0,038	0,024	0,015	0,010	0,007	0,005	0,003	0,002
0,03	R	0,247	0,083	0,027	0,009	0,003	0,001	0,000	0,000	0,000	0,000
	v	0,146	0,092	0,057	0,036	0,023	0,014	0,010	0,007	0,005	0,004
0,04	R	0,404	0,136	0,043	0,015	0,005	0,002	0,001	0,000	0,000	0,000
	v	0,194	0,122	0,075	0,048	0,031	0,019	0,014	0,009	0,006	0,005
0,05	R	0,594	0,199	0,063	0,022	0,008	0,003	0,001	0,000	0,000	0,000
	v	0,243	0,153	0,094	0,060	0,038	0,024	0,017	0,012	0,008	0,006
0,06	R	0,815	0,272	0,086	0,030	0,010	0,004	0,002	0,001	0,000	0,000
	v	0,291	0,184	0,113	0,072	0,046	0,029	0,020	0,014	0,009	0,007
0,07	R	1,067	0,356	0,113	0,039	0,013	0,005	0,002	0,001	0,000	0,000
	v	0,340	0,214	0,132	0,084	0,054	0,034	0,024	0,016	0,011	0,009
0,08	R	1,348	0,449	0,142	0,049	0,017	0,006	0,003	0,001	0,000	0,000
	v	0,388	0,245	0,151	0,096	0,061	0,039	0,027	0,019	0,013	0,010
0,09	R	1,659	0,551	0,174	0,059	0,021	0,007	0,003	0,001	0,001	0,000
	v	0,437	0,275	0,170	0,108	0,069	0,043	0,031	0,021	0,014	0,011
0,10	R	1,998	0,663	0,209	0,071	0,025	0,008	0,004	0,002	0,001	0,000
	v	0,485	0,306	0,188	0,120	0,076	0,048	0,034	0,024	0,016	0,012
0,12	R	2,760	0,913	0,287	0,098	0,034	0,011	0,005	0,002	0,001	0,000
	v	0,582	0,367	0,226	0,144	0,092	0,058	0,041	0,028	0,019	0,015
0,14	R	3,633	1,198	0,375	0,128	0,044	0,015	0,006	0,003	0,001	0,001
	v	0,679	0,428	0,264	0,168	0,107	0,067	0,048	0,033	0,022	0,017
0,16	R	4,613	1,518	0,475	0,161	0,056	0,019	0,008	0,003	0,001	0,001
	v	0,776	0,490	0,301	0,192	0,122	0,077	0,054	0,038	0,025	0,020
0,18	R	5,700	1,872	0,584	0,198	0,068	0,023	0,010	0,004	0,002	0,001
	v	0,873	0,551	0,339	0,216	0,138	0,087	0,061	0,042	0,028	0,022
0,20	R	6,891	2,258	0,704	0,238	0,082	0,027	0,012	0,005	0,002	0,001
	v	0,970	0,612	0,377	0,240	0,153	0,096	0,068	0,047	0,031	0,024
0,30	R	14,385	4,678	1,447	0,488	0,167	0,055	0,024	0,010	0,004	0,002
	v	1,455	0,918	0,565	0,359	0,229	0,145	0,102	0,071	0,047	0,037
0,40	R	24,382	7,881	2,425	0,814	0,277	0,092	0,040	0,017	0,006	0,004
	v	1,941	1,224	0,753	0,479	0,306	0,193	0,136	0,094	0,063	0,049
0,50	R	36,831	11,847	3,629	1,213	0,412	0,136	0,059	0,025	0,009	0,005
	v	2,426	1,530	0,942	0,599	0,382	0,241	0,170	0,118	0,079	0,061
0,60	R	51,701	16,562	5,054	1,685	0,570	0,188	0,082	0,034	0,013	0,007
	v	2,911	1,836	1,130	0,719	0,459	0,289	0,204	0,141	0,094	0,073
0,70	R	68,971	22,016	6,695	2,226	0,752	0,247	0,107	0,044	0,017	0,009
	v	3,396	2,142	1,318	0,839	0,535	0,337	0,238	0,165	0,110	0,085
0,80	R	88,62	28,20	8,55	2,84	0,96	0,31	0,14	0,06	0,02	0,01
	v	3,88	2,45	1,51	0,96	0,61	0,39	0,27	0,19	0,13	0,10

Appendix B

Appendix B8-17

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11
Pipe friction gradient R and calculated flow speed in dependence of circulation $\mathring{V}$.
Roughness: K = 0,007 mm
sp. density: ρ = 998,00 kg/m³
Temperature: t = 60°C
kin. tenacity: ν = 1,02 x 10^{-6} m²/s

	$\mathring{V}$ = circulation (l/s)					R = pressure gradient (mbar/m)					v = speed	
d x s		20 x 1,9	25 x 2,3	32 x 2,9	40 x 3,7	50 x 4,6	63 x 5,8	75 x 6,8	90 x 8,2	110 x 10,0	125 x 11,4	160 x 14,6
$\mathring{V}$	d_i	16,2 mm	20,4 mm	26,0 mm	32,6 mm	40,8 mm	51,4 mm	61,2 mm	73,6 mm	90,0 mm	102,2 mm	130,8 mm
0,90	R	110,65	35,11	10,62	3,51	1,18	0,39	0,17	0,07	0,03	0,01	0,004
	v	4,37	2,75	1,70	1,08	0,69	0,43	0,31	0,21	0,14	0,11	0,067
1,00	R	135,05	42,75	12,90	4,26	1,43	0,47	0,20	0,08	0,03	0,02	0,005
	v	4,85	3,06	1,88	1,20	0,76	0,48	0,34	0,24	0,16	0,12	0,074
1,20	R	190,90	60,18	18,07	5,95	1,99	0,65	0,28	0,12	0,04	0,02	0,007
	v	5,82	3,67	2,26	1,44	0,92	0,58	0,41	0,28	0,19	0,15	0,089
1,40	R	256,15	80,46	24,08	7,90	2,64	0,86	0,37	0,15	0,06	0,03	0,010
	v	6,79	4,28	2,64	1,68	1,07	0,67	0,48	0,33	0,22	0,17	0,104
1,60	R	330,77	103,59	30,90	10,11	3,37	1,09	0,47	0,19	0,07	0,04	0,012
	v	7,76	4,90	3,01	1,92	1,22	0,77	0,54	0,38	0,25	0,20	0,119
1,80	R	414,74	129,55	38,53	12,57	4,18	1,36	0,58	0,24	0,09	0,05	0,015
	v	8,73	5,51	3,39	2,16	1,38	0,87	0,61	0,42	0,28	0,22	0,134
2,00	R	508,05	158,33	46,98	15,29	5,07	1,64	0,70	0,29	0,11	0,06	0,018
	v	9,70	6,12	3,77	2,40	1,53	0,96	0,68	0,47	0,31	0,24	0,149
2,20	R	610,67	189,94	56,23	18,27	6,05	1,95	0,84	0,34	0,13	0,07	0,022
	v	10,67	6,73	4,14	2,64	1,68	1,06	0,75	0,52	0,35	0,27	0,164
2,40	R	722,61	224,36	66,29	21,49	7,10	2,29	0,98	0,40	0,15	0,08	0,025
	v	11,64	7,34	4,52	2,88	1,84	1,16	0,82	0,56	0,38	0,29	0,179
2,60	R	843,85	261,59	77,14	24,97	8,24	2,65	1,13	0,46	0,18	0,10	0,029
	v	12,61	7,95	4,90	3,11	1,99	1,25	0,88	0,61	0,41	0,32	0,193
2,80	R	974,40	301,63	88,80	28,70	9,45	3,04	1,30	0,53	0,20	0,11	0,033
	v	13,58	8,57	5,27	3,35	2,14	1,35	0,95	0,66	0,44	0,34	0,208
3,00	R	1114,24	344,47	101,26	32,67	10,75	3,45	1,47	0,60	0,23	0,12	0,038
	v	14,55	9,18	5,65	3,59	2,29	1,45	1,02	0,71	0,47	0,37	0,223
3,20	R	1263,37	390,11	114,51	36,90	12,12	3,89	1,66	0,68	0,26	0,14	0,042
	v	15,52	9,79	6,03	3,83	2,45	1,54	1,09	0,75	0,50	0,39	0,238
3,40	R	1421,78	438,55	128,57	41,37	13,57	4,35	1,85	0,75	0,28	0,15	0,047
	v	16,50	10,40	6,40	4,07	2,60	1,64	1,16	0,80	0,53	0,41	0,253
3,60	R	1589,48	489,79	143,41	46,09	15,10	4,84	2,06	0,84	0,32	0,17	0,052
	v	17,47	11,01	6,78	4,31	2,75	1,73	1,22	0,85	0,57	0,44	0,268
3,80	R	1766,46	543,83	159,05	51,06	16,71	5,35	2,27	0,92	0,35	0,19	0,057
	v	18,44	11,63	7,16	4,55	2,91	1,83	1,29	0,89	0,60	0,46	0,283
4,00	R	1952,71	600,66	175,49	56,28	18,40	5,88	2,50	1,02	0,38	0,21	0,063
	v	19,41	12,24	7,53	4,79	3,06	1,93	1,36	0,94	0,63	0,49	0,298
4,20	R	2148,24	660,29	192,72	61,74	20,16	6,44	2,73	1,11	0,42	0,23	0,069
	v	20,38	12,85	7,91	5,03	3,21	2,02	1,43	0,99	0,66	0,51	0,313
4,40	R	2353,05	722,70	210,74	67,45	22,01	7,02	2,98	1,21	0,45	0,25	0,075
	v	21,35	13,46	8,29	5,27	3,37	2,12	1,50	1,03	0,69	0,54	0,327
4,60	R	2567,13	787,91	229,55	73,40	23,93	7,62	3,23	1,31	0,49	0,27	0,081
	v	22,32	14,07	8,66	5,51	3,52	2,22	1,56	1,08	0,72	0,56	0,342
4,80	R	2790,47	855,91	249,16	79,60	25,93	8,25	3,50	1,42	0,53	0,29	0,087
	v	23,29	14,69	9,04	5,75	3,67	2,31	1,63	1,13	0,75	0,59	0,357

Appendix B8-18

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11

Pipe friction gradient R and calculated flow speed in dependence of circulation $\mathring{V}$.

Roughness: K = 0,007 mm

sp. density: ρ = 998,00 kg/m³

Temperature: t = 60°C

kin. tenacity: ν = 1,02 x 10^{-6} m²/s

$\mathring{V}$ = circulation (l/s)						R = pressure gradient (mbar/m)					v = speed	
d x s		**20 x 1,9**	**25 x 2,3**	**32 x 2,9**	**40 x 3,7**	**50 x 4,6**	**63 x 5,8**	**75 x 6,8**	**90 x 8,2**	**110 x 10,0**	**125 x 11,4**	**160 x 14,6**
$\mathring{V}$	**d_i**	**16,2 mm**	**20,4 mm**	**26,0 mm**	**32,6 mm**	**40,8 mm**	**51,4 mm**	**61,2 mm**	**73,6 mm**	**90,0 mm**	**102,2 mm**	**130,8 mm**
5,00	R	3023,09	926,71	269,56	86,05	28,00	8,91	3,77	1,53	0,57	0,31	0,094
	v	24,26	15,30	9,42	5,99	3,82	2,41	1,70	1,18	0,79	0,61	0,372
5,20	R	3264,97	1000,28	290,75	92,74	30,16	9,58	4,06	1,64	0,62	0,33	0,101
	v	25,23	15,91	9,79	6,23	3,98	2,51	1,77	1,22	0,82	0,63	0,387
5,40	R	3516,12	1076,65	312,73	99,68	32,39	10,28	4,35	1,76	0,66	0,36	0,108
	v	26,20	16,52	10,17	6,47	4,13	2,60	1,84	1,27	0,85	0,66	0,402
5,60	R	3776,53	1155,81	335,50	106,86	34,69	11,01	4,65	1,88	0,71	0,38	0,115
	v	27,17	17,13	10,55	6,71	4,28	2,70	1,90	1,32	0,88	0,68	0,417
5,80	R	4046,21	1237,75	359,06	114,29	37,08	11,76	4,97	2,01	0,75	0,41	0,123
	v	28,14	17,75	10,92	6,95	4,44	2,80	1,97	1,36	0,91	0,71	0,432
6,00	R	4325,15	1322,48	383,41	121,96	39,54	12,53	5,29	2,14	0,80	0,43	0,131
	v	29,11	18,36	11,30	7,19	4,59	2,89	2,04	1,41	0,94	0,73	0,447
6,20	R	4613,35	1410,00	408,55	129,87	42,08	13,32	5,62	2,27	0,85	0,46	0,139
	v	30,08	18,97	11,68	7,43	4,74	2,99	2,11	1,46	0,97	0,76	0,461
6,40	R	4910,82	1500,30	434,47	138,03	44,69	14,14	5,97	2,41	0,90	0,49	0,147
	v	31,05	19,58	12,05	7,67	4,90	3,08	2,18	1,50	1,01	0,78	0,476
6,60	R	5217,54	1593,39	461,19	146,44	47,38	14,98	6,32	2,55	0,95	0,51	0,155
	v	32,02	20,19	12,43	7,91	5,05	3,18	2,24	1,55	1,04	0,80	0,491
6,80	R	5533,52	1689,27	488,70	155,08	50,15	15,85	6,68	2,70	1,01	0,54	0,164
	v	32,99	20,80	12,81	8,15	5,20	3,28	2,31	1,60	1,07	0,83	0,506
7,00	R	5858,77	1787,92	516,99	163,98	52,99	16,74	7,05	2,84	1,06	0,57	0,173
	v	33,96	21,42	13,18	8,39	5,35	3,37	2,38	1,65	1,10	0,85	0,521
7,50	R	6712,37	2046,75	591,18	187,27	60,44	19,06	8,02	3,23	1,21	0,65	0,196
	v	36,39	22,95	14,13	8,99	5,74	3,61	2,55	1,76	1,18	0,91	0,558
8,00	R	7623,84	2322,98	670,30	212,09	68,36	21,53	9,05	3,64	1,36	0,73	0,220
	v	38,81	24,48	15,07	9,58	6,12	3,86	2,72	1,88	1,26	0,98	0,595
9,00	R	9620,30	2927,61	843,30	266,30	85,64	26,91	11,29	4,54	1,69	0,91	0,273
	v	43,66	27,54	16,95	10,78	6,88	4,34	3,06	2,12	1,41	1,10	0,670
10,00	R		3601,80	1035,98	326,59	104,83	32,86	13,77	5,52	2,05	1,10	0,331
	v		30,59	18,83	11,98	7,65	4,82	3,40	2,35	1,57	1,22	0,744

Appendix B

Appendix B8-19

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.

Roughness: K = 0,007 mm
sp. density: ρ = 997,8 kg/m³
Temperature: t = 70°C
kin. tenacity: ν = 0,414 x 10^{-6} m²/s

Roughness: K = 0,007 mm
sp. density: ρ = 998,20 kg/m³
Temperature: t = 20°C
kin. tenacity: ν = 1,011 x 10^{-6} m²/s

V̊ = circulation (l/s)						R = pressure gradient (mbar/m)			v = speed		
	SDR	11	d_e	160	200	250	315	160	200	250	315
	V	V	s	14,6	18,2	22,7	28,6	14,6	18,2	22,7	28,6
l/s	l/min	m³/h	di	130,8	163,6	204,6	257,8	130,8	163,6	204,6	257,8
5	300	18	R	0,17	0,06			0,13	0,04		
			v	0,37	0,24			0,37	0,24		
6	360	22	R	0,25	0,08			0,19	0,07		
			v	0,45	0,29			0,45	0,29		
7	420	25	R	0,33	0,11	0,04		0,25	0,08	0,03	
			v	0,52	0,33	0,21		0,52	0,33	0,21	
8	480	29	R	0,44	0,15	0,05		0,34	0,11	0,04	
			v	0,60	0,38	0,24		0,60	0,38	0,24	
9	540	32	R	0,55	0,19	0,06		0,42	0,14	0,05	
			v	0,67	0,43	0,27		0,67	0,43	0,27	
10	600	36	R	0,67	0,23	0,08		0,51	0,18	0,06	
			v	0,74	0,48	0,30		0,74	0,48	0,30	
12	720	43	R	0,97	0,33	0,11	0,04	0,74	0,25	0,09	0,03
			v	0,89	0,57	0,36	0,23	0,89	0,57	0,36	0,23
14	840	50	R	1,32	0,45	0,16	0,05	1,01	0,35	0,12	0,04
			v	1,04	0,67	0,43	0,27	1,04	0,67	0,43	0,27
16	960	58	R	1,73	0,58	0,21	0,07	1,32	0,45	0,16	0,05
			v	1,19	0,76	0,49	0,31	1,19	0,76	0,49	0,31
18	1080	65	R	2,19	0,74	0,27	0,09	1,68	0,57	0,2	0,06
			v	1,34	0,86	0,55	0,34	1,34	0,86	0,55	0,34
20	1200	72	R	2,71	0,91	0,33	0,11	2,07	0,70	0,25	0,08
			v	1,49	0,95	0,61	0,38	1,49	0,95	0,61	0,38
22	1320	79	R	3,28	1,11	0,39	0,13	2,51	0,86	0,30	0,10
			v	1,64	1,05	0,67	0,42	1,64	1,05	0,67	0,42
24	1440	86,4	R	3,91	1,31	0,47	0,16	2,99	1,01	0,36	0,12
			v	1,79	1,14	0,73	0,46	1,79	1,14	0,73	0,46
26	1560	93,6	R	4,55	1,55	0,55	0,18	3,48	1,19	0,42	0,14
			v	1,93	1,24	0,79	0,50	1,93	1,24	0,79	0,50
28	1680	100,8	R	5,28	1,78	0,63	0,21	4,04	1,37	0,48	0,16
			v	2,08	1,33	0,85	0,54	2,08	1,33	0,85	0,54
30	1800	108	R	6,07	2,06	0,73	0,24	4,65	1,59	0,55	0,18
			v	2,23	1,43	0,91	0,57	2,23	1,43	0,91	0,57
32	1920	115,2	R	6,92	2,33	0,83	0,27	5,29	1,80	0,63	0,20
			v	2,38	1,52	0,97	0,61	2,38	1,52	0,97	0,61
34	2040	122,4	R	7,82	2,64	0,93	0,31	5,98	2,04	0,71	0,23
			v	2,53	1,62	1,03	0,65	2,53	1,62	1,03	0,65
36	2160	129,6	R	8,77	2,94	1,04	0,35	6,71	2,27	0,79	0,26
			v	2,68	1,71	1,09	0,69	2,68	1,71	1,09	0,69
38	2280	136,8	R	9,78	3,30	1,18	0,39	7,48	2,55	0,90	0,29
			v	2,83	1,81	1,16	0,73	2,83	1,81	1,16	0,73
40	2400	144	R	10,84	3,63	1,31	0,44	8,30	2,80	1,00	0,33
			v	2,98	1,90	1,22	0,77	2,98	1,90	1,22	0,77
42	2520	151,2	R	11,96	4,03	1,44	0,47	9,15	3,11	1,10	0,35
			v	3,13	2,00	1,28	0,80	3,13	2,00	1,28	0,80
44	2640	158,4	R	13,06	4,40	1,58	0,52	9,99	3,39	1,20	0,39
			v	3,27	2,09	1,34	0,84	3,27	2,09	1,34	0,84
46	2760	165,6	R	14,28	4,83	1,72	0,57	10,93	3,73	1,31	0,43
			v	3,42	2,19	1,40	0,88	3,42	2,19	1,40	0,88
48	2880	172,8	R	15,56	5,23	1,87	0,62	11,91	4,04	1,43	0,47
			v	3,57	2,28	1,46	0,92	3,57	2,28	1,46	0,92
50	3000	180	R	16,90	5,70	2,03	0,68	12,93	4,40	1,55	0,51
			v	3,72	2,38	1,52	0,96	3,72	2,38	1,52	0,96
55	3300	198	R	20,43	6,91	2,45	0,81	15,63	5,33	1,87	0,61
			v	4,09	2,62	1,67	1,05	4,09	2,62	1,67	1,05

Appendix B8-20

Pipe friction gradient/flow speed of Wefatherm pipes SDR 11
Pipe friction gradient R and calculated flow speed in dependence of circulation V̊.

Roughness:	K = 0,007 mm	Roughness:	K = 0,007 mm
sp. density:	ρ = 997,8 kg/m³	sp. density:	ρ = 998,20 kg/m³
Temperature:	t = 70°C	Temperature:	t = 20°C
kin. tenacity:	ν = 0,414 x 10^{-6} m²/s	kin. tenacity:	ν = 1,011 x 10^{-6} m²/s

V̊ = circulation (l/s)						R = pressure gradient (mbar/m)			v = speed		
	SDR	**11**	**d_e**	**160**	**200**	**250**	**315**	**160**	**200**	**250**	**315**
	V	**V**	**s**	**14,6**	**18,2**	**22,7**	**28,6**	**14,6**	**18,2**	**22,7**	**28,6**
l/s	**l/min**	**m³/h**	**di**	**130,8**	**163,6**	**204,6**	**257,8**	**130,8**	**163,6**	**204,6**	**257,8**
60	3600	216	R	24,4	8,18	2,91	0,97	18,67	6,31	2,22	0,73
			v	4,47	2,85	1,82	1,15	4,47	2,85	1,82	1,15
65	3900	234	R	28,6	9,61	3,44	1,15	21,89	7,42	2,62	0,86
			v	4,84	3,09	1,98	1,25	4,84	3,09	1,98	1,25
70	4200	252	R		11,16	3,98	1,32		8,62	3,04	0,99
			v		3,33	2,13	1,34		3,33	2,13	1,34
75	4500	270	R		12,83	4,57	1,53		9,9	3,48	1,14
			v		3,57	2,28	1,44		3,57	2,28	1,44
80	4800	288	R		14,61	5,19	1,72		11,28	3,95	1,29
			v		3,81	2,43	1,53		3,81	2,43	1,53
85	5100	306	R		16,43	5,89	1,95		12,68	4,49	1,46
			v		4,04	2,59	1,63		4,04	2,59	1,63
90	5400	324	R		18,44	6,59	2,18		14,23	5,02	1,63
			v		4,28	2,74	1,72		4,28	2,74	1,72
95	5700	342	R		20,57	7,33	2,44		15,87	5,59	1,82
			v		4,52	2,89	1,82		4,52	2,89	1,82
100	6000	360	R		22,81	8,12	2,71		17,6	6,18	2,03
			v		4,76	3,04	1,92		4,76	3,04	1,92
110	6600	396	R			9,86	3,28			7,51	2,45
			v			3,35	2,11			3,35	2,11
120	7200	432	R			11,7	3,89			8,91	2,91
			v			3,65	2,3			3,65	2,3
130	7800	468	R			13,7	4,56			10,44	3,41
			v			3,95	2,49			3,95	2,49
140	8400	504	R			15,94	5,28			12,14	3,95
			v			4,26	2,68			4,26	2,68
150	9000	540	R			18,26	6,06			13,91	4,53
			v			4,56	2,87			4,56	2,87

Appendix B

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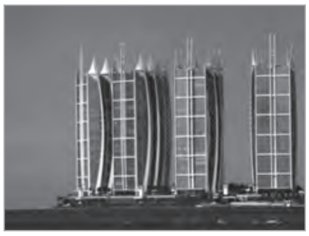

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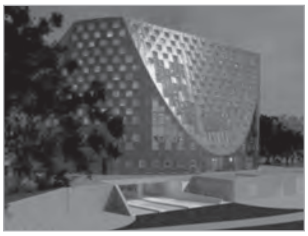

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